

Lancashire, India, and shifting competitive advantage in cotton textiles, 1700–1850: the neglected role of factor prices¹

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In the early eighteenth century, wages in Britain were more than four times as high as in India, the world's major exporter of cotton textiles. This induced the adoption of more capital-intensive production methods in Britain and a faster rate of technological progress, so that competitive advantage had begun to shift in Britain's favour by the late eighteenth century. However, the completion of the process was delayed until after the Napoleonic Wars by increasing raw cotton costs, before supply adjusted to the major increase in demand for inputs.

During the early modern period, India was the world's main producer of cotton textiles, with a substantial export trade. Indian textiles were exported to Britain on a large scale from the seventeenth century.² By the early nineteenth century, however, Britain had become the world's most important cotton textile producer, dominating world export markets, and even exporting to India.³ This dramatic change in international competitive advantage, which must surely rank as one of the most important developments of the industrial revolution period, is often described entirely in terms of developments within Britain, without any reference to India, and with little or no reference to factor prices.⁴ This paper attempts to redress the balance.

This paper links the development of the Lancashire cotton textile industry during the industrial revolution to factor price developments in Britain and India. The import substitution emphasized by Inikori is characterized as a two-stage process: first, a shift from production using traditional skills to production with machine-intensive technology; second, a faster rate of innovation in the machine-intensive technology.⁵ The process was begun and sustained by a major difference in factor prices between Britain and India, with wages in Britain being much

¹ We are grateful to Huw Bowen and Sumit Guha for making unpublished data available to us. We would also like to thank Bob Allen, Maxine Berg, Nick Crafts, George Grantham, Santhi Hejeebu, Frank Lewis, Jonas Ljungberg, Patrick O'Brien, Richard Sutch, and seminar/conference participants at Berlin, Granlibakken (Clio), Kingston, Leicester (Economic History Society), Madrid, Montreal, Oxford, Utrecht (Global Economic History Network), Venice, and Warwick, for helpful comments and suggestions. The financial support of the European Commission Marie Curie Actions (contract no. MRTN-CT-2004-512439) and the ESRC (grant no. R000239492) is gratefully acknowledged.

² Baines, *History*, pp. 55–83; Robson, *Cotton industry*, p. 1.

³ Ellison, *Cotton trade*, pp. 57–70; Robson, *Cotton industry*, pp. 1–3.

⁴ Ellison, *Cotton trade*, pp. 14–70; Landes, *Unbound Prometheus*, pp. 82–8; Rose, *Firms*, pp. 22–37.

⁵ Inikori, *Africans*, pp. 427–51.

higher during the eighteenth century.⁶ This idea of factor price differences driving technological choice is well established in accounts of American industrial development during the nineteenth century. The argument is most closely associated with the work of Rothbarth and Habakkuk, who emphasized the role of land abundance in creating a labour shortage in the New World, and hence higher wages in the United States compared with Britain.⁷ Faced with high labour costs, American entrepreneurs developed a more capital-intensive technology with higher labour productivity.⁸

Mokyr writes, after a discussion of the Habakkuk debate, that 'Most of the debate is carried out in the context of Anglo-American differences, with Britain, interestingly enough, considered the *low-wage* economy (though in the period of the Industrial Revolution it would, relative to the rest of Europe, be the high-wage economy). A comparison between Britain and the Continent during the Industrial Revolution would be worthwhile, but so far has not been attempted seriously'.⁹ In fact, a wider comparison of the international wage differences suggests a much stronger *prima facie* case for factor prices playing an important role in the case of eighteenth-century Britain and India. As early as the seventeenth century, an unskilled labourer earned four to five times as much in Britain as in India.¹⁰ In the middle of the nineteenth century, an unskilled labourer earned less than twice as much in America as in Britain.¹¹ Similarly, the British unskilled silver wage during the second half of the eighteenth century was also less than twice as high as in much of western Europe.¹² The Anglo-Indian factor price comparison is of particular importance in cotton textiles, where India was Britain's major competitor. Chaudhuri hints at the effect of factor prices on the choice of technique, but without really developing the argument. After noting that 'English labour was a great deal dearer than Indian', he goes on to argue that 'It is perhaps not entirely a chance occurrence that the large-scale application of machinery to the production process happened in the textile industry in England'.¹³

One reason for the neglect of factor prices in the history of the cotton industry is thus that the comparative analysis has rarely considered the diversity of wages in the global economy, tending instead to focus on Europe and the United States. However, there appears also to be a second reason, arising from a reluctance to characterize Britain as a high-wage economy during the industrial revolution, a period where the focus has been on the slow growth rather than the high level of British wages. Von Tunzelmann, for example, endorses Habakkuk's view of the US/Britain case, but rejects its applicability to the case of Britain and Europe during the industrial revolution.¹⁴

Some writers have considered the logical possibility of high wages affecting technological choice, but because of their focus on Europe, they have not perceived the huge silver wage gap with India. Consequently, factor prices have been

⁶ Broadberry and Gupta, 'Early modern great divergence', pp. 13–18.

⁷ Rothbarth, 'Causes'; Habakkuk, *American and British technology*.

⁸ David, *Technical choice*; Broadberry, *Productivity race*.

⁹ Mokyr, 'Editor's introduction', p. 88.

¹⁰ Broadberry and Gupta, 'Early modern great divergence', p. 17.

¹¹ Williamson, 'Global labor markets', p. 178.

¹² Allen, 'Great divergence', p. 416; Broadberry and Gupta, 'Early modern great divergence', p. 5.

¹³ Chaudhuri, *Trading world*, p. 238.

¹⁴ Von Tunzelmann, 'Technical progress', pp. 159–60.

accorded only a minor role in the changing competitive advantage in the world cotton textiles market. Thus Landes devotes a short section to high wages as a stimulus to mechanization in his early work, but makes no mention of this inducement mechanism in his later work.¹⁵ Others, such as Deane, only mention wages in the context of the British cotton industry in order to stress the importance of 'an almost inexhaustible low-priced labour supply'.¹⁶

The story of Anglo-Indian competition in cotton textiles begins with the growth of cloth imports into Britain via the East India Company from the seventeenth century. The new cloths, patterns, and designs became increasingly fashionable and thus threatened the livelihood of domestic producers of fine woollens and linens, which were the closest substitutes for printed cottons from India.¹⁷ The pressure from these groups led to protective legislation that remained in force between 1701 and 1774, and opened up new opportunities for British manufacturers via a strategy of import substitution.¹⁸ However, high silver wages in Britain meant that cotton textiles produced domestically using labour-intensive production methods could not compete with Indian goods in third markets. This stimulated a two-stage process of technological change.

First, high wages led to the adoption of a more capital-intensive technology in Britain. Second, this choice of technology resulted in a faster rate of productivity growth in Britain, because of the greater incentive to devote resources to improving technology where capital intensity is higher. This is consistent with the positive relationship between capital intensity, resources devoted to research and development, and the rate of technological progress, highlighted in Schumpeterian models of economic growth.¹⁹ This effect can be explained partly by the greater learning potential on capital-intensive technology.²⁰ In Britain, however, the effect was amplified by the existence of an effective patent system.²¹

There was thus a stronger incentive to devote resources to innovation in the machine-intensive industry of Britain, compared with the labour-intensive industry of India. As productivity increased in the machine-intensive British cotton textile industry and stagnated in India, a shift in competitive advantage occurred. However, the shift was delayed in international markets during the late eighteenth and early nineteenth centuries by a temporary rise in raw cotton prices in Britain, as the increase in production put pressure on factor markets. The shift of competitiveness in the Indian market was delayed further by transport costs, which prevented the British from breaking into the Indian market on a large scale until after 1830.²²

The paper proceeds as follows. Section I provides a brief quantitative overview of developments in the British and Indian cotton textile industries. Factor prices

¹⁵ Landes, *Unbound Prometheus*, pp. 57–60; idem, *Wealth and poverty*.

¹⁶ Deane, *First industrial revolution*, p. 97. R. C. Allen, 'The British industrial revolution in global perspective: how commerce created the industrial revolution and modern economic growth', Nuffield College, Oxford, 2006 [WWW document]. URL <http://www.nuff.ox.ac.uk/users/allen/unpublished/econinvent-3.pdf> [accessed on 13 June 2008], also argues for the importance of high wages in Britain for technological choice during the industrial revolution, although he appears to remain ambivalent about the existence of a real wage gap between Britain and Asia; see Allen, 'Real wages'.

¹⁷ Baines, *History*, p. 106; de Vries, 'Purchasing power'; Berg, 'From imitation to invention'.

¹⁸ Inikori, *Africans*, pp. 428–32; O'Brien, Griffiths, and Hunt, 'Political components'.

¹⁹ Aghion and Howitt, *Endogenous growth*, pp. 85–121.

²⁰ Arrow, 'Economic implications'.

²¹ Dutton, *Patent system*; Sullivan, 'England's "age of invention"'.

²² Ellison, *Cotton trade*, p. 63; Twomey, 'Employment', p. 53.

in Britain and India are then examined in section II, establishing that money wages and the wage-rental ratio were much higher in Britain. Raw cotton was also more expensive in Britain. Section III uses input and output prices to derive estimates of comparative total factor productivity (TFP) levels. The most important proximate cause of the shift in competitive advantage was the faster growth of TFP in Britain, although a temporary increase in raw cotton prices at the end of the eighteenth century delayed the shift. Section IV relates comparative TFP to factor prices, drawing on analysis of nineteenth-century American and British industrial development. Section V concludes.

I

There is widespread agreement that the arrival on a large scale of Indian cotton cloth in Britain in the seventeenth century had a substantial effect on the domestic textile industry. Indian patterns and designs quickly became fashionable and forced domestic textile producers to react, on the one hand lobbying for protection, and on the other hand imitating through printing on wool, linen, and calico.²³

The British cotton industry, which took root in the already established textile producing region of Lancashire, remained small throughout the seventeenth century and the first half of the eighteenth century, since it was not yet competitive with Indian cotton textiles.²⁴ The lack of competitiveness of the early British cotton textile industry can be seen most clearly in the trade data presented in tables 1 and 2. Trade data were collected by customs officials on a value basis, but at 'official' rather than current prices.

Although much attention has been focused in the literature on how these official values provide a misleading guide to current values of trade, particularly after the late eighteenth century, this does not invalidate their use as indicators of trade volumes. Indeed, Flux notes that '(t)he official values appear to give a much better indication on the movements in the volume of trade than one could have expected'.²⁵ Certainly, the increase in the volume of both piece goods and yarn exports during the first half of the nineteenth century (shown in part B of table 1) moves broadly in line with the official values of exports (shown in part A) over the same period. At the beginning of the eighteenth century, British cotton textile exports were a mere 0.5 per cent of their level at the beginning of the nineteenth century. By the 1750s, despite substantial growth, export volumes remained at just 3 per cent of their level in the early 1800s. In part A of table 2, the data on trade values at official prices show how British cotton textile exports were a small fraction of the imports of cotton cloth from India before the 1780s.²⁶

Worries about competition from India in the British market led to pressures for protection. But it should be noted that the pressure for such measures came more from producers of woollens and linens than from the small community of British cotton textile producers, since fine woollens and linens were the closest substitutes for printed cottons from India.²⁷ Initial measures from 1690 took the form of

²³ Wadsworth and Mann, *Cotton trade*, p. 118; Thomas, *Mercantilism*, pp. 25–66.

²⁴ Wadsworth and Mann, *Cotton trade*, pp. 15, 527.

²⁵ Flux, 'Old trade records', p. 81, also cited in Mitchell, *British historical statistics*, p. 446.

²⁶ Davis, 'English foreign trade, 1660–1700'; idem, 'English foreign trade, 1700–1774'.

²⁷ Baines, *History*, p. 106.

Table 1. *Exports of cotton textiles, measured at constant official prices, Great Britain, 1697–1850 (£000 at 1697 prices)*

<i>A. Annual average values at constant official prices (£000 at 1697 prices)</i>					
	<i>Total</i>		<i>Piece goods</i>	<i>Yarn</i>	<i>Total</i>
1697–9	16	1770–9			246
1700–9	13	1780–9			756
1710–19	8	1790–9	2,525	101	2,626
1720–9	16	1800–9	7,603	749	8,352
1730–9	14	1810–19	17,712	1,133	18,845
1740–9	11	1820–9	25,605	3,225	29,830
1750–9	86	1830–9	44,086	7,519	51,605
1760–9	227	1840–9	73,838	12,109	85,947
<i>B. Annual average volumes</i>					
	<i>Piece goods</i>			<i>Yarn</i>	
	<i>Million linear yards</i>		<i>Million lbs</i>	<i>Million lbs</i>	
1800–9	109.5		20.0	7.4	
1810–19	205.0		37.4	12.0	
1820–9	320.3		58.5	35.5	
1830–9	552.4		100.8	84.3	
1840–9	977.5		178.4	136.1	

Sources: Part A: 1697–1808: Schumpeter, *English overseas trade*, tabs. X, XI, pp. 29–34; 1808–1850: Parliamentary Papers, *Finance accounts*. Part B: Robson, *Cotton industry*, p. 331.

Table 2. *British imports and re-exports of cotton piece goods from India, compared with British exports of cotton textiles, 1663–1856*

<i>A. Annual average values at constant official prices (£000 at 1697 prices)</i>			
	<i>Imports</i>	<i>Re-exports</i>	<i>Exports</i>
1663–9	182		
1699–1701	367	340	20
1722–4	437	484	18
1752–4	401	499	83
1772–4	697	701	221
<i>B. Annual average values at current prices (£000)</i>			
	<i>Imports</i>	<i>Re-exports</i>	<i>Exports</i>
1784–6	1,344	395	797
1794–6	1,687	1,148	3,801
1804–6	823	777	16,339
1814–16	515	433	18,994
1824–6	363	430	17,375
1834–6	347	406	22,398
1844–6	478	450	25,835
1854–6	481	532	34,908

Sources: Part A: 1663–1701: Davis, 'English foreign trade, 1660–1700', pp. 164–5; 1722–74: Davis, 'English foreign trade, 1700–1774', pp. 300–3. Part B: 1784–1856: Davis, *Industrial revolution*, pp. 94–125.

import duties, but these were too low to make much impact on the huge labour cost differences.²⁸ From 1701, however, printed calicos and certain other types of cotton cloth imported from India were prohibited.²⁹ The 1701 Calico Act still allowed the importation of white cottons from India for printing within Britain, until further legislation in 1721 prohibited these imports unless they were for re-export. O'Brien, Griffiths, and Hunt see these protectionist measures, which remained in force with various amendments until 1774, as giving an important boost to the British cotton industry.³⁰

By the mid-eighteenth century, Britain's cotton producers were still not able to compete seriously on world markets.³¹ But the search for machine-intensive techniques, driven by the much higher wages in Britain than India, had already begun by this time, and developments occurred before the industrial revolution in all the main sections of preparation, spinning, and weaving.³² However, the crucial 'macro inventions' of the industrial revolution period had not yet appeared, since searching for any particular invention does not guarantee that it will be found immediately.³³ Hence, while labour productivity in Britain was higher than in India, it was still not sufficiently high to offset the higher wages. Indeed, since wages increased more rapidly in Lancashire than in southern England during the eighteenth century, the Anglo-Indian wage gap in cotton textiles increased substantially.³⁴

During the second half of the eighteenth century, however, labour productivity increased dramatically in the British cotton textile industry as a result of further technological progress, while technology and productivity stagnated in India. This led gradually and in stages to a shift in competitive advantage, so that by the early nineteenth century, Britain was dominant in world markets, and was even able to export to India. However, Britain's conquest of world markets was hampered between the 1780s and the 1820s by the high price of inputs resulting from the sudden surge in British demand. This applied most obviously in the labour market, where shortages of handloom weavers famously led to very high earnings. However, it also affected the price of raw cotton in Britain, which reached very high levels in the late eighteenth and early nineteenth centuries.³⁵ However, as supply increased, particularly from the United States, the price of raw cotton in Britain fell back, returning during the 1830s to its level in the early eighteenth century. From this point on, Indian producers were faced with the full force of British competition in their home market as well as in export markets.

Table 2 shows estimates of trade values in official and current prices.³⁶ The figures suggest that the size of the British market for Indian imports was lower than the quantities re-exported through London between the early 1720s and the early

²⁸ Davis, 'Rise of protection', p. 309.

²⁹ Wadsworth and Mann, *Cotton trade*, pp. 117–18.

³⁰ O'Brien et al., 'Political components', pp. 413–18.

³¹ Baines, *History*, p. 81.

³² Timmins, 'Technological change', pp. 34–9.

³³ Mokyr, *Lever of riches*, p. 13; Crafts, 'Industrial revolution', pp. 432–4.

³⁴ Gilboy, *Wages*, pp. 254–64, 280–7.

³⁵ Mitchell, *British historical statistics*, pp. 759–60.

³⁶ As current prices began to deviate substantially from official prices towards the end of the late eighteenth century, Davis, *Industrial revolution*, provides estimates of trade values at current prices, shown here in part B of tab. 2. Official prices show estimates at constant prices. Since the shares of imports, exports, and re-exports are being examined here in order to get an idea of the relative market sizes, it is unimportant whether current or official prices are used.

Table 3. *British cotton textile exports in the Indian market, 1810–19 to 1890–9*

	<i>Annual average Indian consumption of cotton textiles (million yards)</i>	<i>Share taken by British exports (%)</i>
1810–19	1,890	0.1
1820–9	1,890	1.3
1830–9	1,926	2.7
1840–9	1,998	11.5
1850–9	2,142	21.8
1860–9	2,250	24.9
1870–9	2,570	40.1
1880–9	3,200	61.4
1890–9	3,550	51.8

Sources: Indian consumption: 1810–69: derived from the population data in Roy, *Economic history*, pp. 281–3, and the per capita cotton consumption estimates of Ellison, *Cotton trade*, p. 63; 1880–1909: Twomey, 'Employment', p. 46. British exports to India: Sandberg, *Lancashire in decline*, p. 142.

1770s. However, after the repeal of protective legislation, the retention of imports in the home market exceeded re-exports by a considerable margin until the early nineteenth century. At the same time, the export of British-made goods rose dramatically from the early 1790s, indicating that the shift of competitive advantage was beginning to occur.

British-made cottons first broke into the export trade in the African and American markets during the eighteenth century, but success tended to be limited to periods when the availability of Indian goods was restricted by war. Indian goods were still able to take market share from the British-produced cottons in Africa when the disruption of the Seven Years' War ended in 1763.³⁷ The struggle over American independence added to the difficulties of Britain's cotton exporters. However, from the 1770s, technological developments made Britain competitive in Europe, finding a growing market for what were called in the trade data 'Manchester cottons and velverets'.³⁸ The ability of merchants and manufacturers to switch flexibly between the American and European markets was important during the period of the Revolutionary and Napoleonic Wars between 1793 and 1815.³⁹ Not only was British trade with Europe frequently disrupted by the fighting on the Continent during this extended period, but Britain also went to war with the United States between 1812 and 1814. Indian cottons continued to share the West African market equally with British-made cottons during the second half of the eighteenth century, but Lancashire goods pulled ahead decisively after the Revolutionary and Napoleonic Wars.⁴⁰

The penetration of British cotton textile exports into the Indian market proceeded more slowly. Indian producers retained a transport cost advantage which they lacked in competition between the two countries in Africa, America, or Europe, as well as an informational advantage. In order to estimate Britain's share of the Indian market in table 3, it is necessary to make assumptions about cotton

³⁷ Wadsworth and Mann, *Cotton trade*, pp. 159–60.

³⁸ *Ibid.*, pp. 168–9.

³⁹ Edwards, *Growth*, p. 50.

⁴⁰ Inikori, *Africans*, p. 444.

consumption in India, which in turn depend on estimates of population and per capita consumption of cloth. These estimates can be married up with more reliable data on British exports to India to obtain a rough idea of the timing of the shift of competitive advantage in this important market. Table 3 suggests that the British share of the Indian market was negligible before the 1830s, with Indian producers continuing to supply a larger share of their home market until the 1870s. The share of British exports rose to a peak in the 1880s before Indian producers regained some market share.

Before the dramatic rise of Lancashire in the late eighteenth and early nineteenth centuries, the world's most important cotton textile industry was located in India.⁴¹ Chaudhuri argues that India's competitiveness in this industry can be explained by an abundant supply of skilled labour, with specialized tacit knowledge being passed down through the generations in classic Marshallian fashion.⁴² It was this cheapness of skilled labour, rather than the quantity or quality of capital equipment, which underpinned India's domination of the world market. Estimates of weavers' fixed costs confirm that the technology used was highly labour intensive. In early nineteenth-century Bengal, the cost of a traditional loom, sticks for warping, and a wheel for winding amounted to little more than the cost of yarn sufficient for one piece of cloth.⁴³ Hossain's work on eastern Bengal in the eighteenth century echoes the same view that the capital input was minimal, with output being increased by drawing in surplus labour.⁴⁴ The spinning machine or charkha was a simple piece of equipment which needed only one person to operate, while the cleaning of cotton was an intricate, labour-intensive task. Cleaned cotton was dried in the open and teased with a small bow operated by women or a larger bow operated by men.⁴⁵

Raw cotton was available locally and regional varieties often had a crucial impact on the type of cloth produced. Although spinning and weaving activities were widely dispersed throughout the country, regional specialization was a key aspect of the Indian cotton textile industry. Coarse cloth was produced for the local market and was spread across all regions. Fine cloth was produced for interregional and international markets, mainly in the four regions of Gujarat, the Punjab, the Coromandel Coast, and Bengal.⁴⁶

The Gujarat cotton industry exported largely to the Red Sea ports, while exports from the Punjab went overland to Afghanistan, East Persia, and central Asia, and by river and sea to the Persian Gulf.⁴⁷ Before the growth of the European trade, the Coromandel industry exported mainly to south-east Asia, while Bengal supplied upper India. From the seventeenth century, substantial quantities of Indian cotton cloth were exported to Europe, particularly through the English East India Company (EIC) and the Dutch United East India Company (*Verenigde Oostindische Compagnie* or VOC).

⁴¹ Robson, *Cotton industry*, p. 1.

⁴² Chaudhuri, *Trading world*, p. 238. Marshall (*Principles*, p. 225) famously noted that 'The mysteries of the trade become no mysteries; but are as it were in the air'.

⁴³ Mitra, *Cotton weavers*, p. 174.

⁴⁴ Hossain, *Company weavers*, p. 20.

⁴⁵ *Ibid.*, p. 37.

⁴⁶ Chaudhuri, *Trading world*, p. 243.

⁴⁷ *Ibid.*, pp. 243–5.

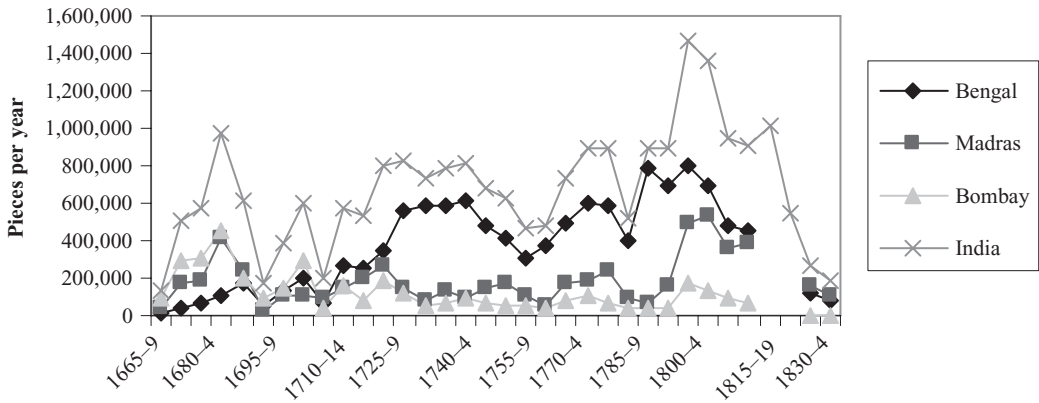


Figure 1. *East India Company imports of textiles from Indian regions (pieces per year)*

Sources: 1665–1759: Chaudhuri, *Trading world*, pp. 540–5; 1760–1834: Bowen, 'East India Company'.

Figure 1 shows the number of textile pieces imported into Britain between 1665 and 1834 by the EIC from Bombay (the Gujarat trade), Madras (the Coromandel Coast trade), and Bengal, with these three centres making up the total Indian trade. Textile imports from India to Britain, which were dominated by cotton cloth, show a strong growth from the 1660s to the 1680s, followed by a sharp downturn due to political conflict and war. A second downturn in the first decade of the eighteenth century can be explained by the introduction of measures to protect British textile producers, together with bullion shortage and war.⁴⁸ Thereafter, imports of Indian textiles to Britain fluctuated around 600,000 to 800,000 pieces for the rest of the eighteenth century. Following the repeal of the Calico Act, imports increased, reaching a peak during the period 1795–9, in line with the data in table 2. After this, imports from India began to trend downwards, collapsing precipitously after the end of the Napoleonic Wars.

The regional balance of this import trade from India changed substantially between the seventeenth and nineteenth centuries. Whereas Bombay and Madras were clearly more important during the seventeenth century, Bengal became the dominant supplier of textiles to the EIC during the eighteenth and nineteenth centuries. The declining importance of the Coromandel Coast as a supplier partly reflected the disruption caused by political conflict.⁴⁹ However, Chaudhuri also notes a relative cheapening of Bengal cottons.⁵⁰

The EIC was the largest European importer of cotton textiles from India, followed by the VOC, with the French and Danish companies trading on a substantially smaller scale.⁵¹ In attempting to understand the effects of British competition on the overall size of the Indian cotton textile industry, however, it is important to bear in mind that India's home market was much bigger than its export sector. Hence the impact on employment was delayed until well into the

⁴⁸ Ibid., p. 295.

⁴⁹ Arasaratnam, *Merchants, companies and commerce*, p. 153.

⁵⁰ Chaudhuri, *Trading world*, p. 296.

⁵¹ Morineau, 'Indian challenge', pp. 252, 266.

Table 4. *Weekly earnings of cotton operatives in Britain and India, c. 1680–1820 (s./d.)*

	Lancashire	India	Lancashire as % of India
c. 1680	6 s./0 d.	1 s./6 d.	400
c. 1770	6 s./11 d.	1 s./6 d.	460
c. 1790	13 s./3 d.	2 s./0 d.	663
c. 1820	10 s./4 d.	2 s./0 d.	517

Notes and sources: India: c. 1680: Brenning, 'Textile producers', pp. 348–9, for southern India.

c. 1770: Arasaratnam, 'Weavers, merchants and company', p. 269, for southern India; Chaudhury, *From prosperity to decline*, pp. 161–2, for Bengal.

c. 1790: Arasaratnam, 'Weavers, merchants and company', p. 269; Ramaswamy, *Textiles and weavers*, p. 156; Mukerjee, *Economic history*, p. 28, for southern India. Chaudhury, *From prosperity to decline*, pp. 161–2; Hossain, *Company weavers*, pp. 52–3, for Bengal. c. 1820: Mitra, *Cotton weavers*, pp. 128–9; Buchanan, *Purnea*, pp. 542–3; idem, *Bhagalpur*, p. 616; Buchanan Hamilton, *Dinajpur*, pp. 296–8, for Bengal. All Indian earnings given on a monthly basis and converted to a weekly basis on the assumption of a four-week month.

Lancashire: c. 1680: Gilboy, *Wages*, pp. 280–7; c. 1770: Wadsworth and Mann, *Cotton trade*, pp. 401–2; c. 1790: Wood, *History of wages*, p. 112; c. 1820: Wood, *History of wages*, p. 127. Lancastrian earnings given on a weekly basis, except Gilboy, *Wages*, given on a daily basis and converted to a weekly basis on the assumption of a six-day week.

nineteenth century, when Lancashire penetrated the Indian market significantly.⁵² However, even here, it is important to realize that there were two phases in the development of the nineteenth-century Indian market. First, Indian producers faced the emerging competition from British goods. However, during the second half of the century, a modern Indian cotton mill industry developed, particularly in the spinning section. The falling price of yarn then allowed the handloom industry to remain competitive in some segments of the domestic cloth market.

II

In this section the wages of cotton textile workers in Lancashire and India are compared. An anonymous author arguing for the protection of the British textile industry in 1701 claimed that the same amount of labour that would cost a shilling in England could be had for two pence in India. He argued that: 'There is no reason to believe that the Indian will take any of our manufactures as long as there is such a difference between the price of English and Indian labour'.⁵³

To what extent did this 6:1 wage differential exist in cotton textile production, and how did it vary over time? Table 4 presents a comparison of earnings in the cotton industry between 1680 and 1820. The Indian earnings are collected from a variety of sources for the Coromandel Coast and Bengal. Data for the early period are taken from several studies of the handloom industry in south-eastern India, while data for the later period are mainly from Bengal. This is in line with the regional shift of production for export between the seventeenth and eighteenth centuries.⁵⁴ The Lancashire earnings for 1770 are taken from the authoritative study by Wadsworth and Mann, and derive originally from the work of Young, based on the weekly earnings of a handloom weaver operating a single loom, with

⁵² More recently, Clingingsmith and Williamson, 'Deindustrialization', have argued that de-industrialization began with the decline in the terms of trade for manufactured goods as agricultural prices rose due to disruption caused by the decline of the Mughal Empire in the eighteenth century.

⁵³ McCulloch, *Early English tracts*, p. 549, also cited in Chaudhuri, *Trading world*, p. 237.

⁵⁴ Chaudhuri, *Trading world*, pp. 540–5.

some assistance from his wife and children.⁵⁵ The Indian data for 1770 are derived from an estimate of the monthly earnings of a loom operated by one weaver and another adult male with the assistance of the weaver's wife and children.⁵⁶ These data put the Lancashire wage at 460 per cent of the Indian wage, a bit less than the 6:1 differential noted by the anonymous tract author, but still extremely large.

The evidence for the wages of spinners is less reliable than that for weavers, but also supports the idea of a large Anglo-Indian wage gap. For Lancashire in 1770, Wadsworth and Mann report a range of 2 s. to 5 s. per week, or an average of 3 s. 6 d., again based on Young's data.⁵⁷ In the case of south India, Wendt suggests an average of 0.44 pagodas per month for the seventeenth and eighteenth centuries for spinners of coarse yarn, with a range of 0.32 to 0.56 pagodas.⁵⁸ This works out at an average of 10.56 d. per week, which gives an Anglo-Indian wage ratio of approximately 4:1, fairly close to the ratio for weaving.

The wage data must be interpreted with caution, since the quality of yarn and cloth varied with the skills of the workers, and this led to variation in earnings. It is therefore important not to pay too much attention to the earnings of a few highly skilled workers producing very high quality cloth or yarn. Although Parthasarathi reports monthly earnings of around 2.5 pagodas, or 5 s. per week in mid-eighteenth-century south India, Broadberry and Gupta show that these earnings cannot be taken as representative of average earnings, since they are not consistent with the extensive wage data collected by other authors for the same region at the same time and do not fit with developments over time in other Indian regions.⁵⁹ Parthasarathi claimed support for his high estimate of the amount of grain which an Indian spinner could buy with his monthly earnings from the work of Brenning, but Broadberry and Gupta point out that Brenning relied on a low grain price rather than high money earnings for this result.⁶⁰

Working back from 1770, the 1680 figure for India has been taken from Brenning's study of the Coromandel textile trade in the late seventeenth century.⁶¹ The weekly data are derived as one-quarter of the estimated monthly earnings of a master weaver operating a single loom with the help of an assistant. The weaver would also have been assisted in ancillary tasks by his wife. For Lancashire, Gilboy's estimate of the daily wage of a craftsman, assuming a six-day week, has been used.⁶²

Working forward from 1770, the earnings in Lancashire in *c.* 1790 have been taken from Gilboy.⁶³ The figure used here is for skilled workers. Wood suggests even higher earnings for handloom weavers during the late 1790s, due to a substantial imbalance between the spinning and weaving sections of the industry at this time, following a number of dramatic improvements in spinning technology,

⁵⁵ Wadsworth and Mann, *Cotton trade*, pp. 401–2; Young, *Six months tour*, vol. iii, pp. 245–8. These figures for the earnings of English weavers are also used by Parthasarathi, 'Rethinking wages', pp. 83–4.

⁵⁶ Since all earnings are attributed to male weavers rather than allocated between weavers and other family members, the true wage of an individual weaver is, if anything, overstated in these sources.

⁵⁷ Wadsworth and Mann, *Cotton trade*, p. 402; Young, *Six months tour*, vol. iii, pp. 245–8.

⁵⁸ Wendt, 'Writing'.

⁵⁹ Parthasarathi, 'Rethinking wages', p. 97; Broadberry and Gupta, 'Early modern great divergence', p. 14.

⁶⁰ Brenning, 'Textile producers', p. 349; Broadberry and Gupta, 'Early modern great divergence', p. 15.

⁶¹ Brenning, 'Textile producers'.

⁶² Gilboy, *Wages*.

⁶³ *Ibid.*, pp. 280–7.

Table 5. *Price of raw cotton in Britain, 1680–1879*

<i>d. per lb</i>		<i>d. per lb</i>	
1680–9	7	1780–9	23
1690–9	7	1790–9	24
1700–9	7	1800–9	15
1710–19	9	1810–19	17
1720–9	10	1820–9	16
1730–9	10	1830–9	8
1740–9	10	1840–9	5
1750–9	16	1850–9	6
1760–9	16	1860–9	15
1770–9	16	1870–9	8

Notes: Before 1800, annual averages for West Indian cotton are calculated as the mean of the range quoted, and decade averages are obtained from the incomplete number of annual observations. After 1800, data are annual average prices for upland or middling American cotton. Allowance has been made for the discount of the British pound against silver during the suspension of convertibility between 1797 and 1821 using data from Officer, *Dollar-sterling gold points*, p. 77.

Sources: 1680–1780: Wadsworth and Mann, *Cotton trade*, app. H, pp. 522–3. 1780–1879: Mitchell, *British historical statistics*, pp. 759–60.

but before the successful introduction of the powerloom.⁶⁴ However, Gilboy suggests a substantial increase in earnings during the course of the 1790s, and spinners' earnings were substantially lower, so Gilboy's figure gives the best guide to the situation in the industry as a whole at the start of the decade.⁶⁵ Since the wages of handloom weavers increased much more slowly in India, the English wage as a proportion of the Indian wage increased. For 1820, the Lancashire earnings data are taken from Wood and refer to all cotton operatives, including factory workers as well as handloom weavers.⁶⁶ With handloom weaving now being threatened by factory production, and with a general rebalancing of supply and demand in the labour market, English wages fell back in cotton textiles.⁶⁷ Mitra shows that the wages of Indian cotton spinners remained constant in money terms between 1790 and 1820.⁶⁸ This is consistent with the change we find in the data, with the English wage falling back to 517 per cent of the Indian level.

Table 5 shows that the price of raw cotton in Britain averaged about seven old pence per pound in both the late seventeenth century and the mid-nineteenth century. However, from the mid-eighteenth century to the early nineteenth century, the price of raw cotton in Britain increased substantially, in response to the sharp increase in demand. The figures need to be interpreted with care, because of the issue of cotton quality. As the English demand for cotton increased, it proved difficult to expand supply from traditional West Indian sources, particularly of the better quality staples.⁶⁹ As prices increased, supply responded from the United States, initially with the growth of long-staple Sea Island cotton in the islands and adjacent mainland of Georgia and South Carolina. Following the

⁶⁴ Wood, *History of wages*.

⁶⁵ Gilboy, *Wages*.

⁶⁶ Wood, *History of wages*, p. 127.

⁶⁷ Money wages also fell in line with prices in England during the postwar deflation; Gayer, Rostow, and Schwartz, *Growth and fluctuation*, p. 818.

⁶⁸ Mitra, *Cotton weavers*, pp. 128–9.

⁶⁹ Edwards, *Growth*, p. 79.

Table 6. *Comparative raw cotton prices in Britain and India, 1710–1830*

	<i>Britain (d. per lb)</i>	<i>India (d. per lb)</i>	<i>Britain/India (India = 100)</i>
1710	8	4.4	182
1740	9	4.6	196
1792–3	24	5.0	480
1802–3	13	6.3	206
1812–13	15	6.3	238
1822–3	8	6.3	127

Sources: India: 1710, 1740: Mukund, *Trading world*, p. 84, gives the cotton price in the south as 23 pagodas per candy of 500 lb in 1710, with one pagoda being equal to eight shillings; Chaudhuri, *Trading world*, p. 471. 1792–1823: Mitra, *Cotton weavers*, pp. 126–7, gives average cotton prices in Bengal as 12.42 rupees per maund of 74.5 lb in 1792–3. Britain: Wadsworth and Mann, *Cotton trade*, app. H, pp. 522–3; Mitchell, *British historical statistics*, pp. 759–60.

Notes: Allowance has been made for the discount of the British pound against silver during the suspension of convertibility between 1797 and 1821 using data from Officer, *Dollar-sterling gold points*, p. 77.

introduction of the yield-increasing ridge method of planting and the invention of Whitney's gin, cultivation spread westwards with short-staple upland cotton. By the early 1800s, American cotton was dominating the English market.⁷⁰ Our figures are average prices for West Indian cotton to 1800, and average prices for upland or middling American cotton thereafter. Note that prices have been adjusted to take account of the discount of the British pound against silver during the suspension of convertibility between 1797 and 1821, using data from Officer.⁷¹

Table 6 shows that India, with its local supply, faced a raw cotton price that was generally cheaper than in Britain. Again, care must be exercised here because of issues of quality. It is possible to find quotes of English merchants which show Indian cotton selling at a discount to upland or middling American cotton in the early nineteenth century. Edwards, for example, shows Surat cotton selling at around 80 per cent of the price of Bowed Georgia at Liverpool in 1801.⁷² However, it must be borne in mind that the section of the Indian cotton industry about which quantitative information is available operated at the high quality end of the market producing for export, and that quotes for high quality cotton from Surat suggest that it sold at a premium.⁷³ The lower price of raw cotton gave India a further competitive edge over and above the lower wage costs. Furthermore, whereas raw cotton prices followed a sharply upward trend in Britain after 1740, the increase was much more gradual in India. Raw cotton prices remained high in Britain until the end of the Revolutionary and Napoleonic Wars.

Even allowing for quality differences and wartime inflation, the data in tables 5 and 6 suggest that relative raw cotton costs played an important role in the timing of the shift in competitive advantage. For just as the British cotton industry began to experience dramatic productivity growth in the late eighteenth century that could offset the high wages, raw cotton costs rose rapidly to delay the shift in competitive advantage. As raw cotton prices fell back after the end of the Napoleonic Wars, the effects of the productivity growth were realized and Lancashire cotton textiles replaced Indian textiles in world markets.

⁷⁰ Ibid., pp. 89–93.

⁷¹ Officer, *Dollar-sterling gold points*, p. 77.

⁷² Edwards, *Growth*, p. 122.

⁷³ Ibid., p. 81.

Table 7. *Interest rates in Britain and India (% per annum)*

	Britain			India
	Consols	Land	Buildings	Secured loans
c. 1680	—	4	6	8
c. 1770	4	4	6	10
c. 1790	4	4	5	12
c. 1820	4	3	5	12
c. 1840	3	3	5	7

Sources: Mitchell, *British historical statistics*, p. 678; Clark, 'Cost of capital', p. 273; idem, 'Debt', pp. 416, 434; Moosvi, 'Indian experience', pp. 337–9, 342, 351–2.

If the rental price of capital were also much higher in Britain, then the high wages would not have provided an incentive to substitute capital for labour. It is therefore necessary to consider the rental price of capital (R) in the two countries, given by:

$$R = P_K(i + \delta - \hat{P}_K) \quad (1)$$

where P_K is the price of capital goods, i is the rate of interest, δ is the depreciation rate and a circumflex over a variable indicates a proportional rate of change.

Table 7 provides a range of interest rate data for Britain, including the return on consols and the return on housing and on land.⁷⁴ For India, interest rates on secured loans are taken from Moosvi, who argues that by the mid-nineteenth century these rates were about 2 per cent above the London rates on equivalent loans.⁷⁵ Mitra's claim that an interest rate of 12 per cent was typically paid on loans to the European companies until the middle of the eighteenth century is consistent with this evidence.⁷⁶ This suggests broad comparability between the Indian series on secured loans and the British series on the rate of return on buildings. Feinstein shows a depreciation rate for Britain of around 1.5 per cent, and this is assumed to apply also to India.⁷⁷ In the absence of reliable continuous series on the price of capital goods, the capital gains term is set to zero for both countries. Allen measures the price of capital goods in Britain as an average of the prices of iron, non-ferrous metals, timber, and bricks.⁷⁸ For India, less comprehensive data are available, and thus table 8 has a more restricted focus on the price of bar iron. The price data for bar iron in Britain are taken from Mitchell and Hyde, and are compared with unpublished Indian price data made available by Guha.⁷⁹ Although the price of capital goods was higher in Britain than in India, this was offset by lower interest rates.⁸⁰

⁷⁴ Mitchell, *British historical statistics*; Clark, 'Cost of capital'; idem, 'Debt'.

⁷⁵ Moosvi, 'Indian experience', p. 351.

⁷⁶ Mitra, *Cotton weavers*, p. 67.

⁷⁷ Feinstein, 'National statistics', p. 427.

⁷⁸ Allen, 'British industrial revolution' (see above, n. 16), p. 6.

⁷⁹ Mitchell, *British historical statistics*; Hyde, *Technological change*.

⁸⁰ It should be noted that although the price of capital goods was in general lower in India than in Britain, this did not apply to the modern textile machinery, which was largely imported from Britain; Saxonhouse and Wright, 'New evidence', p. 512.

Table 8. *Rental price of capital in Britain and India (£ per ton)*

	Britain		India	
	P_K	$P_K(i + \delta)$	P_K	$P_K(i + \delta)$
c. 1680	15	1.125	8.63	0.820
c. 1770	15	1.125	8.63	0.992
c. 1790	19	1.235	8.63	1.165
c. 1820	11	0.715	8.63	1.165
c. 1840	9	0.585	8.63	0.734

Sources: Price of bar iron in Britain: Hyde, *Technological change*, pp. 44, 81, 104; Mitchell, *British historical statistics*, pp. 762–3. Price of bar iron in India: unpubl. data, made available by Sumit Guha. Interest rates from tab. 7. Depreciation rate from Feinstein, 'National statistics', p. 427.

Table 9. *Comparative Britain/India costs and prices (India = 100)*

A. Costs				
	<i>Wage (W/W^*)</i>	<i>Raw cotton price (C/C^*)</i>	<i>Rental price of capital (R/R^*)</i>	<i>TFI price</i>
c. 1680	400	182	137	206
c. 1770	460	320	113	270
c. 1790	663	480	106	357
c. 1820	517	127	61	150

B. Prices and TFP			
	<i>TFI price</i>	<i>FOB price (P/P^*)</i>	<i>TFP (A/A^*)</i>
c. 1680	206	200	103
c. 1770	270	200	135
c. 1790	357	147	243
c. 1820	150	53	283

Sources: Wage, raw cotton price, and rental price of capital derived from tabs. 4–8. Prices FOB derived from Chaudhuri, *Trading world*, pp. 540–5, for 1680 and 1770, extended to 1790 and 1820 using Cuenca Esteban, 'British textile prices', pp. 101–2, and idem, 'Factory costs', p. 755. Weights of 0.25 for the wage, 0.5 for the raw cotton price, and 0.25 for the rental price of capital derived from Edwards, *Growth*, p. 240, and Jones, *Increasing return*, p. 105.

III

Table 9 shows comparative Britain/India total factor input (TFI) prices as a weighted average of wages, raw cotton costs, and the rental price of capital. The weights are based on the data of Jones and Edwards, with raw cotton costs making up around half of total costs, and with the other half split evenly between labour and capital costs.⁸¹ It is tempting to think that this TFI price ratio reflects the comparative total factor productivity ratio (A/A^*), since the levels equivalent of the familiar cost dual TFP equation is:

$$A/A^* = \frac{(W/W^*)^\alpha (C/C^*)^\beta (R/R^*)^{1-\alpha-\beta}}{(P/P^*)} \quad (2)$$

where A is total factor productivity (TFP), W is the wage rate, C is the cost of raw cotton, R is the rental price of capital, P is the price of cotton yarn or cloth, and

⁸¹ Jones, *Increasing return*, p. 105; Edwards, *Growth*, p. 240.

α and β are the shares of wages and raw cotton in costs. An asterisk indicates the numeraire country, which is taken as India. In competitive markets, the selling price must be equal, so the denominator in equation (2) may at first sight appear to be unity.

However, it is important to note that the correct prices to use in the denominator here are prices free on board (FOB), whereas the selling prices (SP) include transport costs (T):

$$SP = P + T \quad (3)$$

In table 9, it is assumed that the initial FOB price ratio was 200, obtained from information on the East India Company mark-up on Indian textiles.⁸² This has been extended forwards from 1770 using a British cotton textile price index together with the assumption of stagnant FOB prices in India. The British price index is a unit value index of cloth exports taken from the work of Cuenca Esteban.⁸³ This takes on board some criticisms of an earlier series produced by Cuenca Esteban, which Harley believes overstated the decline in cloth prices.⁸⁴ Although Harley still argues in a further exchange that Cuenca Esteban overstates the fall in cotton cloth prices, the differences are now much smaller.⁸⁵ Furthermore, it is worth bearing in mind that there is also a bias in the other direction, since the Cuenca Esteban series excludes yarn prices, which fell much more rapidly than cloth prices during the period 1770–1820.⁸⁶ Evidence in favour of stagnating prices in India over this period is provided by Mitra and Hossain across different varieties of cloth.⁸⁷ The EIC increasingly ran into difficulties in fulfilling its orders for cotton cloth in India, yet was unable to offer higher prices because of the situation in the English market.⁸⁸ The contrast between falling cotton yarn prices in England and stagnating yarn prices in India between 1812 and 1830 is clearly visible in the data assembled by Specker on a variety of yarn counts ranging from 49 to 250.⁸⁹

Given these developments in TFI prices and FOB prices on a comparative basis, it can be seen in table 9 that Britain's TFP advantage increased continually throughout the period, at around 0.3 per cent per annum before 1770, rising to 1.5 per cent per annum during the period 1770–1820. This would be quite consistent with the 1.9 per cent per annum TFP growth rate reported by Harley for the British cotton industry between 1780 and 1860, together with slowly rising or stagnating productivity in India.⁹⁰

The change in competitive advantage in the production of cotton textiles occurred in stages. In the first stage, which continued until the 1770s, the British cotton industry sheltered behind protective measures, with the selling price of

⁸² Chaudhuri, *Trading world*, pp. 540–8.

⁸³ Cuenca Esteban, 'Factory costs', p. 755.

⁸⁴ Cuenca Esteban, 'British textile prices', pp. 101–2; Harley, 'Cotton textile prices and the industrial revolution', pp. 57–60.

⁸⁵ Harley, 'Cotton textile prices revisited'; Cuenca Esteban, 'Factory costs'.

⁸⁶ Harley, 'Cotton textile prices and the industrial revolution', pp. 57–9.

⁸⁷ Mitra, *Cotton weavers*, pp. 192–6; Hossain, *Company weavers*, pp. 53–5.

⁸⁸ Gupta, 'Competition and control'.

⁸⁹ Specker, 'Madras handlooms', p. 207.

⁹⁰ Harley, 'Reassessing', p. 200.

goods produced in India but sold in Britain for re-export being substantially lower than the British FOB price. In the second stage, between the 1770s and the 1790s, competitive advantage started to shift in Britain's favour, with rapid technological progress raising productivity in Lancashire. However, with the wage and raw cotton costs moving in India's favour, the British FOB price remained above the CIF price of Indian goods in Britain. In the third stage, between the 1790s and the 1820s, rapid technological progress continued to raise productivity, while wage and raw cotton costs moved back in Britain's favour. The British FOB price now fell below the CIF price of Indian goods in Britain. As a result, Indian cloth was increasingly displaced from the British market, while Lancashire producers found it easier to compete against India in third markets such as Africa, where transport costs were similar for both countries.⁹¹

In the fourth stage, from about 1830, the productivity gains in Britain, particularly at this time in weaving, reduced the British FOB price still further, so that the British selling price in the Indian market, inclusive of transport costs, could fall below the Indian FOB price in at least some products. Table 3 shows Britain's share of the Indian market growing from 2.7 per cent in the 1830s to 61.4 per cent in the 1880s. This view of the dynamics of Britain's penetration of the Indian market during the nineteenth century is broadly consistent with the picture presented by authors interested primarily in the issue of Indian de-industrialization. Clingingsmith and Williamson argue that until the early nineteenth century the Indian cotton textile industry was adversely affected more by shocks emanating from other parts of the domestic economy than by international competition.⁹² Twomey shows that although India became a net importer of cotton cloth from about 1830, handicraft production for the home market turned down only after 1850.⁹³

IV

This paper stresses the link between high wages in Britain and technology, with growing British productivity leading to a shift in competitive advantage. The argument is familiar from the analysis of nineteenth-century industrial development in Britain and the United States, but has not been applied seriously to the shift in competitive advantage from India to Britain in the context of the industrial revolution, where Britain has to be cast in the role of the high-wage producer. As noted in the introduction to this article, we attribute this neglect of factor prices to the focus on Europe and the United States rather than Asia, where the wage differences were much greater, combined with a focus on the slowness of the growth of real wages in Britain rather than their high level.

We see a two-stage process leading from relatively high wages in Britain to substitution into capital-intensive production methods, followed by a faster rate of innovation in the capital-intensive technology. The analysis draws on David's framework.⁹⁴ The first stage, with high wages leading to substitution of capital for labour is analysed in figure 2, where country A is Britain and country B is India.

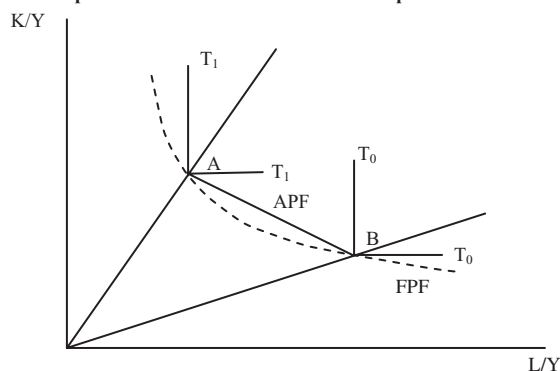
⁹¹ Wadsworth and Mann, *Cotton trade*, pp. 168–9; Inikori, *Africans*, p. 444.

⁹² Clingingsmith and Williamson, 'Deindustrialization'.

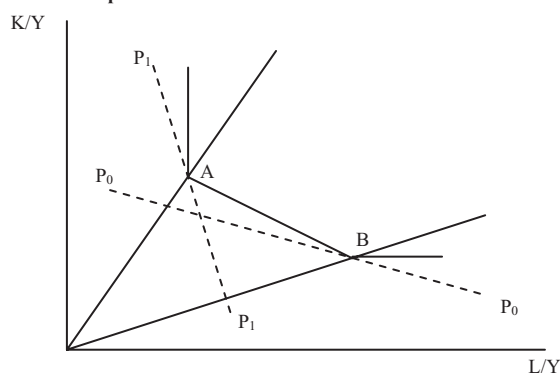
⁹³ Twomey, 'Employment', pp. 40, 53.

⁹⁴ David, *Technical choice*, pp. 19–91.

A. The available process frontier and the fundamental production function



B. The role of factor prices

Figure 2. *Choice of technique*

Source: David, *Technical choice*, p. 63.

Figure 2A characterizes the initial different technical choices in Britain and India at the beginning of the eighteenth century. There are two available technologies, which differ in the proportions of capital (K) and labour (L). Once the technique has been chosen, substitution possibilities are very limited, so that to all intents and purposes fixed coefficient technology can be assumed. The convex combination of these alternative techniques determines the available process frontier (APF), since, in principle, a combination of both processes could be used. If we assume a further set of latent techniques spanning the range of factor proportions, then, joining up the points of minimum input combinations, we obtain a continuously differentiable isoquant of the fundamental production function (FPF).

In figure 2B, relative factor prices are added in. If, as in eighteenth-century India, labour is relatively abundant and hence relatively cheap, the relevant factor price line is P_0 and producers locate at B, using the relatively labour-intensive technique. On the other hand, if labour is relatively scarce and hence relatively expensive, as in eighteenth-century Britain, the relevant factor price line is P_1 and British producers locate at A. Note that although Indian and British producers use different techniques, they nevertheless have access to the same fundamental production function.

The second stage is the faster rate of technological progress on the capital-intensive technology, which is analysed in figure 3. The link between capital

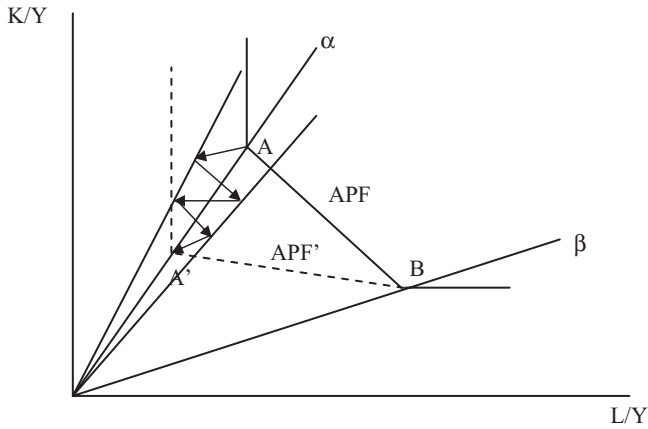


Figure 3. *Localized technological progress*

Source: David, *Technical choice*, p. 66.

intensity and the rate of technological progress is provided in the Schumpeterian growth model of Aghion and Howitt, partly via a process of learning by doing and partly via the scale of resources devoted to research and development (R&D).⁹⁵ More R&D occurs in more capital-intensive sectors. The argument is strengthened in the institutional context of the patent system in England, which provided a stronger incentive to search for improvements in machine-intensive processes, where innovations could be patented. Although economic historians have traditionally played down the role of the patent system, a revisionist strand of research beginning in the 1980s has suggested that by the middle of the eighteenth century patents were playing an important role in encouraging investment in innovation.⁹⁶ Although MacLeod has continued to take a more equivocal view, emphasizing the expense of patenting and the difficulties of enforcement, she nevertheless acknowledges that by the mid-eighteenth century, the system had ‘developed its own momentum and promoted a first-strike mentality among its users: one neglected to patent at one’s peril’.⁹⁷

Although Griffiths, Hunt, and O’Brien seek to play down the role of patents in the textile sector during the industrial revolution period by pointing to the substantial number of non-patented inventions, it should be noted that the majority of the latter were produced in response to prizes offered by sponsoring societies.⁹⁸ Their evidence is thus quite consistent with this article’s emphasis on the role of the profit motive in encouraging innovation in machine-intensive industry. Furthermore, the data show that the propensity to patent machinery was higher than for other innovations.⁹⁹ Thus figure 3 shows technological progress in the capital-intensive technology combined with technological stagnation in the labour-intensive technology.

⁹⁵ Aghion and Howitt, *Endogenous growth*, pp. 85–115.

⁹⁶ Dutton, *Patent system*; Sullivan, ‘England’s “age of invention”’.

⁹⁷ MacLeod, *Inventing*, p. 1.

⁹⁸ Griffiths, Hunt, and O’Brien, ‘Inventive activity’, p. 885.

⁹⁹ *Ibid.*, p. 888.

Table 10. *Best-practice labour productivity in spinning 80 count yarn in England, 1780–1825 (operative hours to process 100 lbs of cotton)*

	<i>Technology</i>	<i>OHP</i>
1780	Crompton's mule	2,000
1790	100-spindle mule	1,000
1795	Power-assisted mule	300
1825	Roberts' automatic mule	135

Source: Derived from Catling, *Spinning mule*, p. 54.

Figure 3 also shows technological progress occurring in a trial-and-error process which was characterized by Atkinson and Stiglitz as local learning.¹⁰⁰ This results in locally neutral technological progress, which can be represented as a movement around a ray through the origin. The 'elastic barriers' surrounding the process ray α in figure 3 can be seen as representing non-convexities in micro-engineering designs.¹⁰¹ Mokyr later made a distinction between macro and micro inventions, which captures the essence of this view.¹⁰² Large 'door-opening' changes are followed by 'gap-filling' improvements which look fairly similar, only better. Technological progress under these conditions was modelled by David as a stochastic process between the elastic barriers around the α -ray, shifting the available process frontier from APF to APF' in figure 3.¹⁰³

The substitution of capital for labour in the British cotton textile industry is well known, and is seen most obviously in the emergence of a machine-intensive factory system, particularly at first in spinning, where the introduction of Crompton's mule at the end of the 1770s led to a substantial gain in labour productivity. Although Inikori suggests that Lancashire firms producing for the West African market were already adopting machine-intensive methods before the ending of protection in 1774, the process accelerated following the repeal of the Calico Act, which opened up the home market to renewed competition from Indian cloth.¹⁰⁴

Catling provides data on English labour productivity for spinning 80 count cotton yarn, using the concept of OHP, or operative hours needed to process 100 pounds of cotton, which is just the inverse of labour productivity.¹⁰⁵ This takes account of the effects of the increasing speed of the newer mules, the increasing number of spindles per mule, and the later practice of operating the mules as pairs. In table 10, the OHP requirement for 80 count yarn in Britain around 1780 was 2,000. For India, Buchanan Hamilton suggests that a woman spinner working full-time could clean and spin two-and-a-half pounds of cotton in a month.¹⁰⁶ Assuming a ten-hour working day and a six-day week, that would translate into around 100 hours to process a pound of cotton, or an OHP of 10,000. Buchanan Hamilton's figure for Bengal finds support in the calculations of spinning produc-

¹⁰⁰ Atkinson and Stiglitz, 'New view'.

¹⁰¹ David, *Technical choice*, p. 81.

¹⁰² Mokyr, *Lever of riches*, p. 13.

¹⁰³ David, *Technical choice*, p. 66.

¹⁰⁴ Inikori, *Africans*, p. 442.

¹⁰⁵ Catling, *Spinning mule*, p. 54.

¹⁰⁶ Buchanan Hamilton, *Dinajpur*, p. 289.

Table 11. *English cotton yarn and cloth prices deflated by general price index, 1780–1829*

	Yarn (d. per lb)			Cloth (s. per piece)	
	18 count weft	40 count warp	100 count twist	Calico	Muslin
1780/4	47	168	—	52	116
1785/9	47	142	761	43	80
1790/4	36	97	318	34	64
1795/9	36	77	112	29	44
1800/4	27	55	80	24	38
1805/9	19	39	66	16	35
1810/14	15	30	50	18	27
1815/19	15	30	62	19	31
1820/4	11	22	51	15	40
1825/9	10	20	52	10	33

Note: Deflated yarn and cloth prices are in constant 1825/9 prices.

Source: Harley, 'Cotton textile prices and the industrial revolution', pp. 55, 59.

tivity by Wendt for southern India, which puts the output of fine thread spinners at 2.2 to 2.4 pounds per month.¹⁰⁷ These figures are consistent with a substantial British labour productivity advantage in spinning as a result of a higher capital-labour ratio. However, it is necessary to be cautious here, because the example is based on a very fine yarn, which was not representative of the industry as a whole. After 1780, real prices fell much more dramatically on fine yarns than on coarse yarns, as can be seen in table 11. Nevertheless, this differential productivity growth had not yet occurred in 1780, so the Anglo-Indian productivity difference on fine yarns may still give a good indication of the overall productivity difference in spinning at this stage.

In weaving, it seems likely that the British capital per worker advantage around 1780 was smaller than in spinning, since technological progress was more limited in weaving before the introduction of the powerloom. As with yarn, there was some variation across cloth qualities in the extent of price falls, with the price of calicos falling more than the price of muslins (table 11). Although Wadsworth and Mann indicate ancillary labour inputs from family members in the Lancashire weaving industry during the first half of the eighteenth century, each loom was operated by only one full-time male weaver.¹⁰⁸ By contrast, there is abundant evidence of more than one weaver per loom from the major cotton textile producing regions of India. In Coromandel weaving, Brennig (for the late seventeenth century) and Arasaratnam (for the late eighteenth century) indicate two full-time male operatives per handloom, in addition to ancillary labour inputs from family members.¹⁰⁹ For Bengal, Mitra's evidence suggests that two men worked per loom in the late eighteenth century, while Prakash reports estimates of one-and-a-half to two persons per loom.¹¹⁰ For finer cloths, more workers per loom were often required.¹¹¹

¹⁰⁷ Wendt, 'Writing'.

¹⁰⁸ Wadsworth and Mann, *Cotton trade*, pp. 324–39.

¹⁰⁹ Brennig, 'Textile producers', p. 348; Arasaratnam, 'Weavers, merchants and company', p. 269.

¹¹⁰ Mitra, *Cotton weavers*, pp. 113–15; Prakash, *Dutch East India Company*, p. 241.

¹¹¹ Baines, *History*, p. 71; Hossain, 'Alienation of weavers', p. 325.

This would all be consistent with Lancashire being able to draw on the technological change that had occurred in the European cotton industry and in textile manufacturing in general during the late medieval and early modern periods.¹¹² In the Indian context, by contrast, Habib has argued that the ordinary loom for the simple weave was practically impossible to develop further until the invention of the flying shuttle.¹¹³ Rather, innovation tended to take the form of new weaving designs and new types of dyeing.¹¹⁴

The analysis so far has painted a picture of stagnating labour productivity in India while the British cotton textile industry was being transformed, which raises the issue of whether the Indian industry was acting rationally in its choice of technology. Here, an analogy can be drawn with the literature on allegations of entrepreneurial failure in late Victorian Britain.¹¹⁵ In many industries, Britain lost market share in the late nineteenth century to American producers using new technology, while the British continued to use old technology.¹¹⁶ As was pointed out by a number of authors in an influential volume edited by McCloskey, however, the new technologies would not have been profitable at British factor prices.¹¹⁷ The same argument applies to British and Indian technology in cotton textiles during the early nineteenth century. Given the much lower wages in India, the savings on labour costs would not have offset the higher capital costs of adopting the British technology. However, when costs on the new technology had fallen sufficiently by the mid-nineteenth century, it became possible to adopt the new technology profitably in India, and a modernized cotton textile industry emerged in Bombay. This indigenous modernized industry, however, adopted a lower capital-labour ratio in response to the low wage costs. For an equivalent machine imported from Britain, an Indian mill used at least twice as many workers as a British mill. Hence, although labour productivity in the modern sector was higher than in the traditional sector, it was still low in international comparative terms.¹¹⁸ Nevertheless, the machine-made products were competitive with British imports at the lower quality end of the market as a result of very low wages, so that domestic producers managed to regain market share from the British after the 1870s.¹¹⁹

The literature following Habakkuk made an important distinction between factor substitution, with high wages leading to a one-off shift to 'more machinery' per worker, and biased technological change, with high wages leading to 'better machinery'.¹²⁰ Some writers sought to endogenize technological progress by arguing for a direct link from high wages to labour-saving technological progress. Cain and Paterson, for example, reported econometric evidence for labour-saving technological progress as well as substitution of capital for labour in American industry between 1850 and 1919.¹²¹ However, in the case of Britain during the industrial revolution, von Tunzelmann argues that technological progress was only

¹¹² Mazzaoui, *Italian cotton industry*, pp. 73–86.

¹¹³ Habib, 'Notes', p. 182.

¹¹⁴ Ramaswamy, *Textiles and weavers*, p. 67.

¹¹⁵ McCloskey and Sandberg, 'From damnation to redemption'.

¹¹⁶ Broadberry, *Productivity race*, pp. 157–209.

¹¹⁷ McCloskey, ed., *Essays*.

¹¹⁸ Clark, 'Why isn't the whole world developed?', pp. 149–52.

¹¹⁹ Ellison, *Cotton trade*, p. 63; Twomey, 'Employment', p. 46.

¹²⁰ Habakkuk, *American and British technology*; Temin, 'Labour scarcity'.

¹²¹ Cain and Paterson, 'Biased technical change', pp. 59–60.

strongly labour-saving after 1830.¹²² Note, however, that our argument does not rely on this type of endogenous innovation, with bias in the direction of technological progress. We argue only for an induced acceleration in the rate of technological progress following the shift to capital-intensive technology in response to the high cost of labour in Britain compared with India. As in figure 3, we do not then require a further bias in the direction of technological progress, but merely locally neutral technological change.

In our view, one factor explaining the acceleration of technological progress after the adoption of capital-intensive techniques was the existence of a patent system, which offered stronger protection of property rights to innovations embodied in machinery than to innovations without the involvement of machinery. This meant that more resources were devoted to innovation in the machine-intensive British cotton textile industry than in the labour-intensive Indian industry. Sullivan points out that machinery and motive power accounted for 42.9 per cent of all patents issued in Britain during the period 1661–1710, rising to 46.6 per cent by 1801–50.¹²³ The shift to a more machine-intensive technology in response to high wages thus carried with it a higher probability of resources being devoted to improving technology and hence a higher rate of technological progress. This description fits the British cotton textile industry very well, and textile innovations played an important role in the acceleration of patenting which occurred in Britain during the late eighteenth century.¹²⁴ Indeed, an examination of Woodcroft's subject matter index of English patents reveals that 'spinning' was the largest category.¹²⁵ All of this inventive activity in spinning led to a dramatic increase in productivity, as can be seen in tables 10 and 11.

It is important to note that this argument is quite consistent with the evidence on the stated aims of inventors in the patent records, which suggests that only a small proportion of innovations in the textile industry were driven by a desire to save labour.¹²⁶ Even allowing for the fact that there were difficulties in openly stating the aim of saving labour during the Luddite era, it seems likely that in a trial-and-error process of improvement, the direction of factor-saving bias would have been at best a secondary consideration.¹²⁷

It should also be noted that in choosing to highlight the neglected role of the patent system, it is not our intention to deny a role for all of the other fundamental factors emphasized by other writers. Indeed, it should be clear that some of these other factors can be seen as underpinning the high wages that we have placed at the centre of our analysis. Mokyr, for example, emphasizes the importance of the skills of the labour force in creating an environment conducive to technological progress in Britain.¹²⁸ In our framework, these labour force skills can be seen as leading to high wages, and it is the interaction between high wages and the patent system which results in the adoption of a more capital-intensive technology and an acceleration of the rate of technological progress.

¹²² Von Tunzelmann, 'Technology in the early nineteenth century', pp. 289–90.

¹²³ Sullivan, 'England's "age of invention"', p. 442.

¹²⁴ *Ibid.*, p. 430.

¹²⁵ Woodcroft, *Subject matter index*; Sullivan, 'England's "age of invention"', p. 431.

¹²⁶ Griffiths et al., 'Inventive activity', p. 895.

¹²⁷ MacLeod, *Inventing*, pp. 158–81.

¹²⁸ Mokyr, 'Technological change', pp. 39–41.

Finally, consideration should be given to the implications of this approach for the question of why the key technological breakthroughs in cotton textiles occurred first in Britain. When Crafts posed this question, the obvious comparator country was France, which was being portrayed in revisionist work as having similar development potential.¹²⁹ However, the revisionism now seems to have been overdone, and in the recent literature on comparative levels of development, France emerges as a relatively low-wage economy in the eighteenth century.¹³⁰ As Zeira points out, where the new technology requires more of one factor as well as less of another, it cannot be adopted without appropriate relative factor prices.¹³¹ As Allen emphasizes, the technology of the industrial revolution was particularly adapted to British factor prices.¹³² The other high-wage European economy was the Dutch Republic, and it is therefore interesting now to restate Crafts's question as 'Why Britain, and not Holland?' rather than 'Why Britain, and not France?'.¹³³ The answer offered here is that while Holland had high wages like Britain, it lacked the large market to provide sufficient rewards for innovation; and while France had a large population to provide a large market, it lacked the high wages to stimulate the adoption of machine-intensive technology which underpinned the process of technological change that occurred in Britain.

V

This article has re-examined the shift of competitive advantage in cotton textiles from India to Lancashire between 1700 and 1850. As well as emphasizing the need to consider developments in Britain and India together, as two sides of the same coin, this article highlights the surprising neglect of the role of factor prices in previous accounts.¹³⁴ The growing imports of cotton cloth from India via the East India Company during the seventeenth century opened up new opportunities for import substitution as the new cloths, patterns, and designs imported from India became increasingly fashionable, and as domestic producers succeeded in securing protection. However, high silver wages in Britain meant that cotton textiles produced domestically using traditional labour-intensive production methods could not compete with Indian goods in world markets. This stimulated a search for new methods of production, which led ultimately to a shift of competitive advantage in Britain's favour.

The shift of competitive advantage occurred in stages. First, a domestic cotton textile industry was established in Lancashire behind protective barriers between about 1700 and the 1770s. Second, between the 1770s and 1790s, Lancashire's

¹²⁹ Crafts, 'Industrial revolution'; O'Brien and Keyder, *Economic growth*.

¹³⁰ Allen, 'Great divergence', p. 416.

¹³¹ Zeira, 'Workers'.

¹³² Allen, 'British industrial revolution' (see above, n. 16), pp. 4–8.

¹³³ Crafts, 'Industrial revolution'.

¹³⁴ Parthasarathi argues that although the early literature stressed competition with India as the driving force behind technological progress in the English cotton industry, India got written out of the story because of a later emphasis on imbalances between the spinning and weaving sections of the English industry as the inspiration for technological change (P. Parthasarathi, 'The European response to Indian cottons', paper presented at the Global Economic History Network Conference, Pune, 18–20 Dec. 2005 [WWW document]. URL <http://www.lse.ac.uk/collections/economicHistory/GEHN/GEHNConference8Papers.htm> [accessed 13 June 2008]). However, he makes no mention of factor prices, and indeed argues elsewhere (Parthasarathi, 'Rethinking wages') that India should be seen as a high wage economy.

competitive position began to improve with the adoption of more capital-intensive production methods, followed by a faster rate of technological progress on the more machine-intensive technology. However, in this second phase, there were offsetting factors, as raw cotton costs moved in India's favour. In the third phase, from the 1790s to the 1820s, with continued technological progress and raw cotton costs moving back in Lancashire's favour, Lancashire became competitive against India in third markets where transport costs were similar for both countries. In the fourth phase, after about 1830, further technological progress completed the shift of competitive advantage, making Lancashire competitive even in the Indian market.

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