Cotton Textiles And The Great Divergence: Lancashire, India And Shifting Competitive Advantage, 1600-1850

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Abstract:

We offer a new, quantitative perspective on the shift of competitive advantage in cotton textiles from India to Britain, centred on the interactions between the two countries. The growth of cotton textile imports into Britain from India opened up new opportunities for import substitution as the new cloths, patterns and designs became increasingly fashionable. However, high silver wages in Britain as a result of high productivity in other tradable goods and services, meant that British producers of cotton textiles could not use labour-intensive Indian production methods. The growth in British labour productivity that resulted from the search for labour-saving technical progress meant that unit labour costs became lower than in India despite the much higher wages in Britain. However, the full effects of the rise in British productivity were delayed until after the Napoleonic Wars by increasing wage and raw cotton costs before supply adjusted to the major increase in demand for inputs. On balance, the effects of British protective measures were neutral.

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I. Introduction

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 (Baines, 1835: 55-83; Robson, 1957: 1). 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 (Ellison, 1886: 57-70; Robson, 1957: 1-3). This dramatic change in international competitive advantage during the Industrial Revolution was surely one of the key episodes in the Great Divergence of living standards between Europe and Asia. However, the literature on the British cotton industry has traditionally focused on domestic production issues, and has had relatively little to say about interactions between India and Britain (Ellison, 1886: 14-70, Landes, 1969: 82-88; Rose, 2000: 22-37).[1] To the extent that a comparative perspective has been taken at all, it has been conventional to compare Britain with other European countries or the United States (Landes, 1969: 159-169; Rose, 2000: 37-56).

This paper analyses the shift in competitive advantage in terms of changing unit labour costs, emphasising the interactions between Britain and India. The growth of cotton textile imports into Britain via the East India Company from the seventeenth century opened up new opportunities for British manufacturers via a strategy of import substitution and re-export substitution, as the new cloths, patterns and designs became increasingly fashionable (de Vries, 1993; Berg, 2002; Inikori, 2002: 428). However, high silver wages in Britain as a result of high productivity in other tradable goods and services, meant that British manufacturers could not use labour-intensive Indian production methods.

[1] This view is perhaps most memorably summarised by the anonymous schoolboy's answer to a question on the Industrial Revolution which began with the phrase "About 1760 a wave of gadgets swept over England" (Ashton, 1948: 48).

Broadberry and Gupta (2005) show that an unskilled labourer in India earned little more than 20 per cent of the English unskilled wage as early as 1600, when Indian wages are converted to pounds sterling at the prevailing exchange rate. Low Indian wages acted as a spur to labour-saving technical progress in the British cotton textile industry. As British productivity increased, a point was reached where Britain's higher wages were more than offset so that unit labour costs were lower in Britain and the reversal of competitive advantage occurred. However, the shift was delayed in international markets during the late eighteenth and early nineteenth centuries by rising wage and raw cotton prices in Britain as the increase in production put pressure on labour and material input markets. The shift in competitiveness in the Indian market was delayed further by transport costs, which continued to give Indian producers an advantage in their home market until the 1860s (Ellison, 1886: 63; Twomey, 1983).

It has been argued that the British cotton industry gained from protection during the eighteenth century (O'Brien et al., 1991). However, once it is recognised that the British cotton industry was innovating in response to a factor cost disadvantage, this argument becomes much less persuasive. Indeed, it even becomes possible to argue that protection in the domestic market was, if anything, likely to delay the shift of competitive advantage, by removing the immediate pressure on domestic producers to innovate. In fact, it seems likely that the effects of protection were neutral, since there is evidence that the Calico Acts were circumvented (Thomas, [1926]).

The paper proceeds as follows. In section II we set out the quantitative dimensions of the development of the industry in the two countries. We then examine comparative wages and productivity in section III, showing the shift in competitive advantage as productivity increased in Britain and stagnated in India. Section IV then adds in raw cotton costs and shows how productivity and cost factors interacted to

bring about the growing dominance of the British cotton industry in world markets. Section V re-examines the issue of high wages and labour saving technical progress, including a section on the implications for protection. Section VI concludes.

II. Development Of The British And Indian Cotton Textile Industries

1. The British cotton textile industry

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 (Wadsworth and Mann, 1931: 118; Thomas, 1926: 25-66). It is significant, however, that there was no attempt by domestic producers to imitate Indian labour-intensive production methods, which could not have been economically viable at British wage rates.

In fact, the cotton industry was probably first introduced into Britain by immigrants from the European continent, fleeing religious persecution. Baines [1835: 99] mentions Walloon and Dutch immigrants to East Anglia in the second half of the sixteenth century. However, the cotton industry did not take permanent root there (Wadsworth and Mann, 1931: 19-20). Rather, the industry took root in the already established textile producing region of Lancashire at the beginning of the seventeenth century, initially through the production of fustians, a combination of cotton weft and linen warp (Wadsworth and Mann, 1931: 15; 527).

The British industry remained small throughout the seventeenth century and the first half of the eighteenth century, since it was not yet

competitive with Indian cotton textiles. The output of the cotton industry is usually gauged from the consumption of raw cotton, measured by retained imports (Deane and Cole, 1969: 185; Hoffman, 1965: 254-257; Farnie, 1979: 7). Table 1 shows that when figures begin at the end of the seventeenth century, raw cotton consumption was only about 2 per cent of its volume at the beginning of the nineteenth century. Indeed, as late as the 1750s, cotton consumption was still less than 5 per cent of the level of the early 1800s.

The lack of competitiveness of the early British cotton textile industry can be seen most clearly in the trade data of Tables 2 and 3. Trade data were collected by customs officials on a value basis, but at "official" rather than current prices. These official prices were set to reflect normal or typical prices ruling in 1694, with great care being taken to eliminate temporary fluctuations (Schlote, 1952: 15). 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, Mitchell (1988: 446) quotes Flux (1899: 81) to the effect 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". 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 2, moves broadly in line with the official values of exports 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 just 3 per cent of the level of the early 1800s. In part A of Table 3, derived from the work of Davis (1954; 1962) on the regional breakdown of trade by commodity, 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.

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 (Baines, 1835: 106). Initial measures from 1690 took the form of import duties, but these were too low to make much impact on the huge labour cost differences (Davis, 1966: 309). From 1701, however, printed calicoes and certain other types of cotton cloth imported from India were prohibited (Wadsworth and Mann, 1931: 117-118). 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 et al. (1991: 413-418) see these protectionist measures, which remained in force with various amendments until 1774, as giving an important boost to the British cotton industry. However, if the British cotton industry is seen as innovating to overcome a labour cost disadvantage, protection could be seen as reducing the incentive to innovate, and therefore delaying the shift of competitive advantage. As we shall see later, such a situation is broadly consistent with the experience of the United States in the nineteenth century. However, in the case of Britain during the eighteenth century, it is more likely that the protective measures were largely circumvented, as is apparent from Chaudhuri's (1978: 278) consideration of Indian exports to Britain.

By the mid-eighteenth century, Britain's cotton producers were still not able to compete seriously on world markets (Baines, 1835: 81). But the search for labour-saving inventions, driven by the much higher wages in Britain than India, had already begun by this time, and Timmins (1996:

34-39) lists developments in all the main sections of preparation, spinning and weaving before the Industrial Revolution. Worthy of note are Lewis Paul's carding cylinder (1746), Lewis Paul's spinning machine (1738) and John Kay's flying shuttle (1733). It is interesting to note that the other major innovation before the Industrial Revolution was the Dutch or engine loom, which originated from the other high wage centre of Europe (Timmins, 1996: 36-37). 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 (Mokyr, 1990; Crafts, 1977). Hence, whilst 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 (Gilboy, 1934). This provides an example of a general phenomenon of input prices being bid up by an increase in demand before supply has responded fully.

During the second half of the eighteenth century, however, labour productivity increased dramatically in the British cotton textile industry as a result of further labour-saving technical progress, while technology and productivity stagnated in India. This led to a shift in competitive advantage, so that by the early nineteenth century, Britain was dominant in world markets, and even able to export to India. Between 1780 and 1800, output grew at an annual rate of 10.8 per cent, while exports expanded at an astonishing 14.0 per cent per annum. During the first half of the nineteenth century, output continued to grow at an annual rate of 5.0 per cent, while exports increased at a rate of 6.3 per cent per annum. However, Britain's conquest of world markets was hampered during the early stages of the Industrial Revolution between the 1780s and the 1820s by he 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 (Mitchell, 1988: 759-760). However, as supply increased, particularly from the United States, the price of raw cotton in Britain fell back to the level of the early eighteenth century during the 1830s, and Indian producers were faced with the full force of British competition.

As current prices began to deviate substantially from official prices towards the end of the late eighteenth century, Davis (1979) provided estimates of trade values at current prices, shown here in part B of Table 3. These figures suggest that after the repeal of the protective legislation, imports exceeded re-exports by a considerable margin until the beginning of the nineteenth century. However, exports exceeded imports already by the early 1790s.

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. Wadsworth and Mann [1931: 159-160] show that 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. With the struggle over American independence adding to the difficulties of Britain's cotton exporters, it is perhaps fortunate that 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" (Wadsworth and Mann, 1931: 168-169). As Edwards (1967: 50) notes, 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. 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. Inikori (2002: 444) shows that Indian cottons continued to share the West African market equally with British-made cottons during the second half of the eighteenth century, but that Lancashire goods pulled ahead decisively after the Revolutionary and Napoleonic Wars.

The penetration of British cotton textile exports into the Indian market proceeded more slowly, however, since Indian producers retained a transport cost advantage which they lacked in competition between the two countries in Africa, America or Europe. To estimate Britain's share of the Indian market, it is necessary to make assumptions about cotton consumption in India. Ellison [1886: 63] assumes cotton consumption of 2½ lb per head of population, which leads to the estimates of total cotton consumption in Table 4. This can be married up with reliable data on British exports to India to obtain estimates of Britain's market share. Ellison's data suggest that Indian producers supplied a larger share of their home market than British producers until at least the 1860s. Twomey (1983: 46, 53) makes similar assumptions to estimate the share of British exports in the Indian market as rising from 10 per cent in 1850 to a peak of 60 per cent in 1880-84 before falling back to 50 per cent by 1910-14.

2. The cotton textile industry in India

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 (Robson, 1957: 1). Chaudhuri (1978: 238) argues that India's competitiveness in this industry can be explained by an abundant supply of skilled labour, with specialised tacit knowledge being passed down through the generations in classic Marshallian

fashion.[2] Occupations related to the production of particular types of textiles were caste-based and led to regional specialisation. 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 specialisation 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 (Chaudhuri, 1978: 243).

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 (Chaudhuri, 1978: 243-245). 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). The European companies set up trading posts along the coast and encouraged the settlement of weavers. This was particularly true of the Coromandel Coast in the south of India (Ramaswamy 1985: 120-121). In Bengal, textile production was primarily a domestic rural industry. Although there were urban centres of production, weavers showed much less mobility than in the Coromandel (Chaudhury 1995: 158).

Part A of Table 5 shows the number of textile pieces exported to Britain between the 1660s and 1750s by the EIC from Bombay (the Gujarat trade), Madras (the Coromandel Coast trade) and Bengal,

[2] Marshall [1920: 225] famously noted that “The mysteries of the trade become no mysteries; but are as it were in the air.”

together with the data on textile exports to Europe via the VOC. Although the textile data include small amounts of silk goods and mixtures of silk and cotton, they are dominated by cotton cloth. Total textile exports from these three key centres of the Indian cotton textile trade to Britain show a strong upward trend from the 1660s to the 1680s, followed by a sharp downturn due to political conflict and war with the Mughal Empire. 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 (Chaudhuri, 1978: 295). However, ways were found around the protective measures and Indian textile exports to Britain fluctuated around 600,000 to 800,000 pieces for the rest of the first half of the eighteenth century. Part B of Table 5 picks up the story from the 1770s to the 1790s, but with the Gujarat trade passing through Surat rather than Bombay. Note that Indian exports to Britain continued to thrive during this period.

Note, however, that the regional balance of the Indian export trade to Britain changed substantially between the seventeenth and eighteenth 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 century. The declining importance of the Coromandel Coast as a supplier partly reflected the disruption caused by political conflict, particularly during the Mughal-Maratha wars (Arasaratnam, 1986: 153). However, Chaudhuri (1978: 296) also notes a relative cheapening of Bengal cottons, which suggests that the shift in competitive advantage between India and Britain was foreshadowed by a regional shift in competitive advantage within India. Exports via the VOC were generally lower than via the EIC, and exports by the French and Danish companies were lower again (Morineau, 1999: 252, 266).

Table 6, taken from Twomey (1983), shows Indian cotton textile exports during the late eighteenth century and the first half of the nineteenth century. The figures for Bengal in the 1790s match well with the figures from Table 5, although the higher figures for total India suggest that the three centres account for only about half the trade. Table 6 suggest that there was a sharp decline in Indian cotton textile exports to the British market only from the 1790s, which accords with the pattern of British imports in Table 3. Note, however, that the decline in total Indian exports to all markets was substantially slower.

3. Textile prices and the world market

Our explanation of the shift in competitive advantage relies on the existence of an integrated world market in cotton textiles. Although transport costs provided local producers with a limited amount of shelter from international competition in local markets, even with a relatively light product such as cloth, competitive forces also clearly stopped local prices from getting too far out of line with world market prices. This was much less true of grain prices in the early modern period, since grain was much more expensive to transport on account of its high weight-to-value ratio (Broadberry and Gupta, 2005).

Textile prices and grain prices for England during the period 1500-1850 are shown in Figure 1, based on Phelps Brown and Hopkins (1981: 44-59). The relative price of textiles clearly trended downwards over the period as a whole, as agricultural prices increased more rapidly than textile prices. Note that English textile prices showed no trend increase or decrease in nominal terms during the seventeenth and eighteenth centuries, which amounted to a substantial real price decline (Shammas, 1994). This is the context in which we need to assess what was happening to textile prices in India, with prices on world markets setting limits to the prices that could be paid to Indian producers. As already

noted in the discussion of lobbying for protection in Britain, there was a clear appreciation amongst textile producers of competition between types of cloth, with fine woollens and linens seen as close substitutes for printed cottons (Baines, 1835: 106). Hence the Indian export prices charted in Figure 2 for the period 1665-1759 show little upward trend. However, they also indicate a fairly constant differential between the higher prices in Madras and Bengal than in Bombay, reflecting differences in the type of cloth produced in the different regions. The constraint imposed by the price that could be obtained on the English market is illustrated by the fact that after 1760, the East India Company's offer price to the weavers in Bengal at times fell short of the weavers' cost-determined asking price, so that supply to the EIC fell short of demand (Hossain, 1988: 55).

It seems likely that, against this generally competitive background, the EIC enjoyed monopsony power in at least some regions of India in some periods, due to the scale of its operations. Nevertheless, the general framework of analysis is one of international competition within an integrated world market for cotton textiles. As technical progress in Britain put downward pressure on cotton textile prices, Indian producers found it increasingly difficult to compete, and competitive advantage in cotton textiles shifted from India to Britain. As Mitra (1978: 193) put it, "In 1818, the Dacca factory was closed down. It was not the freight, nor the protective duty which prompted the Court to abandon it in 1818, but the sharp reduction in prices of English cotton goods of a similar description and the fine piece-goods of Bengal increasingly lost their market."

III. Wages And Productivity In India And Lancashire

1. Anglo-Indian wage differences in cotton textiles

The cotton textile industry adds value to raw cotton, using labour intensive production processes. Hence competitiveness on world cotton textile markets depends largely on comparative unit labour costs, given by the ratio of comparative money wages measured in a common currency and comparative labour productivity in volume terms. In this section we compare the wages of cotton textile workers in Lancashire and India. Chaudhuri (1978: 237) notes the views of an anonymous author writing in 1701 that the same amount of labour as would cost a shilling in England may be had for two pence in India. To what extent did this six-to-one wage differential exist in cotton textile production, and how did it vary over time?

Broadberry and Gupta (2005) show that the money wages of unskilled and skilled labourers in India were already much lower than in Britain by the end of the sixteenth century, when compared at prevailing exchange rates. Since currencies at this time can be compared on the basis of their silver content, this is labelled the silver wage. Although the silver wage was much higher in Britain than in India, providing greater command over tradable goods, it should be noted that the price of non-tradable goods was also much higher in Britain. Hence, differences in the grain wage, defined as the silver wage divided by the price of grain, the principal foodstuff, were much smaller. Differences in living standards (or real consumption wages) lie somewhere between the limits set by silver wage differences and grain wage differences.

Table 7 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 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 discussed earlier. The Lancashire earnings for 1770 are taken from the authoritative study of Wadsworth and Mann [1931], and derive originally from the work of Arthur Young, based on the weekly earnings of a handloom weaver operating a single loom, with some assistance from his wife and children.[3] The Indian data for 1770 are derived from an estimate of the monthly earnings of a loom operated by two men with the assistance of their wives and children.[4] These data put the Lancashire wage at 600 per cent of the Indian wage, consistent with the six-to-one differential noted by Chaudhuri's (1978: 237) anonymous tract author.

Working back from 1770, we take the 1680 figure for India from Brennig's (1986) study of the Coromandel textile trade in the late seventeenth century. 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, we have used Gilboy's (1934) estimate of the daily wage of a craftsman, assuming a six-day week.

Working forward from 1770, we take the earnings in Lancashire for circa 1790 from Gilboy (1934: 280-287). The figure used here is for skilled workers. Wood (1910) 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 but before the successful introduction of the powerloom. However, Gilboy (1934) suggests a substantial increase in earnings during the course of the

[3] These figures for the earnings of English weavers are also used by Parthasarathi (1998: 83-84).
[4] 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.

1790s, and spinners' earnings were substantially lower. 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 (1910: 127) and refer to all cotton operatives, including factory workers as well as handloom weavers. 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.[5] Mitra (1978: 128-129) shows that the wages of Indian cotton spinners remained constant in money terms between 1790 and 1820, so that the English wage fell back to 517 per cent of the Indian level.

2. Anglo-Indian productivity differences in cotton textiles

Direct estimates of the level of labour productivity in cotton textile production for both England and India during the crucial Industrial Revolution period are scarce. Nevertheless, there is sufficient information to shed quantitative light on the changing balance between Anglo-Indian wage and productivity differences, and hence in comparative unit labour costs. We focus first on comparative levels of labour productivity around 1770 and then turn to establishing trends over time.

Dealing first with comparative levels of labour productivity in spinning, Catling (1970: 54) provides data on English labour productivity for spinning 80s cotton yarn, using the concept of OHP, or operative hours needed to process 100 lb of cotton, which is just the inverse of labour productivity. 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. If a machine is tended by three operatives and has an output of 25 lb per hour, then the

[5] Money wages also fell in line with prices in England during the post-war deflation (Gayer et al., 1953: 818).

OHP is 12. In Table 8, the OHP requirement for 80s yarn around 1780 was 2,000. For India, Catling suggests a rough estimate of 50,000 for the Indian OHP around 1780, which would give Britain a huge labour productivity advantage. For coarser counts, however, Buchanan Hamilton (1833: 289) suggests that a woman spinner working full-time could clean and spin two-and-a-half pounds of cotton in a month. 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. These figures would also suggest a substantial British labour productivity advantage in spinning.

In weaving, it seems likely that the British labour productivity advantage around 1770 was smaller than in spinning, since technological progress was more limited in weaving before the introduction of the power loom. There are, nevertheless, clear suggestions in the literature of a higher capital-labour ratio in Lancashire than in India. In Coromandel weaving, Brennig (1986: 348) for the late seventeenth century and Arasnaratnam (1980: 269) for the late eighteenth century, indicate two full-time male operatives per handloom, in addition to ancillary labour inputs from family members. Mitra (1978: 113-115) also presents evidence to suggest that two men worked per loom in late eighteenth century Bengal. In the Patna region of the Bengal Presidency, Sinha (1984: 26-27) finds three weavers per loom towards the end of the eighteenth century. A similar capital- labour ratio is also suggested by Buchanan Hamilton (1833: 296) and Hossain (1988: 40-41). Typically, three men worked per loom for finer textiles with design and two per loom for coarser textiles. Estimates of weavers' fixed costs confirm that the technology used was highly labour intensive. Buchanan Hamilton's (1833: 298) survey put the cost of a loom at two-and-a-half Rupees, less than a weaver's monthly earnings. The cost of a weaving shop or shed was put at 4 Rupees and accessories at less than a quarter of a Rupee. The cost

of yarn for two pieces of cloth, at 5 Rupees, was the main part of the production cost. Hossain's (1988: 20) work on eastern Bengal in the eighteenth century echoes this view, arguing that the capital input was minimal, with output being increased by drawing in surplus labour.

Descriptions of Indian weaving equipment by contemporary writers suggest the use of rudimentary technology, such as a warp set up on four bamboo sticks by two men on open ground and then fixed to the loom. It took these two men ten to thirty days to lay the warp (Hossain 1988: 40). One of these men held by hand two small wheels around which the thread was wound as he laid the warp. The loom was placed in a pit inside a weaving shed. The weaver sat on the side and operated the loom (Taylor, 1840: 174-175). Simple, though numerous, tools were used in spinning and weaving. These tools were made of locally available materials such as bamboo, reed, wood and wire (Hossain, 1988: 48). While the technology remained stagnant, it is likely that Indian productivity was nevertheless high by pre-industrial standards, due to the extent of the division of labour, where each task was performed by a certain social group. The spinning and embroidery were done by the women, washing and dyeing by specific caste groups.

Although Wadsworth and Mann [1931: 324-339] also indicate ancillary labour inputs from family members in the Lancashire industry during the first half of the eighteenth century, each loom was operated by only one full-time male weaver. This suggests that before the major technological changes of the second half of the eighteenth century, the Indian industry started out with two to three times as much labour per handloom as the English industry. If we assume that English and Indian looms were capable of producing the same output, this would result in a two-to-one or three-to-one labour productivity advantage for England over

India.[6] This would be consistent with Lancashire being unable to compete seriously on world markets at the beginning of the eighteenth century, since wages were four times higher than in India. It would also 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 (Mazzaoui, 1981: 73-86).

Turning now to trends in comparative labour productivity over time, there are clear signs of labour saving technical progress in the Lancashire cotton industry during the eighteenth century, particularly in cotton spinning. The key technological breakthrough in spinning came at the end of the 1770s. Crompton's mule, introduced in 1779, combined innovations from Hargreaves' spinning jenny, introduced in 1764 and patented in 1770, and Arkwright's water frame, patented in 1769 (Timmins, 1996: 40-43). While mules remained hand-driven, they were limited in size to around 100 spindles, setting limits to the increase in labour productivity over the older single-spindle jersey wheel technology. However, once power was applied, the capacity of a single mule increased to upwards of 1,200 spindles by the early 1830s (Timmins, 1996: 43).

Technical progress in spinning led to a sharp fall in the relative price of cotton yarn from the first half of the 1780s. However, as can be seen in Table 9, the real price fall was greater in the higher counts, with mechanisation making the spinning of very fine yarns in England an economic proposition for the first time (Harley, 1998: 50). On the coarse counts that dominated the trade at this time, such as 18s weft, real prices fell by a factor of about four between the first half of the 1780s and the first half of the 1820s. On finer counts such as 40s warp, the real price fell

[6] This amounts to the assumption of a common Leontieff production function.

by a factor of nearly 8, and on very fine counts such as 100s twist, it fell by a factor of 15.

However, spinning was only one task in the preparation of finished cotton cloth, and technical progress was much less dramatic in other parts of the industry, including preparation and finishing as well as weaving. In weaving, although machinery was being continually improved, there were no major technological breakthroughs between Kay's flying shuttle, patented in 1733, and the successful application of power to the loom, which was a long drawn-out affair from the 1770s. The development of an economic powerloom proved a daunting technological challenge, and was only really achieved on a commercial basis by Sharp and Roberts in 1822 (Timmins, 1996: 46). This imbalance between spinning and weaving helped to generate the high wages of handloom weavers in the late eighteenth century apparent in Table 7. Given the less rapid technical progress in weaving than in spinning, we should expect the real price of cotton cloth to decline more slowly than the real price of yarn, and this is borne out by Table 9. The real price of calico fell by less than a factor of 4 between 1780/4 and 1820/4, while the real price of muslin fell by less than a factor of 3.

Since labour was not the only input, we need to demonstrate that real prices declined in line with increasing labour productivity before the former can be used as an indicator of the latter. We see that the fall in the real price of 100s yarn in Table 9 is very close to the increase in labour productivity for 80s yarn in Table 8. Both are very fine counts for this period, so the high measure of agreement is reassuring. We have taken the fall in the real price of cloth, the final product, as the best guide to the increase in productivity in the cotton industry as a whole. Cuenca Esteban (1994: 101-102) suggests a fall in the nominal price of cotton textile exports by a factor of 4.65 between 1770/4 and 1820/4, which translates into a fall in the real price by a factor of 6.53.

3. Unit labour costs

Now consider the implications for competitiveness between Lancashire and India in Table 10. Competitiveness is measured here by comparative unit labour costs (*ULC/ULC**):

$$\frac{ULC}{ULC^*} = \frac{eW/W^*}{y/y^*} \qquad (1)$$

where an asterisk denotes the numeraire country, in this case Britain. Comparative unit labour costs are calculated as the ratio between comparative money wages converted to a common currency and comparative labour productivity (*y/y**). Money wages in India (*W*) and Britain (*W**) are converted to a common currency in terms of their relative silver contents (*e*).

In 1770, wages in Britain were about 6 times higher than in India, but labour productivity in Britain was only between two and three times higher than in India. This meant that the ratio of comparative silver wages to comparative labour productivity, or comparative unit labour costs, took a value well above 100. With much higher unit labour costs than in India, Britain had a substantial competitive disadvantage in world markets. By 1820, however, with productivity having increased in Britain by a factor of 6.53 and with the assumption of stagnation in India, productivity in Britain had risen to 1625 per cent of the Indian level. Since British wages had by this time fallen back to around 517 per cent of the Indian level, unit labour costs were now lower in Britain than in India, and Britain had the competitive edge in world markets.

IV. Comparative Costs, Prices And Changing Market Shares

1. Raw cotton costs

We see the shift in competitive advantage in cotton textiles from India to Britain as driven primarily by changing comparative unit labour costs. However, it is helpful also to take into account differences in raw cotton costs. Table 11 shows that the price of raw cotton in Britain averaged about 7 old pence per lb 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 and before supply had responded fully.

In Table 12, we see that India, with its local supply, faced a raw cotton price that was generally cheaper than in Britain, which gave India a further competitive edge over and above the lower wage costs. But what is interesting to note is that whereas raw cotton prices followed a sharply upward trend in Britain after 1740, the increase was much more gradual in India. Of particular significance was the sharp rise in raw cotton costs in Britain during the period of the Revolutionary and Napoleonic Wars. What Table 11 and 12 suggest is 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.[7] As raw cotton prices fell back after the end of the Napoleonic Wars, the effects of the productivity growth were realised and Lancashire cottons replaced Indian cottons in world markets.

[7] It is possible that a small part of the increase in the price of raw cotton during the Napoleonic War period reflects an increase in quality, with the growing importance of supplies from the United States. However, the increasing price is also visible in cotton imports from other areas.

2. Comparative costs and prices

Table 13 shows comparative GB/India combined costs as a weighted average of wage and raw cotton costs. The weights are based on Jones (1933: 105) and Edwards (1967: 240), together with the assumption that the Anglo-Indian other costs ratio was the same as the raw cotton costs ratio. It is tempting to think that this combined cost ratio reflects the comparative total factor productivity ratio (TFP/TFP*), since the levels equivalent of the familiar cost dual TFP equation is:

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

where *A* is total factor productivity (TFP), *W* is the wage rate, *C* is the cost of raw cotton, and *P* is the price of cotton yarn or cloth. An asterisk indicates the foreign country, which is taken as India. In competitive markets, the selling price must be equal, so it is tempting to think that the denominator in equation (2) should 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*):

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

In Table 13, we assume that the initial FOB price ratio was 200, obtained from Chaudhuri's (1978: 540-548) information on the East India Company mark-up on Indian textiles. This has been extended forwards from 1770 using the British cotton textile export price index from Cuenca Esteban (1994: 101-102), together with the assumption of stagnant FOB prices in India. Evidence in favour of this latter assumption is provided by Mitra (1978: 103-130), who notes that the EIC increasingly ran into difficulties in fulfilling their orders for cotton cloth in India, yet were unable to offer higher prices because of the situation in the English market. Given these developments in combined costs and FOB prices on a comparative basis,

we see in Table 13 that Britain's TFP advantage increased continually throughout the period.[8]

The change in competitive advantage in the production of cotton textiles occurred in three stages. In the first stage, which extended until the last quarter of the eighteenth century, the selling price of Indian goods in the British market (*SP**) was lower than the British FOB price (*P*) for most products, which were therefore not produced in Britain. In this stage, the British industry focused largely on the production of fustians.

In the second stage, towards the turn of the century, competitive advantage had started to shift in Britain's favour. With rising productivity in Lancashire, the FOB price in England now fell below the CIF price of Indian goods in Britain for a growing range of products, so that Britain increasingly displaced India from the home market. Also, Britain became increasingly able to compete against India in third markets such as Africa, where transport costs were similar for both countries.

In the third stage, from about 1830, the productivity gains in Britain, particularly now 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. We have already seen in Table 4 how Britain's share of the Indian market grew from 3.9 per cent in 1831-35 to 58.4 per cent in 1880-81. This view of the dynamics of Britain's penetration of the Indian market during the nineteenth century, based on the work of Ellison [1886] is broadly consistent with the picture presented by Twomey (1983), who is interested in the issue of Indian de-industrialisation. Twomey (1983: 40, 53) argues that although India became a net importer of cotton cloth from

[8] A similar comparative TFP path emerges with Leontieff technology, but with Britain's TFP growth advantage 1.28 per cent per annum over the complete period 1680-1770 rather than 1.06 percent using Cobb-Douglas technology as in Table 13.

about 1830, handicraft production for the home market turned down only after 1850.

V. High Wages And Labour Saving Technical Progress

1. Wages and induced innovation

The idea of a link between high wages and labour saving technical progress was originally proposed by Hicks (1932: 125). Although Salter (1960: 43) criticised Hicks's argument on the theoretical grounds that "(t)he entrepreneur is interested in reducing costs in total, not particular costs such as labour costs or capital costs", the idea has persisted in empirical work, particularly where there are large differences between countries in factor prices and productivity (Acemoglu and Zilibotti, 2001). In the historical literature, this approach is most closely associated with the work of Habakkuk (1962). However, Habakkuk's focus was on the case of the United States and Britain during the nineteenth century, with Britain cast in the role of the low wage economy, and high wages inducing labour saving technical progress in the United States.

Economic historians have been reluctant to apply this approach to the case of the Industrial Revolution, with Britain cast in the role of the high wage producer. Von Tunzelmann (1981: 159-160), for example, endorses Habakkuk's view of the US/UK case, but explicitly rejects its applicability to the case of Britain and Europe during the Industrial Revolution. This reluctance to characterise Britain as a high wage economy during the Industrial Revolution probably owes it origins to the long running standard of living debate, which emphasises the slowness of real wages to rise for the working class. For example, von Tunzelmann (1995: 6-7) notes that "With the current orthodoxy of the standard-of-living debate being that wages in England did not begin to rise appreciably in real terms until the second or third decades of the nineteenth century, and

even then not very rapidly, there was little in the way of a renewed incentive to economize upon labor". However, this is quite consistent with the findings emphasised in Broadberry and Gupta (2005), that whilst silver wages were much higher in northwest Europe than in Asia, grain wages were not. Since the price of grain was also relatively cheap in India, workers' living standards were not as low as suggested by the fact that Indian silver wages were only 20 per cent of the British level. However, British firms competing with Indian producers had to think in terms of the silver wage, since they had to sell on world markets at the world silver price.

Griffiths et al (1992: 892) find that 42.8 per cent of all innovations in the British textile industry during the eighteenth century could be assigned to the category "factor saving", with the bulk of the rest of the innovations being assigned to various categories of product rather than process innovation. However, Griffiths et al (1998) take the argument a step further, claiming that there is little support for the idea of induced innovation, at least as it has been conventionally presented in the cotton textile industry during the Industrial Revolution, in terms of a sequence of challenges and responses. But one way of interpreting the difficulty that they find in identifying a simple pattern of bunching in patenting activity around particular stages of production at particular times is to follow David (1975) in assigning a key role to factor prices in initially pushing the high wage economy on to a more capital-intensive point on the available process frontier, with subsequent technological progress driven by "local learning". In this kind of trial and error process, technological progress tends to preserve initial factor proportions, but we need not expect all inventors to specifically mention factor saving as a driving force behind their particular innovations, and in a stochastic environment there are likely to be variable delays between challenge and response.

Since silver wages were four times higher in Britain than in India, it is not surprising that British producers seeking to imitate Indian cotton textiles could not adopt labour intensive Indian production methods. Rather, British producers needed to find new production methods, and it is this search which led them to the innovations of the Industrial Revolution. The scale of this Anglo-Indian silver wage difference prompts us to put it at the heart of the developments in cotton, and hence at the heart of the Industrial Revolution. Some writers have considered the logical possibility, but without perceiving the huge silver wage gap, have resisted giving it anything other than a minor role. Thus Landes (1969: 115-116) devotes one paragraph to high wages as a stimulus to mechanisation, but makes no mention of the inducement mechanism in his later work (Landes, 1998). Others, such as Deane (1965: 97), only mention wages and the British cotton industry to stress the importance of "an almost inexhaustible low-priced labour supply".

In our view, it is the combination of the focus on Europe rather than Asia together with the consideration of grain wages rather than silver wages that accounts for the previous neglect of the link between the Anglo-Indian wage gap and labour-saving technical progress in the British cotton industry. Thus although Parthasarathi (2001) makes a direct comparison between Britain and India, he focuses on the grain wage and hence follows other "world historians" in minimising the differences between Europe and Asia during the early modern period (Frank, 1998; Pomeranz, 2000).

2. Biased technical change

Before we conclude in favour of labour-saving technical progress, however, we must confront another strand in the literature, which emphasises the slow growth of capital during the Industrial Revolution, combined with the rapid growth of labour as population growth increased.

Von Tunzelmann (1994: 289-290) claims that technical progress in the economy as a whole was only strongly labour saving after 1830. The data which underpin this conclusion are reproduced here in Table 14. Working at the level of the economy as a whole, although total net fixed capital stock per head of population did increase before 1830 at an annual rate of 0.2 per cent, this rose to 1.5 per cent after 1830. However, as Williamson (1990: 272) notes, the apparent modesty of Britain's investment requirement during the Industrial Revolution had much to do with under-investment in dwellings and social overhead capital rather than in plant, equipment and machinery, which is of most relevance to labour saving technical progress. Indeed, plant, equipment and machinery per head was already increasing at an annual rate of 0.8 per cent between 1760 and 1830, rising to 2.2 per cent after 1830.

Disaggregated data by industry are more patchy, and for cotton textiles, we have only the capital stock data of Chapman and Butt (1988), which refer largely to buildings. Nevertheless, there is evidence of an increasing capital labour ratio before 1830 as well as after, and this is consistent with labour saving technical progress in the cotton textile industry.

3. Implications for protection

As noted earlier, it has been argued by O'Brien et al. (1991) that the British cotton industry gained from protection during the eighteenth century. However, once it is recognised that the British cotton industry was innovating in response to a factor cost disadvantage, this argument becomes much less persuasive. Indeed, within the induced innovation framework, it even becomes possible to argue that protection in the domestic market, if anything, delayed the shift of competitive advantage, by removing the immediate pressure on domestic producers to innovate.

Wadsworth and Mann [1931: 118, 128] play down the significance of the Calico Acts for cotton, since linen could also be used for printing, and import barriers could anyway do nothing to offset India's competitive advantage in export markets. Furthermore, as Chaudhuri (1978: 278) notes, a consideration of Indian exports to Britain suggests that the measures must have been circumvented even in the British market. Part A of Table 3 certainly shows continued growth of the volume of imports from India during the eighteenth century, although the broad equality of re-exports and imports until the repeal of the protective legislation in 1774 suggests that the East India Company at least paid lip-service to the principle that this cloth should not reach the British consumer. Thomas [1926: 135-137] cites legal documents from prosecutions as well as allegations by contemporaries to implicate the East India Company in smuggling, but the scale of such operations remains difficult to ascertain.

In practice, then, it seems likely that the effects of protection on the British cotton industry were neutral, with the Calico Acts being circumvented. Note, however, that there is an example from the nineteenth century of a high wage cotton textile producer sheltering behind tariff barriers and failing to become competitive in world markets. The United States adopted very high tariffs during the nineteenth century, securing a large share of the domestic market, particularly in lower quality coarse goods (Harley, 2001). As noted earlier, high wages in manufacturing in the United States are often seen as inducing labour saving technological progress (Habakkuk, 1962; David, 1975). In the case of cotton textiles, this led to the widespread adoption of the high-throughput technologies of ring spinning and the automatic loom (Jones, 1933; Sandberg, 1974; Lazonick, 1986). However, the US cotton industry never became competitive on world markets for any sustained period, since the wage cost disadvantage always outweighed any labour productivity advantage (Saxonhouse and Wright, 1987; Broadberry and

Marrison, 2002). Had the Calico Acts succeeded, it is possible that the British cotton industry, like its American counterpart, would never have become competitive in world markets.

VI. Conclusions

The shift of competitive advantage in cotton textiles from India to Lancashire was a key episode in the Great Divergence of living standards between Europe and Asia. This paper offers a new perspective on this major development, centred on comparative unit labour costs, and emphasising the interactions between the two countries. We emphasise the growing imports of cotton cloth from India via the East India Company during the seventeenth century, which opened up new opportunities for import substitution as the new cloths, patterns and designs became increasingly fashionable. However, high silver wages in Britain as a result of high productivity in other tradable goods and services, meant that British producers of cotton textiles could not use labour-intensive Indian production methods. This stimulated a search for new methods of production that economised on the use of labour. As labour productivity increased in Britain and stagnated in India, comparative unit labour costs moved in Britain's favour. Had protection of the domestic market succeeded, this may have removed the spur to innovation provided by the high wages compared to India, thus delaying the shift of competitive advantage.

The shift of competitive advantage occurred in three stages. First, a small cotton industry was established in Lancashire between 1600 and 1770. Although labour productivity was higher than in India, wages were even higher so that Lancashire was unable to compete seriously with India. Second, between 1770 and 1830 labour saving technological progress raised labour productivity and made Lancashire competitive in

world markets despite high wages. During this second phase, the shift of competitive advantage in international markets was delayed by rising wage and raw cotton costs, before supply responded fully to the increased demand in factor and material input markets. Third, after 1830, further technical progress made Lancashire competitive even in the Indian market.

Table 1: Raw cotton consumption, Great Britain 1697-1849 (million lb)

	Annual average consumption		Annual average consumption
1697-99	1.1	1770-79	4.8
1700-09	1.1	1780-89	15.5
1710-19	1.3	1790-99	28.6
1720-29	1.5	1800-09	59.6
1730-39	1.7	1810-19	93.4
1740-49	2.1	1820-29	166.5
1750-59	2.8	1830-39	320.7
1760-69	3.5	1840-49	526.3

Sources: 1697-1780: Wadsworth and Mann [1931: Appendix G]; 1780-1810: Baines [1835: 347]; 1810-1849: Ellison [1886: Table 1].

Table 2: Exports Of Cotton Textiles, Measured At Constant Official Prices, Great Britain, 1697-1850 (£000 At 1697 Prices)

A. Values at constant official prices (£000 at 1697 prices)

	Total		Piece goods	Yarn	Total
1697-99	16	1770-79			246
1700-09	13	1780-89			756
1710-19	8	1790-99	2,525	101	2,626
1720-29	16	1800-09	7,603	749	8,352
1730-39	14	1810-19	17,712	1,133	18,845
1740-49	11	1820-29	25,605	3,225	29,830
1750-59	86	1830-39	44,086	7,519	51,605
1760-69	227	1840-49	73,838	12,109	85,947

B. Volumes

	Piece goods		Yarn
	m lin yds	m lb	m lb
1800-09	109.5	20.0	7.4
1810-19	205.0	37.4	12.0
1820-29	320.3	58.5	35.5
1830-39	552.4	100.8	84.3
1840-49	977.5	178.4	136.1

Sources: Part A: 1697-1808: Schumpeter (1960: Tables X, XI); 1808-1850: Parliamentary Papers (various years), *Finance Accounts: Trade and Navigation*. Part B: Robson (1957: 331).

Table 3: British imports and re-exports of cotton piece goods from India, compared with British exports of cotton textiles, 1663-1856

A. Values at constant official prices (£000 at 1697 prices)

	Imports	Re-exports	Exports
1663-69	182		
1699-1701	367	340	20
1722-24	437	484	18
1752-54	401	499	83
1772-74	697	701	221

B. Values at current prices (£000)

	Imports	Re-exports	Exports
1784-86	1,344	395	797
1794-96	1,687	1,148	3,801
1804-06	823	777	16,339
1814-16	515	433	18,994
1824-26	363	430	17,375
1834-36	347	406	22,398
1844-46	478	450	25,835
1854-56	481	532	34,908

Sources: Part A: 1663-1701: Davis (1954: 164-165); 1722-1774: Davis (1962: 300-303). Part B: 1784-1856: Davis (1979: 94-125).

Table 4: British cotton textile exports in the Indian market, 1831-35 to 1880-81

	Indian consumption of cotton textiles (m lb)	Share taken by British exports (%)
1831-35	375	3.9
1856-60	455	35.3
1880-81	600	58.4

Source: Ellison [1886: 63].

Table 5: Indian exports of textiles to Europe (pieces per year)

A. 1665-1759

	To Britain via EIC from:				To Europe via VOC
	Bengal	Madras	Bombay	Three centres	
1665-69	7,041	37,078	95,558	139,677	126,572
1670-74	46,510	169,052	294,959	510,521	257,918
1675-79	66,764	193,303	309,480	569,547	127,459
1680-84	107,669	408,032	452,083	967,784	283,456
1685-89	169,595	244,065	200,766	614,426	316,167
1690-94	59,390	23,011	89,486	171,887	156,891
1695-99	130,910	107,909	148,704	387,523	364,613
1700-04	197,012	104,939	296,027	597,978	310,611
1705-09	70,594	99,038	34,382	204,014	294,886
1710-14	260,318	150,042	164,742	575,102	372,601
1715-19	251,585	200,495	82,108	534,188	435,923
1720-24	341,925	269,653	184,715	796,293	475,752
1725-29	558,850	142,500	119,962	821,312	399,477
1730-34	583,707	86,606	57,503	727,816	241,070
1735-39	580,458	137,233	66,981	784,672	315,543
1740-44	619,309	98,252	95,139	812,700	288,050
1745-49	479,593	144,553	60,042	684,188	262,261
1750-54	406,706	169,892	55,576	632,174	532,865
1755-59	307,776	106,646	55,770	470,192	321,251

B. 1771-1792

	To Britain via EIC from:			
	Bengal	Madras	Surat	Three centres
1771-74	652,158	182,588	93,683	928,429
1775-79	584,889	197,306	48,412	830,607
1780-84	435,340	79,999	40,488	555,827
1785-89	697,483	67,181	38,800	803,464
1790-92	727,717	170,442	38,707	936,866

Sources: 1665-1759: Chaudhuri (1978: 540-545); Morineau (1999: 273-274). 1771-1794: Milburn [1813, vol.2: 234].

Table 6: Indian exports of cotton textiles, 1790-1859 (thousand pieces per year)

	Exports to Britain		Total exports	
	Bengal	Total India	Bengal	Total India
1790-99	787	2,200		4,500
1800-09	1,331	1,824		
1810-19		1,358		
1820-29		431		
1830-39	6	271	478	3,000
1840-49		304		2,606
1850-59				2,279

Source: Twomey (1983: 42-44).

Table 7: Weekly earnings of cotton operatives in Britain and India, circa 1680-1820 (s/d)

	Lancashire	India	Lancashire as % of India
c.1680	6s/0d	1s/6d	400
c.1770	9s/0d	1s/6d	600
c.1790	13s/3d	2s/0d	663
c.1820	10s/4d	2s/0d	517

Sources and notes: India: circa 1680: Brennig (1986: 348-349) for southern India; circa 1770: Arasaratnam (1980: 269) for southern India, Chaudhury (1999: 161-162) for Bengal; circa 1790: Arasaratnam (1980: 269), Ramaswamy(1985: 156), Mukherjee (1967:25) for southern India; Chaudhury (1999: 161-162), Hossain (1988: 52-53), Chaudhury (1999: 163-165) for Bengal; circa 1820: Mitra, (1978: 128-129), Buchanan Hamilton, (1833: 296-298) for Bengal. All Indian earnings given on a monthly basis converted to a weekly basis on the assumption of a 4-week month. Lancashire: circa 1680: Gilboy (1934: 280-287); circa 1770: Wadsworth and Mann [1931: 401-402]; circa 1790: Wood (1910: 112); circa 1820: Wood (1910: 127). Lancastrian earnings given on a weekly basis, except Gilboy (1934), given on a daily basis and converted to a weekly basis on the assumption of a 6-day week.

Table 8: Best-practice labour productivity in spinning 80s yarn in England, 1780-1825 (operative hours to process 100 lb of cotton)

	Technology	OHP
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 (1970: 54).

Table 9: English cotton yarn and cloth prices deflated by general price index, 1780-1829

	Yarn (d per lb)			Cloth (s per piece)	
	18s weft	40s warp	100s 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
1810/4	15	30	50	18	27
1815/9	15	30	62	19	31
1820/4	11	22	51	15	40
1825/9	10	20	52	10	33

Note: The general price index used to deflate the nominal prices is from Feinstein (1995). Deflated yarn and cloth prices are in constant 1825/9 prices.
Source: Harley (1998: 55, 59).

Table 10: Anglo-Indian comparative wages, labour productivity and unit labour costs in cotton textiles, 1770-1820 (India=100)

	Comparative silver wages	Comparative labour productivity	Comparative unit labour costs
1770	600	250	240
1820	517	1625	32

Sources: Derived from Tables 7-9. See text for details.

Table 11: Price of raw cotton in Britain, 1680-1879

	d per lb		d per lb
1680-89	7	1780-89	23
1690-99	7	1790-99	24
1700-09	7	1800-09	17
1710-19	9	1810-19	19
1720-29	10	1820-29	16
1730-39	10	1830-39	8
1740-49	10	1840-49	5
1750-59	16	1850-59	6
1760-69	16	1860-69	15
1770-79	16	1870-79	8

Sources: 1680-1780: Wadsworth and Mann [1931: Appendix H]; 1780-1879: Mitchell (1988: 759-760).
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.

Table 12: Comparative raw cotton prices in Britain and India, 1710-1830

	GB (d per lb)	India (d per lb)	GB/India (India=100)
1710	8	4.4	182
1740	9	4.6	196
1792-93	24	5.0	480
1802-03	14	6.3	222
1812-13	20	6.3	317
1822-23	8	6.3	127

Sources: India: 1710, 1740: Mukund (1999: 84) gives the cotton price in the south as 23 pagodas per candy of 500 lb in 1710, with 1 pagoda equal to 8s (Chaudhuri, 1978: 471); 1792-1823: Mitra (1999: 126-127) gives average cotton prices in Bengal as 12.42 rupees per maund of 74.5 lb in 1792-93; Britain: Wadsworth and Mann [1931: Appendix H]; Mitchell (1988: 759-760).

Table 13: Comparative GB/India wage and cotton costs combined (India =100)

	Wages *(W/W*)*	Raw cotton *(C/C*)*	Combined costs $(W/W^*)^{0.5}(C/C^*)^{0.5}$	FOB price (P/P*)	TFP (A/A*)
c.1680	400	182	270	200	135
c.1770	600	320	438	200	219
c.1790	663	480	564	150	376
c.1820	517	127	256	43	596

Sources: Wages and raw cotton costs derived from Tables 7 and 12; Prices FOB derived from Chaudhuri (1978) for 1680 and 1770, extended to 1790 and 1820 using Cuenca Esteban (1994).

Table 14: Capital- labour ratios in Great Britain, 1760-1850 (1850=100)

	Whole economy		Cotton
	Total net fixed capital stock per head	Plant, equipment, machinery per head	Fixed capital per worker
1760	63.4	36.3	
1770	62.6	36.6	
1780	62.9	39.0	
1790	64.8	43.9	
1800	67.8	47.1	
1810	69.1	50.6	13.9
1820	69.9	52.4	22.3
1830	74.1	64.5	26.0
1840	85.2	82.1	47.3
1850	100.0	100.0	100.0

Sources: Whole economy: capital stock from Feinstein (1988: 454); population from Wrigley et al. (1997: 614); Cotton industry: fixed capital in current prices from Chapman and Butt (1988: 124-125) converted to constant prices using the implicit deflator of gross capital in manufacturing from Feinstein (1988: 433, 448). Employment from Mitchell (1988: 376).

FIGURE 1: Textile and grain prices in England, 1500-1850

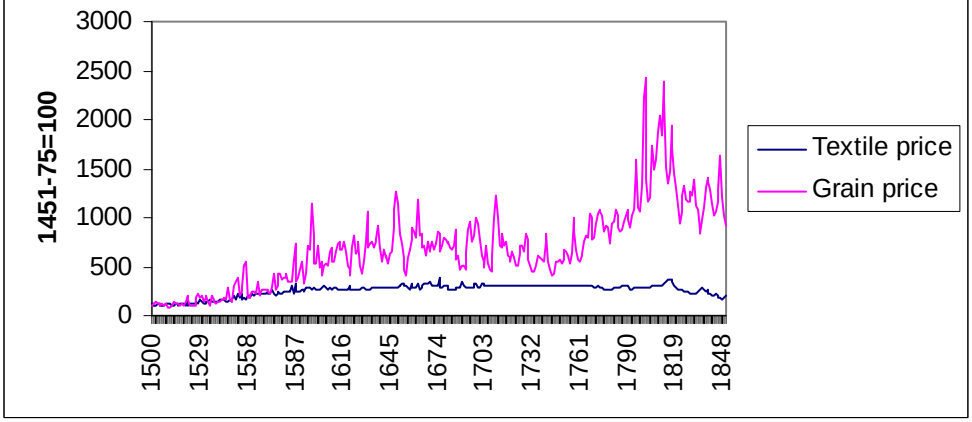
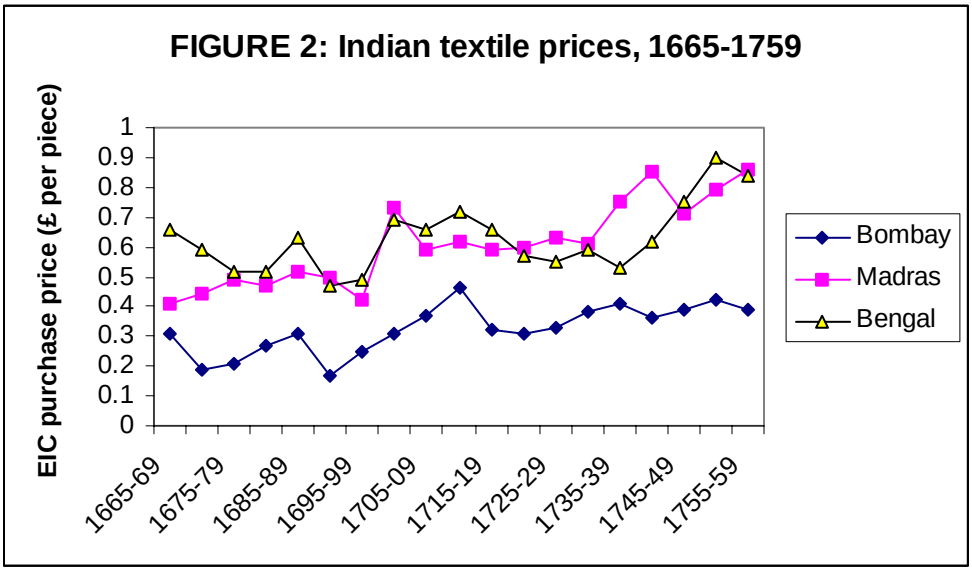


FIGURE 2: Indian textile prices, 1665-1759



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