ECN 110B, Spring 2004
World Economic History
Gregory Clark

2. The British Industrial Revolution, 1760-1860

In the eighty years or so after 1780 the population of Britain nearly tripled, the towns of Liverpool and Manchester became gigantic cities, the average income of the population more than doubled, the share of farming fell from just under half to just under one-fifth of the nations output, and the making of textiles and iron moved into the steam-driven factories. So strange were these events that before they happened they were not anticipated, and while they were happening they were not comprehended.[1]

"The whole of nature is unceasingly studied, requested, worked upon, fecundated, husbanded," Marquis de Biencourt, writing of England in 1784.

Introduction

By 1850, at the apogee of its power, Britain had 1.8% of world population. The area of the British Isles is only about 0.16% of the world land mass. Yet Britain then produced two-thirds of world output of coal and one half of world production of cotton textiles and iron. Output per worker was higher in Britain than in any other country. It had enormous colonial possessions including much of India and Pakistan, Canada, Australia, New Zealand, and Ireland. Its navy was the largest in the world, and British defense doctrine called for it to be bigger than the next two largest navies combined. In 1842 it had humiliated the ancient Chinese empire and forced it to cede Hong Kong and to allow the British to ship opium into China. In 1860 the British and French captured Beijing and forced even more humiliating terms on the empire.[2] Britain was so confident of its manufacturing prowess that it pursued an armed policy of forcing free trade on other countries, confident that its manufactures would sweep away protected infant industries in other countries. Thus Britain used a show of force in Persia in 1841 to force it to concede most

[1] D. N. McCloskey, "The Industrial Revolution in Britain 1780-1860: A Survey," in Roderick Floud and Donald McCloskey, The Economic History of Britain since 1700.
[2] It is claimed that by 1855 Chinese tariff policy was firmly under British control, the only restraint on the British being the fear of toppling the current regime by pushing them too far.

favored nation status. It intervened in Egypt in 1841 out of displeasure with the protectionist Pasha.[3] With its colonial possessions such as India, Britain in the nineteenth century similarly imposed a policy of strict free trade, even though wages in India were less than one sixth those of Britain by the late nineteenth century.

The ascendance of this minor country on the northwest corner of Europe, which in 1700 had a population about one-third that of France (and about 4% that of both China and India) to the position of power it occupied is traditionally seen as being largely the result of the Industrial Revolution which occurred in Britain between 1770 and 1850.[4]

Even within Britain the Industrial Revolution changed the balance of power. Up until 1770 the center of population and political power was the south. London had a population of over 500,000 and was the center of Government. The next largest towns in 1760 were Bristol and Norwich, both in the south (see figures 1 and 2). Manchester, the center of the cotton industry had a population of only 17,000. But the Industrial Revolution was a phenomenon of the North of the country, and population, income and political power moved in favor of the north. By 1830 Manchester had a population of 180,000, and within 50 miles of Manchester lay most of the cotton textile mills. Thus by 1850 the Manchester area was producing about 40% of the world cotton textile production.[5] The centers of traditional woolen cloth production in the southwest and around Norwich were replaced by the factory industry in Yorkshire. These areas deindustrialized losing population to the north or to emigration abroad as wages stagnated and unemployment rose. Thus the town of Worcester in the southwest went from 13,000 in 1779

[3] The British and French in 1845 intervened in Uruguay in support of a liberal regime that favored freer trade.
[4] The dating of the Industrial Revolution is largely arbitrary, and the start has been variously given as 1760, 1770 and 1780, while again the end is sometimes given as 1860.
[5] Liverpool which was the port for Manchester and the cotton textile region similarly grew from 34,000 in 1773 to 78,000 by 1801.

down to 11,000 by 1801. And Norwich in the south grew by only 1,000 people from 1752 when it had 36,000 to 1801.

Three questions arise concerning the Industrial Revolution in Britain. The first is "What was it?" At the most basic level of description what happened in Britain in the period 1760 to 1860 that leads it to be regarded as a period of great historical significance? Here we shall see there is a conflict between the traditional views of the Industrial Revolution that emphasize the revolutionary nature of the period and modern views that have emphasized that the events of 1760 to 1860 were merely an evolution from what had come before. Remember at the time the Industrial Revolution was occurring no-one used that term to describe events: it was introduced by Toynbee in the late nineteenth century. In the same way we do not know yet the term that will be attached to these epoch in the history of the USA. The second question is what was the effect of the Industrial Revolution on output per worker? And what was the source of these effects in terms of our growth accounting model? The third question is why did this Revolution occur in Britain? Any why did it occur in 1760?

In the traditional view **four** revolutions with completely different natures and mechanisms occurred simultaneously in Britain in the years 1760 to 1860: the **Industrial Revolution**, the **Demographic Revolution**, the **Agricultural Revolution**, and the **Transport Revolution**. We first lay out what the traditional view of what happened in each area is.

Figure 1: England in 1800

The Industrial Revolution

In the traditional view this was an **unexpected** and **rapid** transformation of key industrial sectors by mechanical innovations. The key sectors transformed were the cotton textile industry, the power producing industry (with the steam engine), the iron and steel industry, and eventually transportation with the introduction of railroads. The traditional account stresses that there were **a few key innovations** in each sector. These innovations led to the emergence of factory production and large scale modern industry. This new industrial economy in turn led to the imposition of factory discipline on workers and to their ultimate deskilling to the role of machine tenders. It also created social changes such as the proletarianization of much of the population, urbanization, and great accumulations of capital and hence great inequality in incomes.

We certainly see both dramatic technical innovations, as detailed below, and a huge growth in industrial output in Britain in this period. The output of a group of manufactured products whose quantities are measurable (textiles, metals, sugar, beer, hides, paper, tobacco, soap, candles) increased 6-fold over these years. The growth of this great industrial economy, it is argued, also led to the ascendance of the British empire by providing the resources and the technology for military conquest.

Cotton Textiles

The cotton industry was certainly rapidly transformed. The traditional textile industries in Europe prior to 1700 used linen and wool as raw materials. Sheets and undershirts were made of linen, outer garments of wool. Cotton was an exotic and expensive material that did not grow in western Europe. The cotton industry in Lancashire developed in the early eighteenth century as a result of trade with Egypt and India. It was still a minor industry in 1760, using only about 2.6 million pounds of cotton in 1760 (as compared to 90 million pounds of wool consumed in the

woolen industry). Adam Smith in the Wealth of Nations published in 1776 hardly notices the industry, even though he was writing in Glasgow, an early center of the cotton industry. But raw cotton consumption rose dramatically by 1850, as Table 1 shows.

Table 1: Cotton Consumption 1760-1850

Year	Cotton Consumption (million lbs.)	Growth Rate
1760	2.6	-
1800	51.6	7.5%
1850	621.0	5.0%

By the 1830s cotton represented 20% of British imports, and cotton goods were 50% of British exports. The cotton industry rose from being about 0% of GNP in 1760 to about 8% of GNP by 1812. By 1860 65% of all the cotton goods produced in Britain were for export, as were 38% of woolen goods and 40% of linen goods. The reason cotton production rose so rapidly, and were so successful internationally, was the price of cotton goods fell dramatically, as figure 2, which gives costs in shillings per pound, shows.

Table 2: The Cost of Yarn

Year	Raw Cotton (s. per lb.)	Yarn (s. per lb.)	Manufacturing Cost (s. per lb.)
1784	2.0	11.0	9.0
1812	1.5	2.5	1.0
1832	0.6	1.0	0.4

The cost of manufacturing 1 lb. of cotton yarn in 1784 was equivalent to 1 week's wage for an unskilled manual laborer. By 1832 it was equivalent to less than 3 hours wages. Cotton yard could be produced so cheaply in British factories that it displaced hand spun yard even in countries like India where the wages of workers were one sixth of those in Britain. By 1850 the only countries that had cotton spinning industries that survived were those like the USA which imposed protective tariffs against British imports. Otherwise Britain would have produced almost all of the cotton textiles in the world.

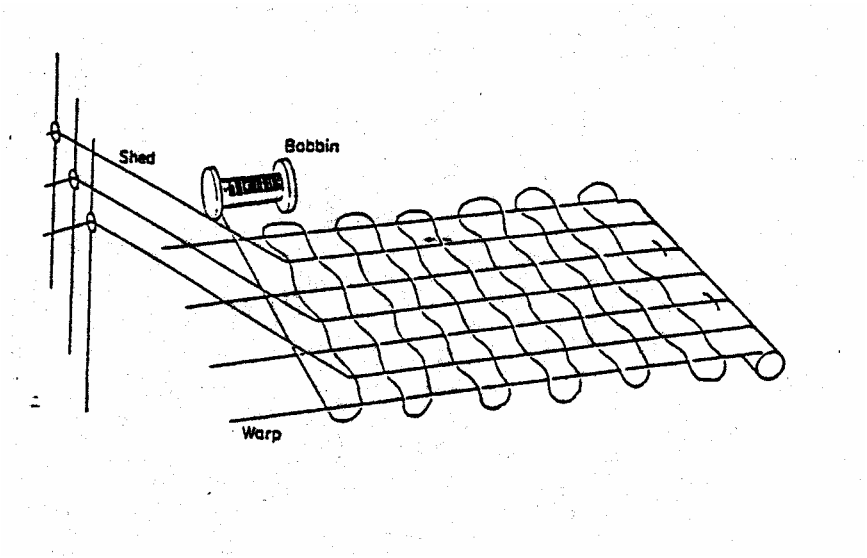
The reason that costs in the industry fell so dramatically were that there was a series of mechanical innovations in the cotton spinning and in the weaving industry which began as early as 1733. I will describe these in some detail since one interesting question we will ask is why these innovations occurred only in Britain in the early eighteenth century.

In 1700 the textile industry was almost entirely a domestic one. Women spun the yarn on the distaff or spinning wheel, then men wove it on looms in special rooms in weavers cottages or in loom sheds. Except for fulling woolen cloth the industry was all human powered and required enormous inputs of labor. Spinning was the most labor intensive part of the industry, since each spinner could only spin one thread at a time. It was mainly done in Europe using the spinning wheel (which was itself an earlier innovation in spinning.) To make cotton yarn a ball of cotton fibers has to be drawn out for fineness and at the same time twisted for strength. The spinner on the wheel would do this one thread at a time, using their fingers to pull out and twist the yarn. It thus took well over a week to spin a pound of yarn. That clearly imposes a strong limitation on the amount of clothing that any person is going to be able to consume.

The first two major innovations were actually designed for the woolen industry since at that stage cotton was important. The first change occurred in weaving. Weaving is a simple process

conceptually. A series of stronger threads, called the "warp" threads is drawn out parallel. They are attached by loops to a set of vertical threads called the "harness." One half of them are lifted to form the 'shed' through which the cross or 'weft' threads are passed. Then the other half if lifted, and the weft is passed back through. The weft is wound around a bobbin. Before 1733 this was thrown by hand from one side of the loom to the other (see figure 3). This meant that any cloth more than 3 feet wide required two people to weave it — one to throw and the other to catch the shuttle. It also meant that the insertion of the weft was necessarily a slow

Figure 3: The Basic Weaving Process



process. "The flying shuttle," that propelled the weft mechanically across the loom was invented by John Kay, a weaver and a mechanic in Yorkshire in 1733. In the 'flying shuttle' the bobbin is carried in a little vehicle called a 'shuttle,' which has wheels and is pointed at both ends. The shuttle is projected at speed from one side of the cloth to the other, and back again. Thus the name. The projection is done from a kind of launching box at each side of the loom, which

propel the shuttle out to the box at the other side of the loom when the weaver jerks a cord. In this way the weaver can weave much more speedily, and can weave cloth of any desired width.

Kay did not have instant success with his device. He was persecuted by the weavers in Yorkshire who feared unemployment as a result of his improvement. After failing in a legal case to protect his patent he fled to France in 1753 to take up an offer of royal patronage there. But in spite of worker opposition the flying shuttle soon became an essential part of any loom in Britain. And despite the demonstration projects funded by the French crown in France the flying shuttle was very slow to catch on there.

The next major innovation came in spinning cotton. Cotton spinning in factories actually consists of a series of steps. The cotton is first “carded” which is a process by which the tangled fibers are aligned in the same direction in a loose rope called “roving.” Then by progressive steps this roving is both stretched out (and so made thinner) while at the same time being twisted to give it strength. Mechanical silk spinning mills has existed for long before 1769. They were developed in Italy in the 16th century.[6] Silk is a material that is very easy to spin. The fibers are very long, and being sticky they hold together easily. Cotton and wool both have much shorter fibers, so the threads formed from them are thus much more fragile. Thus spinning them is more difficult. Before the eighteenth century these fibers had to be spun by hand. The 'spinster,' almost always a woman and hence the modern use of the word, would use her fingers to draw out the thread which was then given twist by the spindle of the spinning wheel.

In 1738 Lewis Paul, a small scale inventor in the garment industry combined with John Wyatt, originally a ship's carpenter, to develop a mechanically powered "spinning engine," to spin cotton and wool. Wyatt and Paul's machine was similar to silk throwing machinery, but their innovation was the idea of using rollers to draw out the loose rope of cotton or wool, called

the 'roving.' The thread then went to a flyer that both twisted it and wound it onto a bobbin. The basic design is shown in figure 4. The twist was imparted to the yarn by the device of the flyer which was already in use in the Saxony spinning wheel. Paul also developed a carding machine which was patented in 1748. Though technically at least partially successful, the Lewis and Paul engine was a financial failure resulting in the bankruptcy of its promoters. Wyatt and Paul's machine does not appear to have worked well, though factories were set up using it in 1740, 1741, 1742 and 1744. The first factory was powered by two asses, and employed ten girls. The 1744 factory used water power, and had 250 spindles and 50 workers, and operated for some years.

Wyatt and Paul's idea was only successfully implemented thirty years later by Richard Arkwright in 1769. Arkwright had little or no education, and had been trained as a barber. Experiments in dyeing hair led him into the occupation of wig making, and he spent much time touring county fairs buying human hair. In his travels he met a clock-maker named Kay in 1767 who told him of making a model of a mechanical spinning machine for Thomas Highs, a local mechanic. Arkwright financed Kay to develop a new model of a spinning machine. In the process the services of a local blacksmith and watch