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World Economic History

5. The Spread of the Industrial Revolution, 1860-2000

Introduction

As we saw, it is not clear when the great turning point in human history, the Industrial Revolution, actually arrived. Arguments can be made for dating this to the middle ages, arguments can be made for dating it to the late nineteenth century. But by 1860 there was a steady expansion of the production possibilities year by year through the development of new production knowledge in the most advanced economies.

But the fact that modern economic growth comes from an increase in knowledge, rather than from capital accumulation, or from the exploitation of natural resources, seemed to imply that it would spread with great rapidity to all of the world. For while developing new knowledge is an arduous task, copying innovations is generally much easier. The new technologies of the early Industrial Revolution were not particularly sophisticated. They were quickly transmitted to other European countries despite the ban on exports of machinery and of artisans. Table 1 shows how long it took for discoveries originating in Britain before 1850 to reach other parts of Europe and other parts of the world. The increasing prosperity and economic power of Britain impressed both governments and individuals in foreign countries. There was thus a rapid response in terms of attempts to import the new British technologies. A series of Acts were passed in Britain in the eighteenth century restricting the export of both artisans and machinery, plans, or models in the textile and other industries. Only after 1825 were artisans free to take employment abroad, and only after 1842 was the export of machinery liberalized.[1] How much these legal prohibitions slowed the export of British technology is not known, but machines and workers did flow to other countries.[2]

[1] Henderson (1965), pp. 4, 139-41.
[2] It was estimated that by 1824 there were up to 1,400 British artisans in France alone. Ibid., p. 141f.

TABLE 1: TIME LAGS IN THE DIFFUSION OF INNOVATIONS

Country	*Newcomen Engine*	*Spinning Jenny*	*Water Frame*	*Mule*	*Power Loom*	*Watt Engine*	*Steam Railway*
Great Britain	**1712**	**1768**	**1769**	**1779**	**1800**	**1775**	**1825**
France	1726	1772	1779	1800	-	1778	1832
Belgium	1721	-	1801	1821	-	1791	1835
Netherlands	-	-	1785	1839	-	-	-
Germany	1722	1782	1783	1799	1842	1791	1835
Switzerland	-	-	-	-	-	1824	1847
Spain	-	-	-	-	-	1789	1848
Portugal	-	-	-	-	-	1803	-
Italy	-	-	-	-	-	1787	1839
Austria	1724	-	-	-	-	1817	1838
Hungary	1733	-	-	-	-	1803	-
Sweden	1728	-	-	-	-	-	-
Russia	-	-	-	-	-	1790	1838
U.S.A.	1755	1775	1789	1789	1811	1803	1830
Canada	-	-	-	-	-	1811	1836
Brazil	-	-	-	-	-	1810	1854
Argentina	-	-	-	-	-	-	1857
Mexico	-	-	-	-	-	1818	-
India	-	-	-	1817	-	1800	1853

Notes: The Table gives the date of the first use I found recorded of the machine. Its use earlier than this date is possible.

Sources: Henderson (1965), Jeremy (1981), Pollard (1981), Rolt and Allen (1977), Tann and Breckin (1978), Woodruff (1976).

In Table 1 the time taken to start steam railways is a good indicator of the time it took to notice an innovation in Britain in the Industrial Revolution period and organize the capital and expertise to export it. As can be seen even though the railway in its modern form was not fully developed until the Liverpool-Manchester line of 1830, adoption of railways was rapid in many countries. By 1840 ten countries had established rail lines of their own. India had completed a railway by 1853 even though it was one of the world's poorest countries. Thus the lag in actual diffusion of the technology is quite modest even in the early nineteenth century. Similarly if we look at the steam engine we again see modest lags.

Globalization of the World Economy

In the course of the late eighteenth and nineteenth century there were a series of technological, organizational and political developments that seemed to imply the integration of all countries into a new industrialized world.

The technological changes were the development of railways, steamships, and the telegraph. The organizational change was the development of specialized machine building firms in Britain and later the USA. The political changes were the extension of European colonial empires to large parts of Africa and Asia, and political developments within European countries.

Technology

In the course of the nineteenth century land transportation, even in the poorest countries, was revolutionized by the spread of railways. Table 2 shows the miles of railroad completed in selected countries by 1850, 1890, and 1910. The great expansion of the rail network in the late nineteenth century, even in very poor and underdeveloped countries such as Russia and India, improved communication immensely (remember the circumference of the earth is only 26,000 miles).

TABLE 2: RAILWAY MILEAGE COMPLETED

Year	*Britain*	*USA*	*Germany*	*France*	*Russia*	*India*
1850	6,088	9,021	3,639	1,811	311	0
1890	17,291	208,152	26,638	20,679	19,012	16,918
1910	19,999	351,767	38,034	25,156	41,373	32,789

Ocean transport was similarly revolutionized in this period by the development of the steamboat. In the 1830s and 1840s while steamships were faster and more punctual than sailing ships, they were used only for the most valuable and urgent cargo such as mail because of their very high coal consumption which limited the amount of cargo they could carry. To sail from Bombay to Aden in 1830 the *Hugh Lindsay* "had to fill its hold and cabins and pile its decks with coal, barely leaving enough room for the crew and the mail." (Headrick (1988), p. 24). The liner *Britannia* in the 1840s required 640 tons of coal to cross the Atlantic with 225 tons of cargo. Thus even in the 1850s steam power was used only for perishable cargoes, and on some routes.

But in the 1850s and 1860s four innovations lowered the cost of steam ocean transport:

1. Screw propeller.

2. Iron hulls (iron hulled boats were 30-40% lighter and gave 15% more cargo capacity for a given amount of steam power).

3. Compound Engines.

4. Surface condensers (previously steamboats had to use seawater to make steam which produced corrosion and fouling of the engine).

These last two innovations greatly reduced the coal consumption of engines per horse-power per hour. In the 1830s it took 4 kg to produce one hp-hour, but by 1881 it was down to 0.8 kg. This directly reduced costs but since it also allowed ships to carry less coal and more cargo there was a further reduction in costs. Real ocean freight fell by nearly 35% from 1870 to 1910.

The speed of travel to the East was enhanced by the opening of the Suez Canal in 1869. The canal saved 41% of the distance on the journey from London to Bombay and 32% of the distance on the journey from London to Shanghai. In 19—the Panama Canal had similarly dramatic effects on transportation between Europe and the West Coast of America.

The last of the important technical innovations in the late nineteenth century was the development of submarine cables for the telegraph. In the 1840s before the telegraph it took 5 to 8 months for a letter to go from Britain to India. Thus if an Indian firm bought British textile machinery and ran into problems with it, it would take then at best ten months to receive any return communication from the machine builders. In 1851 the first submarine telegraph cable was laid between France and England, and by 1866 a successful transatlantic telegraph service had been established. By 1865 India was linked to Britain by a telegraph system partly over land which could transmit messages in 24 hours.

These changes together made the world a much smaller place in the late nineteenth century than it had been earlier. Information could travel much faster. We know, for example, that the average time it took news to travel from Rome to Cairo in the first three centuries AD, when Egypt was a province of the Roman Empire, was about one mile per hour. As late as the early eighteenth century it had taken four days to send letters 200 miles within Britain. With the telegraph, rail, and steamship it was possible to send information across the world in much faster time. The steamship and railroad also made travel faster and much more reliable for people and goods. And the development of the steamship made the cost of reaching far-flung places quite low as long as they had good access to ocean navigation. The technological basis for the export of the Industrial Revolution technologies to almost any country in the world thus seemed to have been completed by the last quarter of the nineteenth century.

In 1906, for example, it cost 8 s. to carry a ton of cotton goods by rail the 30 miles from Manchester to Liverpool, but only 30 s. to ship those goods the 7250 miles from Liverpool to Bombay. By the late nineteenth century industrial locations with good water access which were on well established shipping routes – Bombay, Calcutta, Madras, Shanghai, Hong Kong – could get access to all the industrial inputs of Britain at costs not too much higher than many firms in Britain. In part this was because since Britain's exports were mainly manufactures with high value per unit volume there was excess shipping capacity on the leg out from Britain, making the transport of industrial machinery and parts to underdeveloped countries such as India relatively cheap.

Organizational Changes

In the early nineteenth century a specialized machine building sector developed within the Lancashire cotton industry. These machinery firms, some of which such as Platts were exporting at least 50% of their production as early as 1845-1870, had an important role in exporting textile technology. These capital goods firms were able to provide a complete "package" of services to prospective foreign entrants to the textile industry, which included technical information, machinery, construction expertise, and managers and skilled operatives. By 1913 the six largest machine producers employed over 30,000 workers (Bruland (1989), pp. 5, 6, 34). These firms reduced the risks to foreign entrepreneurs by such practices as giving them machines on a trail basis, and undertaking to supply skilled workers to train the local labor force.

Table 3 shows the number of orders for ring spinning frames Platt took (each order typically involved numbers of machines) for a sample of nine years in each of the periods 1890-1914, and 1915-1934. Indeed for ring frames England was a small share of Platt's market throughout these years.

Similar capital goods exporters developed in the rail sectors, and later in the U.S. in the boot and shoe industry. In the railways British construction crews completed railways in many foreign countries under the captainship of such flamboyant entrepreneurs as Lord Brassey. The reason again for the oversees exodus was in part the saturation of the rail market within Britain by the 1870s after the boom years of railway construction. By 1875 in a boom lasting just forty-five years 71% of all the railway line ever constructed in Britain was completed. Thereafter the major markets for British contractors and engine constructors were overseas. India, for example, got most of its railway equipment from Britain, and the Indian railway mileage by 1910 was significantly greater than that of Britain, as Table 2 above shows.

Table 4: Platt Ring Frame Orders by Country, 1890-1934

Country	Sales, 1890-1914 (9 years)	Sales, 1914-1936 (9 years)
Austria	4	0
Belgium	17	15
Brazil	95	43
Canada	15	17
China	5	64
Czechoslovakia	14	10
Egypt	0	5
England	110	74
Finland	1	0
France	41	31
Germany	47	6
Guatemala	1	1
Hungary	0	4
India	66	132
Italy	69	29
Japan	66	117
Mexico	75	7
Netherlands	7	2
Nicaragua	2	0
Peru	7	0
Poland	41	8
Portugal	8	0
Russia	131	23
Spain	95	35
Sweden	3	0
Switzerland	3	0
Turkey	0	6
USA	2	0
West Africa	0	2

Source: Platt Ring Frame Order Books, Lancashire Record Office.

Political Changes

A number of political developments should have sped the export of technology in the nineteenth century. The most important of these was the expansion of the European colonial territories. By 1900 the European powers controlled as colonies 35% of the land surface of the world, even excluding from this reckoning Asiatic Russia. Thus of a world area of 57.7 million square miles Europe itself constitutes only 3.8 m square miles, but by 1900 its dependencies covered 19.8 m square miles. The British empire was the largest covering 9.0 m square miles, the French had 4.6 m square miles, The Netherlands 2.0 m square miles, and Germany 1.2 m square miles.

Even many countries formally outside of the control of European powers were forced to cede trading privileges and special rights to Europeans. Thus China was forced in the course of the nineteenth century to cede various treaty ports such as Shanghai to the imperialists. The political control by countries such as Britain of so much of the world allowed entrepreneurs to export machinery and techniques to low wage areas with little risk of expropriation. Thus the great increase in the scope and effectiveness of British political power in the course of the nineteenth century made it easier to export capital from Britain to support new textile industries.

Most of the Indian subcontinent and of Burma was brought under British administrative control in 1858, and Egypt fell to Britain in 1882. In 1842 the British secured Hong Kong from China, and in 1858 a concession in Shanghai. These were all localities with very low wage rates and easy access to major sea routes. The joint effect of these technological and political developments was to create by 1900 an expanded British economy spanning the globe. British policy within its empire was to eliminate barriers to trade, and to allow economic activity to proceed wherever the market deemed most profitable. In India, for example, despite protests from local interests the British insisted on a free trade policy between Britain and India. Any manufacturer who set up a cotton mill in Bombay was assured that he or she would have access to the British market on the same terms as British mills.

The nature of British imperialism also ensured that no country was restrained from the development of industry up until 1917 by the absence of a local market of sufficient size. Because of the British policy of free trade pursued in the nineteenth century Britain itself and most British dependencies were open to imports with no tariff or else a low tariff for revenue purposes only. The large Indian market which took a large share of English textile production, for example, was open on the same terms to all foreign producers. There was a 3.5% revenue tariff on imports, but a countervailing tax was applied to local Indian mills at the insistence of Manchester manufacturers. The Chinese textile market, at the insistence of the Imperial powers was protected by a 5% ad valorem revenue tariff also.

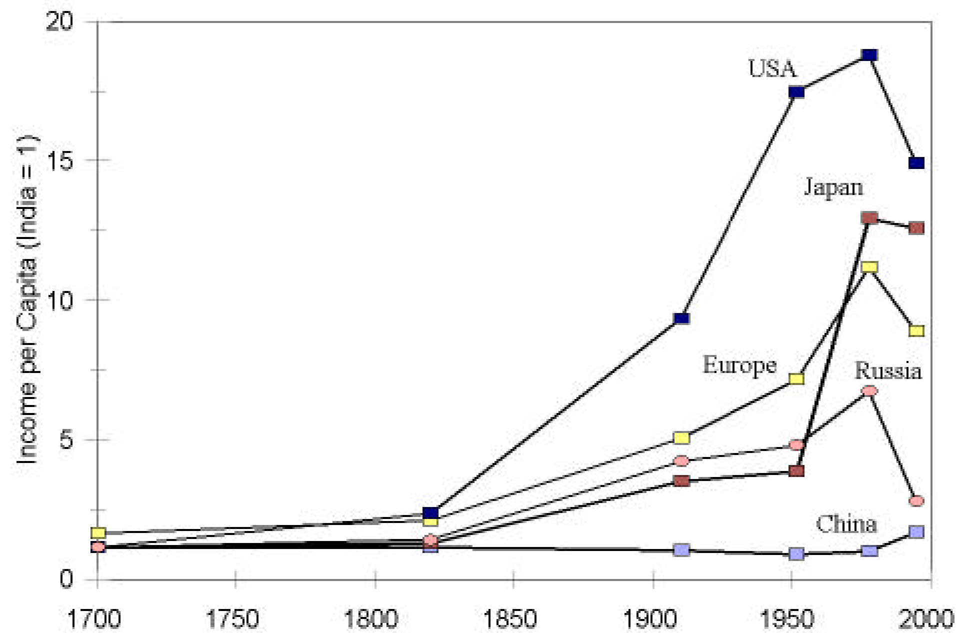
The Growth Record

We have seen why we should have expected rapid industrialization in the late nineteenth century, and a growth of all countries in the world economy. What actually happened?

The answer surprisingly is that the result of the Industrial Revolution was a big increase in the disparity in incomes per capita between countries which persists to the present day. Some countries began to catch up rapidly with Britain in terms of industrial output per capita and of income per capita by the late nineteenth century. Others showed no gains in income per capita compared to the pre-industrial world.

Thus figure 1 shows income per capita for a number of major countries or regions from 1700 to 1992, all measured relative to India. There is clear divergence in incomes per capita, at least up to 1978. There are signs in the figure of some convergence in the last period from 1978 to 1992. But this is in part because while in 1910 China and India were among the world's poorest economies, by the 1990s a number of countries in Africa had become much poorer than India. In 1910 India and China seem to have been the poorest countries in the world, and income per capita varied by a factor of about 9 to 1 around the world. By 1990 the income in some Sub-Saharan Africa countries was no higher than in India in 1910, and incomes per capita by then varied by a factor of about 30 to 1 around the world.

Figure 1: Incomes per Capita Relative to India



Sources: 1700, 1820, Maddison (1989), 1910, Prados de la Escosura (2000) and Maddison (1989), 1952, 1978 and 1992, Penn World Tables.

Table 4: Income per Capita, 1910 and 1990

Country	GDP per capita relative to India, 1910	GDP per capita relative to India, 1990	Calculated Efficiency (TFP), 1910 α=0.33, γ=0.1	Calculated Efficiency (TFP), 1990 α=0.33, γ=0
USA	9.4	14.3	3.9	4.4
Australia	9.2	11.4	2.9	3.5
Canada	9.1	13.6	3.6	3.8
Great Britain	8.0	10.5	4.4	3.8
New Zealand	7.9	8.9	3.1	-
Argentina	7.6	3.7	4.0	2.3
France	7.2	11.0	3.9	3.6
Germany	7.0	11.6	4.2	3.4
Sweden	6.0	11.7	3.6	3.3
Italy	4.9	9.9	3.1	3.8
Spain	4.8	7.6	2.8	3.4
Ireland	4.8	7.5	2.9	-
Finland	4.6	11.1	2.8	3.0
Russia	4.2	-	2.2	-
Portugal	3.7	5.9	2.5	2.8
Japan	3.5	11.3	2.8	2.7
Ottoman Empire	3.3	3.0	2.0	-
Philippines	2.4	1.3	1.8	-
Thailand	1.6	2.8	1.3	1.5
Korea	1.5	5.3	1.5	2.4
Indonesia	1.3	1.6	1.2	-
China	-	1.0	-	-
Zimbabwe	-	0.9	-	0.6
Zambia	-	0.5	-	0.7

Sources: Prados de la Escosura (2000). Penn World Tables (PWT 5.6)

Notes: Efficiency in the third column is computed assuming full capital mobility between countries, according to equation (5). Efficiency in the fourth column is computed using information on capital stocks.

The most notable case of success was the USA that seems to have surpassed Britain in terms of income per capita before 1880. By 1913 as table 5 shows industrial output per capita in the US exceeded that in the United Kingdom (= Britain plus Ireland). Thus by 1914 the USA was the richest economy in the world, and also the biggest economy, a position it has remained in until this day. Within Europe a small group of countries – Germany, Belgium, and Switzerland – drew close to British levels of industrial output per capita by the beginning of the First World War. These countries were all close to each other in Northwest Europe. Indeed if we were to look at industrial development in regional rather than national terms in 1913 we would see that it was largely confined to two major areas. The first was the North and Central USA in a belt running from New England to Wisconsin. The second was a band a couple of hundred miles wide which ran Southeast from Britain through Belgium, Northern France, Western Germany, Switzerland, and the North of Italy.

Outside of this core area of industrialization, large areas of the world, including Europe, remained largely devoted to peasant agriculture as they had been in the 18th century. Industrial output per capita in the South and East of Europe in 1913 was only about as high as in Britain in 1800, early in the Industrial Revolution. Thus one way of assessing these countries' development is to note that they lagged about 110 years in development behind Britain. These peripheral areas in Europe remained largely agricultural. While in 1913 the share of the population employed in agriculture in Britain was a mere 8%, in Romania it was 80%, and in Bulgaria 82%.

TABLE 5: INDUSTRIAL OUTPUT PER CAPITA, 1750, 1860, 1913

COUNTRY	***1750***	***1860***	***1913***	***share of population in primary industry 1913***
United Kingdom	**10**	**65**	**115**	**8**
Belgium	9	28	88	23
Germany	8	15	85	37
Spain	7	11	22	56
Russia	6	8	20	75
USA	4	21	126	-
China	8	4	3	-
India	7	3	2	80

Source: Bairoch.

Outside Europe the effects of the Industrial Revolution in Britain were even more slight in terms of the development of some huge areas such as India and China. Per capita industrial output actually declined in both India and China, as these countries moved into position of exporting raw materials (wheat, jute, indigo, and opium in the case of India) to pay for manufactured imports from Britain.

The result of the Industrial Revolution was thus an increased concentration of world economic output in a very small portion of the world. Two areas, the northwest of Europe along the Rhine river and the USA produced a very large share of world economic output by 1913. Within Europe the share of manufacturing capacity in 1913 was distributed as following:

United Kingdom	27%
Germany	32%
France	13%
Other	28%

Spain, Italy, Portugal, Austria-Hungary, Romania, Poland, and Russia together accounted for less than one quarter of all manufacturing capacity in Europe in 1913, despite having the bulk of the population.

Table 6 shows the effects of the technological advance in the late nineteenth century. It gives the shares of various regions in world populations and incomes in 1860 and 1913.

Table 6: World Population and Income Shares

	1860		1913	
	Population	***GNP***	***Population***	***GNP***
Northwest Europe	11%	29%	11%	28%
North America, Oceania	3	15	7	34
"European"	14	46	18	63
Southeast Asia, China	62	32	53	15

India is a nice example of this pattern of income divergence after the Industrial Revolution. The output per capita in India relative to Britain and the USA was:

	India/Britain	*India/USA*
1860	0.21	0.25
1913	0.15	0.11
1937	0.15	-
1992	0.10	0.07

There is thus no sign of any tendency of India in this long period to narrow the gap between itself and economically advanced countries such as the USA. As late as 1931, 150 years after the factory was introduced in Britain, less than 1% of Indian workers were employed in modern factory industries.

The dominance of Britain and its free trade ideology in much of the world circa 1910 meant that trade barriers were low for the countries with the majority of world population in 1910 – India (including modern Pakistan, Bangladesh and Burma), China, Britain, Ireland, Egypt, Nigeria, South Africa. However, the trade patterns for the factors of production within this relatively open world market were often not what we might expect. In particular, the densely populated countries of the East – India, China and Egypt (counting the cultivable land) seem to have been net exporters of land, and net importers of labor. Table 7, for example, shows British India's commodity trade in 1912. The only manufactured good that India exported any quantity of was jute sacking. In the case of cotton the raw material content of India's exports of raw cotton about equaled in value the raw material value

Table 7: The Commodity Trade of British India, 1912-13

Commodity	Imports $ m.	Exports $ m.	Net Exports $ m.
Grain, pulse and flour	0.42	195.64	195.21
Jute, raw	0.00	87.76	87.76
Cotton-raw	7.21	91.20	83.99
Seeds	0.00	73.68	73.68
Hides and Skins	0.71	53.11	52.40
Tea	0.23	43.13	42.90
Opium	0.00	36.41	36.41
Oils	16.94	2.78	-14.15
Sugar	46.33	0.00	-46.33
Other raw materials	34.20	64.79	30.58
All Raw Materials	**106.04**	**648.50**	**542.46**
Cotton-piece goods	195.73	39.58	-156.15
Metals	50.30	3.48	-46.81
Railway plant	20.77	0.00	-20.77
Hardware	17.57	0.00	-17.57
Jute-piece goods	0.00	74.20	74.20
Other Manufactures	108.88	5.99	-102.90
All Manufactures	**393.25**	**123.26**	**-270.00**

Source: United States, Department of Commerce (1915), Bureau of Foreign and Domestic Commerce, Special Consular Reports, No. 72, British India (Washington: Government Printing Office, 1915).

of India's imports. Thus India effectively exported its raw cotton to Britain to be manufactured there, paying for this with the export of other raw materials. The effective net raw material export of India in 1912 was about $460 million. With Indian GDP measured in US prices at about $11.5 b. this implies that exports of raw materials were about 4% of Indian GDP. Why was densely populated India poor and agricultural in 1912, as opposed to being poor and industrial?

The Cause of the Great Divergence – Diverging Efficiencies

Economists have struggled largely without success to understand why the onset of modern economic growth has been associated with an increasing disparity in incomes per person across countries.

Recent research by Pomeranz and others suggests that in 1800 differences in income per capita were modest around the world. In part this result is unsurprising once you understand how income was determined in the Malthusian era. In a Malthusian world of slow technological advance living standards themselves reveal nothing about an economy's level of technology, or its direction. Thus, the Europeans who visited Tahiti in the eighteenth century were astonished by two things (in addition to the Islands' sexual mores) – the stone-age technology of the inhabitants, who so prized iron that they would trade a pig for one nail, and the ease and abundance in which they were living. But that abundance was purchased by a high rate of infanticide that ensured a small number of surviving children per couple and consequently good material conditions. Tahiti was not a candidate for an Industrial Revolution, no matter how well fed its inhabitants.

The claim for the sophistication of Chinese and Japanese technology in the eighteenth century lies more properly with their ability to maintain more people per square mile at a high living standard than any European economy could. The low level of Tahitian technology in the late eighteenth century is evident in Tahiti's capacity to support only 14 people per square mile as opposed to England's 166.[3] Japan was supporting about 226 people per square mile from 1721 to 1846, and the coastal regions of China also attained even higher population densities: in 1787 Jiangsu had an incredible 875 people per square mile. It may be

3 These population figures for Tahiti come from the years 1800 to 1820 when there may already have been some population losses from contact with Europeans. See Oliver (1974).

objected that these densities were based on paddy rice cultivation, an option not open to most of Europe. But even in the wheat regions of Shantung and Hopei, Chinese population densities in 1787 were more than double those of England and France. China had pushed pre-industrial organic technology much further by 1800 than anywhere in Europe. The West was clearly behind.

So in the world before 1860 differences in technological capacities largely showed up as differences in population densities. The arrival of the Industrial Revolution in some ways just made manifest the enormous differences in capabilities that have always existed between societies.

Why did income per capita decline in poor countries such as India and China relative to the advanced economies such as the US since 1800? In this chapter I argue that the overwhelmingly cause was a decline in the relative efficiency of **utilization of technology** in these countries relative to the more successful economies such as Britain and the USA. Conventional estimates report that about one third of the difference in incomes per capita between countries comes from capital (conventionally measured), and the rest from efficiency (TFP) differences.[4] But this assumes that differences in capital per worker across countries, which are very highly correlated with differences in income per capita and measured efficiency since World War II, were exogenous. In a world where capital can flow between economies capital/worker should be regarded as an endogenous variable, and would itself *respond to* differences in the country productivity levels.

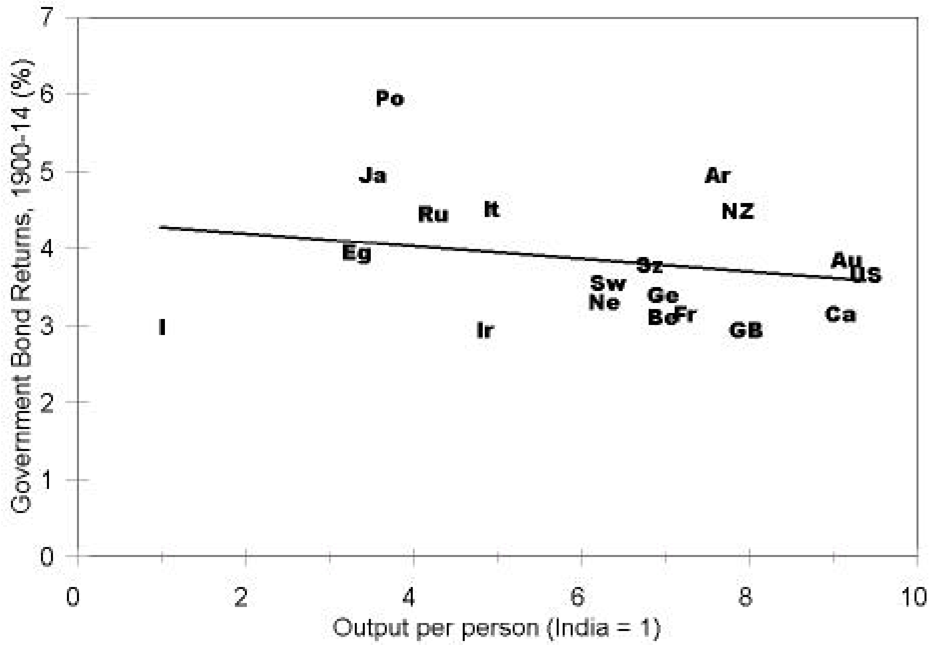
There is plenty of evidence that by the late nineteenth century transport and communications had advanced to the extent that we can regard capital as flowing freely around the world. Figure 2, for example, shows rates of return on government bonds in nineteen countries at a variety of income levels in 1900-14 as a function of the relative level of output per capita in each country in 1910. There was variation in the rates of return on these various government bonds in the range of about two to one. But importantly this variation had little correlation with the income level of the country. Indeed if we regress government bond rates in 1900-14 on output per capita though the slope coefficient is negative it is statistically insignificantly different from 0. Rates of return on government bonds seem uncorrelated with income.

We can also get rates of return on private borrowing by looking at returns on railway debentures. Railways were the biggest private borrowers in the international capital markets in the late

[4]See, for example, Easterly and Levine (2000).

nineteenth century. And their capital needs were so great that if they were able to borrow at international rates of return it would help equalize rates of return across all assets in domestic capital markets. Table 8 shows the realized rates of return earned by investors in railway debentures in the London capital market between 1870 and 1913. Again there are variations across countries. But importantly for our purposes this variation shows no correlation with output per person. Indeed India, one of the poorest economies in the world had among the lowest railway interest costs because the Indian Government guaranteed the bonds of the railways as a way of promoting infrastructure investment.

Figure 2: Government Bond Returns, 1900-14



Notes: Output per person is measured as an index with India set equal to 1. For the US Municipal Bonds yields were used. Egyptian income per person was assumed the same as the Ottoman Empire. Irish returns were assumed the same as British returns. Indian and New Zealand returns are from 1870-1913. The symbols used are: Au, Australia, Ar, Argentina, Be, Belgium, Ca, Canada, Eg, Egypt, Fr, France, Ge, Germany, GB, Great Britain, Ir, Ireland, It, Italy, Ja, Japan, Ne, Netherlands, NZ, New Zealand, Po, Portugal, Ru, Russia, Sw, Sweden, Sz, Switzerland, US, United States of America.

Souces: Table 1. Edelstein (1982) - India, New Zealand. Homer and Sylla (1996) – Britain, Ireland, USA, France, Germany, Belgium, Netherlands, Canada, Italy, Switzerland. Mauro, Sussman and Yafeh (2001) – Argentina, Egypt, Japan, Russia, Sweden, Portugal, Australia (sterling bonds in London).

Table 8: Rates of Return on Railway Debentures, 1870-1913

Country or Region	Relative Output per Capita (India = 1)	Rate of Return (%)
USA	9.4	6.03
Canada	9.1	4.99
United Kingdom	7.9	3.74
Argentina	7.6	5.13
Brazil	-	5.10
Western Europe	6.1	5.28
Eastern Europe	4.1	5.33
British India	1.0	3.65

Source: Table 1. Edelstein (1982), p. 125.

World capital markets were so well integrated by 1914 for three reasons: the huge overseas investments of the British, the British Empire, and the popularity of the gold standard. The British by 1910 had overseas investments that amounted to about twice their Gross Domestic Product (GDP). This implied that about one third of the capital owned by British investors was invested abroad. The existence of this huge pool of investment seeking a home overseas helped make London the pre-eminent world financial center before 1914. But it also helped lubricate the market by creating a center where investors and borrowers could gather, and where information about opportunities could be aggregated. The British Empire aided the export of capital from all the advanced economies to the poorer ones by giving investors security through the guarantee offered by imperial laws and protections. Finally the pegging of many currencies to gold in the late nineteenth century removed a lot of the currency risk from investing abroad, since the relative value of many currencies remained unchanged for 30 or 40 years prior to 1914.

The numbers in table 8 show just how the market valued these investments in London. We can also ask if the real rate of return on capital (rather than this financial rate of return) might not be much higher in countries like India. This can be calculated by looking at the profits of firms located in various parts of the world compared to the book value of their capital (the cost of their initial investment). Here we find for 1870 to 1913 for British companies investing at home, in the Empire, and in other foreign countries:

Britain	10.7%
British Empire	12.9%
Foreign	10.7%

The similarity in rates of return suggests that whatever was slowing down the rate of industrialization in poor countries it was not a lack of capital – for capital invested abroad seems to earn no more than capital invested at home in the case of British investors. This is what we would expect if capital markets functioned reasonably well.

The one case we can find where capital markets seem to have functioned very badly is the USA. Here rates of return throughout the nineteenth century were much higher in the west than in the older settled east. In the 1850s, for example, as the central valley of California was being settled mortgage loans were at the rate of 50% per year at a time when mortgages in Boston were at 6%. Rates fell rapidly in California but in the 1890s interest rates on the west coast were still 4-5% above those in the Northeast. The reason for these disparities seems to have been legal limitations on the development of interstate banking which made it difficult for capital to flow from one market to another. Yet despite the persistently high cost of capital the West developed rapidly in the late nineteenth century.

This rough equalization of returns to poor and rich countries was achieved by significant capital flows into these countries. By 1914 Egypt, the Ottoman Empire, Argentina, Brazil, Mexico and Peru had all attracted at least £10 per head of foreign investment (Pamuk (1987)).

In a world of rapid capital mobility, how should we calculate the relative efficiency of different economies?

Suppose as an approximation that output depends on capital, labor and land in the way shown below (in technical terms this is called a Cobb-Douglas production function) so that:

$$Q_i = A_i K_i^{\alpha} L_i^{ß} T_i^{?} \qquad (1)$$

where T_i denotes land and A_i the efficiency (TFP) of country i. Choose units so that A_i, K_i, Y_i and T_i are 1 in India. Taking capital stocks as exogenous the income per capita of other economies relative to India would be:

$$(Q_i/L_i) = A_i(K_i/L_i)^{\alpha} (T_i/L_i)^{?} \qquad (2)$$

The rental on capital is given by:

Assuming that this is everywhere the same we can set it equal to 1. In that case capital per worker in country i relative to India, would be

$$(K_i/L_i) = A_i^{1/(1-\alpha)} (T_i/L_i)^{?/(1-\alpha)} \qquad (3)$$

The amount of capital employed would thus depend on the level of efficiency of the economy. The more efficient an economy the more capital it would attract, which would have a second round effect in increasing income per person. Substituting (3) into (2), we obtain the following expression for output per capita:

$$(Q_i/L_i) = (A_i)^{1/(1-\alpha)} (T_i/L_i)^{?/(1-\alpha)} \qquad (4)$$

Notice that the right-hand side of (3) and (4) are identical, so that capital/worker and output/worker are equal with capital endogenous and rates of return equalized across countries. It follows from (4) that we can calculate relative efficiencies in the world economy circa 1910 as,

$$A_i = (Q_i/L_i)^{(1-\alpha)} (T_i/L_i)^{-?} \qquad (5)$$

Thus, in this case we can calculate the relative efficiency for each country relative to India from just the relative outputs per capita and the relative amount of land per person. Since the share of land in national income, ?, has become very small in recent years (5) suggests that the sole significant cause of differences in income per capita between India and the USA and other advanced economies since the Industrial Revolution has been differences in efficiency.

The assumption here that capital will be proportional to output finds support in the international economy of the 1990s. Using a sample of countries including those in Table 4 for 1990, figure 3 shows capita per worker versus GDP per worker, with both measured relative to India. Recall from (3) and (4) these should be equal with full capital mobility. From the figure, capital is clearly closely proportional to output. Regressing the log of capital per worker on the log of GDP per capita on all countries for which capital stock measures are available for 1990, we find:

$$\text{Ln(Capital/worker)} = -0.01 + 1.32 \ln(\text{GDP/worker}),$$

$$N=60,\ R^2=0.85.$$

The coefficient on ln(GDP/worker) is somewhat higher that unity, but still seems consistent with the hypothesis that capital is roughly proportionate to output, as implied by full capital mobility with Cobb-Douglas production functions across countries.

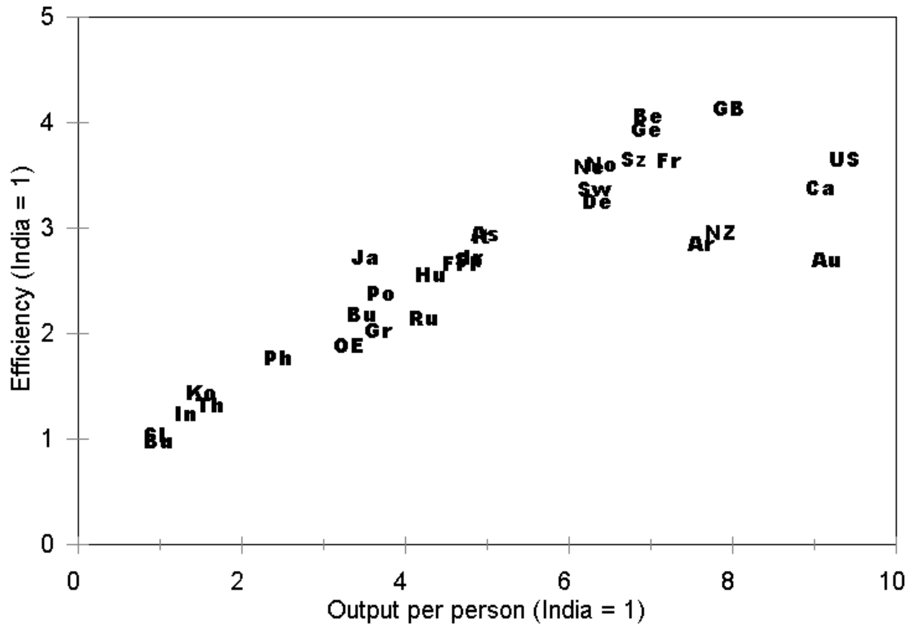
Figure 3: Capital per Worker versus GDP per worker, 1990

Source: Penn World Tables (5.6).

For 1910 we do not have reliable estimates of capital stocks. Column (3) of table 1 and figure 4 shows the implied efficiency of the various countries in the world in 1910 for which we have data, relative to India, assuming the share of capital in national income was 0.33 and that of land was 0.1. Differences in the land endowment per person were great enough that even assuming land had only a 10% share in output we seem to be overcorrecting for the effect of land on income per capita. Thus there is no reason to believe that the efficiency of the US, Canadian or Australian economies was really below that of Great Britain in 1910. What we also see that in a world of free flowing capital modest differences in the efficiencies of economies get translated into much bigger differences in income through generation of additional savings by higher income and the movement of capital to the high efficiency areas.

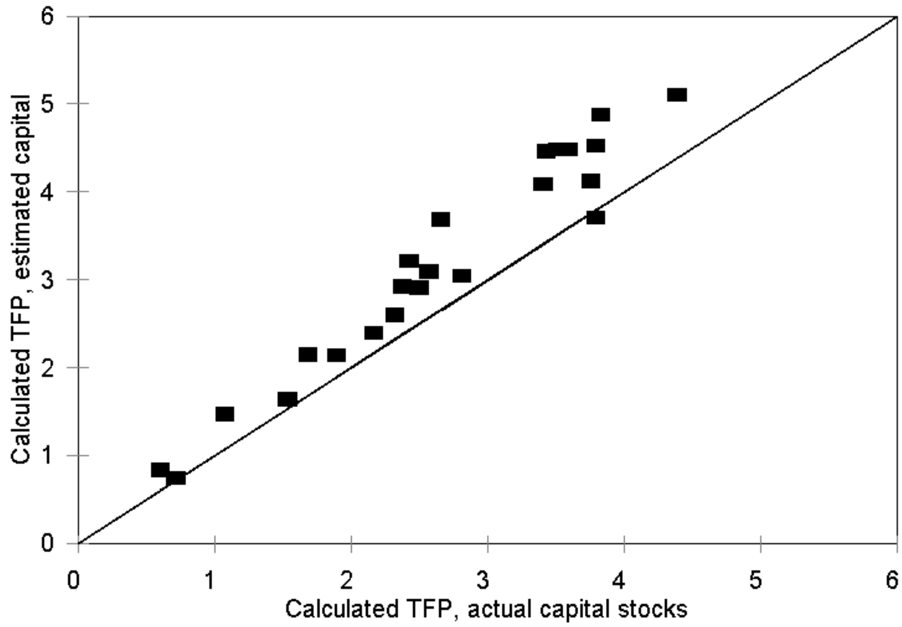
For 1990 we do have estimates of the actual capital stock of economies. Here we can estimate efficiency levels using the actual capital stocks, or using the assumption of perfect capital mobility. It turns out that it does not matter much which assumption we use. Figure 5 shows relative efficiencies calculated in each way. They are clearly highly correlated. Thus by 1990 it seems plausible to regard efficiency as the primary driver of differences in income per capita across countries, with capital playing a secondary and derivative role.

Figure 4: Calculated Differences in Efficiency (TFP) circa 1910



Note: Output per person is measured as an index with India set equal to 1. Efficiency is measured as an index with India again set to 1. The country symbols are A, Austria, Au, Australia, Ar, Argentina, Be, Belgium, Bu, Burma, Ca, Canada, Cy, Cyprus, De, Denmark, Fi, Finland, Fr, France, Ge, Germany, GB, Great Britain, Gr, Greece, Hu, Hungary, In, Indonesia, Ir, Ireland, It, Italy, Ja, Japan, Ko, Korea, Ne, Netherlands, NZ, New Zealand, OE, Ottoman Empire, Ph, Phillippines, Po, Portugal, Ru, Russia, SL, Shri Lanka, Sp, Spain, Sw, Sweden, Sz, Switzerland, Th, Thailand, US, United States of America.

Figure 7: Efficiency Calculated with and without Capital Stock Information, 1990



Note: Efficiency is calculated using $\alpha = 0.33$.

Why does efficiency differ?

Here there are just two possibilities. Poorer countries were unable to get access to the new Industrial Revolution technologies produced by countries such as Britain or later the USA, or they were unable to utilize these effectively.

Were investors in poor countries slow to adopt the new technology of the Industrial Revolution because of institutional barriers? Such barriers would include insecure property rights, import and export controls for goods and technology, and outright bans on "western" technology exports or imports.

We can certainly find cases of economies with completely dysfunctional institutions. Consider the case of Zaire since independence from Belgium in 1960. A civil war was followed by the rule of Mobuto Tsese-Tseko for 32 years from 1965 until 1997. Since Mobuto was overthrown and exiled Zaire has seen constant turmoil, with some of the country occupied by foreign armies, the president who succeeded Mobuto (Laurent-Desire Kabila) assassinated by one of his own presidential guard, and replaced by his son.

Corruption and official theft was so rampant under the rule of Mobuto that it has been referred to as a "Kleptocracy." As a result since gaining independence from Belgium Zaire has seen its infrastructure crumble. Many towns have lost their road links to other parts of the country because there was no public money to repair the roads. The police and army mainly earn their salaries by coercing the public for money on fictitious charges, or by letting real criminals loose in return for bribes. Any business requires special licenses and dispensations, so that any profitable enterprise is liable to have its profits confiscated on one excuse of another. The situation of the infrastructure is so dire that it pays to fly potatoes into Kinshasa, the capital, from outlying towns, rather than try to move them by road. Vehicles trying to take produce to market have to carry two or three extra workers to push them out of the huge potholes. Yet if all these mobile road crews were employed by the government the roads could be repaired. The breakdown of the infrastructure means that farmers outside the towns cannot market their produce and so engage only in subsistence agriculture.[5] It is not hard to understand why Zaire fails to attract modern technology.

Mexico from 1821 to 1876 is another example of an economy that seems to experience institutional failure. In this period there

[5] A good recent book on Zaire is title West Along the Equator.

was great political instability, with 75 governments in the course of 55 years. Property rights were very ill defined. There was no patent law, and no limited liability corporations. Economic activity of any kind required special licenses and dispensations. But the constant political turmoil meant that these were of little lasting worth. Legal decisions were heavily influenced by bribes, by political pressures, and by ties of kinship. Thus any modern enterprise entering the market could find itself held hostage. As in modern Zaire the infrastructure was in disrepair. It was very hard to reach many provinces from Mexico City because of bad roads and bandits on the roads. Provincial governors often had little incentive to improve the situation because the poor communications gave them much greater power. From 1800 to 1860 the income per capita in Mexico slipped from 40% of that in Britain to 13%.

But such examples of dramatic institutional failure are the exception rather than the rule. In the case of India the political and legal framework was very stable after 1857 as shows up in the rates of return on capital. For the British administrators took their guidance on economic matters from the British Classical tradition of Smith, Recardo, and Mill. They ensured stable and well-defined property rights, tried to collect revenue in a way that would be least distortionary to the economy, and eliminated most tariff barriers by the 1880s. They neither promoted or hindered the growth of modern industry, since how could government officials know better than the market where India's comparative advantage lay?[6] Yet under the guidance of these model bureaucrats, schooled in Mill's **Political Economy**, and later in Marshall's **Economics of Industry**, India manifestly failed to develop (Misra (1977), pp. 199-200).

Many European countries such as Russia, Spain, and Italy which had little industrial development before 1914 also did not manifest great institutional instability. They sometimes differed in their choice of economic institutions from Britain or the USA which were largely laissez-faire until 1914. Russia, for example, allowed legally binding cartels. In the rolling stock industry, for example, 97% of production capacity was controlled by one such syndicate in 1907. Such legal cartel agreements are heavily disapproved in the economic tradition of Britain and America. It is argued that such monopolization leads to high prices (which reduces output below what is socially optimal), but also and more

[6] There was "almost unanimous opinion in favor of non-intervention except in the area of provision of public works" (Ambirajan (1978), p. 219).

importantly it keeps out new entrants to the industry who will force the adoption of new, more efficient techniques.

Yet we find that Russia was here just following the model of Belgium and Germany who both allowed legally binding cartels, and yet who both had rapid growth of industry in the late nineteenth century. Thus there is little evidence that the institutional structure played much role for most of the poorer countries in Europe or the colonized Third World countries.

Were investors in poor countries unable to utilize new technologies profitably because of differences between there markets and the markets of the countries where the technology was generated? One popular idea has been the efficiency of production increases with the scale of the market. Consequently low income regions are unable to produce at the same level of efficiency as high income countries because they face a much smaller market for any output. This in turn keeps incomes low and perpetuates the vicious circle. Thus

poverty Þ **small demands in any market**
Þ **inefficient production**
Þ **poverty**

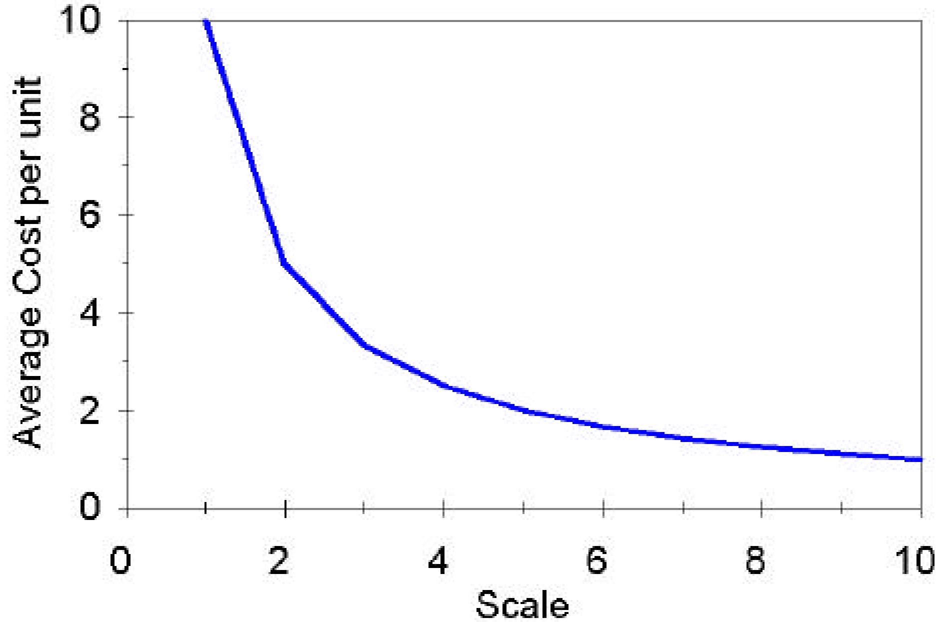
Thus Stephen Haber writing of Mexico's development in the late nineteenth century notes:

> One of the requisites of large-scale industrialization is a market that can absorb the vast quantities that a modern manufacturing plant is capable of producing. Modern capitalism requires not only highly efficient production, but also a well-developed consumer market. The two are inseparable (Haber (1989), p. 27).

The key notion is that the average cost of production declines with the scale of output. This is shown in figure 5. Regions with a large market have demand curves which are far from the origin in the figure. Regions with a limited market demand have demand curves close to the origin. If there are competitive producers in the market then the profits will be zero and p = ac.[7] Thus the average cost of production will be much greater in the small market than in the larger.

[7] A technique with increasing returns to scale can still be one with a competitive market if the benefits of larger scale accrue to all firms in the market. That is, the benefits must be external to the individual firm.

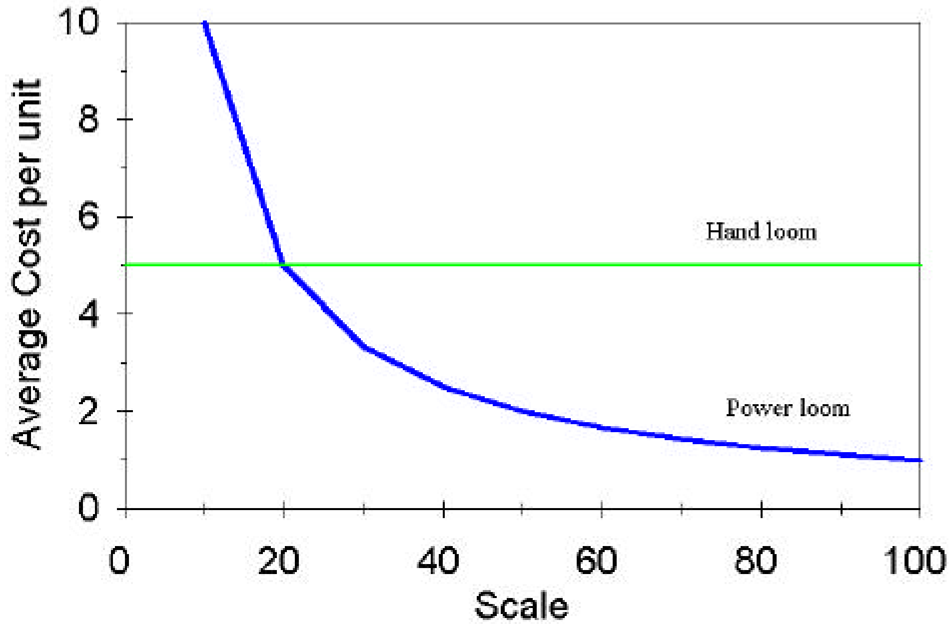
Figure 5: Average Costs With Increasing Returns to Scale



The average cost can decline for a number of reasons. Adam Smith identified one in 1776 in The Wealth of Nations summarized by his famous statement "The division of labor is limited by the extent of the market." This is the idea that if the market demand is very small then producers cannot divide up the production process into a number of stages but must do each of them themselves. Thus when factories were introduced cotton was made into cloth in something like 12 discrete steps. But if the market is very small then each producer has to do all the steps themselves because dividing the work into these twelve steps would involve perhaps a work force of 200 people each cotton mill (the different stages require different numbers of people). But in this case the producer has to use only methods which involve a small amount of mechanization or else most of the machinery will lie idle most of the time. Further normally the different steps in production require different amounts of skill. The large scale producer is able to assign low paid unskilled workers to the least skilled tasks, and save high skilled workers for the high skill jobs thus saving on wage costs. But with one producer doing everything they have to be skilled enough to complete all the tasks thus driving up costs. Since in actual practice in the textile industry the most skilled jobs were paid at as much as 4 times the rate of the least skilled the increase in costs from not being able to specialize was thus considerable.

Another reason average costs can decline with scale is that there are a number of techniques available where some have a low fixed cost but a high marginal cost and others have a high fixed cost but a low marginal cost. Thus cloth in 1850 could be produced by both handlooms and power looms. Handlooms which had a low fixed cost produced small amount of output per worker, so that the marginal cost of producing cloth, which was mainly the labor cost was high. Power looms had a much higher fixed cost, in part since to be economically operated they needed to be run in units of at least 50 looms, but they produced about 8 times the output per worker. Thus they had a much lower marginal cost. The average cost functions for each technique are shown in figure 6.

Figure 6: Costs for Hand and Machine Weaving Techniques



On this argument the industrialization of poorer countries after 1850 was delayed by their poverty. If they adopted the new technologies of the industrial revolution then they would be forced to operate the plants at less than capacity because of the small size of the local market. Again Haber notes of Mexico in the late nineteenth century,

> the imported technology was inappropriate to the shallow and limited Mexican market. It had been designed to meet the needs of the mass production/mass consumption economies of the United States and Europe. Engineered for large-batch production, it was far too big for the Mexican market. In order to industrialize rapidly, Mexico was therefore forced to combine the production apparatus of a mass consumption economy with a market incapable of absorbing the quantity of goods that plant could produce. The result was a severe problem of excess installed capacity (Haber (1989), p. 31).

As an example he cites the case of the cement industry. Between 1906 and 1911 Mexican cement plants worked at on average only 43% capacity. The reason was that each plant could only sell to consumers in a range of about 150 miles from the plant, because of heavy transport costs. Thus the limited market meant that each plant was never fully utilized, driving up average costs.

Now the problem of market demand in poor countries could be solved in one way, which was to sell to the export market. If poor countries had access to the world market then their demand curves would not be any different from those of the developed countries. In the cases of goods as heavy in relation to their value as cement this would perhaps not be feasible, but there is a large range of goods where transport costs are not so high relative to the value of the goods – yarn and cloth, and boots and shoes, for example. And I stressed above that technological changes which reduced the cost of ocean shipping had made any location on the ocean or with water access to the ocean able to participate in world markets with little transport barrier.

Haber argues in the case of Mexico that exporting manufactured goods was too costly around 1900 for a number of reasons

(1) Mexico had no direct shipping connection with many of the potential markets for its products. The shipping routes to Mexico all ran directly to the USA or Europe. These were the markets with the fiercest competition. The markets with more potential were in other underdeveloped countries in Latin America. But

there were no direct connections between Mexico and any major South American port. Thus when Mexico sent a trade mission to Brazil in 1903 they had to go there via the USA and England. This created a transport cost barrier between Mexico and many foreign markets.

(2) The population of Mexico was concentrated in the mountainous interior. To export goods required an expensive rail journey to the ports. Because of limited demand freight rates on Mexican railroads were high. Thus the port city of Tampico, on the East coast of Mexico, got its cement from England, shipped via the port of Liverpool, a distance of over 5,000 miles. This was because it was more expensive to ship it a few hundred miles by rail from a producer in the interior of Mexico.

(3) There was fierce competition in world markets from established producers in the USA and Europe.

(4) US and European exporters could provide long term credit to customers because of their extensive and well developed financial systems. These producers often accepted raw materials instead of cash as payment for goods when selling to countries outside Europe.

(5) The simple manufactured goods that early Mexican industry was producing – textiles, boots and shoes, and beer for example – were the same ones that many other developing countries were also attempting to produce. Thus the market in many countries such as Brazil and Cuba was already supplied with these goods. To protect their infant industries these countries also often erected protective tariffs.

A fact finding trip in 1902-3 to explore the potential of export markets in Brazil, Uruguay, Argentina, Chile, Peru and Central America underwritten by the Mexican Government concluded for the above reasons that there was no potential market for any Mexican industry in any of the above countries, and indeed terminated the trip early without bothering to visit Central American countries. Mexican industry was thus confined to the small home market as late as 1902, with all the costs that implied.

Does this account prove that Mexican industrialization was impeded by problems of increasing returns to sale? The face that the port of Tampico could import a product as heavy as cement from Britain reinforces the point made above that by the late nineteenth century ocean transportation was cheap. The problem in Mexico was that the population was concentrated in the mountainous interior with no water access to the coast, and the railways were inefficient and costly. This was a problem that was in some ways peculiar to Mexico. Most other countries did not have to rely on road and rail transport to anything like the same extent. This shows up when people have calculated to gains to different economies from introducing the railroad in the nineteenth century, a calculation that had been done for the USA, Mexico, England, and Russia. Mexico is the country which was estimated to have benefited much more than any of the others from the introduction of the railroad because in the other cases water transport provided a cheap alternative. Thus in many ways Mexico was an untypical underdeveloped country in 1900.

But if places like Tampico were able to participate in the world market why were Mexican investors not erecting cotton mills there and exporting to the largest unprotected export market in the world at that time, the United Kingdom? The answer Haber falls back on is that Mexican products were only potentially competitive in the markets of other undeveloped economies such as Brazil, not in Britain. But Mexico had much lower labor costs than in Britain, so why would that be the case?

Lesson from the Cotton Mills

We see above that the conventional explanations of the failure of countries such as India to industrialize quickly in the wake of the Industrial revolution in Britain do not work very well. The puzzle of the lack of industrialization is made more acute if we look at one industry in detail, cotton textiles.

As noted in Chapter 2, the Industrial Revolution in Britain had as its centerpiece a revolution in the cotton textile industry, with the adoption of the factory system of production and its associated new machinery. The textile industry was revolutionary in that output per unit of inputs rose rapidly from 1770 onwards. But it was also revolutionary in its ability to employ, with minimal supervision, large numbers of unskilled and uneducated workers. The replacement of skilled lifetime workers by cheaper types of labor did not occur at once, and was not completely possible until the development of the ring spindle in the late nineteenth century. But all through the nineteenth century adult males, traditionally the most expensive and intractable form of labor, were less than 30% of cotton textile operatives even in Britain where skill-intensive mule spinning predominated (Deane and Cole (1962), 190). By the late 1930s for example, when the Japanese cotton spinning industry had labor productivity levels not much below that of Britain, the labor force in Japan was 88.5% female, the average age of female cotton operatives was 17.0 years, and the average length of service was 2.33 years.[8]

The ability of the textile industry to keep both operative skills and education and the need for supervision to a minimum is well illustrated by ring spinning. This was a new spinning technique developed in the nineteenth century which was successful in part because it minimized the skill demands on workers. Since then the tasks in ring spinning have consisted of all or some of the following five tasks:

1. Piecing. This consists of twisting together the broken pieces of thread or roving when a break occurs in the spinning process.

2. Creeling. This is when the spinner replaces the bobbins supplying the roving to the spindle when they have been depleted or are about to be depleted.

3. Cleaning. This consists of wiping away tufts of loose cotton fibers which accumulate on the spinning frames.

4. Doffing. This is when operatives remove the full bobbins of spun yarn and replaces them with empty bobbins. This is normally done at regular intervals by specialized squads of doffers.

5. Patrolling. Walking around the machines inspecting for spindles in need of operations 1 to 3.

There are also a variety of ancillary tasks such as oiling the machines and sweeping the floor which are done by specialist ancillary workers at regular intervals.

The organization of the work is very simple. Each spinner ("piecer" in India) is assigned a set of spindles. During work hours the spinner walks around the set of spindles on the same path. Each spindle is inspected to see if it needs piecing, creeling or cleaning. If so the task is performed. Thus spinners do not need to be literate. Nor do they need any special strength or dexterity. Nor do they need to plan ahead. They merely proceed from spindle to spindle doing whichever of the three tasks is necessary.

8 Shindo (1961), 233-6.

The tasks in carding, opening, drawing, and roving – the precursors to the actual spinning – had exactly the same character. In the earlier tasks there was more creeling and doffing and less repairing of end breaks. It was just for these reasons that the textile industry was hailed by some, and reviled by others, as the precursor of a new industrial order where work would be machine regulated and machine paced.

The technological advances in the textile industries in Britain, with the associated fall in manufacturing costs, created a vast overseas market for British textile products. Circa 1820 the British cotton industry exported about 50% of its output. By 1900 output had increased 10 fold in physical terms, and exports were almost 80% of production. The woolen industry which grew 5 fold in the same period exported about 30% of its production (Deane and Cole (1962), 187, 196). British exports throughout this period were nevertheless severely constrained by import barriers in most potential overseas markets. For example, Britain was selling some cotton cloth to Mexico in the late nineteenth century despite tariffs of 133% ad valorem.[9]

Since operative skills were relatively unimportant in the industry, and since money wages in Britain were already by 1770 among the highest in the world the constant worry of the textile industry was that it would lose its vital export markets to low wage competitors. Initially, as we saw, Britain tried to maintain a competitive advantage by preventing the exports of textile machinery and skilled textile mechanics. But this ban was widely evaded, so that by 1846 both these controls were repealed.[10] So it seemed that by the late nineteenth century Britain would soon lose its advantages in textile production. As Farnie comments,

> The successful establishment of such (spinning) mills was facilitated by the simplicity of spinning technology, by the recruitment of unskilled labor to master an art no more difficult than that of hand sewing, by the small scale of economic operation, and by the limited need for managerial expertise, especially in the spinning of course yarn. Their creation was also facilitated by the absence of any 'humane restrictions' on the hours of labour, by

9 "Ad Valorem" means the tariff was calculated as a percentage of the value of the import.

10 In part this repeal came because of the growing importance of the textile machinery industry in Britain. British textile machinery was as competitive in foreign markets as British textile products, and the machine makers wanted access to this large market.

> removal of restrictions on the export of machinery from England, by the interest acquired in the export market by the textile engineers of Lancashire,..., and by the services of English foremen and managers as teachers (Farnie (1979), p. 178).

A contemporary writer on the cotton industry similarly noted that:

> (In the cost of labor) India enjoys a great advantage over England, for the advantage which England possessed in regard to skilled labor most certainly does not apply as in former years ... with the marvelously perfect and self-acting machinery of today no special skill is required on the part of the attendant. The machinery itself supplies the intelligence; all that is required from the workman is attention in "following up" the machinery, such as piecing up broken ends, doffing, and other simple details, which are performed by the native Indian cotton factory operative almost as well as by his European brethren, and at far less cost to the spinner (Walmsley (1893), p. 50).

The underdeveloped economies all had lower wages than Britain. The largest British overseas market, for example, was India. But India had wage rates which were about one sixth of those of Britain, and by the 1850s a cotton textile industry using British machinery and some British management began to develop there. Many thought that the British industry could not survive in the face of this low wage competitor. It seemed to them that the cotton textile industry would lead to the rapid industrialization of underdeveloped countries by making good use of their plentiful supplies of cheap but illiterate and unorganized labor.

Table 9 shows the comparative costs of England and its competitors in some low wage countries circa 1910.

TABLE 9: COTTON TEXTILE COSTS, CIRCA 1910

Country or Region	*Weekly Wage (55 hours)*	*Plant and Machinery Cost ($/spindle)*	*Coal Cost ($/ton)*	*Total Manufacturing Cost (England = 100)*	*Implied Profit Rate (%)*
U.S. South	6.5	17.4	3.8	130	–0.7
England	5.0	12.7	2.5	100	8.0
Spain	2.7	19.3	6.5	91	10.5
Mexico	2.6	19.3	10.0	94	9.6
Russia	2.4	20.7	7.2	91	10.3
Italy	2.4	16.0	7.2	81	13.8
Japan	0.8	24.6	2.6	73	14.1
India	0.8	17.6	5.0	61	19.1
China	0.5	16.3	3.2	53	22.1

Source: Clark (1987).

The table shows that wages in the textile industry varied widely in 1910. Wages in England were 10 times those in China. Indeed wages were so low in China that mills would sometimes search workers leaving the mills to ensure they had not stuffed any cotton into their pockets, since even small amounts of cotton would have added significantly to their wages (a pound of raw cotton was worth about $0.25). Wages in England were double those of such slowly developing European countries as Italy, Spain and Russia. Those most underdeveloped countries had a huge labor cost advantage. Wages were the most important element in producing cloth after the costs of the raw cotton in most countries. Thus in England in 1911 the cost structure (excluding cotton) was:

Wages	62%
Depreciation of machinery plus supplies	12%
Power (coal)	3%
Interest costs on capital	22%

Machinery was much less expensive in Britain that in most other countries. This was because England was the center of the cotton machine building industry, and most other countries bought their machinery from England. Their costs were thus inflated by the costs of transporting the machinery to their mills, and the additional costs of setting it up when mechanics had to be brought out from England. It is estimated that the cost of shipping English machinery to US mills was about 25% of the value of the machinery. The countries which had very high machine costs such as Russia often had a tariff on machine imports.[11] The lower machinery costs in Britain might be regarded as an example of increasing returns to scale. Since Britain had the largest industry it had developed the largest machinery building industry, which had lower costs than most foreign competitors, and so enjoyed the benefits of relatively cheap machinery.

England also had low power costs, because the cotton industry lay on top of a coal field. Some other countries such as Mexico had very high power costs because coal had to be imported first by sea and then by rail from the port.

[11] Japanese mills were very expensive per spindle because the costs included dormitories built to accommodate the workers who were mostly teenage girls.

The fourth column of table 9 shows what total manufacturing costs would be in each country based on the costs in columns 1–3, if each country used exactly the same technique as in Britain. That is if they opened the same number of hours, used boilers on their steam engines that used as much fuel per hour as in England, and ran the machines at the same speed as in England. The last column shows the implied profit rate in each country if they were to sell output in the English market. Thus most of the low wage countries should have been able to sell output profitably in the British market in 1910 given that capital costs did not seem to be very much higher in poorer countries as we saw above. Some of them such as India and China should have been able to make enormous profits. Certainly they should have been able to easily undersell the British in their own markets.

The low wage countries actually had a major advantage in general over British producers. Labor laws in Britain by their period limited adult workers to 55 hour weeks, and children to half this number of hours. The English mills chose not to run at night, perhaps in part because again of labor laws restricting the use of women and children on night working. Female workers represented over 60% of the English mill labor force, and an even higher proportion in some occupations such as weaving. Thus the average English mill ran for only 2775 hours per year. In many other countries, particularly the low wage countries, the mills ran for many more hours per year. Mexican mills, for example, were estimated to run 6750 hours out of 8760 in the year, or an average of 18.5 hours per day. The work day was longer, double shifts were worked, and fewer holidays were taken. This reduced the capital costs of production substantially, by reducing the capital costs per spindle hour. Table 9 shows the hours of operation of the mills in the various countries and their revised capital costs, total manufacturing costs, and implied profit rates. As can be seen now all the low wage countries look as though they ought to have been able to undersell the English even with slightly higher capital costs. Some seemingly ought to have made enormous profits as in the case of the Chinese mills. What kept the English in the world market?

TABLE 10: COTTON TEXTILE COSTS ADJUSTING FOR HOURS

Country or region	*Hours per year*	*Plant and Machinery Cost ($/spindle)*	*Total Manufacturing Cost (England=100)*	*Implied Profit Rate (%)*
US South	3450	16.0	126	–0.8
England	2775	12.7	100	8.0
Spain	4455	14.6	84	14.1
Mexico	6750	11.5	82	14.4
Russia	4061	16.1	84	16.6
Italy	3150	16.1	79	13.5
Japan	6526	13.4	62	25.2
India	3744	15.3	58	23.4
China	5302	11.9	48	32.9

The puzzle is all the stronger since many of the lowest wage producers both had cotton and access to major ocean trade routes. Thus, India, China, Egypt, Uganda, Russia, Peru, Mexico, and Brazil all produced cotton.

We know that despite their seeming cost advantages the textile industries of other countries lagged well behind the British in 1910 in terms of size and output. In 1913 Britain still had 39% of the world stock of spinning spindles, and Britain and U.S.A. – the highest wage countries in the world – between them had 61% of the world stock of spindles. Since many of the cotton textile industries in other countries developed behind large tariff barriers, the size of the industry in each country does not indicate its production costs relative to those in Britain. In markets where there was no tariff barrier (India and China), or where goods were imported across tariff barriers, Britain was still dominant, and was clearly one of the lowest cost producers in the world in 1913 despite higher wages than most of her competitors.

Table 11 shows a measure of the relative costs of textile production in 1913 in each country which is the net exports of each country (exports of cotton textile goods minus imports). The low cost producers are clearly Britain, followed at a distance by Japan, Italy, France and Germany. Though it is also clear that countries differed in competitiveness according to whether we consider the yarn market, the gray cloth market or the bleached or dyed cloth market. In yarn for instance the low cost producers were clearly Britain, Japan and India. Almost all other countries imported yarn. For gray cloth, which is cloth that has not been dyed, Britain stands alone. For colored cloth Britain has the largest market share, followed by Germany, France and Italy.

The nature of British imperialism ensured that no country was restrained from the development of a cotton textile industry up until 1917 by the absence of a local market of sufficient size. Because of the British policy of free trade Britain itself and most British dependencies were open to imports with no tariff or else a low tariff for revenue purposes only. The large Indian market which took a large share of English production was open on the same terms to all foreign producers. There was a 3.5% revenue on imports, but a countervailing tax was applied to local Indian mills at the insistence of Manchester manufacturers. The Chinese market, at the insistence of the Imperial powers was protected by a 5% ad valorem revenue tariff also. Australia also maintained an ad valorem tariff of only 5% and had no mills of her own. Thus in 1910 the total size of the open market was in the order of $400 m. This market would be enough to sustain 35 m. spindles and 400,000 looms. In 1910 the British industry, the largest in the world, had only 55 m. spindles and 650,000 looms in operation. The total stock of spindles in the world was only 135 m. Thus by the early twentieth century a vast market for cotton textile products was open to any entrant in the industry. But by 1910 the only major entrant was Japan.

In India Britain continued until 1910 to dominate almost all sectors of the market completely, as table 12 shows. The only sector where there was any competition was from Japan in the coarse yarn market. What was the secret of British success?

TABLE 11: COTTON YARN AND WOVEN GOODS, NET EXPORTS, 1910

Country	*Net exports ($ m)*			
	All	***Yarn, thread***	***Gray woven***	***Colored***
Net Exporters:				
UK	453.2	83.4	99.8	270.0
Japan	26.2	22.3	4.6	–0.7
Italy	23.9	4.2	2.9	16.8
France	23.4	–2.7	4.3	21.9
Germany	15.0	–11.3	–2.7	28.9
U.S.A.	8.5	–3.5	8.3	3.6
Spain	5.9	0.0	(5.9)	
Austria-Hungary	3.4	–4.1	0.2	7.3
Netherlands	3.2	–13.8	7.5	9.5
Russia	2.7	–4.4	(7.2)	
Major Importers:				
British India	–100.1	17.8	–53.1	–64.8
China	–80.9	–40.8	–10.6	–29.5
Argentina	–28.6	–2.7	–0.9	–25.0
Australia	–24.8	–2.0	–1.2	–21.6
Ottoman Empire	–19.7	–1.1	–7.4	–11.2
Egypt	–18.2	–1.4	(–16.8)	
Canada	–11.6	–1.9	–0.8	–8.8
Brazil	–11.1	–2.5	0.0	– 8.6

Notes: Other large net importers were Romania (–9.9), Chile (–9.3), Algeria (–9.2), British South Africa (–7.7), Venezuela (–4.3), Bulgaria (–4.3). Numbers in parentheses are those where gray and colored cloth is given together.

Sources: Tariff Board (1912), Vol. 1, Appendix A, pp. 212-218.

TABLE 12: COTTON TEXTILE IMPORTS TO INDIA, 1906-1910

Category of good	*% of imports from Britain*
Gray yarn, counts 1-25	57.2
Gray yarn, counts 26+	99.6
Bleached, dyed yarn	88.1
Thread	87.1
Gray cloth	98.7
Bleached cloth	97.0
Colored cloth	87.9
All	95.1

Notes: The higher the yarn count the finer the yarn.

Other Industries

It is hard to find other industries that are found across a wide range of countries at different income levels. Railways are another such industry. Output in each country is measured as a weighted sum of the number of tons of freight hauled, the ton-miles of freight, and passenger-miles of passengers. Both tons of freight and ton-miles were used because the average length of haul varied greatly and the fixed costs in hauling freight from loading and unloading were substantial compared to the costs of hauling goods another ton-mile.[12] Freight output was thus estimated as (tons×\$0.285 + ton-miles×\$0.0066). The quality of passenger service varied greatly, which shows up in the revenue generated per passenger-mile. For India, for example, this was 2.4¢ per mile for first class and 0.4¢ for fourth class. We thus adjusted passenger-miles by assuming first class was equivalent everywhere and weighting passenger miles in other classes according to the relative revenue generated per passenger-mile. This weighted passenger-miles was multiplied by \$0.023, the average revenue per passenger mile for first class. Table 13 shows the implied output per worker and output per track mile in \$. On this measure output per worker in the USA in 1914 was six times output per worker in India, even though India was using an equivalent technology.

12 From freight revenues across countries we estimate that the cost of freight hauling a ton of freight x miles in the USA in 1914 in \$(0.285+.0066z).

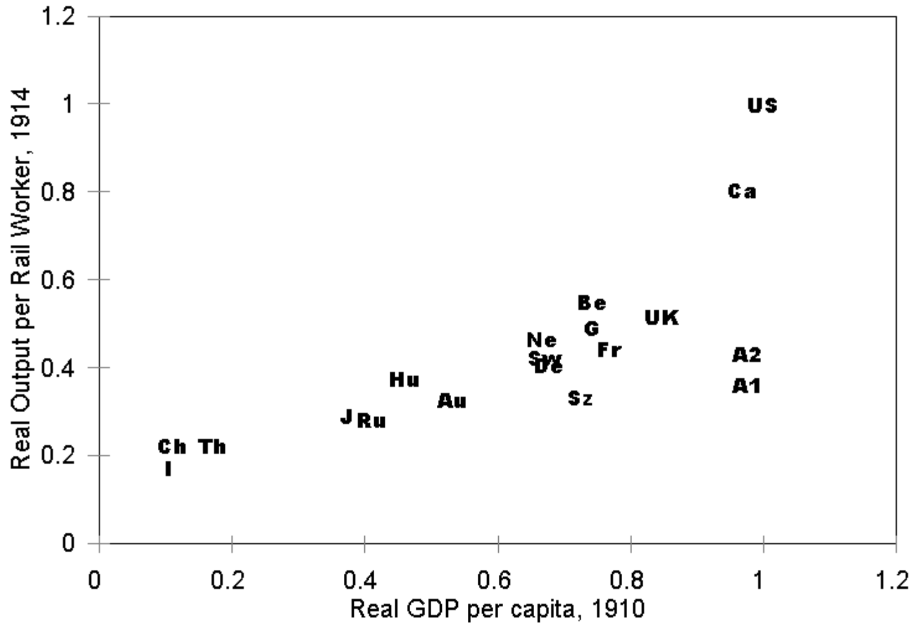
Table 13: Railroad Operating Efficiency circa 1914

Country	Year	Output per worker, $	Output per track mile, $	Efficiency (USA=1)	Miles per locomotive per year
Australia	1914	691	4,421	0.41	24,243
Austria	1912	567	9,677	0.61	16,934
Belgium	1912	959	10,332	0.78	18,282
Canada	1914	1,400	5,487	0.62	25,175
China	1916	389	5,495	0.37	30,408
Denmark	1914	709	6,669	0.53	15,006
France	1911	772	7,451	0.59	22,926
Germany	1913	857	11,826	0.81	25,746
Hungary	1912	653	5,443	0.45	-
India	1914	297	4,208	0.28	-
Japan	1914	507	6,488	0.46	27,196
Netherlands	1912	812	6,982	0.57	32,330
Romania	1913	489	6,738	0.46	23,340
Siam	1914	389	2,128	0.21	17,592
Sweden	1912	739	3,288	0.35	22,442
Switzerland	1913	577	6,831	0.49	-
UK	1912	898	9,457	0.72	25,854
USA	1914	1,743	10,565	1.00	26,092

Sources: Boag (1912), Bureau of Railway Economics (1915), various national railway statistics.

Note: Our method means that output per worker is measured in the same prices everywhere.

Figure 7: Output per worker on railways versus GDP per capita, 1910



Note: A1 is New South Wales, A2 is South Australia. Otherwise country codes as before.

Since Indian rail equipment was mostly imported from Britain, a better comparison might be with the UK. UK output per worker was three times output per worker in India. Figure 7 shows output per worker on the railways circa 1914 in the countries for which we can get data, versus real GDP per capita for the same countries in 1910. This low output per worker in the poorer countries has little to do with capital/labor substitution in response to lower wages. One measure of the intensity of capital utilization is the number of miles locomotives were driven per year. This varies much less across countries and is uncorrelated with the level of income of the country. As column 5 of table 5 shows, the overall efficiency of the rail systems of these countries also varies greatly. The efficiency of the Indian rail system was only 28% of the US system, and 39% of that in the UK. These differences in the efficiency of operation of the rail system between countries like India and the USA and UK are almost as great as the differences in calculated TFP for these economies as a whole.

Note that the Indian rail system, for example, had extensive English expertise in its operation. In 1910 the Indian railroads employed 7,207 "Europeans" (mainly British) and 8,862 "Eurasians" (principally Anglo-Indians) who occupied almost all the supervisory and skilled positions. Indian locomotive drivers were employed only after 1900, and even as late as 1910 many of the locomotive drivers were British.[13]

The problem of operating western technology efficiently in poor countries like India was the main barrier to the spread of this technology. Table 14, for example, shows the gross profit rates of Bombay cotton mills by quinquennia from 1905-9 to 1935-9, as well as the size of the Bombay industry and the output per worker in Bombay as an index with 1905-9 set at 100. As can be seen profits were never great, but the industry grew substantially in the era of modest profits up to 1924. Thereafter, however, profits collapsed (as a result of Japanese competition) and the Bombay industry soon began to contract. The last column shows what was happening to output per worker in Japan, where using the same machinery as in India, in both cases purchased from England, output per worker increased greatly.

[13] Morris and Dudley (1975), pp. 202-4, Headrick (1988), p. 322.

Table 14: The Bombay Industry, 1907-1938

Year	Gross profit rate on fixed capital	Size of the Bombay Industry (m. spindle-equivalents)	Output per worker in Bombay (Index)	Output per worker in Japan (Index)
1905-9	0.06	3.09	100	100
1910-4	0.05	3.43	103	115
1915-9	0.07	3.68	99	135
1920-4	0.08	4.05	94	132
1925-9	-0.00	4.49	91	180
1930-4	0.00	4.40	104	249
1935-9	0.02	3.91	106	281

Notes: Profits and output per worker were calculable only for the mills listed in the Investor's India Yearbook.

Source: Wolcott and Clark (1999).

Thus the crucial variable in explaining the success or failure of economies in the years 1800-2000 seems to be the efficiency of the production process within the economy. And the differences in the ability to employ technology seemingly got larger over time between rich and poor countries.

The Nineteenth Century Interpretation – Differences in Workers

A number of writers of the late nineteenth century and even earlier argued that the ability of the British industry to pay high wages and still prosper derived mainly from the much greater intensity of labor in Britain compared to Europe and most of the rest of the world. These writers argued that British workers operate more machinery each so that the wage cost advantage of the low wage countries was mitigated or completely eliminated. Marx, interestingly, endorsed this view. Volume 1 of Capital published in 1867 contains a short chapter, "National Differences in Wages," which quotes the differences in staffing levels on textile machinery between different European countries and attributes them to differences in labor intensity (Marx (1977), 701-706). For Marx it was a further proof of the poor treatment of workers under capitalism that the higher wages of workers in the advanced capitalist economy were in large part the result of greater efforts by the workers. And indeed it seemed that the cost of labor to the manufacturer did not vary much across countries at different stages of economic development.

This view of higher British labor intensity was not original to Marx. He was merely quoting what seems to have been for British and American economists of the late nineteenth century a kind of orthodoxy. Indeed there are discussions at the time focused on such questions as how many Chinese workers, or Indian workers, or African workers are the equivalent of one British worker. There are also discussions about whether differences in labor efficiency did or did not completely offset differences in day wages so that the real cost of labor is everywhere constant.[14]

[14] See, for example, Thomas Brassey (1879), pp. 157-196, James Jeans (1884), 623-4, Schulze-Gaevernitz (1895), 85-130.

When we look at the international cotton textile industry around 1910 we do find that the evidence on output per worker and output per machine is consistent with the nineteenth century story. Table 15 shows for a group of countries the wage rate in cotton textiles, the aggregate number of machines per worker, and the output per hour of spindles spinning 20s yarn. As can be seen the number of machines per worker varies by a factor of 6:1, but the output per machine per hour is fairly constant. The last column of the table shows the implied labor cost per pound of yarn or cloth produced if machines in all countries ran at the same rate. As can be seen the difference in raw labor costs of 18:1 shown in the first column declines to a difference in labor cost per pound of cloth or yard of about 3:1. Differences in manning levels were not enough to completely offset the wage cost advantages of the low wage countries, but they reduce them very substantially.

The same phenomena of wage cost advantages being largely offset by lower wage countries employing more workers per machine is seen if we follow the fortunes of four countries with large cotton textile industries from 1880 to 1980 – Britain, the USA, Indian and Japan. Table 16 shows the wage per hour in the textile industries of these countries compared to the USA from 1880 on. As can be seen through this long period there have been persistent huge gaps in wages across these countries, which have been getting wider. In 1880 a US textile worker was paid seven times as much per hour as an Indian worker. By 1967 the US worker was paid 14 times as much.[15]

[15] Real wages would vary by less since the Indian price level was always lower. But what matters for international competition in textiles is the money wage cost.

TABLE 15: MACHINES PER WORKER AND OUTPUT PER MACHINE, CIRCA 1910

Country or Region	*Weekly Wage (55 hours)*	*Loom Equivalents Per Worker*	*Output per Spindle (oz/hour)*	*Real Wage Cost (England=100)*
US North	8.8	3.0	0.60	106
U.S. South	6.5	2.6	0.60	100
England	5.0	2.0	0.65	100
Spain	2.7	0.9	-	120
Mexico	2.6	1.1	-	95
Russia	2.4	1.1	-	87
Italy	2.4	0.9	0.67	107
Japan	0.8	0.5	0.63	64
India	0.8	0.5	0.56	64
China	0.5	0.5	0.52	40

Source: Clark (1987).

TABLE 16: RELATIVE MONEY WAGES IN COTTON SPINNING (USA = 100)

Year	*USA*	*UK*	*India*	*Japan*
1880	100	95.6	13.7	-
1890	100	82.0	11.1	10.3
1900	100	93.8	11.7	12.5
1913	100	81.3	12.7	13.0
1924	100	57.9	11.0	19.6
1937	100	43.3	7.8	-
1949	100	29.0	8.3	10.9
1956	100	36.1	7.9	18.2
1967	100	47.7	6.9	23.0

Table 17 shows the output per worker in spinning a standard yarn, 20s yarn, across these same countries over the same period. Yarn of different thicknesses requires different amounts of labor to produce for reasons we shall consider below, so the comparison is done for yarn of a standard fineness.[16] These measures of output per worker-hour in spinning do not make any adjustment for the vintage of the machinery. For Britain in the period after 1920 this tends to depress output per worker since after 1920 the cotton industry, which was 40% of the world industry in 1913, experienced a protracted decline with very little investment in new machinery. Japan, on the other hand, had the advantage of very high rates of investment in most years.

TABLE 17: OUTPUT PER WORKER IN COTTON SPINNING (lbs/hr, 20s yarn)

Year	*USA*	*UK*	*India*	*Japan*
1880	2.6	2.9	0.7	-
1890	-	3.7	0.8	0.8
1900	-	-	0.9	1.3
1913	4.7	3.9	0.8	1.7
1924	5.3	3.4	1.1	2.0
1929	6.8	-	1.1	3.0
1937	8.0	4.0	-	4.0
1949	12.9	5.0	1.1	3.7
1956	-	4.7	1.5	6.8
1967[a]	39.5	12.2	4.3	13.2
1978[b]	-	29.4	-	4.0

Notes: [a]Lowest cost mills.
[b]40s count yarn.

[16] Yarn fineness is measured by the number of hanks of 840 yards of the yarn that weight one pound. A 20s yarn is one where 20x840 yarns weigh a pound. It was the most commonly produced yarn in most countries. A 40s yarn is twice as fine, a 10s yarn twice as course. Yarn counts in cotton varied from 1s to 200s.

These differences in output per worker was so great that they implied that labor costs per pound in producing yarn varied by much smaller amounts across these economies. Table 18 shows the labor cost per pound of 20s yarn relative to the cost in India. As can be seen the huge gap in nominal wages between India and Britain and the USA is not completely offset by differences in labor productivity, but labor costs per pound vary by much less across countries than do wage rates.

TABLE 18: LABOR COST PER POUND IN COTTON SPINNING (INDIA = 100)

Year	*USA*	*UK*	*India*	*Japan*
1880	192	182	100	-
1890	-		-	
100	64			
1913	137	154	100	54
1924	185	127	100	192
1937	182	156	100	-
1949	103	76	100	49
1956	-	149	100	52
1967[a]	146	198	100	78

Notes: [a]Lowest cost mills.
Sources: Tables 8.10 and 8.11.

The much larger labor input per pound of yarn produced in the low wage countries was not generally compensated for by greater amounts of output per machine per hour. Table 19 shows output in pounds per 100 spindle-hours in producing 20s yarn. Output per spindle-hour varies surprisingly little across the four economies at any one time, and despite the great changes in labor productivity the relative outputs per spindle-hour change little over time.

TABLE 19: OUTPUT PER SPINDLE-HOUR IN COTTON SPINNING (20s yarn)

Year	*USA*	*UK*	*India*	*Japan*
1880	(2.26)	(3.13)	2.10	-
1890	(2.53)	(3.55)	3.07	2.59
1900	3.07	-	3.07	3.67
1913	3.25	(3.30)	3.00	4.36
1924	3.13	2.94	3.24	4.17
1929	3.26	-	3.36	4.39
1937	3.33	3.83	-	4.49
1949	3.83	3.64	2.90	4.44
1955	-	3.27	3.32	4.89
1964	-	3.59	3.10	-
1967[a]	5.35	4.42	4.17	6.73

Notes: [a]Lowest cost mills.
Brackets indicate the most tentative observations.
Output given in lbs per 100 spindle hours

The Modern Interpretation – Managerial Inefficiencies

Despite the unchanging nature of the international differences in performance in the industry the "labor intensity" explanation seems largely to have disappeared in the early twentieth century from the neoclassical world view, though it was still common belief in the international textile industry at least up until 1930. A 1929 report in the Journal of the Textile Institute on the Indian industry states baldly, for example, "India is obliged to engage three persons in place of one employed in the Lancashire mills" (Cotton Yarn Association (1929a), T11).[17]

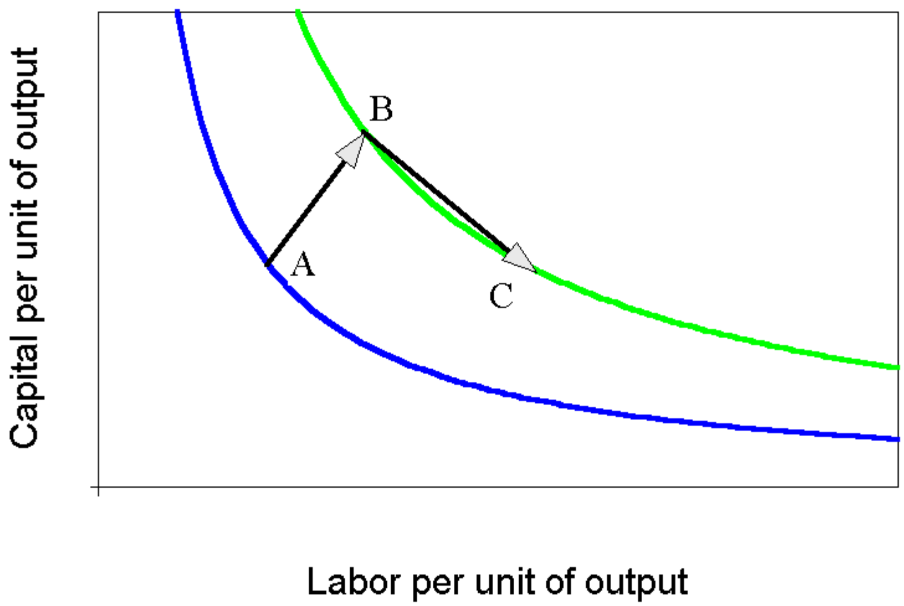
Economists now mainly attribute the poor performance of industry in underdeveloped economies not to low intensity of effort by workers but to a generalized failure by management to productively employ all the inputs in production – capital and raw materials as well as labor. This is called the "X-efficiency" interpretation. Unskilled labor is assumed to be of the same quality everywhere.

Why, in this case, is output per machine-hour the same across economies while output per worker is much lower in low wage countries. On the modern view this is because two things are occurring simultaneously. The first is that because their management was and is poor in low wage economies they consequently employ both more capital and more labor per unit of output. This is shown in figure 20. The vertical axis shows the capital used per unit of output, the horizontal axis the labor employed. The closer a country is to the origin the more efficient its industry is. Point A thus shows the labor per unit of output (L/Q) and capital per unit of output (K/Q) in the USA. Point B shows how much capital and labor would be required in Indian mills if managers there used the same mix of inputs as a result of the poor management in these countries.

The second thing that happens, though, is that managers in low wage economies are encouraged by the low wages to **substitute** labor for capital. We think of managers in the US and in India as facing a set of choices about how much labor and capital to employ shown by the curves running through points A and B. These **isoquants** show the various combinations of capital and labor that will produce a unit of output. If labor is expensive relative to capital managers will be encouraged to choose a point on the isoquant that uses small amounts of labor and large amounts of

[17] Another observer of the Indian cotton industry writes, "Labour in India is undoubtedly on a very low par, probably it comes next to Chinese labour in inefficiency, wastefulness, and lack of discipline" (Pearse (1930), 188).

Figure 20: Production Choices in the USA and India



capital. Similarly if labor is cheap they should switch to a combination where large amounts of labor are employed and small amounts of capital. Thus the managers in India faced with very cheap labor rationally choose to use the combination of capital and labor represented by point C.

To see how this process operates in practice consider weavers assigned to looms. If there is one weaver per loom as in India in 1910 then whenever the looms runs out of weft thread, or a warp thread breaks, the workers will be there immediately to fix the problem. Thus there will be a high level of output per unit of capital. If, as in the US, each worker tends 8 looms, then it will typically take some time for the loom to be put back in service after the weft runs out or the warp breaks. For the weaver is not constantly watching each machine and he or she is often busy repairing one of the other machines. Here output per worker will be high but output per machine will fall.

The modern view of the cotton textile industry is that the low wage costs in poor countries lead managers to add so much more labor per machine that they were able to get output per machine back up to the level of the advanced economies despite their general inefficiency. But they did so at the expense of further reducing output per worker.

Thus the two effects operate as follows in the poor countries.

	L/Q	***K/Q***
inefficiency	↑	↑
substitutions	↑	↓
total effect	↑	0

For labor the inefficiency of managers and the substitution from low wages reinforce each other to drive up markedly the amount of labor employed per unit of output. For capital managerial inefficiency and substitution effects are offsetting so that there is no net effect.

For this process to operate in the way described output has to be generated from capital and labor in a very special way. That is, it has to be the case that

$$Q = AK^{a}L^{b}$$

This is the Cobb-Douglas production function we used as an approximation for the whole economy above.

Most modern writing on the textile industry has embraced the X-efficiency view of international differences in Q/L and Q/K. Indeed the history of the Indian industry has been reinterpreted in this light. Thus Morris notes of the mills in Bombay in the 1920s and before that:

The relative price of factors and the specific incentives for the entrepreneurs were both strongly on the side of having the mills operate long hours, producing as much product as possible, without particular regard to labor efficiency. In other words this thoroughly rational judgment encouraged what seemed to be so many outsiders to be a thoroughly wasteful use of labor.

What we see then is that there are two competing visions of what went wrong in the textile industries of poor countries. The nineteenth century view that stresses the problem lay with the workers and the twentieth century view where the problem lay with the managers. If all we have are records of output, labor and capital, then we cannot tell the difference between them, since they make the same predictions at this level. To see which one is correct we have to look directly at the issue of management in poor countries, and at whether it was possible to substitute labor for capital in the way assumed by the modern view.

Management in Low Wage Economies

Did poor countries suffer from poor management? Managers, like machines, can be exported. This was particularly easy in the cotton textile industry since cotton mills had a relatively small managerial structure. The managers supervised the purchase of the cotton, set the machines for the type of output that was being produced and supervised the workers. But since the workers had, as noted above, rather well defined tasks the required supervision was not very great.

In the cotton textile industry around 1910 when the differences in manning levels were already very clear Britain not only exported machines, it also exported large numbers of managers and skilled workmen who supervised foreign mills. India, China, Russia, Brazil and Mexico all had significant numbers of British managers around 1910. Thus in 1895 there were 55 mills in Bombay, the center of the Indian industry. 27 of these had British managers. In these mills there were 190 weaving masters, spinning masters, carding masters and engineers. These were the deputy managers who supervised the loom sheds, the spinning and carding rooms and the steam machinery of the mills. Of these 77 were British. Similarly least a third of the Chinese industry was under British management in 1915, and some of the mills owned by Chinese entrepreneurs were operated by British mill managers. Most Brazilian mills had British managers, room bosses, and engineers.

Further in places like Bombay the industry was highly competitive. Thus in 1925 there were 85 cotton textile mills in Bombay. 45 of these had gone broke and been reconstituted under new management at some point in their history, and 16 had transferred managerial control voluntarily.[18] Thus mills with weaker management were failing, and there should have been constant competitive pressure for the adoption of the best managerial practices.

[18] The first mill in Bombay was started in 1856.

Substitution Possibilities

The modern view of the excess labor forces of mills in poor countries depends on the management being able to substitute labor for capital. But there are some techniques in cotton mills where such substitution is not possible. One such task is doffing. The doffers remove the full spindles of yarn at set intervals from the spinning machines. The machines are stopped while the doffing is done all at once. For doffing we have some good information for India at various dates. Machines spinning 20s yard would typically be doffed once every three hours in India in the 1930s or 1940s. In all countries doffing involved stopping all the spindles on a frame (typically 250–400 in India) until all were changed. Since it took at maximum about 3.3 seconds (excluding rest allowances) to doff each spindle, if one person only were to doff the entire frame it would take 20 minutes. Thus the spindles would be stopped for doffing for 20 minutes out of each 200, or 10% of the time. To avoid this utilization loss in all countries doffing was done by specialized doffing squads which typically might contain 5-10 doffers. This reduces the doffing time per frame to 2–4 minutes, only about 1–2% of running time.[19]

The typical Indian mill of 50,000 spindles would need 18-20 doffers at US performance standards for doffs per hour. Since doffing is done on a regular and planned basis (unlike piecing which is erratic in its occurrence) there is no problem of reduced output from machine interference from having smaller numbers of doffing teams. Thus the US performance standards would seemingly impose no machine utilization losses in Indian mills – it would still be possible to form doffing squads as large as were used anyway.

Table 21 shows the information we have for various countries on how many spindles were doffed per hour at various dates. As can be seen the Indian rates of doffing are extraordinarily low all the way from 1907 to 1961, and show very limited improvement over this period. In the 1940s Indian doffing rates are 13% of US rates.

[19] In Japan in 1929 Pearse reports doffing squads of 5 and 8 workers who would doff a frame in about 1 minute. In India in 1930 the doffing of the whole frame seems to have taken longer, 2–3 minutes, but we do not know the size of the doffing gangs (Pearse (1929), 55, 65; Pearse (1930, 129, 133, 138).

TABLE 21: SPINDLES DOFFED PER WORKER PER HOUR

Year	*USA*	*Britain*	*India*	*Japan*
1907	-	-	102	-
1921	728	-	118[a]	-
1944	606	354	124[b]	-
1946	770	-	-	-
1949	933	570[c]	-	-
1950	-	-	-	505
1959	1000	-	-	-
1969	-	600[d]	-	-
1978	-	-	160[e]	-

Notes: [a]Bombay City and Island. Calculated from Shirras (1923) on the assumptions that there is one side per ring spinner (170 spindles), that output per spindle-hour averages 0.038 lbs., and that the weight of the doff package is 0.084 lbs (the same as Britain in 1949).

[b]India except the Bombay Presidency.

[c]Lowest cost mills.

[d]Assumed performance in modernization study.

[e]South Indian mills. Doff package assumed to be 0.12 lbs.

Sources: Shirras (1923), Cotton Spinning Productivity Team (1951), Ratnam and Rajamanickam (1980), Doraiswamy (1983), Textile Council (1969).

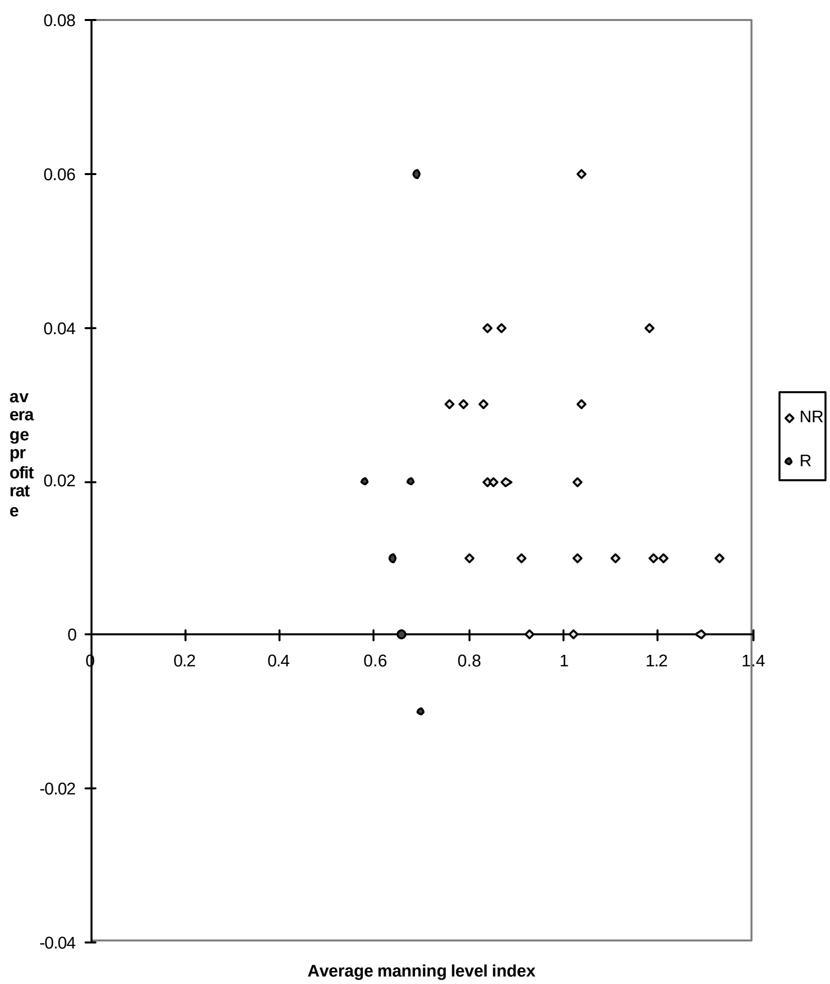
WHY WAS LOW WAGE LABOR INEFFICIENT? – THE CASE OF INDIA

While it seems clear from the above that the cause of the "overmanning" of the cotton industry in poor countries resides in the workers, explaining why there are so many workers in these mills is not easy, even in cases where we have lots of information on what the mills were doing as in Bombay in the years 1890 to 1938. There are at least two possible explanations of overmanning in India in this period. The first is that overmanning was a result of the characteristics of the Indian labor force: Indian workers were either preferred low effort levels, or were incapable of delivering higher effort levels. The second is that Indian workers had exactly the same preferences and capacities as workers in high labor productivity countries, but Indian labor market conditions caused them to combine and restrict output per worker in an attempt to spread the work available to as many workers as possible.

The managers in Bombay in the 1920s knew that by the standards of Britain and the USA their mills were overmanned. Why didn't they get rid of the excess workers? Also after 1924 the industry was under severe stress with many mills suffering losses, and little or no new investment. The answer to this question from the point of view of the managers seems to be that the firms that did move aggressively to reduce manning levels in the 1920s and 1930s did not make any more profit. There was no strong signal that this was the right direction to move in. Figure 8.4 shows the profit rate earned by a variety of mills in Bombay in the years 1935-38 on the vertical axis. As can be seen the average **gross** profit rate is only about 2%, so that the firms are mostly losing money. On the horizontal axis is a measure of how much labor firms were using per unit of equipment. A high number on this index implies a lot of workers per spindle and per loom. A low number indicates a firm that has few workers per unit of capital. The firms that were known to have deliberately tried to reduce their manning levels, to "rationalize" labor use, are represented by black circles. They are all clustered at the left end of the graph. They are clearly distinguished from the other non-rationalizing firms through their lower labor use. However, the rationalizers on average made no more profit than the non-rationalizers. The average profit rate of the rationalizers in these years was 1.7%, while that of the non-rationalizers was 2.0%. There was nothing in the experience of the Bombay industry to suggest that shedding surplus labor lead to higher profits.

Bombay Dyeing and Manufacturing was the most profitable of the rationalizers. But its average profit rate for the period was still only 6 percent. Even this mill was not a great success, at least in the eyes of its managers. According to the minutes of the Bombay Dyeing Board of Directors meetings, the profits of the mill company were sufficient to induce replacement of some worn out equipment. Between 1930 and 1938 the Board authorized average annual expenditures on equipment of Rs. 374,469, approximately 1.3 percent of the value of their fixed capital stock. But on net, the number of their spindles and looms declined. And during these years, the Board also authorized large expenditures of profits on government bonds. By 1938, the market value of the company's holdings of government bonds was Rs. 8,026,989 - sufficient to extend their capital stock 25 percent, had they regarded investment in the cotton industry as profitable.

FIGURE 7.4
Average Profit Rates and Manning Level Indices, 1935-1938



The reason shedding labor did not result in higher profits is in part because firms which shed labor paid higher wages to those who remained in employment. Thus in the years 1935-37 the average daily wage per worker on the rationalized mills was Rs. 1.26 compared to Rs. 1.11 for non-rationalized mills. Similarly if we compare the change in wages on mills from 1924 to 1935-38 with the change in labor utilization we find that while in the rationalized mills workers' nominal wages fell 6 percent, in non-rationalized mills wages fell 21 percent.

In general firms with higher labor efficiency paid a wage premium. When we examine two cross sections of wages from Bombay constructed for 1924, and for 1935-7 we find a positive association between the average wage and the number of machines tended per worker. Thus if we regress

$$\text{Ln(wage)}_i = a + b\ln(\text{labor per machine})_i + e_i$$

for both these samples the estimated values of b in each case are between -0.2 and -0.35. We can also take a sample of firms and compare their percentage wage gain from 1924 to 1935-7 with the increase in machines per worker. Here we get an estimated coefficient of -0.4. This suggests that at least one quarter of any gains from lower manning levels were eaten up in higher wages. The true figure would actually be even higher, since the variable "labor per machine" measures actual versus required labor only with an error component created by variations in how fine the yarn being produced was, the vintage of the equipment, and the inaccuracy of the stated mill labor forces. It is thus possible that all or most of the expected profit from eliminating workers did not appear because of the higher wages workers had to be paid in the more efficient mills.

But was the problem one of worker incapacity or of worker resistance? The fact that wages increased is in itself, unfortunately, consistent with both views. In a competitive labor market workers can be employed under terms that would imply differing amounts of effort per hour. Firms that demand greater efforts will have to pay higher wages. Thus it could well be that firms in Bombay had on average chosen the optimal wage-effort combination given the capacities and inclinations of the workers. Those that tried to extract more effort from their workers had to pay more to retain them.

But if workers had power over firms and used it to restrict effort levels for fear of unemployment, then we might also see a positive association between wage levels and manning levels. If the workers opposed rationalization, they might make high wage increases a condition for higher manning levels. This would slow the spread of rationalization by ensuring that the majority of the benefit went to laborers. Indeed in the Ahmedabad industry the strong labor union organized by Mahatma Gandhi bargained for a rule in spinning that wages would increase 75 percent for doubling the work completed. The Delhi Agreement of 1934 compromised on a gain of 45 percent. We would expect, however, that if managers had to pay less than a 1 percent increase in wages for a 1 percent reduction in manning levels, decreasing manning levels would still increase profits. The wage effect should attenuate the profit effect, not remove it entirely.

That there was no profit effect implies that the unobserved costs associated with rationalization eroded all further benefits. Partly this was because the increase in machinery could not be just foisted upon the workers. Preparations were undertaken to minimize the effort requirements per machine, despite the apparently minimal tasks of the workers before rationalization. There were also ongoing costs. These included better machine maintenance and better cotton quality, both being designed to reduce the breakage rate. Stones claims in fact that he was keeping workers' total effort levels constant. While it is clear that rationalization did increase effort levels, the firms that had gone furthest in rationalization did incur significant other costs. Unfortunately, these reductions in effort per machine, as were the wage increases, are consistent with both views of Indian labor. Management may have had to decrease effort levels either because the average worker could not or would not work harder, or because labor had the power to resist uncompensated increased work loads.

But while labor may have controlled work conditions in Bombay, this story cannot readily explain the stagnant productivity of the entire subcontinent. It was claimed by many observers for example, that workers in places like Bombay clung to outdated work norms such as one worker per side of a ring frame. Thus Sreenivasan states that:

> Before independence, work allocation was purely on an ad hoc basis and was dependent on the tradition of that particular region. If a worker attended to 200 spindles in one mill, he did the same in all the mills in the locality (Sreenivasan (1984), 172).

If labor resistance based on outdated work norms in the declining center of Bombay was the problem, rationalizing managers would have had enormous incentive to move to new locations. The day wages of workers were generally cheaper outside the established textile centers. In fact, there was enormous growth in such places as Ahmedabad, Cawnpor, Nagpur, Madras, Delhi and Coimbatore in the interwar period. But while machinery and employment expanded, productivity there also remained at its prewar levels. Why did the managers of these new mills in isolated locations not train the workers to operate two, three, four or five sides of a spinning frame each? If staffing levels in the main centers of the industry were purely conventional, why should managers reveal the convention to the newly recruited workers in Madras or Coimbatore?

One theory of labor resistance was that Indian workers had normal complements of machinery which they staffed. It was sometimes said for example that workers in spinning insisted on operating only one side of a spinning frame. In this case, since the workers were illiterate by and large, and since frames would vary in length and in the number of spindles they contained, we would imagine that managers in India would have an incentive to order longer frames with more spindles, or pack more spindles onto frames of given length (if the mill buildings constrained the length of the frames). Yet when we compare Indian machine purchases around 1910 with those of other countries we find Indian ring machines had no more spindles than those of other countries.

When we look at machine speeds we again see no sign that labor was regarded as being in surplus in Indian mills. Machine speeds in India on a given fineness were the same as counties where the wage level was 6 to 14 times that of Indian mills. Indian mills did not push up speeds to the maximum that was technically feasible and then use extra labor to fix the increased number of thread breaks that would result. Countries such as Japan and China whose wages were about the same as those of India in 1910 were running their machines much faster.

Thus there is no evidence comparing other countries that Indian managers regarded themselves as operating with surplus labor that they could use at zero cost. The second form of evidence that Indian managers did not regard labor as being costless is that they were changing the machines ordered in the period 1890-1929 toward ones that used less labor. One way of using less labor was to make the input and output packages larger so that they had to be changed less often. Thus the average size of the output bobbins spinning 20s yarn went up from 13.8 in^3 circa 1890 to 15.72 in^3 circa 1929. Similarly the average size of the input bobbins on 20s yarn moved up from 80.22 in^3 circa 1890 to 115.1 in^3 circa 1929. Indian managers were choosing machines that occupied more floor space, but that saved on labor. Why would they do this if they were constrained to have surplus labor?

There were a number of peculiarities in the way Indian workers were supervised and paid, and all of these have been credited by some author with explaining the low productivity of the workers. Indian mills were notable for two features: management would subcontract the organization of labor to "jobbers" or "room bosses" who would sometimes by paid per unit of output, and the workers would be allowed considerable freedom about how and when they worked. In British run mills room bosses were used in part since the British managers were often unable to communicate directly with the workers (though managers were offered bonuses to learn the local languages), but they were utilized also in Indian run mills. Koh, for example, argues that,

> The abuses associated with the jobber system cumulatively brought about industrial inefficiency. The agricultural character of the Indian labor force and the jobber system were merely two aspects of the same phenomenon: the instability of the labor force. The instability – manifest in high rates of turnover, absenteeism, and inter-mill movement – was harmful to the efficiency of the workers... (Koh (1966), 121).

The jobber typically was recruited from the ranks of the workers, and had the task of recruiting workers and disciplining them so that the machines under his care were fully utilized. He might be paid a piece rate per unit of output from his machines, but he was not a full sub-contractor in that the mill paid the workers itself. Also the mill manager would establish the numbers of workers needed in each department. Jobbers only hired the workers to fill these positions.

Jobbers, however, were able to extract payments from workers seeking positions when the mill wage was high relative to alternative employment opportunities. This was the basis of one of the common criticisms of this system. It was argued that jobbers would select workers for employment on the basis of the size of the bribe they would offer, not the workers' qualifications. Mill managers could theoretically veto the choices of the jobbers, but often the hiring was done early in the morning before the managers arrived at the mills. Morris argues that the jobber's interests "were frequently at odds with any attempt to create a stable, efficient, and disciplined work force."

If this complaint had significant force it is hard to understand why the system continued for at least 70 years in Bombay until it was changed in the early 1930s under government pressure. It could only mean that management was incompetent.

But there is no reason to believe that jobbers would hire or keep incompetent workers. Many of the workers were paid by a piece rate. Those most able to offer a bribe would be those who could earn most at the job. Further the jobber was judged, and was often paid, by reference to the output of the machines under his care. If he hired an incompetent worker output would suffer, and he would lose income. If managers moved to formal hiring departments they would have no information on the quality of workers presenting themselves at the mill. Workers did not have written references. That was the value of the jobber to the mill. As Morris notes "when the power of the jobber did interfere with the objectives of a determined employer the jobber could be sacked and he and his hands, if they supported him, replaced with a minimum of difficulty." Jobbers might be under pressure to hire incompetent relatives or clients, but they would have to restrict their charity or they would risk losing their position.

The second peculiarity of Indian mills was their very lax discipline. The cotton mills in England were noted for their early introduction of strict systems of factory discipline. Workers, even those who were on piece rate, were expected to appear at opening time each morning, to work all the hours the mill was open, to stay at their own machines, and to refrain from socializing while working. Indian mills by comparison were very undisciplined, at least up until 1930. There continued to be a very high rate of absenteeism in mills at least into the 1960s. The Indian Factory Labour Commission is full of testimony by the employers as to the conditions in the mills, though of course we have to be wary of the biases of the employers. A substantial fraction of workers would be absent on any given day, and those at work were often able to come and go from the mill at their pleasure to eat or to smoke. Other workers would supervise their machines while they were gone, and indeed some manufacturers alleged that the workers organized an informal shift system among themselves. The mill yards would have eating places, barbers, drink shops and other facilities to serve the workers taking a break. Some mothers would allegedly bring their children with them to the mills. Relatives of workers would bring food to them inside the mill during the day. "There was an utter lack of supervision in the Bombay mills." One manager even goes so far as to state that while in the factory the worker "washes, bathes, washes his clothes, smokes, shaves, sleeps, has his food, and is surrounded as a rule by his relations."

It is very hard to get any reliable estimate of how much time workers were absent from the machinery during the work day. The manufacturers in 1908 alleged that 10-30% of the work time was spent in the mill. To partially control this absenteeism some employers used a pass system, where a worker could only leave the mill if they had a pass for their department. Each department would have passes equal to 10-25% of the labor force. But even this modest measure was sometimes successfully resisted by the workers. It should be noted, however, that up until 1911 in the summer months Indian mills at times of full employment ran for all the hours of daylight, up to fourteen hours per day, with only a short thirty minute stop at midday. No worker could labor continuously for seven hours without some kind of break.

Might this indiscipline explain the large numbers of excess workers? By 1930 when I compare Indian mills with those in Britain and the USA the work hours had been reduced somewhat to a maximum of twelve per day. Supposing that one sixth of these were in fact absent at any time would narrow the labor inputs required in India compared to Britain and the USA. Now there would be only 2.25 Indian workers per British worker under the same conditions, and 4.0 American workers. But this would imply that since the Indian work day for individual workers was really only ten hours, it would be little longer than that in the advanced countries. The British mill workday up until 1919 was ten hours, and the British workers before then were manning as many machines as in the 1920s in ring spinning.

But the freedom of the workers to leave the mill whenever they wanted to will not itself explain most of the excess labor. The worker might be free to leave the machine whenever he or she wished, but in textile production it is easy to check on the output of each workers' machines. If the worker absents himself too frequently, or does not get his co-workers to cover for his absences, then the machine production will drop. Managers in the Indian jute industry certainly claimed to dismiss weavers who fell below a minimum output level, and they sometimes paid bonuses on the piece rate for higher outputs. The easy observability of output per machine made it possible to control workers not by observing all their labor inputs, but by checking that the machines were producing a satisfactory output per hour. And indeed if we compare production per ring spindle per hour in 1930 in India with that in Britain and the USA we find that Indian mills then were able to achieve high machine productivity, despite the continuation of loose disciplinary practices in many mills.

Thus though to may observers it seemed that management in Indian textile mills had little control over labor, the system of labor discipline that evolved seems naturally explained as an informal shift system, where managers left it up to workers to arrange their absences in a way that would not disrupt production. The managers ideally wanted to run the mills for all the daylight hours, and average of twelve hours per day, and for as many days in the year as possible. The workers did not want to work as little as six hours per day, which would have allowed a simple two shift system. So managers preferred to have each worker work ten or so hours a day, taking the breaks whenever was convenient. But by penalizing workers for losses of machine production management could ensure that they were induced to spread their breaks out so as to keep the machinery running continuously.

But I am unconvinced that the structure of employment contracts, and the rigidities of wage bargaining explain much of the excess staffing in India once we control for local conditions. For if all that was limiting staffing levels in Bombay was the system which had become established of having one spinner per side of a frame, then the industry would have had an overwhelming incentive to seek new locations nearer the cotton fields where the workers could be trained to work two, three, or four sides. The day wages of workers were generally cheaper outside the established textile centers. This wage differential had been enough in the late nineteenth century to lead to the establishment of other textile centers at places such as Ahmedabad, Cawnpor, Nagpur, Madras, Delhi, and Coimbatore. The efficiency of workers, measured by machines per workers, does not seem to have been any higher than in Bombay, yet the wage differential was enough to induce this movement of the industry to completely new locations and labor supplies. Why did the managers of the new mills in isolated locations not train the workers to operate two, three, four or five sides of a spinning frame each? If staffing levels in the main centers of the industry were purely conventional, why should managers reveal the convention to the newly recruited workers in Madras or Coimbatore?

The Buckingham and Carnatic mills in Madras, one of the largest and most profitable textile enterprises in India, introduced automatic looms in the 1920s. The staffing of ordinary looms at this time in India was still often one worker per loom, compared to one worker per eight looms in the USA. There would be 20-30 automatic looms per worker in the USA. Three automatic looms only were assigned to each weaver in the Buckingham and Carnatic mills. Since the looms were new to the workers, since they had no reason to expect three looms per weaver any more than ten looms per weaver, if the limitation on staffing previously was a convention, why not choose this moment to establish a more profitable convention?

The implication that I draw is that the conventions which reigned in Bombay and other centers about staffing levels persisted because they did not constrain management as much as such conventions would have in the USA. Even with a free hand managers would not have assigned many more machines per worker because the output per machine would not have been maintained. I think the manufacturer who testified to the Factory Commission in 1908 that,

> They had one man to each loom, because if they gave two looms to one man it would mean a loss of three-eighths of the loom's capacity. They would prefer to stop a loom altogether rather than hand it over to a man working another loom (British Parliamentary Papers (1909), 315),

was correct. Conventions may have restricted staffing levels somewhat, but they managed to survive in India because there was not much gain in labor productivity available from breaking the convention. The industry had a proven capacity to move in search of lower labor costs. If it could get much better staffing levels by moving because staffing levels were conventional it would surely have moved.

Thus while the payment and supervision of labor had an unusual character in India there is no reason to believe that the labor market institutions themselves should have significantly reduced labor efficiency. Workers in India had low labor intensities because they choose them themselves.

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