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Why Isn't the Whole World Developed? Lessons from the Cotton Mills

GREGORY CLARK

In 1910 one New England cotton textile operative performed as much work as 1.5 British, 2.3 German, and nearly 6 Greek, Japanese, Indian, or Chinese workers. Input substitution, and differences in technology, management, and workers' training or inherent abilities do not explain this. Instead local culture seems to have determined worker performance. Such differences, if widespread, would explain much of the international variation in wages. They also have important consequences for understanding labor migration, the choice of technique, and the sources of economic growth.

Why isn't the whole world developed? No concern is more central to economic history than economic development or underdevelopment. Yet often scholars merely discredit older explanations of underdevelopment, such as poor resource endowments, or the lack of markets, or the absence of economic rationality, without proposing any new line of research.[1] Perhaps the most prevalent modern view is that poor countries have remained poor because they cannot absorb the technologies of the advanced industrialized countries. To explain this, some cite the lack of education in poor countries; others, the lack of management skills or an entrepreneurial tradition, the lack of appropriate institutions, or the economies of scale inherent in the new industrial technologies which hinder their small-scale or isolated adoption.[2]

In this article I examine underdevelopment through a detailed study of one industry, cotton textiles, in the early twentieth century. For most of the countries I studied, factory production of textiles was a first step on the path to industrialization. I conclude that the failure of poor

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[1] Floud and McCloskey's recent compilation on the economic history of Britain, although an excellent presentation of recent research, suffers this problem. We learn much more about what did not cause British economic development than about what did. See Roderick Floud and Donald McCloskey, eds., *The Economic History of Britain since 1700* (Cambridge, 1981).

[2] See, for example, Richard Easterlin, "Why Isn't the Whole World Developed?" this JOURNAL, 41 (Mar. 1981) pp. 1–19; David Landes, *The Unbound Prometheus* (Cambridge, 1969); Albert Hirschman, *The Strategy of Economic Development* (New Haven, 1966); Nathan Rosenberg, *Perspectives on Technology* (London, 1976).

countries to dominate textile production in the way their labor cost advantage would suggest proceeds overwhelmingly from inefficient labor rather than from failure to import technology or management skills, or from failure of local capital or input markets, or from scale economies within the textile factories or at the industry level. In cotton textiles all these problems proved minor. Because of this the reasons for the inefficiency of low-wage labor must be the focus of any explanation of the underdevelopment of these countries.

COTTON TEXTILES

When Britain launched the modern factory system in textile production in the late eighteenth century, people had every reason to expect that the Industrial Revolution would soon be a worldwide phenomenon. The new textile technologies were not particularly complex, most textile factory jobs did not require great skill, and every country had a ready local market for yarn and cloth. Despite attempts by the British to prevent the export of industrial technology—the emigration of artisans was prohibited until 1825, and most machinery exports were forbidden until 1842—the new machinery and methods spread quickly to North America and to Europe. By 1825, despite the prohibitions, an estimated two thousand British artisans had emigrated to the Continent.[3] Thus while Britain established the first modern spinning factory in 1771, the French had established one by 1778, one was built in the Ruhr by 1784, the United States and Prussia had spinning mills by 1791, Russia had its first spinning mill by 1793, Switzerland by 1794, the Netherlands by 1795, and Belgium and Saxony by 1799.[4] Even India, 12,000 miles by sea from Britain and very underdeveloped, joined the group in 1817, when a British trading firm shipped out to Calcutta a modern mill powered by steam.[5] Nicolas Koechlin, a prominant Alsatian cotton manufacturer, reported in 1834 that when several leading Alsatian cotton manufacturers visited English factories in 1833 they "saw nothing particularly interesting" and "except in the high numbers, Alsace was not a whit behind hand."[6] Moreover, the Continental manufacturers apparently had great advantages in terms of the cost of labor in the 1830s. Hourly wages compared with Manchester were about 37 percent in Mulhausen in the Alsace, 28 percent in Zurich, 25 percent in some mills in the Vosges, 38 percent in Ghent in Belgium, 47 percent in Rouen, about 36 percent in Austria, and less than 25 percent in

[3] W. O. Henderson, *Britain and Industrial Europe, 1750–1870* (2nd edn., London, 1965), pp. 4–9; and Landes, *The Unbound Prometheus*, p. 148.

[4] Alan S. Milward and S. B. Saul, *The Economic Development of Continental Europe, 1780–1870* (London, 1973), pp. 190, 296, 299, 303; and Henderson, *Britain and Industrial Europe*, p. 143.

[5] S. D. Mehta, *The Cotton Mills of India, 1854 to 1954* (Bombay, 1954), p. 5.

[6] Andrew Ure, *The Cotton Manufacture of Great Britain* (London, 1836), p. lxxv.

Prussia.[7] Continental manufacturers did face higher costs for capital, machinery, repairs, and power (if they were using coal). But in 1834 wages were about two-thirds of the conversion costs (the cost of turning raw cotton into yarn or cloth) in spinning in Manchester, so that the costs of capital, machinery, repairs, and power would have to be at least 128 percent higher in Alsace to equalize costs, and 150 percent higher in Prussia.[8] The cost differences reported by Koechlin are only of the order of 70 percent for Alsace.[9] As these textile industries developed, there was every expectation that such cost differentials would decline substantially, when the size of the local machinery and the repair and capital markets increased, and so too would decline British dominance of export markets.

Yet despite the great labor cost advantages of the Continental countries, and the even greater labor cost advantages of the Asiatic countries, few of them were able to compete with the British outside their protected home markets before World War I. In 1911, 140 years after the establishment of the first spinning mill, 40 percent of the factory cotton spindles in the world were still in Britain; of those outside Britain 22 percent were in the United States or Canada, the only countries with higher wage costs than Britain. Germany, France, Russia, Belgium, Switzerland, Italy, Spain, Portugal, Austria, India, Japan, China, Mexico, and all the other low-wage competitors had only 39 percent of the world stock of spindles.[10] More importantly in 1911 Britain still accounted for 81 percent of the net exports of cotton yarn and cloth in international trade.[11] Britain faced little competition in unprotected markets, since except for the Asiatic countries with their extraordinarily low wages, manufacturing costs in all the low-wage countries were higher than in Britain, making tariff protection necessary if the British were not to overwhelm even their domestic markets.

Recently scholars have excoriated the managers of the British textile industry for their alleged failure to choose the correct techniques in spinning and weaving in the late nineteenth and early twentieth centuries. The decline of the British industry from the 1920s onwards is attributed to these managerial failures.[12] Focusing on management

[7] Ibid., p. xliii, lxxvii.

[8] Ibid., p. lxxviii.

[9] Ibid.

[10] U.S. House of Representatives, Report of the Tariff Board, *Cotton Manufactures* (Washington, D.C., 1912), table 21, p. 46.

[11] Ibid., tables 106, 107, pp. 214–19. World net exports is calculated as the sum of the net sales of yarn and cloth by countries which are net exporters of cotton goods.

[12] See William Lazonick, "Factor Costs and the Diffusion of Ring Spinning in Britain Prior to World War I," *Quarterly Journal of Economics*, 96 (Feb. 1981), pp. 89–109. Also Lazonick, "Competition, Specialization and Industrial Decline," this JOURNAL, 41 (Mar. 1981), pp. 31–38. An earlier criticism of the failure to integrate mills can be found, for the case of the introduction of automatic looms to Britain, in M. Frankel, "Obsolescence and Technological Change in a Maturing Economy," *American Economic Review*, 45 (June 1955), pp. 296–319.

failings seems to me misguided for two reasons. First, given the labor cost advantages of Britain's competitors, what really requires explanation is not the ultimate demise of the British industry but why British textiles continued to thrive for so long. Second, the specific failures attributed to British managers prior to 1914 had very little impact on total costs and should have been completely swamped by labor cost effects. For example, one of the major mistakes attributed to British managers was a failure to switch from mule spinning to ring spinning.[13] William Lazonick has argued that this failure stemmed from the more fundamental error of retaining the horizontal specialization of the British industry into spinning and weaving factories. With separate spinning and weaving mills, yarn has to be shipped from the spinning mills to the weaving sheds. It cost more to ship the ring weft (filling) yarn than to ship mule weft yarn, which he argued made it less costly to retain mules for weft spinning.[14] When this transport cost is calculated, however, the most it could have cost the British for sticking with mules for this reason could be only 1.4 percent of total value added in cotton textile manufacturing.[15] In comparison, British wages per hour were about 6.5 times those of the Indian industry, and since labor costs were about two-thirds of the value added in the industry, the British suffered a 57 percent cost disadvantage on account of wages. The correct question is not why bad choice of technique doomed the British industry, but why an industry apparently so burdened by high costs for its major input could remain so long successful, competing against a host of low-wage competitors.

To illustrate the magnitude of Britain's competitive disadvantage, consider the costs of inputs other than labor in cotton textile production. Cotton was the major input, accounting for about two-thirds of the total cost of cotton cloth, but its cost to Britain's competitors was generally the same or less. Britain had to import all its cotton, and in 1910 it actually cost slightly more to ship cotton from New Orleans to Liverpool than to ship it to Fall River in New England, or to Bremen, Le Havre, Antwerp, or Genoa on the Continent. Once the costs of getting the cotton from the port to the mills are included, the major New England textile towns had an advantage of about $0.0015 per pound over Lancashire mills using American cotton, and on average French

[13] See Rockwood Chin, *Management, Industry and Trade in Cotton Textiles* (New Haven, 1965), p. 85. See also Lazonick, "Factor Costs," pp. 104–7.

[14] Lazonick, "Factor Costs," pp. 102, 104–7.

[15] It cost $0.00446 per pound more to ship ring weft yarn between factories than to ship mule weft yarn, weft yarn forming the cross threads in weaving cloth. The cost of manufacturing standard gray cloth in Britain, exclusive of the cotton, is given in the U.S. Tariff Board report at $0.123 per pound of cloth. The saving of transport costs would only apply to half the yarn, and 25 percent of British spindles were in integrated mills anyway, giving the total extra transport cost as 1.36 percent of the manufacturing cost. (U.S. House of Representatives, Report of the Tariff Board, *Cotton Manufactures*, p. 471).

and German mills had higher costs in the order of $0.0001 per pound because their mills were further inland.[16] The cost disadvantages of French and German mills were trivial, amounting only to a 0.1 percent increase in their total manufacturing costs. India, China, the southern United States, Peru, Brazil, and Egypt grew their own cotton. Only for Mexico and Switzerland did transportation significantly raise cotton costs. There were three other major types of input: buildings, machinery, and supplies (shuttles, bobbins, machine oil, belting, sizing); coal for power and heating; and the capital invested in plant, equipment, stocks of cotton, and work in progress. The great standardization of the international textile industry allows us to estimate the costs of all the inputs for a variety of countries.

Table 1 shows the cost of labor per 55–hour week, the cost of coal per ton, and the cost of a complete spinning and weaving mill (including erection costs) in 15 countries or regions, the data gathered principally from the Special Agents Series of the U.S. Bureau of Foreign and Domestic Commerce. These reports, together with the U.S. Tariff Board report on Cotton Manufactures and other sources, provide a detailed summary of conditions in the international industry around 1910. As the table shows, labor costs varied by extraordinary amounts, Chinese labor costing 10.8 percent of that in Britain, and a mere 6.1 percent of that in the United States. It is true that other costs offset the labor cost advantages of the low-wage countries. The mill and the machinery could cost 100 percent more than in Britain, because most countries imported their machinery from Britain, and thus had to pay transport fees and import duties. Sometimes English mechanics had to be imported to erect the machinery. Shipping added about 25 percent to the cost of English machinery which was imported by U.S. mills, and about 20 percent overall to the cost of French mills built with English machinery.[17] Interestingly, import duties rather than real cost elements were often the most significant factor in increasing costs. Russia in 1911 had a tariff on English machinery which was effectively 45 percent ad valorem, and the total cost of an erected mill in Russia was 63 percent greater than in England.[18] Although both India and China were remote

[16] See Melvin Copeland, *The Cotton Manufacturing Industry of the United States* (Washington, D.C., 1912), pp. 284–86. Because of the extensive development of the Liverpool cotton market, English spinners were able to economize through keeping smaller stocks of cotton at the mills than those of other countries, including the United States. French mills, for example, were reported to have had twice the stocks of cotton that the British mills had (R. B. Forrester, *The Cotton Industry in France* [Manchester, 1921], p. 30). Someone had to hold the cotton stocks, however, between their shipment to Europe in the fall and their eventual use in manufacturing. The merchants of Liverpool who fulfilled this function presumably were appropriately rewarded for the capital they had tied up in these stocks, through receiving a higher price when cotton was passed on to the mills.

[17] Copeland, *The Cotton Manufacturing Industry*, p. 317; Forrester, *Cotton Industry in France*, p. 31.

[18] Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 51, *Cotton Goods in Russia* (Washington, D.C., 1912), pp. 14–15.

TABLE 1
COTTON TEXTILE COSTS AND PROFITS AS IMPLIED BY INPUT PRICES, c.1910

Country or Region	Weekly Wage Rate	Plant and Machinery (dollar/spindle)	Coal (dollar/ton)	Manufacturing Cost (England = 1.00)	Implied Profit Rate
New England	$8.8	$17.43	$3.80	1.59	−8.9%
United States (South)	6.5	17.43	3.80	1.30	−0.7
England	5.0	12.72	2.50	1.00	8.0
Germany	3.8	18.48	4.88	1.00	7.9
France	3.7	16.54	4.67	0.95	9.5
Switzerland	3.7	24.80	6.62	1.15	4.7
Austro-Hungary	2.8	16.38	5.75	0.85	12.6
Spain	2.7	19.33	6.50	0.91	10.5
Mexico	2.6	19.27	10.00	0.94	9.6
Russia	2.4	20.69	7.20	0.91	10.3
Italy	2.4	16.00	7.25	0.81	13.8
Portugal	1.72	17.50	7.00	0.76	15.0
Japan	0.80	24.57	2.58	0.73	14.1
India	0.78	17.56	5.02	0.61	19.1
China	0.54	16.32	3.25	0.53	22.1
Share in costs in England	0.618	0.124	0.034		

Note: The wage rate quoted is the average wage per worker per 55–hour week, not controlling for the sex and age composition of the labor force. The manufacturing cost in column 4 includes as the cost of capital a rate of return of 8 percent on the capital employed. The capital employed per spindle in each country is column 1 of Table 2. The return on capital constituted the remaining 22.4 percent of manufacturing cost in England.
Sources: See Appendix.

from the English machine makers, and had to rely heavily on British mechanics to erect their mills since they were very underdeveloped, their mills cost only 38 percent and 28 percent more than in Britain.[19] Many countries, including France, Spain, Portugal, Italy, Mexico, Russia, Brazil, and Peru obtained at least some of their coal for power from Britain, so their higher coal costs actually reflect the transport costs which were heavy in proportion to the value of coal at the pithead in Britain. But Japan and China had access to cheap Japanese coal. The greater costs of mills in other countries implied that more capital was tied up in the manufacturing process outside Britain, which increased capital costs. While all these charges were greater for Britain's compet-

[19] Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 107, *Cotton Goods in China* (Washington, D.C., 1916), pp. 175–76. W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 13, *Cotton Fabrics in British India and the Philippines* (Washington, D.C., 1907), pp. 23–24. Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 157, *Cotton Goods in British India, Part VI* (Washington, D.C., 1918), p. 39.

itors, nonetheless in 1911 Britain's direct labor inputs constituted about 61.8 percent of the costs of converting cotton into cloth. Depreciation of plant and machinery plus supplies were together only about 12.4 percent of costs, coal was 3.4 percent, and interest costs on capital (assuming a return of 8 percent) were the remaining 22.4 percent.[20] The huge advantage most of Britain's competitors had in labor costs thus outweighed their disadvantages in the costs of other inputs.

The last two columns of Table 1 show the total cost (including capital costs) relative to British costs of manufacturing cotton into cloth in each country and the profit rate this implied on the capital employed, assuming each industry was selling in the same market. The amount of capital per spindle in each industry was constructed by assuming that plant and equipment was on average 25 percent depreciated and that there was a constant value of stocks of cotton and work in progress per spindle across countries. Since I assume that all the countries use inputs in the proportion the British did despite their relative prices being very different, the costs and implied profit rates shown for other countries are minimum estimates, for my assumption ignores the possibility of economizing by changing the proportions of inputs in response to local cost conditions. In countries where coal was expensive, for example, more efficient but more expensive steam engines were employed. If coal had to be transported long distances, more calorific types were used, so that the quoted expense overstates the cost per unit of power obtained.[21] And capital and machinery could be economized upon by running machinery for longer hours. Even so, 10 of the 12 countries in Table 1 with lower labor costs than Britain should have had lower conversion cost and consequently higher profit rates on sales to the international market than British producers, based only on the relative cost information. Further, since many countries protected their domestic textile markets, profit rates for mills producing for these markets should have been even higher than those shown in Table 1. No evidence suggests low-wage producers ever realized the profits predicted here.

Table 1 does not take into account economizing on capital through the use of night work or longer work weeks. Table 2 shows the hours per year that mills in various countries operated around 1910, and the effect this had on the capital employed per spindle per year of output. In some cases, particularly Japan and Mexico, mills operated more than twice as long as in England. Table 2 also shows the manufacturing costs and the

[20] The share of labor, depreciation and repairs, coal, and capital in the manufacturing cost of plain cloth in a British mill can be calculated independently from two sources. The U.S. House of Representatives, Report of the Tariff Board, *Cotton Manufactures*, pp. 462–67, 470–71, appendix D, pp. 799–820; tables 209, 210, pp. 662–65; and G. von Schultze-Gaevernitz, *Cotton Trade in England and on the Continent* (London, 1895), pp. 157–58. The cost shares these sources imply agree fairly closely.

[21] See Forrester, *Cotton Industry in France*, p. 36.

TABLE 2
IMPLIED PROFIT RATES IN COTTON TEXTILES ADJUSTING FOR CAPITAL UTILIZATION, c.1910

Country or Region	Capital per Spindle	Hours per Year	Adjusted Capital per Spindle	Manufacturing Cost (England = 1.00)	Implied Profit Rate
New England	$18.60	3000	$17.62	1.57	−9.4%
United States (South)	18.60	3450	16.04	1.26	−0.8
England	15.06	2775	15.06	1.00	8.0
Germany	19.38	3000	18.35	0.99	8.3
France	17.93	3300	15.96	0.92	10.7
Switzerland	24.12	3250	21.41	1.10	5.3
Austro-Hungary	17.81	3300	15.86	0.83	14.1
Spain	20.02	4455	14.56	0.84	14.4
Mexico	19.98	6750	11.47	0.82	16.6
Russia	21.04	4061	16.13	0.84	13.5
Italy	17.52	3150	16.10	0.79	15.0
Portugal	18.65	3300	16.56	0.74	16.9
Japan	23.95	6526	13.36	0.62	25.2
India	18.70	3744	15.29	0.58	23.4
China	17.76	5302	11.93	0.48	32.9

Sources: See Appendix.

profit rates implied by these hours of operation, given the costs of inputs displayed in Table 1. With capital utilization considered, the profit rate (selling against British competition) in China should have been 32.9 percent not merely 22.1 percent, compared with the British rate of 8 percent. Also total manufacturing costs would be less than half those of Britain. With operating hours taken into effect, only Switzerland, among the low-wage countries, had a lower profit rate than Britain in international markets. Yet in practice only the Japanese, Indian, and Chinese mills provided any competition.

The magnitude of these cost advantages can be appreciated in two ways. The first is to consider that $1 million invested in the Lancashire cotton industry to produce cloth for the Chinese market would accumulate at an 8 percent rate of return to $4.66 million in twenty years. If instead the same money were invested directly in the Shanghai industry, it would, based on this cost data alone, accumulate in twenty years to at least $54.24 million. If we also consider the differences in capital utilization, then the $1 million invested in China should have produced $295.46 million. British firms which invested $1 million for twenty years in the Indian industry should have accumulated $67.04 million. If the investors in India and China had ploughed these putative profits back into the industries, they would have grown at a minimum, without any outside investments, at rates of 23.4 percent and 32.9 percent. While Chinese and Indian mills were profitable prior to 1914, they were not this profitable, and production did not expand anywhere near as fast as these profit rates would suggest.[22] The Indian industry grew at an annual rate of 5.1 percent in the twenty years before 1910, and the Chinese industry at 10 percent per year between 1895 and 1915. If there was such a difference in profit rates, why did Lancashire experience a major expansion between 1900 and 1910?

The second way to see the magnitude of cost advantages in low-wage countries is to consider what wages they should have been able to pay and still achieve the 8 percent rate of return on capital assumed for British mills. The Chinese, selling against British competition, were paying only $0.54 per 55 hours, or 10.8 percent of the British wage. But given the costs of their nonlabor inputs, they should have been able to pay $4.30 per week, or 86 percent of the British wage. And if we also consider their greater utilization of capital, they should have been able to pay $5.01 per week, roughly the same as the British wage. The cost disadvantages of the low-wage countries explain little of their low wages.

LABOR EFFICIENCY

The British remained competitive for so long despite their high labor costs because worker efficiency corresponded closely with the real wage in each country. I use the word efficiency rather than skill because skill connotes a learned ability, and I argue that workers in different countries performed differently not just because they were trained differently or had different levels of experience in the textile industry.

The prima facie case for differences in worker efficiency comes from examining how many machines each worker tended. The broadest measure is an index of the number of spindles and looms per worker. Since the relative importance of spinning and weaving varied across countries, the index is constructed by giving looms a weight of 1, ring spindles a weight of 0.011, and mule spindles a weight of 0.008. This corresponds to the relative numbers of workers needed to man weaving sheds, ring spinning mills and mule spinning mills in Britain in 1910. The measure shown in Table 3 is thus the number of "loom-equivalents" per worker in cotton textiles. Since some countries worked shifts, which would reduce the apparent machines per worker, the index is adjusted to a per-shift basis. The index varies from 0.46 in Greece to 2.97 in New England, or by a factor of 6.46:1. That is, in 1910 each worker in New

[22] Morris D. Morris, *The Emergence of an Industrial Labor Force in India* (Berkeley, 1965), p. 29, reports figures showing profit rates of 27.1 percent on average between 1905 and 1914 in the Bombay industry. This rate greatly overstates the real returns since it includes depreciation on capital and is calculated on the nominal share value of the firms. Since any earlier profits which were not paid out in dividends are added to the capital value of the firm, the real capital stock could be many times the nominal share value. Profits net of depreciation and payments to the mill managing agents averaged only 10.3 percent, but these are still profits as a percentage of the nominal share value.

TABLE 3
IMPLIED COSTS AND PROFITS IN COTTON TEXTILES ADJUSTING FOR WORKER EFFICIENCIES, c.1910

Country or Region	Weekly Wage Rate	Machinery per Worker (loom-equivalent)	Corrected Yearly Labor Cost	Manufacturing Cost (England = 1.00)	Implied Profit Rate
New England	$8.8	2.97	$6.04	1.25	0.9%
Canada	8.8	2.53	7.10		
United States (South)	6.5	2.65	5.00	1.12	4.6
England	5.0	2.04	5.00	1.00	8.0
Germany	3.8	1.28	6.06	1.28	0.1
France	3.7	1.11	6.80	1.33	-1.9
Switzerland	3.7	1.40	5.39	1.36	0.0
Austro-Hungary	2.8	1.24	4.61	1.07	5.8
Spain	2.7	0.91	6.05	1.32	-0.7
Mexico	2.6	1.15	4.61	1.19	2.9
Russia	2.4	1.10	4.45	1.16	3.8
Italy	2.4	0.88	5.56	1.20	1.8
Portugal	1.72	0.88	3.99	1.04	7.0
Egypt	1.69	0.81	4.26		
Greece	1.38	0.46	6.12		
Japan	0.80	0.53	3.08	1.01	7.7
India	0.78	0.50	3.18	0.91	10.6
China	0.54	0.48	2.30	0.75	15.5

Note: The implied costs and profit rates in this table are based on input prices alone and do not allow for differences in capital utilization. Brazil and Peru are omitted from this table, though there is information on their manning levels, because the money wages quoted for textile wages in Brazil and Peru do not appear to correspond to the real wage. Nominal wages in Brazil were equal to those in the United States (South), but real wages were by all indications far lower.
Sources: See Appendix.

England tended more than six times as much machinery per shift as did workers in the Greek industry. This aggregate measure is contaminated by a number of differences between countries: different types of machinery were used (the important difference was the proportion of plain to automatic looms, but in 1910 only North America used automatic looms widely); different proportions of women and children were employed; machines produced different outputs per hour; and the yarn and cloth differed in fineness and quality. But I will show that these overall differences in machinery per worker correspond fairly well with differences in the efficiencies of workers and perhaps even understated the spread of efficiencies because of differences in output per machine.

Figure 1 illustrates that the efficiency of workers was very closely connected to the local real wage rate. Better-paid workers were more efficient, though it is of course not obvious what is cause and what is effect (an important issue considered below). But first, what effect did these differences make to the costs and profit rates in the different textile industries? The last three columns of Table 3 show the real labor costs

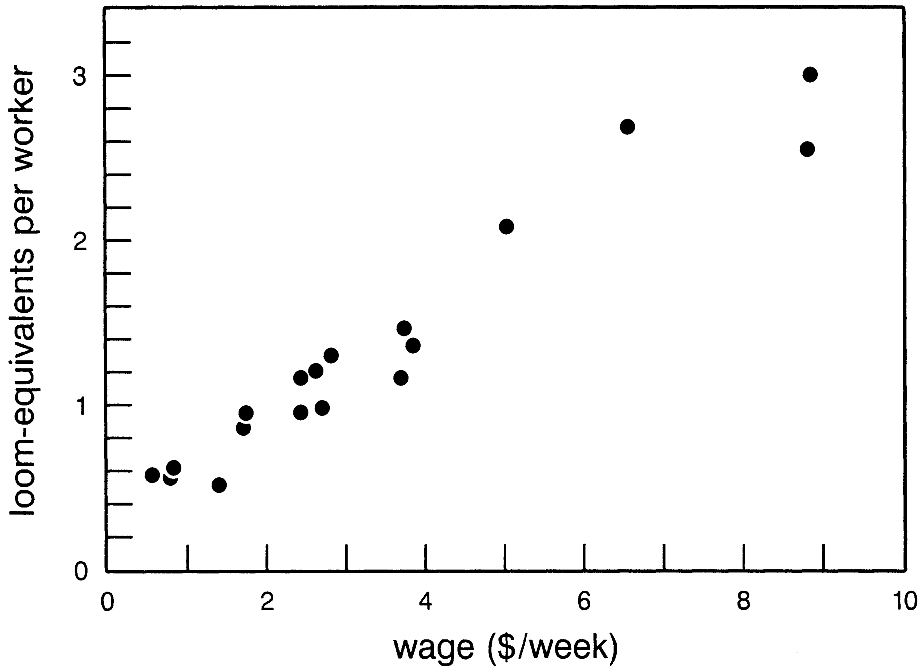

FIGURE 1
LOOM-EQUIVALENTS PER WORKER IN THE COTTON INDUSTRY, 1910

Source: See Table 3.

of the different industries, and the implied costs and profit rates once the efficiency of the local labor is taken into account. Real labor costs turn out to be as high as those in Britain in most countries except for the very low-wage competitors in Asia, so the per-worker wage rate actually tells us very little about the true cost of labor. The only industries with lower costs than Britain, based on factor prices alone, were China and India. Even if we correct for capital utilization, only Japan, India, and China have lower costs and higher profits in competition with the British. Thus taking into account differences in labor efficiency, the only countries which ought to have been able to compete with the British on international markets were India, Japan, and China—the only countries which did in fact compete.

Differences in worker efficiency on the order of 6.5:1 at the extreme will astonish many readers. They may attribute the difference to a number of causes, the first being that the aggregate measure of machines per worker does not take into account each country's selection of machinery types. Only North America, however, had by 1910 adopted the automatic loom on a large scale, which undoubtedly did somewhat inflate the number of loom-equivalents per worker in America. But a detailed examination of the staffing levels on ten particular machines, from those in the preparatory processes (such as carding) through the

TABLE 4
MACHINES PER OPERATIVE, c.1910

Country or Region	Average Weekly Wage	Loom-Equivalents per Worker	Index of Machines per Worker	Ring Spindles per Worker	Plain Looms per Worker
New England	$8.8	2.97	1.55	902	8.0
Canada	8.8	2.53	1.41	750	6.0
United States (South)	6.5	2.65	1.44	770	6.0
Britain	5.0	2.04	1.00	625	3.8
Germany	3.8	1.28	0.63	327	2.9
France	3.7	1.11	0.81	500	2.8
Switzerland	3.7	1.40	0.70	450	2.7
Austro-Hungary	2.8	1.24	0.65	403	2.8
Spain	2.7	0.91	0.73	450	2.0
Mexico	2.6	1.15	0.77	540	2.5
Russia	2.4	1.10	0.77	450	2.0
Italy	2.4	0.88	0.76	436	2.0
Portugal	1.72	0.88	0.65	384	2.0
Egypt	1.69	0.81	0.39	240	1.5
Greece	1.38	0.46			
Japan	0.80	0.53	0.52	190	1.6
India	0.78	0.50	0.33	214	1.9
China	0.54	0.48	0.34	168	1.5
Peru		1.17	0.78	391	3.5
Brazil		0.88	0.67	527	3.0

Notes: The United States and Canada used underpick looms and these were somewhat slower than the standard loom used elsewhere. In Brazil and Peru the nominal wages clearly exceeded the real wage greatly, but no price deflator is available.
Sources: See Appendix.

machines putting twist into the yarn and drawing it into finer strands, up to the final weaving of the yarn into cloth, reveals the same pattern as the aggregate data. Table 4 gives staffing levels on a few of these processes as illustration, and an overall index of staffing levels which controls for differences in the relative number of machines in each country. It shows the same overall pattern as the uncorrected index, though the machinery staffing index does not take into account differences in the number of ancillary workers per machine, where overstaffing appears to have been even greater in low-wage countries. Whatever aspect of textile production is examined, the same fact emerges—low-wage countries employed many more workers per machine. Could anything other than the personal efficiency of workers explain these differences?

CAPITAL-LABOR SUBSTITUTION

At first blush the correlation of wage rates and machines per worker is expected and comforting to those who have invested in an education in economics as an illustration of the influence of relative prices on production choices. And many writers on cotton textiles have uncritically embraced this explanation.[23] How then can we attribute the differences in machinery per worker to differences in the personal efficiency of workers? The answer is that employing more labor per machine is a rational economic response by mill owners to low wages only if they save on some other input as a result. The savings that come most obviously to mind are those of capital, through getting more output per machine. Yet the Special Agents Reports and other sources for 1910 show that low-wage countries were generally getting lower output per machine than the countries with high wages. In Switzerland machinery generally ran more slowly.[24] Clark reports that in Austria: "The mills based their speeds on the English catalogues and production tables and run as near the speeds given as the quality of their help and material will permit."[25] For France, Forrester noted only that "much of the machinery runs just as fast as in Lancashire."[26] Ring spindles on the continent ran at an average speed which was "at least as low as in England," and lower than the speed in New England, the region with the highest wages.[27]

One of the tasks in spinning mills was doffing, which consisted of removing full spools of yarn from the spinning machines. This task would not allow much opportunity for substituting labor for capital, since the speed and output of the machines was independent of how many doffers were used. Yet where the numbers of spindles per doffer are recorded they show the same pattern as overall manning levels.

Table 5 compares output per machine per hour in ring spinning and in weaving around 1910 in a number of different countries, controlling for the fineness of the yarn and the width and type of cloth. The outputs given are ounces per ring spindle spinning 20s count yarn per hour, and yards of plain cloth produced per loom weaving 36–inch-wide cloth with 40 to 50 threads per inch. Table 5 clearly shows that low-wage countries were not getting greater utilization of their capital except through running longer hours. In fact they seem to have gotten significantly lower output per hour around 1910. There is other, more fragmentary evidence for this. The efficiency of spindles or looms was defined as the percentage of a machine's theoretical production, determined by the speed the machine was set to run at, which was actually achieved. British and American manufacturers seem to have assumed that ring spindles would achieve 90 percent efficiency and looms on plain cloth

[23] See, for example, Morris, *The Emergence of an Industrial Labor Force in India*, pp. 32, 203.

[24] See S. L. Besso, *The Cotton Industry in Switzerland, Vorarlberg, and Italy* (Manchester, 1910).

[25] W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 24, *Cotton Fabrics in Middle Europe* (Washington, D.C., 1908), p. 127.

[26] Forrester, *Cotton Industry in France*, p. 41.

[27] Copeland, *The Cotton Manufacturing Industry*, p. 299.

TABLE 5
OUTPUT PER MACHINE PER HOUR, c.1910

Country	Wage	Hourly Output per Spindle (in ounces)	Hourly Output per Loom (in yards)
United States	$8.0	0.601 oz.	5.17 yd.
England	5.0	0.651	6.07
Austria	2.8	0.487	
Italy	2.4	0.670	
Japan	0.80	0.628	5.96
India	0.78	0.562	
China	0.54	0.515	4.01

Source: W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 13, *Cotton Fabrics in British India and the Philippines* (Washington, D.C., 1907), p. 70; W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 18, *The Cotton Textile Trade in the Turkish Empire, Greece and Italy* (Washington, D.C., 1908), p. 90; W.A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 24, *Cotton Fabrics in Middle Europe* (Washington, D.C., 1908), pp. 130–131; W.A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 86, *Cotton Goods in Japan* (Washington, D.C., 1913), pp. 191, 194; Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 107, *Cotton Goods in China* (Washington, D.C., 1916), pp. 162, 164, 166–67.

87.5 percent efficiency.[28] Spindle efficiency was reported at 90 percent in Japan, but only 77 percent in Russia, and loom efficiency 87.5 percent in Japan, but only 80 percent in Russia, and 77.5 percent in Italy.[29]

The 1920s offer more comprehensive and detailed evidence on output per ring spindle for a variety of yarn finenesses in the United States, Britain, Japan, India, and China.[30] The spinning machinery of the 1920s was essentially the same as that of 1910.[31] The evidence from the 1920s also gives details of the amount of twist put into the yarn in each country, which improves the measure, since the more twist put in, the less a ring spindle will produce (if it is running at the same number of revolutions per second). The 1920s evidence suggests that if British

[28] U.S. House of Representatives, Report of the Tariff Board, *Cotton Manufactures*, table 153, pp. 490–93.

[29] W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 86, *Cotton Goods in Japan* (Washington, D.C., 1913), pp. 191, 194; Odell, *Cotton Goods in Russia*, p. 16; Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 48, *Cotton Goods in Italy* (Washington, D.C., 1912), p. 24.

[30] The information on outputs and twist per inch for Japan, India, and China is from Arno S. Pearse, *The Cotton Industry of Japan and China* (Manchester, 1929); Arno S. Pearse, *The Cotton Industry of India* (Manchester, 1930); and Charles K. Moser, *The Cotton Textile Industry of Far Eastern Countries* (Boston, 1930). For the United States the output and corrections for twist per inch are from the National Association of Cotton Manufacturers, *Year Book, 1928*, p. 212. For England the outputs are given in James Winterbottom, *Cotton Spinning Calculations and Yarn Costs* (2nd edn. London, 1921), pp. 204–15.

[31] See Gary Saxonhouse, "Productivity Change in the Japanese Cotton Spinning Industry, 1891–1935" (Ph. D. thesis, Yale University, 1971), p. 123.

output per spindle hour was 100, then that in the other countries was: United States 105, Japan 115, India 99, China 117.

Thus by the 1920s some evidence suggests that Japanese and Chinese mills were utilizing their capital more intensively than British mills were. So, however, did the U.S. mills, which faced higher wages. And Indian mills, with wages as low as those of Japan, showed no evidence of any difference in spinning technique. Even in the 1920s the differences in utilization rates did not dramatically favor the low-wage countries.

Suppose that in 1910, the evidence to the contrary, differences in machine utilization favored low-wage countries on the order of the 15 percent observed for Japan and China in the 1920s. How much of the extra labor per machine in low-wage countries could such differences in capital utilization explain? What fraction of the overall differences in machinery per worker observed in Table 3 could capital-labor substitution at best explain?

The maximum amount of extra labor per machine that increased output per machine could explain is given, where the increased labor in the low wage countries is so large that, the cost per unit of output using the British staffing levels in the low wage country equals the cost of using higher staffing levels and getting more output per machine; that is,

$$rM + wL_B = (rM + wL)/(1 + u)$$

where, M = machinery per unit of output with British technique
L_B = labor per machine with British technique
L = labor per machine in the low-wage country
r = interest cost on the machinery
w = wage in the low-wage country
$1 + u$ = output per machine per hour in the low-wage country compared with Britain.

Rearranging terms and setting $l_B = L_B/M$, $l = L/M$, w_B = the wage in Britain, and $z = rM/w_BL_B$, the ratio of the interest costs of the capital embodied in the machinery to the labor costs in Britain, we get:

$$r + wl_B = (r + wl)/(1 + u), \text{ which implies}$$
$$l = l_B + u(l_B + r/w), \text{ which in turn implies}$$
$$l = l_B[1 + u(1 + zw_B/w)]$$

Thus workers per machine in a low-wage countries could be driven above those in Britain by a factor of $u(1 + zw_B/w)$ at the most because of capital-labor substitution. In 1910 in Britain z was roughly 0.142/0.618 = 0.23. The number of workers per machine in China was 4.25 times those in Britain, and in Japan it was 3.85 times those in Britain. If these low-wage countries had been able to get 15 percent more output per machine, it would thus have explained *at most* an increase of workers per machine of,

$$\text{China } 0.15(1 + 0.23 \times 5.0/0.54) = 0.47$$

$$\text{Japan } 0.15(1 + 0.23 \times 5.0/.80) = 0.37$$

relative to the numbers of workers per machine in Britain. That is, only about 14.5 percent of the extra workers per machine in China, and only about 13 percent of the extra workers in Japan could possibly be explained by increases in output per machine. And it must be emphasized that no evidence suggests that any low-wage country was getting more output per machine than the British in 1910. For both 1910 and the 1920s India shows no greater machine utilization than Britain, so that capital-labor substitution can explain none of the extra 3.08 workers per British worker. Capital-labor substitution is thus irrelevant in explaining the excess manning of the low-wage countries. Also Japan and China were only getting 10 percent more output per spindle per hour than the United States in the 1920s, but since China employed about six times as many workers per machine as the United States, the amount of this gap that would be explained would be less than 10 percent.

RAW MATERIALS-LABOR SUBSTITUTION

It was possible to some extent, in some processes, to save on cotton costs by using more labor. The price of cotton increased with the fiber length, and though yarn of a given fineness could be produced with cottons of various fiber lengths, the yarn was weaker if cheaper cotton was used. Weaker yarns broke more often in the manufacturing process, requiring more labor to repair the broken threads, but this could save on total costs if labor was cheap. Can we explain all or a significant part of the extraordinary manning levels in the low-wage countries by such a cost-minimizing strategy? The answer is no for five separate reasons. Only a few countries with high manning levels used inferior cotton. Those which did employed inferior cotton only on the coarser counts of yarn, though in these countries overmanning was just as great as machines making finer yarns. Even processes entirely unaffected by cotton quality, such as doffing, were overstaffed to as great an extent in low-wage countries. In processes where cotton quality did matter, workers did not spend much more time repairing yarn breakages. And finally where cheap cotton was used, it did not clearly create real cost savings since the value of the output appeared to be correspondingly reduced.

Evidence on the quality of cotton inputs is hard to obtain. But certainly not all low-wage countries used cotton inferior to that the British used for a given count of yarn. For France it was reported that, "a somewhat superior grade of cotton is required to produce the same

TABLE 6
RING YARN STRENGTH IN THE 1920s

Yarn Count	United States	Britain	Japan	India	China
10–19	100	91		60	80
20–29	100	100	79	74	82
30–39	100	115	115	97	110
40–49	100	119	101	95	115
50	100	122		95	
60	100	115		122	
70	100	107		125	
100	100			200	

Note: There are 13 observations on Japanese yarns, 42 on Indian yarns, and 17 on Chinese yarns.
Sources: The information on yarn strengths in Japan, India, and China comes from Arno S. Pearse, *The Cotton Industry of Japan and China* (Manchester, 1929); Arno S. Pearse, *The Cotton Industry of India* (Manchester, 1930); and Charles K. Moser, *The Cotton Textile Industry of Far Eastern Countries* (Boston, 1930). The strengths for the United States come from the Slater Tables of yarn strengths, using the strengths for yarns manufactured on "old" machinery, from George B. Haven, *Mechanical Fabrics* (New York, 1932), p. 132–33. The strengths for Britain come from Henry B. Heylin, *The Cotton Weaver's Handbook* (London, 1908), p. 181.

result" as in Lancashire.[32] Germany similarly used better-quality cotton inputs.[33] In both Peru and Brazil high-quality long-fiber local cotton was used to produce rather coarse yarns, though these countries employed many more workers per machine than the high-wage countries. Cotton quality can explain none of the excessive manning of all these countries, and the same is probably true of many other low-wage countries. Only Japan, India, and China did seem to use inferior cotton for a given count of yarn. This was not, however, unquestionably a policy of saving cotton at the expense of labor. Both India and China had large indigenous supplies of very short-fiber cotton, and Japan was much closer geographically to the short-fiber cottons of China and India than to the long-fiber cottons of the United States, Brazil, and Egypt. The Indian, Japanese, and Chinese industries also faced great demands for yarn for the extensive hand-loom industries of India and China, and hand looms could use weaker yarns than power looms. Evidence on the strengths of Japanese, Indian, and Chinese yarns is, again, only available in the 1920s. As Table 6 shows, for counts coarser than the 30s, Japan, India, and China produced yarns weaker than those in Britain or the United States. For counts above the 30s, however, low-wage countries did not systematically produce weaker yarns; in particular their yarns were as strong as American yarns.

If yarn strength was important in determining manning levels, we would expect that Japan, India, and China would have relatively higher

[32] Forrester, *Cotton Industry in France*, p. 41.
[33] R.M.R. Dehn, *The German Cotton Industry* (Manchester, 1913), p. 51.

machine-to-worker ratios on finer counts of yarn. No such effect appears. Pearse visited one Indian mill in the 1920s, "a very good mill," where the cotton quality was high: "The mixings throughout are too good rather than too low."[34] Importing long-staple Ugandan cotton, they produced counts as fine as the 60s, but even on the finest counts one male ring tender looked after only 260 spindles. In the United States, at such counts, a girl tender would oversee between 1,000 and 1,400 spindles, or four to five times as many. In another mill, where the average count was 29s (a count where American yarns were not much stronger than Indian yarns), a weaver still attended only two looms and a ring spinner tended only 170 spindles.[35] Finally, in a mill manufacturing 60s from Egyptian and American cotton, which produced yarn as strong as that in the United States, a tender still watched only 300 spindles, less than a quarter of the number an American girl would attend at such counts.[36] The strength of yarn does not seem to have much to do with differences in manning levels.

If cotton quality explained overmanning in the low-wage countries, overmanning would have been much greater in the later stages of manufacture, in weaving and in spinning, than in the earlier processes of opening the cotton, carding it, and drawing it into loose ropes. For in the early stages breakages were not a problem or were infrequent. Even in the spinning stages the task of doffing the spools of yarn from the drawing and spinning frames was not affected by cotton quality. Yet all the processes unaffected by cotton quality were as heavily overmanned in the low-wage countries.

Another compelling argument that poor-quality cotton did not cause the low labor productivity of poor countries comes from the amount of time operatives spent fixing yarn breakages. In 1948 operatives in the card room of a British mill using machinery dating from before 1915 spent from 2.1 percent of their time repairing breakages in carding to 6.7 percent of their time on the fly frames. They spent the rest of their time emplacing and removing yarn packages, cleaning and monitoring the machinery, or resting.[37] But in Japan, India, and China, where each operative had only one-fourth or fewer machines to attend as in Britain, over three-quarters of worker time is unaccounted for by British standards. Did they use that time to repair yarn breakages because of inferior cotton? No observers of mills in low-wage countries report any such difference in the nature of the operatives' tasks. Copeland notes in European mills only "as many breakages" as in the United States.[38]

[34] Pearse, *The Cotton Industry of India*, p. 129.
[35] Ibid., p. 149.
[36] Ibid., p. 155.
[37] Great Britain, Cotton Board, Labour Dept., *Report on Labour Redeployment in the Musgrave Cardroom, Bolton* (London, 1948), pp. 17–24.
[38] Copeland, *The Cotton Manufacturing Industry of the United States*, p. 299.

Pearse remarked that Indian spinners "have hardly anything to do" and that "I watched two ring frames for three minutes; there was not a single end down" (which means there were no broken threads).[39]

Finally, even in countries like Japan, India, and China, which used inferior cotton, the cheaper cotton inputs seem to have been fully reflected in the final output value. At a count of 20, the difference in yarn strength suggests that Japan, India, and China may have saved from 8 to 12 percent of cotton costs.[40] The yarn was not worth as much, however, since the product was less durable. The prices Clark and Pearse give for different Japanese yarns suggest that yarn produced using only American cotton was worth about 8.5 percent more than that made from a mixture of Indian and American cotton.[41] This would imply that the cheaper cotton was fully reflected in the final value of the product, leaving no room for poor quality cotton to explain the employment of more labor inputs.

TECHNOLOGY GAPS

Were the low-wage countries employing inferior machinery or techniques? The answer here is decisively no. We can be particularly clear about this since in 1910 Lancashire and New England dominated the textile industry. Though New England made many technological and organizational advances, Lancashire was the more important center because of its textile machinery industry, which supplied all or most of the textile machinery (and the manuals giving operating instructions and speeds) to most manufacturers outside North America. Thus textile mills around the world used very similar machinery. The first Indian mills, for example, were completely British in design and equipment, including even the stones that the machines sat upon.[42] In 1927 an authority firmly stated that "the Bombay Cotton mills are in no way inferior to the Lancashire textile factories in their general equipment and manufacturing resources."[43] French mills erected just before World War I "would stand comparison with the best in England or the United States."[44] In Brazil British mechanics sent by British machine makers

[39] Pearse, *Cotton Textile Industry of India*, p. 129.

[40] From the relative strength of Indian and U.S. yarns it appears that in the 1920s Indian mills used cotton which had fibers slightly less than one-eighth of an inch shorter for 20s yarn. Pearse gives a set of prices of cottons in India, together with the length of the cotton fiber. (Pearse, *Cotton Industry of India*, pp. 42–43). These prices show that with cottons of staple around seven-eighths of an inch, an increase of staple length of one-eighth inch increased cotton prices by about 12 percent. A similar calculation for the Memphis market for staple of one inch gives the same result (National Association of Cotton Manufacturers, *Year Book, 1928*, pp. 138–41).

[41] Clark, *Cotton Goods in Japan*, pp. 80–81.

[42] Clark, *Cotton Fabrics in British India*, p. 13.

[43] S. M. Rutnagur, *Bombay Industries: the Cotton Mills* (Bombay, 1927), p. 24.

[44] Forrester, *Cotton Industry in France*, p. 31.

erected most of the equipment.[45] Where non-English machinery was used, as it was to some extent in weaving in Germany, Switzerland, France, and Italy, commentators found it generally equivalent to English machinery. Thus Besso notes, "The differences in style and design between machinery of Swiss and English make are no greater than those between the work of different English firms.[46]

Britain also supplied the managers and skilled workmen to operate the machinery and train the workforce in many countries, particularly India, China, Russia, Mexico, and Brazil. In 1895, of Bombay's 55 mill managers, 27 were British, as were 77 of the 190 weaving masters, spinning masters, carding masters, and engineers.[47] At least one-third of the Chinese industry was under British management in 1915, as were some of the mills owned by Chinese entrepreneurs.[48] Most Brazilian mills had British managers, room bosses, and engineers.[49] Many non-British managers, particularly in Germany and Switzerland, received their training in Lancashire. Besso in fact claims that the average Swiss manager was better trained than the average English manager.[50]

Nor did the low-wage countries employ secondhand machinery which required more labor because it embodied a lower machine-labor ratio or because it was partly worn out. The literature never discusses an active secondhand machinery market, nor does it quote prices for secondhand machines in any countries. One reason for the absence of used machinery markets was the expense involved in setting up machinery in a mill. Clark's estimates for an Italian spinning mill show setting-up costs to be nearly 20 percent of the final cost of the erected machinery.[51] These fitting-up expenses reduced the incentive for an established mill to sell off old but still serviceable equipment. In 1911, despite the industry's reasonably fast growth rate of 3.3 percent per year from 1860 to 1910, 22 percent of the spinning frames and 25 percent of the looms in the United States were more than twenty years old.[52] Thus the low-wage countries generally purchased new machinery. It was the growth rate of the capital stock which principally determined the average age of machinery in a country.

Since the low-wage countries (especially Japan, India, and China) had much higher capital stock growth rates in the late nineteenth century and early twentieth century than Britain, vintage effects should have

[45] W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 36, *Cotton Goods in Latin America, Part II* (Washington, D.C., 1910), p. 48.

[46] Besso, *Cotton Industry*, p. 16.

[47] Rutnagur, *Cotton Mills*, p. 294.

[48] Odell, *Cotton Industry in China*, p. 158.

[49] Clark, *Cotton Goods in Latin America, Part II*, p. 46.

[50] Besso, *Cotton Industry*, p. 16.

[51] Clark, *Cotton Fabrics in British India*, p. 88.

[52] U.S. House of Representatives, Report of the Tariff Board, *Cotton Manufactures*, table 147, p. 472.

worked to increase the machine-worker ratio in low-wage countries relative to Britain. It is important to consider this since a competing reason for the inefficiency of labor is the more rapid growth of the industry, and hence the lesser experience of operatives in many low-wage countries.

LABOR EXPERIENCE

So far I have argued that labor had to be less efficient in the low-wage countries in two ways, both of them arguments by exclusion. If labor were not much less efficient, the low-wage countries should all have had crushing cost advantages in competition with the British in the international market. Yet, except for the Asiatic countries, the low-wage competitors could survive only through tariff protection. And the Asiatic countries were not doing anywhere near as well as their cost advantages would imply. In addition, the observed differences in machinery per worker cannot be explained by input substitution in response to low wages, or by differences in the management, the technology, or the machinery.

There is also direct evidence that the personal efficiency of workers in low-wage countries was low. American and British visitors to cotton mills elsewhere in the world almost universally noted the low quality of the labor. Clark remarked that English mills had the advantage over Swiss mills, "because of the greater efficiency of their operatives, which more than compensates for the higher wages paid."[53] Besso concurred that "more work people are required to tend the machinery" in Switzerland and that "it is largely due to the inferiority of Swiss operatives."[54] Clark noted of Egypt that "the inefficiency of the help available . . . has probably had the largest effect in retarding the industry" and that "it takes two or three operatives to do the work of one English operative."[55] Equivalent comments can be found for Germany, France, Italy, Spain, Peru, Japan, India, and China.[56]

What were the sources of these variations in labor efficiency? A variety of explanations seem possible: the amount of experience workers had in the textile industry, the amount of general education workers

[53] Clark, *Cotton Fabrics in Middle Europe*, p. 161.

[54] Besso, *Cotton Industry*, p. 68.

[55] W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 18, *The Cotton Textile Trade in the Turkish Empire, Greece and Italy* (Washington, D.C., 1908), p. 48.

[56] Apart from those in the Reports of Clark and Odell, such comments can be found in Forrester, *Cotton Industry in France*, pp. 42–43; Great Britain, House of Commons, *Report of the Indian Factory Labour Commission, British Parliamentary Papers, Cd. 4292*, 1908, p. 20; Great Britain, House of Commons, *Minutes of Evidence taken before the Indian Industrial Commission, British Parliamentary Papers, Cmd. 234*, 1919, p. 278; Moser, *Cotton Textile Industry of the Far Eastern Countries*, pp. 15, 68; Pearse, *Cotton Industry of Japan and China*, pp. 165, 172; Pearse, *Cotton Industry of India*, p. 53.

had, the nutritional status of workers, or culturally determined attitudes to work.

Experience in the cotton textile industry is an obvious influence on the competence of workers, and studies of particular national industries have sometimes cited the increase in worker experience as important in determining labor productivity.[57] Certainly many of the countries with low labor efficiencies were new to the cotton industry in 1910. The Chinese had been forced to allow foreigners to build mills only after 1895, before which the Chinese industry had been very small. So the experience of workers would seem a good candidate as a major source of poor labor efficiency. On inspection, however, such an explanation turns out to be chimerical.

The basic constraint on the average experience of workers was the growth rate of the local industry. Industries which grew quickly had, by necessity, relatively inexperienced work forces. Elements of choice could also enter. In Japan, mills chose to employ a transient labor force composed of young girls who would leave the mill upon marriage. But almost all other countries sought to employ labor on a permanent basis. Thus the basic determinant of the average workers' experience was how rapidly employment was growing.

The first difficulty in posing worker experience as an explanation is that no simple association exists between labor productivity and the growth rate of the local industries. The southern United States had the second highest number of machines per worker in 1910, yet its stock of equipment grew at the rate of 9.4 percent per year from 1890 to 1910, one of the fastest growth rates in the world, and only slightly less than the growth rate of the Chinese, Japanese, and Brazilian industries. It chiefly employed the labor of southern hill farmers and their families, who were completely inexperienced not only in textiles but in any kind of factory work.[58] Over the same period the Chinese industry grew about 10 percent per year, but China had more than five times as many workers per machine in 1910. Similarly from 1890 to 1910 the New England and the French industries grew at nearly the same annual rate, 1.6 percent and 1.7 percent respectively. Yet France employed nearly three times as many workers per machine.

The second difficulty is that the effect of experience on the competence of machine tenders is slight, as measured by earnings, once the initial training period is passed. In 1921/22 women operatives in the southern United States who had ten to twenty years' experience earned only 39 percent more than those with only one to two years' experience.

[57] See Gary Saxonhouse, "Productivity Change and Labor Absorption in Japanese Cotton Spinning, 1891–1935," *Quarterly Journal of Economics*, 91 (May 1977), pp. 195–219.

[58] Copeland, *Cotton Manufacturing Industry of the United States*, p. 34.

In Japan in 1930 the comparable increase in earnings was 44 percent.[59] The number of loom-equivalents per worker in New England was 2.97 in 1910, compared with 0.48 in China. Supposing that the typical New England operative had 15 years' experience, but the typical Chinese operative only 1.5 years, an adjustment of machinery per worker for experience would increase machines per worker in China from 0.48 to 0.68 loom-equivalents per worker. Even this extreme assumption would remove only 8.0 percent of the gap in manning levels between China and New England.

Under reasonable assumptions the average experience of workers in countries where the industry was growing more quickly would not be that much shorter than in the mature centers of the industry. The only simplifying assumptions needed are that workers leave the industry at a rate D which is the same for all workers, and that the industry labor force grows at a constant rate g. Given these assumptions, the average experience of workers in the industry (EXP) will be:

$$EXP = \int_{-\infty}^{T} (T - t)\, H(t)\, e^{-D(T-t)} dt / L(T)$$

where $L(t)$ = labor force at time t
$= L(T)\, e^{-g(T-t)}$
$H(t)$ = new hires at time t
$= (g + D)L(t)$
$T - t$ = experience of workers hired at time t

For an industry with no growth of employment a reasonable assumption about the average length of tenure is ten years, implying $D = 0.1$. The average length of tenure is then generated by plugging in the growth rate of equipment in each industry. Table 7 shows the growth rates and implied average tenures of workers in the industry. The last column lists the effects that the calculated differences in experience should have had on the number of machines per worker, based on the earnings-experience profiles given in Saxonhouse and Wright. The table shows that the effects of experience on worker efficiency are trivial in comparison to the overall differences.

The fact that some places, like Japan or New England in the early nineteenth century, could deliberately recruit young girls for short factory tenures prior to marriage (the so-called Lowell system) is in

[59] Gary Saxonhouse and Gavin Wright, "Two Forms of Cheap Labor in Textile History," in Saxonhouse and Wright, eds., *Technique, Spirit and Form in the Making of Modern Economies: Essays in Honor of William N. Parker* (Greenwich, 1984), table 24, p. 24.

TABLE 7
GROWTH RATES, WORKER EXPERIENCE AND IMPLIED LABOR EFFICIENCY, 1910

Country or Region	Average Weekly Wage	Loom-Equivalents per Worker	Industry Growth Rate, 1890–1910	Average Years of Experience	Predicted Machines per Worker
New England	$8.8	2.97	1.6%	8.6	109
Canada	8.8	2.53	2.4	8.1	108
United States (South)	6.5	2.65	9.4	5.2	100
Lancashire	5.0	2.04	0.9	9.2	110
Germany	3.8	1.28	3.1	7.6	105
France	3.7	1.11	1.7	8.5	109
Switzerland	3.7	1.40	−0.4	10.4	113
Austro-Hungary	2.8	1.24	2.6	7.9	107
Spain	2.7	0.91	2.0	8.3	108
Mexico	2.6	1.15	2.5	8.0	107
Russia	2.4	1.10	4.2	7.0	104
Italy	2.4	0.88	5.4	6.5	103
Japan	0.80	0.53	9.6	5.1	100
India	0.78	0.50	5.1	6.6	103
China	0.54	0.48	10.0	5.0	100
Brazil		0.88	11.3	4.7	99

Note: The industry growth rate is calculated as the growth of the stock of spindles and looms, where both figures are available, and as the growth rate of the stock of spindles otherwise. The predicted machines per worker is inferred by taking the predicted increase in earnings with experience as implying a proportionate increase in machinery supervised with experience. The increase in earnings with experience is calculated by assuming the experience-earnings relationship is linear. Evaluating the influence on earnings of experience by more exact methods would affect the results little.
Sources: See Appendix.

itself evidence that the experience of individual workers did not matter much. For the wage savings of such a system were small in comparison with international differences in output per worker.

Perhaps the earnings-experience profiles derived by cross-section studies do not measure the whole contribution of experience to workers' productivity. Suppose workers undergo a general type of learning which is passed on from one to another as experienced workers instruct newcomers in shortcuts. This learning would depend on the cumulative experience of the labor force, and hence would not appear in the experience-earnings profiles as a benefit of any individual's service length.[60] If such learning exists, it is peculiar that management is not able to observe and codify it. Surely the British managers and room bosses imported to establish the Indian industry must have had comprehensive knowledge of work methods, since many had started as

[60] I am grateful to Gavin Wright for pointing this out.

workers. Why were they not able to instruct Indian workers in these methods? And to return to an old refrain, if experience matters so much, why were southern United States workers so efficient and French workers so inefficient?

Further, if we are to consider the effects of experience, then we should also take into account the fact that faster growth gave many low-wage countries an advantage in that their machinery was newer. New machinery reduced the amount of labor per machine in two ways: new machinery required less repair to keep it running, and new machinery often embodied a higher machine-worker ratio (in the spinning processes, for example, older machinery had fewer spindles per frame, which limited to some extent the manning levels). Thus the estimates of the manning levels on new mills in Britain and the United States are typically much lower than the manning levels on existing machinery. The magnitude of the effect is not known, but if (as the Tariff Board data suggests) machines lasted on average twenty-five years or more and the labor required per machine increased by only 1 percent for every year older the machine was, it would give China (with a 10 percent growth rate) an advantage of 5 percent in manning levels over Britain (with a 0.9 percent growth rate), which is half of the disadvantage China suffered from its less experienced workforce. A 2 percent increase in labor requirements for every year machinery aged would almost exactly counterbalance any disadvantages rapidly growing countries had from inexperienced labor.[61] Thus differences in the amount of on-the-job training of workers in different countries should have mattered little in determining manning levels.

INHERENT LABOR QUALITY

If training on the job is not relevant, perhaps workers in the low-wage countries were inherently inefficient because of poor nutrition they received as children or because of the type of general training at home imparted to children in those cultures or because they received little or no formal education. The amount of formal training workers received would certainly correlate with the wage level in each country. And at least in India textile workers were small because they were inadequately nourished in childhood. The Indian Factory Labor Commission of 1908 found that a large sample of adult male factory operatives weighed on

[61] If the machine-worker ratio on new machinery is increasing at a rate of v relative to the machine-worker ratio on old machinery, the rate of growth of machinery investment is g, and machinery has a life of N years, then the machine-worker ratio on the existing stock of machinery relative to that on new machinery will be:

$$k = \left(\frac{g}{g + v}\right) \frac{e^{(g+v)N} - 1}{e^{gN} - 1}$$

average only 105.4 pounds.[62] This is certainly light by modern standards, and indeed by the standards of late-nineteenth-century British industry. In Britain in 1878 adult male artisans weighed on average 132.5 pounds, which probably represents fairly well the weights of Lancashire textile operatives.[63]

But the nature of operatives' tasks in textile work has to be considered. Few tasks demanded any literacy whatsoever. Most demanded only the ability to perform the same few simple operations repeatedly. It might take months to acquire the necessary dexterity and stamina, but the job for most workers was highly routine. Strength did not matter in most tasks, so small size should not have hampered operatives. Moser, visiting Indian mills in the 1920s, noted that "the workers in this mill, as in most others I visited, were lean of frame and appeared nimble of hand."[64] Certainly if the current nutrition of operatives impeded their efficiency, the employers could cheaply supplement the operatives' diet and get great gains in output. In Japan employers maintained and fed employees in dormitories at the mill. And at least some German mills had company dining rooms with subsidized food.

Further evidence against the view that the workers in low-wage countries were inherently incapable comes from the New England industry. It employed the most efficient operatives, but in fact many workers came from countries whose own textile industries had very inefficient employees. The Immigration Commission Report in 1911 shows 27.8 percent of the workers in northern cotton mills to be Polish, Portugese, Greek, or Italian, even though in Poland, Portugal, Greece, and Italy between three and six times as many workers were required per machine as in New England.[65] The Poles, Portugese, Greeks, and Italians who emigrated to New England probably had little formal education, and certainly little more than their compatriots in the textile mills of Europe. Perhaps only the most robust and energetic workers in these countries found their way to New England, but the necessary degree of selectivity would exceed any reasonable expectation. And why then, if immigrants are simply in general more vigorous, did Brazilian mills, which employed large numbers of Portugese and some Italians and Germans, have operatives only one third as efficient as those in New England?[66] Both New England and Lancashire mills employed many Irish migrants. Why did the Irish who happened to get on the boat to Lancashire exhibit lower efficiency as cotton operatives than those who instead took the boat to New England? Similarly

[62] *Report of the Indian Factory Labour Commission*, appendix C.

[63] Charles Roberts, *A Manual of Anthropometry* (London, 1878), table 9, p. 86.

[64] Moser, *Cotton Textile Industry of the Far Eastern Countries*, p. 101.

[65] U.S. Senate, Immigration Commission, *Abstracts of the Reports of the Immigration Commission* (Washington, D.C., 1911), table 7, pp. 329–33.

[66] Clark, *Cotton Goods in Latin America, Part II*, p. 48.

TABLE 8
EARNINGS OF U.S. MALE IMMIGRANTS IN MANUFACTURING, 1910

Country of Origin	Efficiency of Textile Workers (home country)	Average U.S. Wage (England = 100)	Average Age	Age–Adjusted Wage (England = 100)
Canada	124	78	39.0	75
England	100	100	38.7	100
Germany	63	96	40.9	90
France	54	93	36.1	98
Switzerland	69	99		
Austro-Hungary	61	85	31.6	93
Spain	45	106	31.4	115
Mexico	56	90	32.7	102
Russia	54	80	30.7	95
Italy	43	80	29.6	98
Portugal	43	57	26.4	79
Greece	23	60	26.5	83
Japan	26	75	29.5	93

Note: The adjusted earnings are derived by regressing earnings on the average age, and then subtracting the estimated effect of age on earnings. Estimated in this way, age explains 44 percent of the variance of the reported earnings.

Sources: The earnings and average age of immigrants are from U.S. Senate, Immigration Commission, *Abstracts of the Reports of the Immigration Commission* (Washington, D.C., 1911), table 22, p. 367; table 26, p. 371; table 88, pp. 463–64.

German mills employed numbers of migrant Poles, Swiss mills employed migrant Italian workers, and the Peruvian mills employed Chinese workers, none of whom showed the extraordinary productivity of immigrants to the American mills. Even within national boundaries factory operatives in cotton textiles were often migrants to industrial centers from distant agricultural areas, since the industry tended to concentrate in a few centers.

Suppose strong selectivity was operating, so that foreign emigrants to the United States in the early twentieth century represented only the best and brightest their countries had to offer. Then we would expect that if there was the same percentage outflow to America from each country, the earnings of emigrants in the United States would still correlate with the income levels of the home country, since the select group from each country would be handicapped differentially by conditions in its country of origin. In fact earnings differences among different immigrant groups in American manufacturing and mining are small, once corrected for the average age of workers. The first column of Table 8 gives the efficiency of textile operatives in textile-producing countries in the early twentieth century. The second column reports the earnings of adult male immigrants from these countries in American manufacturing and mining industries in 1910, where the earnings of English immigrants are set at 100. The last two columns give the average age of each immigrant group and the earnings corrected for the average

age. Clearly the substantial differences in the efficiency of operatives in different textile industries are not reflected in the earnings of workers from those countries employed in American industry. Nor did the most underdeveloped countries send a much more select group of migrants to the United States. The volume of immigration from southern Italy, Poland, and Portugal was larger in proportion to the home population than that from many of the more advanced northern European countries such as England, France, and Switzerland by this period. Whatever created the inefficiency of workers in these countries does not appear to have been inherent to the workers themselves.

LOCAL EFFECTS

Whatever limits the efficiency of workers in low-wage countries seems to attach to the local environment, not to the workers themselves. The workers were, it appears, capable of tending to more machinery but either chose not to do so or were constrained from doing so. It should be noted that local textile managers were often not free to select the machinery manning levels they desired. The local managers in many low-wage countries insisted that the workers could tend more machinery but refused to do so. Pearse notes of Indian spinning mills in the 1920s that "there is only one side for each tender to look after; they have hardly anything to do, but they will not take on more spindles except at full rate of wages."[67] He notes of another Bombay mill:

> The operatives in this mill refuse to attend to more machinery. I watched two ring frames for three minutes; there was not a single end down, yet the workpeople would not look after more than one side. They said that they are satisfied with the present wage, and that there are so many men who want work and cannot get it that it would be unfair if they were to attend to more machines.[68]

Moser, an American visitor to India in the 1920s, is even more adamant about the refusal of Indian workers to tend as many machines as they could ". . . it was apparent that they could easily have taken care of more, but they won't . . . . They cannot be persuaded by any exhortation, ambition, or the opportunity to increase their earnings."[69] In 1928 attempts by management to increase the number of machines per worker led to the great Bombay mill strike.[70]

Similar stories crop up in Europe and Latin America. Clark noted that Mexico could not introduce automatic looms because "the Mexican operatives are very conservative, and as they have been accustomed to running two to four looms, usually not over three, it has as yet been

[67] Pearse, *Cotton Industry of India*, p. 158.
[68] Ibid., p. 129.
[69] Moser, *Cotton Textile Industry of the Far Eastern Countries*, p. 101.
[70] Vera Anstey, *The Economic Development of India* (4th edn., London, 1952), p. 276.

found impossible to persuade them to run any larger number of automatic looms."[71] In the 1920s one big labor-policy issue for the new Soviet state was an attempt to force weavers to operate three looms as opposed to the traditional two. The attempt to introduce six or more looms per worker in Britain in the early twentieth century caused a long struggle between the managers and the weavers' union. In France between 1900 and 1904 many of the industrial disputes were "concerned with the increase in the number of looms to be minded and the piece rate to be paid."[72]

It would not be correct, however, to interpret the above as indicating that the key to differences in worker efficiency in textiles lay in the strength of unions in textiles, the nature of bargaining between labor and management in the factories, or the labor recruitment strategies of different textile industries. That would not explain why the machine manning disputes occurred at a level which was predictable from the real wage level of the country. In India the struggle was over two looms per weaver as opposed to one, in Russia three versus two, in France and Mexico, four versus three, and in Britain six versus four. The proximate cause of inefficiency in at least some cases was the workers' refusal to accept more machinery, but the choices of workers correlated with the local real wage. Whatever constrained the choices of workers in cotton textiles, or whatever determined their preferences, must have applied to all of the local labor force. Unfortunately the sources on the textile industry do not allow me to go with any confidence beyond this limited ascription of responsibility to local influences. But this in itself is not a modest or an uncontroversial claim.

LESSONS FROM THE MILLS

Whatever the precise cause of the differences in worker efficiency in the international textile industry in 1910, they have important implications for the understanding not only of underdevelopment, but also of economic growth, the reasons for large labor migrations, and the factors determining choice of technique. There is every reason to expect that what was true of cotton textiles was true of other industries, so that all industries presumably faced the same problems of labor inefficiency in the poorer countries. Indeed a study of European and American agriculture in the early nineteenth century finds great differences in the length of time it took workers to do simple manual tasks between the areas of advanced agriculture and high incomes and the backward areas. Grain was hand-threshed three times more quickly in North America than in Eastern Europe, with no discernible sacrifice of output in

[71] Clark, *Cotton Goods in Latin America, Part I*, p. 22.
[72] Forrester, *Cotton Industry in France*, p. 42.

America. British and North American agricultural workers also were more efficient at simple manual tasks than medieval English peasants.[73]

Another implication is that if the differences in worker efficiency had been eliminated, then wages of cotton textile workers in underdeveloped countries could have been raised close to those of the developed countries, since their nonlabor costs did not exceed those of the developed countries by much, as can be seen in Tables 1 and 2. Had the local industries been competing in a free market, the equilibrium wages (given the nonlabor costs) would have been $4.09 per week in the United States, $4.35 in China, $3.93 in India, $3.01 in Japan, $3.16 in Russia, $3.96 in Italy, $4.12 in France, and $3.80 in Germany. Britain, with its low-cost machinery industry and cheap coal, could have paid $5.00 per week. If, as I anticipate, other industries were like textiles, then the major source of the underdevelopment of poor countries was the inefficiency of their labor, rather than their inability to absorb modern industrial technology.

One remarkable feature of world industrialization since 1780 has been the extent to which workers have migrated to a few industrial centers, instead of capital and management migrating to the available supplies of cheap labor. The costs of movement for workers would seem to be much higher than those for other factors of production, given the difficulties of adjusting to new languages and cultures and the desire to remain close to parents and other relatives and friends. The existence of these costs is borne out by the substantial wage differentials which often exist even within the same country. Adam Smith, observing that while commodity prices had equalized across Britain in 1776 there were substantial differences in wages between parishes only a few miles apart, commented "it appears evidently from experience that a man is of all sorts of luggage the most difficult to be transported."[74] In Germany in 1913 per capita income varied by over two to one between different provinces.[75] Yet from the eighteenth century onwards great migrations of workers occurred within many countries and across national boundaries. Between 1903 and 1910 nearly 10 million people left Europe for the United States, most to be employed in manufacturing industry.[76] Why wasn't it more profitable to move capital and expertise from America to Europe? In the case of textiles the costs of such movements were not particularly great in comparison with labor costs, even when the movement was to very underdeveloped countries. Only

[73] Gregory Clark, "Productivity Growth without Technical Change: European Agriculture before 1850" (unpublished manuscript). See also Gregory Clark, "The Cost of Capital and Medieval Agricultural Technique" (unpublished manuscript).

[74] Adam Smith, *The Wealth of Nations* (New York, 1937), p. 75.

[75] Alan Milward and S. B. Saul, *The Development of the Economies of Continental Europe 1850–1914* (Cambridge, 1977), p. 64.

[76] Brinley Thomas, *International Migration and Economic Development* (Paris, 1961), pp. 10–11.

if worker efficiency was determined by the local environment can we understand why such migration of labor exists, for only in this way could workers escape the constraints on their productive capacity in their original location.

In analyzing choice of technique between countries or over time it is often taken that there is a fundamental unit of measurement, an hour or day of unskilled labor, whose price relative to other factors of production determines the appropriate choice of technique. But this study shows that there is no such universal constant. The true relative cost of capital and labor cannot be inferred simply from the price of each, and in fact in textiles varied within rather narrow bounds. Thus while wages in textiles varied by a factor of 16 to 1, the true labor cost varied by only 3 to 1, and some of this variation is measurement error. Nor did any monotonic connection exist between wages and the true labor cost. Some low-wage countries had labor costs quite as high as those of the highest wage areas. Much discussion has considered whether and how the high cost of American labor influenced U.S. technological development.[77] If cotton textiles are any guide, it may well have been that nineteenth-century American labor costs were no higher than those elsewhere, undercutting the premise of this whole line of enquiry.

Outputs per worker increased greatly in all the national textile industries over the nineteenth and early twentieth centuries. In England in 1850 the average weaver tended only 2.2 power looms compared with 3.44 in 1906, despite the fact that looms in 1906 were about 50 percent faster than those of 1850.[78] The number of spindles per operative increased also. In 1833 the mule spinning frame had 440 spindles on average, but by 1910 this had increased to 1080, with no increase in workers per frame, despite the fact that the speed of spindles had more than doubled.[79] Differences in manning levels among countries suggest that it is unsafe to infer that the increase in output per worker resulted solely from technical progress, whether this was embodied in new machinery or disembodied learning-by-doing. The same forces that created national differences in the efficiency of labor could be operating over time, and labor intensification could thus be an important source of productivity increases. Testing this proposition directly is very difficult, but I make a preliminary attempt elsewhere for British agriculture from 1660 to 1840, an investigation which suggests that labor intensification

[77] H. J. Habakkuk, *American and British Technology in the Nineteenth Century: the Search for Labor-Saving Inventions* (Cambridge, 1962), is the most celebrated argument for the influence of high American wages. Paul David, *Technical Choice, Innovation and Economic Growth* (Cambridge, 1975), chap. 1, contains an extensive summary and discussion of the various labor scarcity analyses of American technological development.

[78] George Henry Wood, *The History of Wages in the Cotton Trade* (London, 1910), p. 143.

[79] Wood, *History of Wages*, pp. 141–142.

was indeed an important source of productivity increase.[80] Technological change may not be the overwhelming cause of high per capita incomes in modern industrialized countries, as has been recently thought.

These lessons from the mills will undoubtedly seem to some as merely destructive of conventional wisdom on underdevelopment without suggesting any replacement. Nevertheless, identifying the effects of the local environment or culture on the labor force as the source of the poor performance of textile mills in low-wage countries is a significant advance in understanding development. For if we can isolate one factor as supremely important, no matter how poorly we comprehend that factor at present, we are in a much better position to direct future research on economic growth.

Appendix

The sources for the labor, plant and machinery, and coal costs in Table 1, the hours of work in Table 2, the manning levels in Table 3, and the growth rates of the industries in Table 7 are listed here, in alphabetical order by author.

S. L. Besso, *The Cotton Industry in Switzerland, Vorarlberg, and Italy*. (Manchester, 1910).

Chen-Han Chen, "Regional Differences in Costs and Productivity in the American Cotton Manufacturing Industry, 1880–1910," *Quarterly Journal of Economics*, 55 (Aug. 1941), pp. 533–66.

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 13, *Cotton Fabrics in British India and the Philippines* (Washington, D.C., 1907).

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 18, *The Cotton Textile Trade in the Turkish Empire, Greece and Italy* (Washington, D.C., 1908).

W.A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 24, *Cotton Fabrics in Middle Europe* (Washington, D.C. 1908).

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 31, *Cotton Goods in Latin America, Part I* (Washington, D.C., 1909).

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 36, *Cotton Goods in Latin America, Part II* (Washington, D.C., 1910).

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 44, *Cotton Goods in Latin America, Part IV* (Washington, D.C., 1911).

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 69, *Cotton Textiles in Canada* (Washington, D.C., 1913).

W. A. Graham Clark, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 86, *Cotton Goods in Japan* (Washington, D.C., 1913).

Melvin Copeland, *The Cotton Manufacturing Industry of the United States* (Washington, D.C., 1912).

R.M.R. Dehn, *The German Cotton Industry* (Manchester, 1913).

R. B. Forrester, *The Cotton Industry in France* (Manchester, 1921). Great Britain,

[80] Clark, "Productivity Growth without Technical Change."

House of Commons, Textile Factories Labour Committee, *Factory Labour in India*, Cmd. 3617, 1907.
Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 46, *Cotton Goods in Spain and Portugal* (Washington, D.C., 1911).
Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 48, *Cotton Goods in Italy* (Washington, D.C., 1912).
Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 51, *Cotton Goods in Russia* (Washington, D.C., 1912).
Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 107, *Cotton Goods in China* (Washington, D.C., 1916).
Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 124, *Cotton Goods in British India, Part I* (Washington, D.C., 1916).
Ralph Odell, U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 157, *Cotton Goods in British India, Parts V,VI* (Washington, D.C., 1918).
U.S. House of Representatives, Report of the Tariff Board, *Cotton Manufactures* (Washington, D.C., 1912).
T. A. Uttley, *Cotton Spinning* (Manchester, 1905).
William Whittam, Jr., U.S. Bureau of Foreign and Domestic Commerce, Special Agents Series, No. 15, *Report on England's Cotton Industry* (Washington, D.C., 1907).
T. M. Young, *American Cotton Manufacture* (London, 1902).