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COLONIALISM AND TECHNOLOGY CHOICES IN INDIA: A HISTORICAL OVERVIEW

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HISTORICAL analysis of British colonialism in India has, by and large, been centered around the exploitation of the colony by the metropolitan country. It has been generally recognized that the colonial government consciously and deliberately adopted policies that had deleterious effects on the economy and polity of the subject country and the "mystic bond of racial affinity" among the masters did the rest.[1] Even though the genesis of this line of thought can be traced back to the publications of an influential group of nineteenth century writers and scholars and nationalist leaders like Jawaharlal Nehru later provided it with a great deal of respectability,[2] most of the more authentic and comprehensive works pursuing this approach came out during the first two decades of India's independence. Perhaps a people with a glorious past but dismal present was trying to discover during the initial phase of national identity the basic cause of the plight, and blaming the erstwhile alien masters served this purpose well. Whatever the case, interesting research stressing this thesis has considerably tapered off in recent years.

I am not arguing that British colonialism was anything but exploitative—obviously the very nature of colonialism leads to such a condition—but it seems to me that many more issues beyond the exploitation paradigm need to be investigated in the interest of a more comprehensive and more meaningful understanding of the dynamics of economic change during the British rule. The attitude adopted by the Indian promoters of industry for the selection of technology for their industrial ventures is one of the problems. Why did the Indian promoters of modern industry—during the first phase of industrialization at any rate—imitate their British counterparts in the field of technology? Racial consideration played no overt role in

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[1] Perhaps the most prestigious of the works in this field are those by Chandra [6] and Bagchi [1]. The quote, originally from a 1944 position paper of the All India Manufacturers' Organization, is approvingly used in Bagchi [1, p. 166]. Also see Bipan Chandra's, T. Raychaudhuri's, and Toru Matsui's essays in *Indian Economic and Social History Review*, Vol. 5, No. 1 (March 1968) discussing M.D. Morris, "Towards a Reinterpretation of Nineteenth Century Indian Economic History," appearing in the same issue, which is less hostile to colonial regime.

[2] See in this context Naoraji [22], Ranade [28], Dutt [10], also Dutt [9] [8] and Nehru [23].

it and there was no official fiat to compel Indians to use a specific technology. Also, in certain spheres of industrial management, the Indians did depart from British practices. I have discussed some of these innovations elsewhere (Tripathi [38]); here I wish to address the problem of technology choice, and how colonialism influenced it at various stages of India's industrial development.

I. THE TEXTILE PRODUCERS

Our discussion must start off with the cotton textile industry because this field was a challenge for the Indian entrepreneurship at the first stage of the country's industrialization. Overcoming heavy odds—an indifferent and sometimes even hostile government, deficient labor supply, and practically no experience in setting up or managing modern industrial ventures—the Indians developed an industry that was almost an exclusive preserve of Manchester which never looked kindly at the prospects of rising competition from a colony. While the management structure and ownership pattern of the Indian mills bore no resemblance whatsoever with those of the British textile companies, the manufacturing system was an exact replica of Manchester's. Not only the technology—spinning and weaving machinery—was of the same type but also the physical layout of the premises and arrangement of the facilities were similar. During the early years of the industry, when no alternative had yet been developed, this was understandable. But even subsequently when mechanical devices, more compatible with the Indian conditions, were available, the Indians, by and large, continued to patronize the technology the British manufacturers favored.

Perhaps the most telling example is that of the persistence of the mule spindle in Indian cotton mills. Developed first in 1779 in Great Britain, it had become, as a result of subsequent improvements, the most favored spinning technology throughout the world by the time India launched its textile industry in the mid-1850s. Although technological experts in the United States had been experimenting with a new device, the ring spindle, since the 1830s, it still suffered from many technical limitations and had not yet come in general use even in the American mills where the mule reigned supreme. It was quite natural under these conditions for the early Indian promoters of cotton mills to adopt this device for their spinning operations.

The ring system in the meantime underwent several modifications and improvements, leading to the elimination of most of the deficiencies. By the beginning of the 1870s, the American invention began to threaten the supremacy of the mule. Even though the superiority attributed to the American device in certain aspects was debatable, the device displayed at least two features about which there was no question: it was better suited to the spinning of coarser types of yarn, and it required much less labor efficiency to operate it. As most Indian mills were then concentrating on the production of coarse goods and as the supply of skilled labor

was always scarce, the Indian manufacturers should have found the ring system more attractive than the mule. Though slightly more expensive than the mule, the ring frame was capable of spinning more yarn at lower running cost and was cheaper in the long run. The price difference thus could not have been a major impediment to its introduction in India.

And yet, few Indian producers took notice of the new spinning machine. That the older mills would have found it difficult to incur heavy expenditure involved in replacing the mule with the ring is not difficult to understand, but even the companies set up after the ring technology had attained a measure of perfection showed preference for the mule without even evaluating the alternative. J.N. Tata was the first Indian industrialist to appreciate the merit of the American technology and he applied it in his Empress Mill at Nagpur, replacing the old mules in 1883 (Harris [12, pp. 30–32]). Tata was not yet the towering personality in Indian business that he would become later; he was still seen more as a maverick than innovator by most of his contemporaries. Whatever the reason, few were inspired by his successful experimentation to switch over to the ring. Only one company—and that too a British firm, the Connaught Mills in Bombay—followed his example. Although the number increased subsequently, the share of rings in the total Indian spindlage was still limited to barely 28 per cent in 1891. Surprisingly, the last decade of the nineteenth century, a period of major hardship for the Indian textile industry caused by a series of unfavorable circumstances, witnessed a somewhat swifter rise, but the diffusion of the ring technology on the whole still remained rather slow—so slow that not until 1909, more than a quarter of a century after the Tatas had first introduced it, did its share in the total spindles installed in Indian mills reach the 50 per cent mark. The real spurt in the use of the ring occurred only after 1920, and it was not until the mid-1930s that India used about 90 per cent rings in the total number of spindles in its cotton factories. Even then, the mule did not disappear altogether and continued to be in use in larger or smaller numbers in about one-fourth of the Indian companies. The pace of change had been slow throughout these years not only in the older centers of textile production like Bombay and Ahmedabad, where replacement cost could have been a possible deterrent, but also in the Punjab and the United Provinces (now Uttar Pradesh) which witnessed the rise of this industry much later (Kiyokawa [17]).

In contrast, most other textile-producing countries were much quicker to adopt the ring technology. In Japan, for instance, where factory production of textiles started about a decade later, the shift away from mule began around the same time as in India. But in a brief span of two years, the proportion of ring jumped from 13 to 57 per cent of the total number of spindles in use, and by 1890 more than 90 per cent of the spindles in Japanese factories used rings (Otsuka, Ranis, and Saxonhouse [24, pp. 50–55]). The size of the Japanese industry was, of course, much smaller and, therefore, the number of ring spindles in Indian mills in absolute

terms was much larger. What is important, however, is that the ring technology was widely accepted among Japanese textile manufacturers. As a matter of fact, the mule practically disappeared from their factories by the end of the century.

Obviously, the mule was characterized by certain advantages: it worked better with Indian cotton; it could spin higher as well as lower counts of yarn; the yarn produced by it was of better quality than the ring could yield; changing counts on the mule was easier and cheaper; and the mule was cheaper to install even if the running cost was higher than in the case of the ring. In view of the fact that Indian mills, by and large, were producing coarse goods almost until the end of the First World War, most of these advantages of the mule, even if they were real, had little bearing on the Indian industry. But human mind does not always act on pure rational grounds, and it is possible that the advantages of the mule might have played some role in preventing a rapid diffusion of the ring in India. However, the Indian failure to adopt the use of blends of superior and inferior varieties of cotton for their spinning operations is surprising.

The process owes its origin to the cotton crisis of the early 1860s caused by the American Civil War. The European mills then proceeded to the mixing of the short-staple Indian cotton varieties with American cotton, much superior in quality, to compensate for the erratic and inefficient supply from the United States. The innovation was found to be so satisfactory that the Europeans continued to adopt the practice even after the United States resumed regular shipments (Tripathi [35, pp. 70–72]). The Indians must have known of the successful European experiment—after all a product of their own country was one of the constituents of the blend—but they paid no attention to this possibility in their own manufacturing operations.

Several benefits would have accrued to them, had the Indians followed the European lead. They could have produced coarse goods with better quality, without pushing up unduly the production cost, than the Indian staple by itself was capable of producing. The mills specializing in the production of higher counts of yarn could have reduced the cost of production without compromising with the quality. It was believed, rightly or wrongly, that the mule worked better with the Indian staple. If it was so, with the adoption of the blending method the diffusion of the ring technology would have been easier inasmuch as the presence of a superior variety of cotton in the blend would have neutralized to some extent the hypothetical advantage of the mule. While the Indian manufacturers remained blind to these possible benefits, the Japanese in contrast adopted the practice almost right from the start.

The adoption of the ring frame and practice of mixing cotton, among other things, helped the Japanese to cut costs and produce goods better suited to their target markets—China and Japan where coarse varieties of cloth were preferred because of the climatic conditions—and sell them at prices lower than others. The

result was that India, which had emerged as the major supplier of textile goods to East Asia by the beginning of the 1880s, began to experience Japanese competition by 1890 and was supplanted in these markets by its tiny competitor by 1913. Worse still, Japan began to make inroads into the Indian market as well where the Japanese varieties surprisingly enjoyed price advantage despite heavy tariffs. The First World War temporarily halted the Japanese assault, but the danger assumed an alarming proportion around the early 1920s (Mehta [20, pp. 46–47, 77–78] and Kang Chao [16, pp. 94–95]). This was to a large extent due to the failure on the part of Indian producers to realize the value of yet another new technology.

The technology in question was the automatic power loom. Well until the end of the nineteenth century, ordinary power looms were used for factory-based production of cloth. Although many experiments to develop the automatic power loom had been conducted in the nineteenth century, it was not until 1894 that an English inventor patented a device, known as the Northrop power loom after his name. However, an American firm commercialized its production, as the automatic loom was considered unsuitable for weaving most of the specialized products of the British mills. The new technology would greatly reduce the labor cost, because one weaver could handle ten to thirty looms at a time in comparison with three or four in the case of simple power looms. The factors preventing the use of the automatic device in Great Britain were not applicable to India, and the British-controlled Binny Mills in Madras had in fact worked with automatic power looms since 1914 with excellent results. Still the device received scant attention from the Indian producers, and even as late as 1934 ordinary looms constituted as much as 97.6 per cent of all looms in India.[3]

The Japanese attitude to the automatic power looms was just the opposite. They started experimenting with it as early as 1900, barely within years after its invention, but the initial efforts to introduce the Northrop varieties did not succeed. The rising labor cost after the First World War changed the situation drastically and led to the use of automatic power looms in the Japanese factories. In the meantime, an inventor Sakichi Toyoda (who had earlier developed a power loom which had started replacing the foreign machines in Japanese factories as early as 1900) was busy developing an indigenous device despite financial difficulties. He eventually perfected his system by the middle of the 1920s. This accelerated the process of replacement of ordinary looms by the automatic types in Japanese factories. The Japanese manufacturers had also adopted several other processes, such as warp-stop motion, which improved the efficiency of even ordinary looms. All this helped Japan increase its labor productivity manyfold in comparison with India. According to a well-documented assessment, while a Japanese weaver could operate six

[3] Pearse [25, p. 9], also Binny Ltd. [3, pp. 210–11] and ILO [14, pp. 48–56]. Interestingly, the share of ordinary looms in the total number of looms in Great Britain was just about the same, 97 per cent.

looms, a typical weaver in Bombay could handle only two (Kiyokawa [18] [17], Bagchi [1, pp.254–55], and Buchanan [5, p. 381]).

The Indian attitude to the textile technologies was very much in tune with that of the British producers. The popularity graph of ring frame in England started rising only after the First World War; the British never adopted the system of blending different varieties of cotton wool; and they continued to prefer ordinary power looms to the automatic device for a long time—even longer than the Indians—perhaps because of the compulsion of their product mix. Why did the Indians follow the British lead? Why did they remain oblivious to the developments in other textile-producing countries and the possible benefits accruing from them to their own operations?[4] There was, of course, no official fiat which forced the choice on Indians, and none has seriously attempted to explain it with reference to the presence of an alien government in India—a factor to which most of India's economic ills are often attributed. Vague reference to an overall laissez-faire outlook of the colonial administration of India and the presence of a national monarchy in Japan in this context is not valid.[5]

More serious explanations center around "the organizational and institutional environments" in India. The proponents of this view argue that since most of the promoters of Indian mills came from mercantile families, and since they had neither the knowledge nor the experience of dealing with modern technology, they concerned themselves primarily with financial aspects, and left technical matters to the care of British experts. And these experts had a natural bias for British technology as most of them had been sent by British machinery makers, local talents being unavailable thanks to almost nonexistent technical education (Otsuka, Ranis, and Saxonhouse [24, p. 71]).

True, a large number of the early promoters of Indian mills had been traders and moneylenders before entering the industry. But so were the promoters of the Japanese firms; few if any were experts in technical matters. And Japanese mills, too, at the initial stages had to depend on foreign experts about technological aspects (Seki [31, pp. 15–17] and Smith [32]). But while the Indian mill owners accepted the British experts' advice almost uncritically and continued to use their services much longer, the Japanese producers were much less subservient to the foreign advisers and replaced them with indigenous personnel much sooner.

The above argument fails to explain why the role of the British experts had an aura of near-finality for the Indian mill owners. It also seems to presuppose erroneously that entrepreneurs must possess personal knowledge of technological intrica-

[4] See Buchanan [5, pp. 203–205] for India's imitation of Britain, also ILO [14, pp. 48–56]. Robson [30, p. 339] gives statistics on British technologies.

[5] M.D. Morris, who normally takes a more sympathetic view of British colonialism, has recently mentioned this as one of the explanations. See his review of Otsuka, Ranis, and Saxonhouse [24] in *Journal of Japanese Studies*, Vol. 15, No. 1 (Winter 1989).

cies, whereas all they need is to communicate intelligently with their technical managers and evaluate effectively the alternatives recommended. Against this background, the relative differences between the Indian and Japanese attitudes to technology are easily explainable: the Indians lacked a technological inclination unlike the Japanese.

The Indian promoters of cotton mills were the product of a society which could not have generated a great deal of technological orientation. Admittedly, India could boast of a rich scientific heritage and outstanding technological achievements in the past, the evidences of which can be seen in many parts of the country even today. However, this had failed to create a multiplier effect because little attention had been paid to develop and sustain an environment conducive to scientific research and experimentation. As the educational curriculum remained heavily weighted in favor of languages and classics, applied skills were passed on from father to son from generation to generation. This paved the way for routinization of certain methods and techniques but could not generate the quest for technological innovation. Widespread illiteracy reinforced this tendency still further. Such a society could hardly nurture a strong technological tradition and whatever of it had developed had already exhausted itself much before the colonization process of India began (For details on this, see Rahman [26, pp. 25–52], Rahman et al. [27, pp.1–23], and Bhattacharya [2]).

In contrast, the technological base of the Japanese society had become quite stable long before the process of industrialization started in that country. This, ironically, was partly due to the policy of seclusion strictly enforced by the pre-Meiji regime. While the country was cut off from the rest of the world, opportunities for agricultural pursuits were expanding partly due to the official patronage. The only way to facilitate the exploitation of the new opportunities was to improve the indigenous know-how. Consequently, a large class of writers emerged in Tokugawa Japan—Thomas C. Smith calls them "technologists"—for whom this became the primary concern. The cause of economic progress for them was more important than anything else, and this was possible only through the introduction of better methods in forestry, sericulture, mining, and sugar manufacturing, and the use of improved seeds, fertilizers, and farming implements. The technologists endeavored to discover these methods and instruments and disseminate the results obtained through their writings (Smith [33] and Jansen [15]). Whether and to what extent were their recommendations adopted is beside the point. The development of such a large body of applied literature concerned with practical problems of agriculture and industry indicates a widespread interest in such matters among the Japanese masses, nearly half of whom could read and write. This in general must have created a more innovative approach to technology. The textile producers of Japan were the beneficiary of this social inheritance.

The adverse effects of the lack of technological orientation were compounded by

the impact of what I would like to call the "colonial syndrome" on the business behavior of Indian mill owners. By colonial syndrome I mean an instinctive inclination of a subject people to emulate the practices, behavior, and institutions of the ruling country, resentment against political subjugation notwithstanding. Ample evidences relating to other spheres can be cited to support the view that the Indians in general suffered from this affliction during the formative years of the textile industry. However, this tendency was much more evident in the choice of technology. Great Britain then was the leading industrial nation in the world, and the Indians had much greater exposure to its glittering economic might due to the imperial connection. They naturally concluded that the technology that was good for the most successful industrial country would also be good for them. The advice of the British experts regarding technology fell on receptive ears.

Lack of a strong technological tradition coupled with the colonial syndrome, thus, created among the Indian mill owners some sort of technological myopia which placed an unwarranted and undesirable limit on their technological choices and even inhibited experimentation to modify the imported technology to suit Indian conditions and needs. Seen in this perspective, their preoccupation with financial aspects of their enterprises and uncritical acceptance of their foreign technicians' recommendations were not the cause but the effect of their inability to play an effective role in matters relating to technology.

The poor state of technical education or slow development of it could have had only marginal effects on the prevailing conditions. True, there were only two engineering colleges in the country at the onset of the Indian textile industry, and little attention was paid to developing technical education almost up to the end of the 1880s. Progress remained slow even during the subsequent period, and it was not until after the end of the First World War that the situation somewhat improved. Indian technicians, however, had begun to replace British experts soon after the establishment of the first mill. The number of foreign staff continued to decline with the corresponding rise in the number of Indian personnel so that by the end of the nineteenth century less than 50 per cent of the technical positions were filled by foreigners. In almost every category of higher posts in Bombay mills, Indians outnumbered Englishmen. And yet, the Indian preference for technology continued to conform to the British lead rather closely. As a result, the rising number of indigenous technical staff did not exert a significant effect on the choice or evaluation of technology. Since the Indian technicians themselves could not have remained immune to what we have called the colonial syndrome, their presence did not affect appreciably the process of evaluating various available technologies. It is also possible that the owners of the mills did not always have the same confidence in the competence of the Indian experts as in that of the British hands even though the quality of the British staff was not very high—another evidence of the colonial syndrome (Kiyokawa [17] and Mehta [20, p. 106]).

Moreover, the Indian cotton producers made practically no attempt to develop indigenous techniques or even modify the imported ones to suit the Indian needs. The undeveloped state of technical education would have made any significant experimentation difficult during the initial stages of the industry, but the situation remained unchanged even after the number of Indian technicians in the industry increased considerably. The Indian industrialists did not attempt to develop indigenous cotton machinery almost until the end of the British rule, and the real progress took place only after independence. It is possible that given some encouragement and the hope that the results obtained would find some application in the factories, the Indian technicians and even the artisans would have made some attempts that could have had a multiplier effect. In fact, during the First World War, when the imports were difficult, the local craftsmen at least in Ahmedabad did produce substitutes for some small parts to ensure that the mills continued running.[6] But the end of the war put an end to their initiative as the industrialists now had access to sources in which they had greater trust.

Comparison with Japan is again revealing. The process of addressing the problem of developing indigenous technology began almost immediately after the establishment of the first cotton mill in that country. A new kind of spindle known as *gara-bo* spindle, began to be produced commercially by the middle of the 1870s. Even though the device using power from a waterwheel was rather primitive by Western standards, it captured a large domestic market because of its low cost. It continued to be in use in the waste spinning industry even after the spinning mills discarded it in favor of better substitutes. Efforts to develop indigenous weaving technology began a little later; still, as we have seen earlier, Japan had its own power loom, almost comparable to the imported machine in quality, perfected before the end of the century and an automatic power loom a little later. Unlike the *gara-bo* spindle which was an improvement over the existing handspinning system, the Toyoda automatic power loom was a modification of the imported technology to suit the Japanese needs and conditions (Kiyokawa [18]).

The Japanese contribution to indigenous technology using these twin routes—improving an existing indigenous system or modifying a foreign device—increased in later years as the technical education took firm roots. But the initial momentum was provided largely by the sense of technological autonomy generated by the work of the technologists of the bygone era on the one hand, and the absence of colonial syndrome on the other. As the country proceeded further on the road to industrialization, technological independence—reflected in the modification of imported technologies to suit the country's needs and environment, if not in original innovations—emerged as a national creed for the Japanese industrialists.

[6] This information is based on discussion with Gujarat Panchal Samaj, Ahmedabad and a magazine published by them.

The fact that a national monarchy promoted this process by providing necessary infrastructure and environment in no way minimizes the importance of the dynamism that characterized the industrial entrepreneurship in Japan from the very inception of modern industries. The Indian approach, at least in matter of technology, remained rather static.

We have concentrated our analysis on the behavior of Indian textile manufacturers for three reasons. First, modern industry started in India with the textile industry. Second, cotton manufacturing developed into and remained the largest, the most organized, and the most impressive expression of Indian entrepreneurship throughout the colonial period. And lastly, India had had a rich tradition of textile production, and the industry had held a major position in the Indian economic life for centuries before modern manufacturing devices were introduced in the country. Both the past history of the industry and the power and size it acquired by the end of the nineteenth century should have reduced the possible risk involved in, and thus induced, technological experimentation. That it did not happen makes the Indian failure all the more striking.

II. THE LATER PHASE

The formative years of the Indian textile industry coincided with the period of considerable goodwill for the empire in India and great appreciation for everything British. This was reflected in the world of business where a remarkable degree of cordiality prevailed between the Indian and British businessmen operating in India. As the areas of operation of these two groups were by and large separate, the possibility of conflict between them was indeed limited. The Indian industrialists under these conditions were still not conscious of their distinct identity. This might have been an important factor, it may be argued, behind their uncritical fascination for the British technology during this period. The gap between the two groups began to widen around the turn of the century and became almost unbridgeable by the beginning of the 1920s because of the combination of a variety of factors, including the rise of a militant nationalism indicative of mass disaffection against the imperial connection.[7] And yet, the technological choices of the promoters of the industries that started developing in the first half of the present century bore no evidence that India was developing any sense of technological autonomy. The only difference between their approach and that of the textile manufacturers was that their search, unlike the textile producers, was not confined to Great Britain alone.

Let us take the case of steel. The industry remained almost synonymous with the House of Tatas as the Tata Iron and Steel Co. Ltd. (TISCO) at Jamshedpur was the only concern in the field well up to the onset of independence. J.N. Tata, its

[7] For a comprehensive discussion see Tripathi [39].

founder, first explored the possibility of securing technical experts in Great Britain. This was understandable because most technical processes for producing steel had been developed and perfected in that country. Having failed in his attempt because of the British belief that a steel venture had little chance of success in India—this belief was also a major factor in Tata's failure to attract British capital—he turned to the United States, the largest single producer of steel in the world. This, too, was understandable as indigenous expertise in intricate steel technology was not available (Fraser [11, pp. 51–52] and Bagchi [1, pp. 292–93]).

What, however, cannot be easily explained is that even such a progressive business group, whose founder's acute appreciation of the role of science and technology in a nation's development had resulted in the establishment of the prestigious Indian Institute of Science at Bangalore, continued to depend on foreign technical personnel at senior levels almost up to the end of the colonial rule. The first concrete step to develop technical expertise of the Indian staff was not taken until 1921 when the Jamshedpur Technical Institute was set up, and an apprentice school to develop trained technicians was established only in 1927. The process of Indianizing the works did not begin until 1931, the first Indian general manager did not take over until 1938, and as late as 1944 the company still had some foreign experts filling senior posts. Under these conditions, the question of any significant modification in the imported technology and development of the indigenous process did not arise. In fact, every time the TISCO diversified into new product lines, it turned to foreign, usually British, companies for collaboration (TISCO [34, pp. 23–24], Verrier [42, pp.68–70], and Ray [29, pp. 85, 90]). Even more revealing of the TISCO's indifference to technological aspects is the fact that practically no attempt was made to increase the efficiency of its production system with a view to reducing costs per unit of output or improve quality for given cost. This could have been possible with some attention paid to research and development. But changes in the production function via technical progress did not contribute significantly to the company's rate of growth (Dhar and Nath [7]).

Tata's other ventures, too, depended on imported technology with no attempt to modify it or use it as a base to develop indigenous know-how. Of these, the hydroelectric system comprising three concerns—Tata Hydro-Electric Power Supply Company Ltd., Andhra Valley Power Supply Company Ltd., and Tata Power Company Ltd.—was for all practical purposes managed by an American syndicate between 1930 and 1951, and the Tata Engineering and Locomotive Company Ltd. (TELCO) was not launched until 1945. The Tatas, therefore, cannot be held responsible for the static approach to technology development in the power supply system, and TELCO had yet to start production before colonialism ended. However, this house, whose founder had been the first Indian mill owner to appreciate the relative advantage of the ring frame, was as slow in later years as other textile producers in adopting new technological devices such as automatic power looms.

Also, even the cement industry, of which the Tatas were among the pioneers, did not reflect any indigenous attempt to contribute to the technical know-how, even though the technology required was fairly simple, unlike steel or power production which required an intricate network of processes. The early cement companies imported machinery from a variety of sources, but after almost all of them amalgamated to form the Associated Cement Companies (ACC) in 1936, a Danish firm F.L. Smidth and Company, which was a world leader in the field, became the major source of technology (Harris [12, pp. 230–33] and Tripathi and Mehta [41, pp. 63–70, 172]). Even the ACC with its unassailable position in the market did little to promote necessary research and development.

Like cement, sugar production required rather simple technology and Indians had produced their own varieties of unrefined sugar from time immemorial under the traditional method. They were not attracted by modern technology for quite sometime. Even after some British firms, such as Thomas Parry and Company and Begg Sutherland and Company, had set up production facilities as early as the second half of the nineteenth century, not much later than the onset of the Indian cotton textile industry—and some had even introduced minor innovations—only one Indian producer, the House of Narang, had entered the field before the end of the 1920s. It was only after the government granted protection in 1931 that Indian-promoted units appeared in large numbers. The industry reaped large profits as a result of protection and was seldom short of financial resources, but no attempt was made to promote research and development except in the government laboratories (Brown [4], Bagchi [1, pp. 357–90], and Ray [29, 143–44]), the results of which had little impact on the continuing hold of imported know-how on the Indian production process.

The industries mentioned above were promoted by persons who had little personal insight into technical matters. Their choice of technology was based either on the understanding they had gained through their exposure to the developed economies of the West or they simply followed the lead of early pioneers in this field. However, even the entrepreneurs with technical competence did not demonstrate a will or desire to promote technological innovation.

The case of Kirloskar Brothers illustrates this point. The founder, Laxmanrao Kirloskar, was definitely an engineer of considerable ability who in his early business career developed some improved agricultural implements for the benefit of the Indian farmers, bearing the stamp of his innovative ability. However, as the business developed into a house and more sophisticated goods were produced, like centrifugal pump, oil engine, machine tools, and electric motors, the Kirloskars decided to collaborate, mainly with British firms. Even though Laxmanrao's three sons—Shantanu, Rajaram, and Ravi—were highly trained engineers, well versed in the technical aspects of their various product lines, their expertise was reflected more in duplicating the imported technology with a great deal of success than in

promoting indigenous know-how. The same applies to the Seshasayee Brothers, trained as electrical engineers in the United States, who played a pioneering role in rural electrification in South India in the 1930s and later set up the prestigious Fertilizers and Chemicals Travancore Limited (FACT) just before the independence. The only difference was that they depended more on the American technology than the British.[8]

The story is repeated in chemical industry. The industry did not make much headway in colonial times and the contribution of the Indian promoters to whatever little development took place was not very impressive. Most of the companies in the field continued to concentrate their activities on the production of sulfuric acid and chemicals based on it; the production of alkali group, comprising various forms of soda and compound based on them and involving more complex technology, began only toward the end of the British rule. Most of the Indian companies engaged in the production of chemicals were controlled by bigger houses—Tata, Dalmia, and Seshasayees—but some were small ventures set up by persons with a considerable technical expertise. In fact, among the first to start chemical production in India was Praful Chandra Rae who had a Ph.D. degree in chemistry from the University of Edinburgh and taught the subject for sometime at the Presidency College, Calcutta. His operations, launched as early as 1892, later developed into the modest Bengal Chemical and Pharmaceutical Works Ltd. at Calcutta. Another chemistry professor, T.K. Gajjar, set up a chemical plant around the same time out of which grew the Alembic Chemical Works Ltd. at Baroda (Tripathi and Mehta [41, pp. 116–46]). The technological vision of neither the established houses nor the technically qualified entrepreneurs went beyond import substitution. Technology development was their lowest priority.

Political sympathies did not affect the situation either. We may recall that the Swadeshi movement in the first decade of this century did not place emphasis on developing indigenous technology; the mills were directed merely to use Indian stores. In fact, in view of the public attitude against the use of imported cloth, many new mills were set up or the capacity of the existing ones expanded all using imported machinery. Although Indian nationalism became increasingly militant during the following years, Indian industrialists remained by and large apolitical or their anti-British feelings remained more or less subdued (Tripathi [40]). The nationalist sympathies of a few, however, were more pronounced. Laxmanrao Kirloskar, who had been a victim of racial discrimination in his early career, was one of them. His house, however, took no concrete steps to enable India to move closer to technological autonomy, as we have seen earlier.

Walchand Hirachand's case is still more revealing. Unlike Kirloskar, he had not

[8] Tripathi and Mehta [41, pp. 131–46]. Information on Seshasayees is gathered from company publicity material.

experienced racial discrimination. However, no Indian businessman was more vocal in his support for the nationalist aspirations, none had greater hatred for British rule, and few surpassed him in his zeal for economic independence for India. But neither his shipping venture, challenging the British monopoly in Indian waters, nor his agribusinesses including sugar at his Ravalgaon Farm, gave any evidence of his concern for technological autonomy. The ships he bought for his Scindia Steam Navigation Company Ltd. were all British-made, repairs and maintenance remained in the hands of British technicians, and extensive discussions with British experts preceded the launching of his stillborn shipbuilding project. Britain then was among the leading shipbuilding nations in the world, and Walchand's preference for British vessels and British expertise had a rational basis. But even a person with his vision did not attempt to develop indigenous technological capability.

His Ravalgaon Farm Enterprises continued to depend on imported technology with no concern for research and development. For his automobile scheme, even though he could not entertain the thought of financial participation by possible foreign collaborators, he had to depend on them (Chrysler of the United States and Fiat of Italy) for technology. G.D. Birla too, more subdued in his nationalist feelings, was following exactly the same course in his scheme to produce passenger cars indigenously (Tripathi and Mehta [41, pp. 147–69] and Ray [29, pp. 126–38, 145–68, 183–209]). That Walchand's Premier Automobiles Ltd. and Birla's Hindustan Motors Limited continued to produce the same models for almost forty years, a kind of world record, reflects their low concern for developing the nation's technological autonomy.

We have dealt here only with those manufacturing industries which had achieved some degree of development before independence under Indian management and control or which were pioneered by Indians. Some steps to develop glass, matches, aluminum, light engineering, and paper industries were also taken particularly during the twentieth century, but Indian presence in these fields remained too limited to be noticed. Also, no technological innovation was recorded except in the case of paper and matches but here, too, the momentum was allowed to be lost. An indication of the static Indian approach to technology is the number of patents applied for. While the applications started to rise after the turn of the century, the number of Indian applicants remained small; most of them were Europeans or non-Indian residents in India. As late as 1930, out of 1,099 applications filed in Indian patent offices, only 212 originated in India; the others were from Europeans. And most of these 212 were related to simple agricultural implements, irrigation equipment, or other devices centered around craftsmanship (Morris [21, p. 639]).

III. CONCLUSION

This technological inertia cannot be attributed to explicit acts or policies of the

colonial regime. By introducing technical education, even late, and developing it, even inadequately, the government may have provided at least a base for scientific and technological discoveries. The colonial regime should also be given credit for setting up agencies for scientific and technological research relating to selected industries; Harcourt Butler Institute of Technological Research, All India Imperial Council of Sugar Technology, Imperial Council of Agricultural Research, and Forest Research Institute, to mention some of the most important ones. The efforts of at least some of these yielded good results. Bamboo pulp for manufacturing paper, for instance, was developed at the Forest Research Institute and the Hadi process for producing sugar was developed at the Department of Agriculture in the United Provinces. Also private individuals developed innovative processes such as the invention of M.C. Nandi of Comilla for producing matches (Bagchi [1, pp. 391–96, 362] and Ray [29, p. 155]). Arguably, the government could have been more active, but there is no evidence that it obstructed or discouraged technological experimentation, or consciously and deliberately encouraged the use of any particular kind of know-how. It has been argued that if the government had supported the process of industrialization by offering protection, the Indian enterprises would have been in a better position to implement programs of research and development. The experience of the industries that came under protection such as steel and sugar, and also of those that developed despite government indifference if not antipathy such as cotton textile is sufficient to rule out this argument.

The only factor that may have prevented the Indian industrialists from paying adequate attention to technological innovation was their easy access to foreign technology, due to the imperial connection, and their instinctive feeling that the technology produced or preferred in the metropolitan country—and by association in other relatively developed countries which incidentally were all white—was unquestionably superior to what they had or what they could develop indigenously.[9] There was, thus, no psychological motivation to invest in research and development, which by its very nature would have entailed high costs with uncertain results. And since foreign exchange controls were not clamped until the Second

[9] I would like to cite two incidents relating to two different periods in the history of Indian industrialization which may suggest that given a different set of circumstances, Indian craftsmen could have risen to the occasion. The first incident took place in the initial phase of the development of the textile industry. The engineer sent by the English machinery suppliers for erecting the first mill at Ahmedabad could not arrive in time and the machinery was constructed by Indian staff with the help of locally available English engineers. The other incident took place in the last decade of colonialism. The House of Lalbhai, desirous to set up a starch company, had ordered machinery from Germany. The Second World War broke out soon after the machinery was dispatched and the machinery never arrived. Also the German expert advising the promoters was interned and sent to Australia. Undaunted, the Lalbhais, using the services of an Indian engineer, constructed the machinery with the help of drawings already sent by the suppliers. Anil Starch, among the first producers of starch in India, was thus launched. For details see Tripathi and Mehta [4, pp. 44–45] and Tripathi [37, pp. 81–82].

World War—the end of the colonial period—importers of foreign machinery did not have to overcome this constraint. As the prospects of industrial application of the processes developed indigenously were remote, scientists and technologists in the universities and research establishments had little incentive to make any effort in this respect. As a result, the weak technological tradition of the precolonial days was not fostered during the colonial period and was strengthened only marginally.

I have argued elsewhere that a welcome, though unintended, by-product of the British ruling presence was the emergence of a better climate, though not commensurate with the country's potential, for industrial entrepreneurship in India (Tripathi [36]). The rather passive attitude to technological choice and development was yet another unintended by-product of colonialism. Even as the development of modern industries in colonial India, no matter how limited and lopsided, provided a base for postcolonial transition, the unfortunate hangover of a static approach to technology, generated by the colonial syndrome, seems to have inhibited the indigenous contribution to technical advancement in Indian industries for a long time even after the country became free.

Even a casual look at the industrial scene in postcolonial India would bear this out, although a comprehensive assessment of the Indian industrialists' approach to technology is yet to be made.[10] Their record of modernizing and updating the technology for traditional industries such as textiles leaves much to be desired, and their preferred strategy to bring in technology for more sophisticated industries such as automobiles and electronics has consisted of collaboration with multinational enterprises. Cases of outright purchase of technology have been rare, for the will and capacity to assimilate and adopt imported technologies have been mostly absent. No wonder then that research and development (R&D) in Indian industrial firms accounts for a negligible percentage of their annual turnover.

As a cumulative result of all this, free India has not been able to move vigorously in the direction of even process innovation, much less product innovation. A sad commentary indeed on a nation boasting of one of the largest technical manpower in the world! Undeniable, the regressive policies of the government stifling unduly the freedom of the private enterprise until very recently have been responsible to some extent for this state of affairs, but the colonial legacy of soft-option approach to technology must also share the blame.

To understand the full implication of colonialism, thus, it is not enough to analyze the policies and pursuits of the colonizer, which can be nothing but exploitative. In fact, exploitation is such an integral component of colonialism that to stress it is to attempt to validate an axiom; to try to prove what needs no proving. To look at the other side of the coin, to probe colonialism's impact on the victim's

[10] Perhaps the most competent among the few works available on the subject is that of Lall [19]. Hilding [13], though dealing with a specific industry, discusses general policy issues.

attitude, ethos, and behavior may perhaps be more rewarding. In the case of technology choices by industrialists in colonial India, this certainly seems to be true.

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