Learning to Innovate vs. Learning to Manufacture: Towards an Alternative Technology Strategy

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Introduction

It is useful, both analytically, and also in terms of delineating a manageable area of inquiry, to distinguish between three categories of industrial technology relevant to the post-independence Indian experience. The first of the categories comprises an epochal genre, of new sources of energy from nuclear processes, of advanced forms of communication and control based on electronics, on extending the boundaries of technological inquiry itself through space and ocean exploration and, finally, on developing new methods of processing material such as biotechnology. Both the initial and the sustaining impetus for these efforts came largely from their perceived nexus with the security concerns of the Indian State. On the whole, in scientific and technological terms, there have been considerable achievements in these fields.

The second category of technology to have received systematic, if less sustained, attention is that of the indigenous manufacture of basic raw materials, intermediate goods, and the more complex capital goods (steel, petrochemicals, non-ferrous metals, large scale machine-tools and electrical equipment). Manufacturing units in the public sector were established, largely during the second and third Five Year Plan periods in these sectors. Here, too, substantial capabilities were achieved technologically, particularly in the training of skilled designers and shop floor operatives. In these cases however, policies have been subject to a degree of political vagary. Due to a variety of reasons both connected with the slow growth of the economy which led to poor capacity utilisation in these units, and their perceived relative distance from primary defence concerns, the State permitted attrition in the actual innovative capability of these units in the subsequent plan periods. These phases of attrition were marked by the Union budgets of 1976, 1980, 1985, and 1991, during each of which a fiscal environment which militated against the technologically productive interaction between these manufacturing units, and their potential customers, largely in the private manufacturing sector was further reinforced. This process of attrition has been

documented in some detail though the emphasis, perhaps naturally, has been on the pressures exerted by transnational corporations (as suppliers of ready-to-use manufacturing technology) on State policy towards the public sector, and insufficiently on the conceptual, organisational and political impediments to establishing the technological interaction mentioned earlier. The public enterprises themselves, the institutional form of this exercise in regard to the creation of technological capacity, have been severely handicapped in consolidating their achieved level of innovational capacity. Principally, this has been due to their inability to generate surpluses, which could relieve them of dependence on the general budget to support their capital expenditure programmes. With this dependence goes a debilitating subordination to technologically wayward policies. In spite of these pressures, many of these enterprises have shown a considerable degree of dynamism.

It is, in fact, precisely this lack of technological linkages which is one of the areas of concern to this paper, which aims to examine the reasons for the torpidity apparent in the third genre of technology, that of final goods manufacture within Indian private industry. It is with this third level of technological systems, predominantly in the batch processing industries that the failure has been the most marked. These systems are embodied in the private corporate sector, which in terms of the number of firms and of technological transfer agreements, dominate the country's industrial sector.

The Indian National System of Innovation

The concept underlying policies for establishing a private sector manufacturing base in the batch processing industries in India was the phased manufacturing programme (PMP). This, as the name implies, was a programme drawn up jointly by an Indian firm and a foreign collaborator, approved by the government. Under it, specific components were expected to be produced within the country and their import to be prohibited after a set time period. Thus, moving through the stages of the import of complete units and, subsequently, the assembly of these units from imported components, the PMP was expected to lead to the growth of generalised indigenous manufacturing capacity. While it was not presumed that all components could be manufactured indigenously, it was expected that the programme would cover items where economies of scale could be achieved, either in the manufacturing unit itself, or in ancillary units that would fully use their capacity by providing components to several assemblers. By and large, at the level of manufacturing capability, the programme was successful. In terms of what is called standard modern technology, India was well placed to produce a large range of capital goods. These matched the overall environmental conditions (for example, the capacity for preventive maintenance and the facilities for major overhauls) not only in India, but in other countries of the

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Third World. The country was successful in exporting machinery, the constraint often lying in its inability to match the credit granting facilities available to its competitors.

Thus, abstracting in the first instance from questions of quality and price, the Indian manufacturing sector has shown impressive post-Independence advances in the sheer range of products indigenously produced. However, these firms have not been able to generate a base for innovation in design, manufacture, quality and reliability, and cost reduction, even taking into account all the relevant factors: the fact that innovations are nowadays often multinational in nature, the necessarily limited home market for products and components incorporating advanced technologies, and so on. Even in terms of upgrading manufacturing technology, which might not amount to an internationally acceptable innovation, the performance of the Indian private sector has, with a few notable exceptions, been abysmal.

Criticism of Indian made products (of their quality, of the lack of product innovation and of their price) began almost simultaneously with the transition from imports to assembly, in the late 1940s and the mid-1950s. These criticisms became more vocal with the deepening effects of import-substitution and indigenisation, which accompanied the Second and Third Five-Year Plans (1956–60 and 1961–65). By the 1980s, with the replacement in the dominant developmental paradigm of import-substituting industrialisation with that of export-oriented industrialisation, public disenchantment with these characteristics could be used to drown out rational discussion of underlying technological issues (Kaplinsky, 1984).

One of the crucial technological issues sidelined by this paradigmatic shift was that of linkages between sectors. Not only does the performance of these private sector firms have implications for other companies within the same sector, their technological non-performance constrains the effectiveness of organisations to which they provide both components and market in the previous two technology domains (the epochal and the public sector capital goods manufacturers). In other words, too great a degree of dualism (in competence) across technological sectors can hold back the progress of the more advanced sectors.

The continued large-scale resort to foreign collaborations in the process of diversifying the manufacturing base gave rise to concern over the source of technology. Explicit high-level discussion of this issue can be traced to the report of the Third CSIR Review Committee, published in 1964. Subsequent research showed that lack of relevant technological expertise, perhaps inevitable in the historical context of colonialism, could take on a self-perpetuating character. Initial imports of capital goods and technical services needed to start production were accompanied by a degree of external

managerial control over decision-making by foreign collaborators, who had an interest in continuing to provide these goods and services. However, even 10 years later, when a technical evaluation committee was established to monitor the technological content of collaborations, this appears to have been largely an administrative adjunct.[1] There was some professional monitoring of the technological growth of firms that had been granted approvals starting from 1973, but it is not clear how effectively this was able to force firms into a different mode of operation. Fiscal concessions for the establishment of R and D centres easily led to the multiplication of organisational fifth wheels. Simply put, Indian policy did not require the development of a conception and operational procedures analogous to the PMP in the area of technological competence.

This had its effect even on the functioning of development banking institutions in addition to administrative regulatory institutions, where conservatism could in any case be expected. In fact, it has been argued that the problem was not only that India did not have a technology policy, but that its foreign exchange conservation policy was directly responsible for the unacceptable levels of performance. Considerations of foreign exchange outflows, which flowed from the need to achieve collaboration agreements in the most economical way possible, may actually have led to higher costs in the longer term. In other words, it was argued, greater flexibility in lumpsum and/or royalty payments might actually have resulted in a higher grade of information transfer and on fewer restrictions on exports (which would have increased the size of the market).

Much of this line of criticism was, in fact, directed against the implicitly Listian philosophy, which the 1950 Fiscal Commission proclaimed as the creed of Indian developmental thought. Critics pointed to the unrealistic character of attempting import-substitution in a situation where, firstly, the market was small, thus preventing the lowering of costs that the achievement of economies of scale would allow; and where the lack of competition, both internal and from transnational corporations, prevented any incentives for Indian firms in sheltered markets to undertake manufacturing innovations.[2] To buttress this argument, critics pointed out that even in specific product groups where economies of scale did exist, firm behaviour was little different from the general lack of technological dynamism observed elsewhere. Further, Indian firms might be excused from investing in R and D on a scale necessary to achieve results (comparisons were made of the entire turnover of some of the biggest Indian firms with merely the R and D budgets of their transnational competitors). However, even when innovations, or laboratory scale processes indigenously developed within public sector research institutions were available, firms rarely took advantage of these to

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commercialise the knowledge through innovations in manufacturing methods.[3]

The responses required to correct the situation naturally were those implicit in the nature of the analysis and criticism. Markets that would support manufacture at economically viable scales of production should be sought by directing the attention of Indian industry to world demand, if this were necessary. This would also set standards of quality, price and expectations of product innovations. Pressure on Indian firms to invest in the manufacture of these commercially new products and processes would come as a result of the competition of transnational corporations, which would be permitted to operate in the internal Indian market. Manufacturing input costs could be made comparable for Indian and foreign firms by reducing duties on imported items, which would provide corresponding pressures on Indian component manufacturers and input suppliers to improve quality and reduce prices. Criticism essentially focused on the policy-induced lack of incentives for incremental technical change stemming from shopfloor initiatives, let alone for innovations that involved coordinated R and D, manufacturing and marketing efforts within and across firms.

The discussion of the technological performance of Indian industry that began with the report of the Third CSIR Review Committee in 1964, continued through the 1960s and the 1970s, with successive relaxations in the administrative regime. During this period, what seems to have happened was the greater use of technologically based skill and care in the collaboration negotiation process. The technology package was unbundled, approaches were made to a greater variety of suppliers and costs were consequently reduced. What still predominated, however, was a situation where Indian firms were buyers of technology, exchanging cash for knowhow. It was still an inevitably weak situation, which all buyers in a near monopolistic market are in, whatever the degree of informed skill used in negotiation.

Collaboration between Indian firms and foreign suppliers of technology has been the major channel through which the manufacturing base in the country has been diversified (Nayar, 1983). From the Third Five-Year Plan (1961–66) onwards, however, debate has centred on the efficacy of this mechanism in achieving the goal of self-reliance (India, 1967). This was also the period of UNCTAD's preeminence, when it was the thrust for a new international economic order that underlay negotiations over trade and aid. It is, therefore, not surprising that both official and academic analyses of the technological problems of Indian industry addressed issues centred on the concomitants of achieving a new economic order; of evolving a code of conduct for technology transfer; on the methodology of bargaining with technology suppliers; and, more generally, on the methods of acquiring adequate technological knowledge

in each agreement, so that 'repetitive' imports of technology were obviated (India, 1989; Patel, 1982; Subrahmanian, 1972; 1978).

Simultaneously, there was an awareness of the internal constraints to generating technological dynamism: the relatively small size of the internal market for most industrial products which, *a priori*, precluded threshold levels of R and D expenditure by firms; the oligopolistic nature of this market that deflected attention away from innovation; the presence of conglomerate groups whose industrial interests straddled the major sectors of industry and presented major barriers to entry of new firms; and the problems inherent in the attempt to establish self-reliance through barriers to the ill-effects of the world market by the mechanism of administrative controls on imports and on foreign exchange transactions (Bagchi, 1971; Desai, 1972; Mitra, 1981). In fact, the problem was even more complicated than it would seem: the most dynamic firms, Tata Engineering, Bajaj Auto and Escorts, amongst others, all belonged to the 'big business groups' and all operated in oligopolistic markets (Lal, 1987). However, before it could be established that these stray cases were exemplars, rather than oddities, it was necessary to examine the behaviour of the large universe of firms that had imported technology and, indeed, even of those that had not (Desai, 1984a; 1984b; 1990). The point is that the technological base of the economy depends critically not on the market leaders, but on the firms that represent what might be termed the 'modal' level of competence. This is because the production of complex industrial products requires some degree of sub-contracting and this interdependence presupposes an equal order of ability, technologically, amongst parts and component suppliers and the core manufacturing firms (Bhagavan, 1990). Estimation of the 'modal' level of technological development is a major exercise, however, requiring estimates in broad aggregates of relevant technology specific indicators and detailed case studies (Desai and Taneja, 1990).

It is well known that much of the technology transfer across OECD countries takes place on a knowledge barter basis, where acquisition in one specific area is matched by supply in another (although individual firms may be pure buyers or sellers) (Chesnais, 1988). This aspect of technological capability, i.e., the ability to provide core technology to firms in other countries while importing the know-whow of other elements had been absent from the Indian concept of self-reliance. In India, the concept, related as it was to the public sector, had been largely confined to establishing capability within the country itself. The export of engineering services and projects undertaken by some public sector units to OPEC countries in the 1970s, ironically, represented a unilateral (expertise for oil) transfer of knowledge. The Indian presence in the process of international technological transfer was limited to joint ventures involving standard engineer-

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ing knowhow, rather than partnerships with countries of comparable capability based on complementary knowledge bases (Thomas, 1982; Lal, 1988).

Effective participation in the international exchange of technological knowledge requires a much greater degree of competence across the entire industrial spectrum than that existed in India. Unless this spread existed, the more advanced firms were forced to concentrate in-house (the exact analogue of the national technology effort, which had tended to autarchy). This inevitably increased costs, but more germane to the present discussion, it reduced the chances of diffusion of more advanced technologies through inter-firm cooperation.

Learning to Make vs. Learning to Make Better

The half century of developments in India since Independence has demonstrated that there is a difference between the expertise required to make a commodity and that needed to make it better or cheaper, i.e., to innovate. Research in the late 1970s, in fact, confirmed that if the experience of production was expected to contribute to technical change, two sets of knowledge and information were required. One arose from production experience; the other, more general, needed to be acquired from elsewhere (R and D activities within the firm or from specialised research institutes) and brought into intimate contact with the more immediate and specific production experience.[4] The production of capital goods alone, important as it is, does not in itself imply technological mastery.

Certainly, for most industrialists, it appeared to be that technology was treated as synonymous with plant and machinery: it was seen as something fixed and given, an artefact, which was to be acquired (Bell et al, 1982:154). It was not something to be adapted and improved, let alone produced through any conscious efforts within the firm, possibly with the help of specialised R and D institutions. It was something that a firm either had or did not have, and in the latter case, it was simply to be bought in the form of the specific manufacturing system appropriate for the product. In such a scheme of things, 'technical change', i.e., technological upgradation was to be effected by the repeated import of the necessary capital goods and production related services. A low order of priority (if any at all) was given to investment in resources for effecting technical change within the firm.

Codification of technology, essential for a firm intending to go into the business of innovation, is the result of the distillation of the experience of technologists and workers, and its subsequent documentation, so that the experience becomes replicable (Desai, 1984b). Codification, as embodied in designs, specifications, patent descriptions and other documents, is thus a record of a specific stage of technological evolution. Innovation, defined as

the improvement of this record on the basis of experience and experimentation is considerably enhanced if there is co-operation between the seller of technology, the buyer using the technology, and capital goods manufacturers. For innovation, storage, retrieval and revision of information within the firm are essential. Conversely, they are not obligatory for building up a manufacturing production system with the collaboration of a foreign firm.

This prerequisite reinforces the natural tendency amongst many indigenous entrepreneurs to seek modes of response to external stimuli for change, which are other than those involving investment in the resources necessary to effect a firm's own technical change (Bell et al, 1982:154). The competitive response to a firm's economic environment was predominantly focused on product differentiation and the associated marketing effort, rather than on responses that centred on productive efficiency and on cost and price reductions. This diagnosis has been confirmed by empirical investigations into Indian firms (Desai, 1984b:245-261).

Interestingly, even critics of India's Listian development strategy did not feel that its policies were obsolete, only that they were misplaced from the point of view of productive efficiency and were conducive to corruption.(Mirrlees, 1968; Bhagwati and Desai, 1970; National Council of Applied Economic Research, 1971; Desai, 1972). It was in the mid-1980s that the 'lessons of Japan' and later of South Korea began to draw attention to aspects of the system of innovation seemingly far removed from the issues of technology. These issues included the historical process by which the industrialists as a class developed and the specific forms in which the workers' subordination congealed in the change from handicraft production to the corporate form of organisation. This was featured in the structure of industrial relations legislation that represented, in a legal form, the extant resolution of the class struggle. All these issues were recognised in the early stages of planned development in India. However, the approach to their individual resolution did not take adequate account of the necessity of integrating these solutions into the substantive technological features of the national system of innovation.[5]

Although the colonial Indian economy was predominantly agrarian, it had specific features that made it possibly unique in the ex-colonial world. Chief amongst these was the relatively highly developed class of business entrepreneurs. With the development of the Indian cotton textile industry from the mid-19th century and the involvement of Indians in large-scale trading activities associated with the imperial industrialised economies, a (large-scale) merchant and broker/intermediary community had crystallized (Tyabji, 1995). The two World Wars had allowed capital 'accumulation' in

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other ways, including blackmarketing and swindling in government contracts.

With the repatriation of British interests in jute, engineering and plantations at the time of Independence, and with the home market assured, such capital 'accumulations' were invested in associated enterprises, particularly in eastern India. A large number of very reputable firms thus came under the control of individuals or groups who had a tenuous connection with the industrial economy. The point to be emphasised here is that while the merchants and broker/intermediaries could appreciate the imperatives of the industrialisation process, the other social groups could not.[6] Overnight they were transformed from members of slightly risque social groups, into 'captains of industry'. As T.T. Krishnamachari, Minister for Commerce and Industry, was to remind Jawaharlal Nehru, while they might privately agree that some industrialists were unsavoury, they were the only industrialists that the country had. Business had to be done with them.[7]

Doing business, however, was not coterminous with allowing the firms to be managed in any way the industrialists chose. Significantly, there is also evidence that the necessity of administrative coercion in these matters was understood by the more advanced entrepreneurs. Sumant Moolgaonkar of the Tata promoted firm of Telco pointed out to Krishnamachari that the government was the only agency through which the productive efficiency of the manufacturing sector could be increased.[8] As an industrial manager, Moolgaonkar saw the problem at the level of the individual firm, though it actually lay at the level of the social composition of the industrialists.

Theoretically, the importance of moving away from the firm to the social group is emphasised by the role of the state in extending the time horizons of the business community. This, along with the appropriate technological educational inputs, helps in the problematical transformation of a class of merchant-usurers to industrialists (Tyabji, 1989). In India, the major instruments for channelling resources into activities necessitating longer time-horizons were in the form of legislation, specifically the Capital Issues Control Act, the Companies Act and the Industrial Development and Regulation Act. All these Acts represented potentially coercive administrative measures, aimed at strengthening the 'industrial' characteristics of private resource allocation decisions.

However, a project to extend the timehorizon of an entire social group, and that of the dominating social force at that, requires not only the acquiescence of such measures by the more advanced sections of this group of proto-industrialists; it also requires an adroit combination of these measures to ensure compliance with the accumulation norms of an industrial society. These comprise the distinctive problems that attempts at directing post-

Independence economic growth would pose for the political and administrative executive. It is, in fact, precisely these attempts to direct and regulate processes of economic development, in the period from 1947 to 1991, that have been severely criticised in recent years. However, the criticism (as also the original, publicly stated, policy intention) has ignored the crucial role of state-sponsored structural change, which accompanies economic growth (and industrial development, in particular) in predominantly agrarian societies.

The importance of moving away from the firm to the social group can be further appreciated by a reading of the eccentric, but important article by Upendra Trivedi (Trivedi, 1982). It argues that the roots of the lack of technological innovativeness lie in the social origins of the Indian capitalist community. He draws attention to the fact that even Jamshedjee Tata preferred to 'employ foreign professors at fancy salaries' rather than support Mahendralal Sircar's efforts based on 'purely native genius'. Implicit in the article is the view that this short-circuiting of the entire cycle of building up a stock of scientific personnel from the roots, by importing a knowledge-base of advanced scientific workers at the Indian Institute of Science was the model replicated in independent India. In this model the simple import of manufacturing hardware supposedly embodied the process of technology transfer. Opposing this view, P.M.S. Blackett argued forcefully that countries such as India should import those technologies that were as close to the technological frontier as possible, subject to their being appropriate in a dynamic, long-term sense (Blackett, 1968).

Trivedi's article is important despite two quite outstanding omissions; the first being one on the role of the state in extending the time horizons of the business community, while the second is the historical contestation between industrialists and workers, which creates both capitalists and workers (Rueschemeyer and Evans, 1985:53). State encouragement towards long-term investments, along with the appropriate technological educational inputs, helps in the problematical (and celebrated) transformation of a class of merchant-usurers into industrialists.

Even in the colonial era, there were stray cases of individual bureaucratic efforts to help this process along in the case of small-scale industry using rudimentary technology, if not handicraft skills (Tyabji, 1995). However, clearly, any major effort at transformations of this kind can only be sought in the post-Independence state structure. With the help of Trivedi's propositions, the issue can be reformulated in sharper terms: what were the philosophical and organisational-administrative shortcomings in the structure of the Indian state apparatus that led not only to the continued apathy towards innovation, but even to the near collapse of the Indian

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manufacturing class in the post-1991 period?

As against this argument, there were outstanding exceptions to the general situation in the field of transport/mechanical engineering industries—Telco, Punjab Tractors and Bajaj Auto.[9] The point seemed to be that firms in similar market situations had very different histories of relative technological dynamism. If policies had really been to condone, if not actually to encourage, the repetitive process of technology imports, or of the frequent extensions to collaboration agreements, the behaviour of such firms was inexplicable. Their success highlighted the importance of granting technological volition or agency, an aspect of entrepreneurship, its legitimate explanatory role. It was the quality of the leadership that informed the decision-making systems of the firms, the degree to which operating personnel and R and D organisations should be positively encouraged to interact, as also various other features of plant and firm management that were equally important factors.

The National System of Innovation in India was notably silent on the question of the obsolete methods of management of industrial relations and underlying these, attitudes towards historical changes in the labour process.[10] Although there were discrete historical stages in the post–Industrial Revolution evolution of the labour process, until the 1970s, the labour process was one associated with its then predominant form: the large-scale assembly line manufacturing standardised products for mass markets, i.e., with Henry Ford's innovations.[11] It was with the plant visits to Japanese automobile manufacturers in the late 1970s and early 1980s, that representatives of the US industry learnt, to their great surprise, that the source of Japanese superiority lay not in advanced manufacturing technology, but in the adoption of a new phase in the evolution of the labour process, associated with management practices known variously as just-in-time, or Toyotaism (Kaplinsky, 1991:592-93).

Even in countries where the managerial ethos is more advanced than in Indian business houses, the challenges posed by the Japanese example were acute. The message that a process of economic transformation was underway is not lost on managers in Europe and the United States. The biggest barrier is a social one, of transforming a way of industrial life organised around the principles of Taylor's scientific management. The gains in competitiveness that firms could achieve with a committed workforce were apparent, but they usually failed in these countries because they are imposed within a context of a relationship adversarial to the integration of thinking and doing. This was a task that required a new definition of both workers and managers. For industrial revitalisation, the historical legacy had to be addressed directly.

The legacy derived from the manner in which the class struggle between

workers and owner-managers was resolved during transition from the merchant financier/marketer (or the putting-out) system to manufacturing forms of production. The terms of that transformation had a crucial impact on the organisation of business enterprises in all countries for decades to follow (Best, 1990:252-53). The effect of 19th century working-class struggles in Britain in spurring technological advances in manufacturing is now a familiar story. Although the struggles were intended to improve working conditions in general, and to shorten the working hours in particular, their effect was also to intensify competitive pressures on individual firms. Adoption of better machinery and management practices was the most creative, even if not the most widespread, response to these pressures.

In the Indian context, the diffusion of reforms in managerial practices, initiated in isolated cases as a result of pressures from below, were inevitably long drawn out processes. Although the Bombay textile industry completed the transition from managerial commission on the basis of production to a system of commission on profits by the 1920s, Ahmedabad textile interests continued with the old system for a much longer period. In the textile industry, the jobber's role as a recruiting/disciplining agent remained largely unchanged, though it was subject to intense workers' opposition during periods of heightened class struggle, up to the late 1940s. The attempt to shorten the working day lasted from 1875 to 1948 when an amended Factories Act granted recognition to an eight-hour day.[12] The managing agency, as an organisational form, still continued until as late as 1969.

The logic of this argument lays great emphasis on the *attitudes* towards workers and towards shopfloor management that Indian industrialists have displayed at critical moments in recent history. The rationale for this lies in a point made well in an article incorporating the 'social analysis of economic history' of the United States: that in historiographical terms, an analytical approach based on the perceptions of significant individuals and institutions can provide the outlines of an alternative (Livingstone, 1987:82).

Conclusions

An analysis of the Japanese experience has highlighted both the historical nature of the problem of technological dynamism and the historically determined context in which the solution evolved. The problem lay in the nature of contemporary technology and the forms in which innovation was currently expressed. These factors determined the technical aspects of public interventions, appropriate for their encouragement. However, the solution was composed of two more elements: the way in which the industrialists themselves had evolved as a social group, principally through contestation, both with competing industrialists and the working class; and a related issue,

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the specific forms in which workers' subordination to the power of industrial managers congealed in the course of the highly contested change from handicraft production to the factory form of organisation. This subordination was expressed both in the organisation of work and authority (management practices) within the firm, and in the structure of industrial relations legislation. The legislation, in particular, represented in a legal form the society-wide resolution of the contestation. These ingrained features, of firm-level management practices and industry-level industrial relations, set limits to the effects that market competition alone could have on building pressures for technologically productive change, unless the historically determined issues were simultaneously addressed.

These issues lay in the domain of political economy and could only be satisfactorily settled by initiatives taken at the political level of the state executive. Interestingly, all the three components of the official Indian perception of technology capability creation (the 'National System of Innovation') were the result of political initiatives. Most significant was the proposal for the public ownership of specific industries where technology acquisition was perceived to require the evaluation of a range of non-commercial considerations. As a result, manufacturing capabilities were established in industries identified as representing critical additions to the stock of technological knowledge. The second prong of the strategy consisted of import-substituting industrialisation, embodied in the phased manufacturing programme (PMP). This programme, which envisaged the systematic increase in the proportion of components manufactured indigenously, was an essential part of all foreign technological collaboration agreements in large-scale industries. Finally, there was encouragement of reverse engineering, of copying and improvisation, principally through support to the small-scale industrial sector.

On two matters of critical significance, however, the design of the Indian innovation system was silent: first, on the conditions of existence of industrial workers, even from the point of view of improving their 'efficiency', and second, on the modernisation of the system of industrial relations, in order to introduce true collective bargaining. Consequently, the innovation system, by ignoring the labour process, denoted an exclusively 'engineering' conception of technology.

This was a surprising lapse. From the very beginning of modern industry in India in the pre-Independence period, Indians were acutely aware of the obstacles facing the development of a machine building industry. By default, Indian industry could advance technologically only through the route of improvements to the labour process, whether this followed a capitalist or a philanthropic imperative. Thus, there was in India the possibility of the early recognition that both the labour process and the 'engineering' process were

organic components of technology, and of this comprehension becoming generalised as the commonsense of Indian industrialists.

However, there is another issue: the legacy of the trade union movement as it emerged in Ahmedabad and Bombay. A Gandhian inspired topdown organisation, the Textile Labour Association in Ahmedabad and a determined effort by communists to organise the Bombay textile workers provided two competing models of organising the relationship between managers and workers. The specific combination of institutional measures selected by the industrialists—of the managing agency system, jobbers, Gandhian-inspired trade unionism and, above all, the objective of preventing the continuing communist domination of the textile workers—set the framework for the legal structure of industrial relations. Post Independence support by the state to trade unions with a leadership hostile to Marxism created a piquant situation where collective bargaining could not be established as a general, legally supported principle for the conduct of industrial relations.

The result of this is that the evolution of the labour process in Indian industry as a whole has not developed even to the stage of Taylorism. While Western attempts to refine the division of labour were principally motivated by wage-cost reductions, subsequent stages clearly had the intention of reducing workers' bargaining position, based on their privileged knowledge of shopfloor working conditions. These stratagems were necessitated by the right to collective bargaining that the recognition of trade unions and industrial relations legislation had brought about. In India, the absence of collective bargaining, and the perpetuation of trade union leadership committed to the consolidation of managements' existing powers (even if this leadership is extreme in pushing for workers' monetary benefits), has precluded the necessity of advances to Taylorism and Fordism. A legacy of acrimonious industrial relations has left complex problems for managerial regimes that now wish to move towards Toyotaism, just-in-time and other features characterising Japanese systems of industrial management. These are predicated on trust and a movement in the centre of gravity of management-worker contestation.

Had the appropriate changes taken place, then Indian industry might have developed its own version of the link between the knowledge-to-make and the knowledge-to-make-better, currently seen as hallmarks of the Japanese National System of Innovation. All these issues were, in fact, recognised in the early stages of planned development in India. However, the approach to their individual resolution did not take adequate account of the necessity of integrating these solutions into the substantive technological features of the 'National System of Innovation'.

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So, Indian developments do not show an entire absence of comprehension of what technology constitutes, particularly in the post-war era of the 'Age of Automation'. There are sound reasons, then, why analysis of the technological features of Indian industrial developmental experience is of importance. A systematic review of the reasons why the scattered elements of comprehension were not coherently integrated in Indian policy initiatives is critical even now, if Indian industrialisation is to advance. Also, the Indian experience can provide important guidelines for other economies that have had similar problems in the transition from manufacture to innovation.

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Notes

1 In the late 1980s, a study could comment that... it seems clear that policy is not designed or administered to generate a *positive* effect on the depth and breadth of the knowledge acquired by Indian firms. There appears to be no positive incentive to induce firms to *increase* these two aspects of the technological content of the agreements they enter into.
Scott-Kemmis and Bell (1988): 96 [emphasis in original].

2 It is ironic that contemporaneously with the growth of such lines of criticism, information about Japanese methods of increasing productivity without recourse to economies of scale became generally known. In particular, the innovation associated with the Toyota production system. See Coriat (1991).

3 In attempts to grapple with solutions to these problems, issues such as the lack of correspondence between the various stages of the entire innovation chain (basic research, applied research, invention, development, innovation) and appropriate institutions was identified. It was also noted that even when the basic knowledge incorporated in earlier stages of the innovation chain were publicly funded, the financial costs of the later stages of this chain devolved almost entirely on the private firm. Parthasarathi (1987).

4 Bell et al. (1982): 151; Suri (1968). Studies by CSIR in the mid-1960s provided evidence of the complete disjuncture between areas of CSIR research and the bulk of technological collaboration agreements.

5 See, for example, the comment made in the introductory paragraphs of the 1952 Committee on Company Law:
A further limitation to the scope of our enquiry arises from the fact that,

although we are concerned with the efficient working of the corporate form of organisation, the problems of industrial management and industrial relations which closely affect it are outside our scope.... Structural and procedural improvements can only create conditions; the efficiency and vigorous working of private enterprise must primarily depend upon the initiative and drive of the management, the organisational and directing ability of managers and the other supervisory staff who are in day-to-day charge of a business undertaking; the technical efficiency of all grades of labour and last but not the least on sound and harmonious relations between labour and management. No reform of company law can secure these desiderata and to that extent the contribution of a sound system of company law to the "efficient and economic management of companies or the development of Indian trade and industry" must be necessarily limited.
India (1952): 13.

6 The most prominent of these, Haridas Mundhra, became notorious in the mid-1950s due to his cavalier disregard for any norms of 'industrial behaviour'.

7 Letter dated 2 September 1954. T.T. Krishnamachari papers, Subject File 8(A): 121, Nehru Memorial Museum and Library. (Subsequently, TTK papers, NMML.)

8 Personal letter from Sumant Moolgaokar of Tata Sons, to T.T. Krishnamachari, Minister of Commerce and Industry, Government of India, 5 October 1953. TTK papers, NMML.

9 cf. Ashok Desai's comment in 1984 that neither Telco nor Bajaj Auto would be able to negotiate a major technology transfer agreement precisely because they were potentially serious exporters. Desai (1984b): 247.

10 In this context, the labour process refers to the system in which human beings of different skill levels are brought together with different sets of machines. This, looser, concept allows for the fact that machines designed to serve the same physical function may be set up with alternative forms of control devices, giving greater or lesser play to the control by workers over production. cf. Kaplinsky (1991): 578.

11 The historical stages may be conveniently associated with their most prominent advocates as follows: 1. The first division of labour in manufacturing (Adam Smith) 2. The separation of skilled and unskilled tasks, allowing wage differentials and reduced wage costs (Charles Babbage) 3. Mechanisation of processes requiring dexterity, thus reducing the autonomy of skilled craftsmen (Andrew Ure) 4. Concentration of production knowledge within management with broad based de-skilling (Taylor) 5. Regulation of the production process through the production line (Henry Ford).

12 For the record, it may be noted that in 1862, 1,200 workers of the Howrah railway station struck work on the demand for an 8-hour working day. Ghosh (1966): 8.