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MANAGEMENT OF TECHNOLOGICAL CHANGE: ISSUES AND CASE STUDIES FROM INDIA

Papers presented at a workshop sponsored by
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Economic Relations

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NOTE

Footnotes and references are located at the end of the chapters in which they are cited.

One Crore equals 10 million

One Lakh equals 100,000

PREFACE

Technological change must be seen as involving a complex inter-action of factors some of which are internal to the firm and others external to it. For analytical purposes it is useful to distinguish between the macro and the micro aspects of management of technological change. At the macro level there are the economic policies which determine the environment in terms of the opportunities and constraints for the management of firms.

An adjustment to technological change within a firm is not just a formal organizational restructuring. It often calls for new or different skills, new job requirements and more importantly a new work culture.

There are not many micro or firm-level studies in India on management of technological change and this should receive particular emphasis in future research.

This document is the outcome of a UNIDO-ICRIER Workshop on Management of Technological Change, held at New Delhi on May 16 and 17, 1988. The document is in three parts: the first part includes papers relating to Issues in the Management of Technological Change; the second part consists of Case Studies of individual firms; and the third part has an Overview.

A major contribution of the Workshop has been the presentation of case studies. The value of these case studies lies in their help in identifying the success factors and winning management strategies for technological change. The number of case studies, however, presented at the Workshop is much too small for generalizations regarding organizational structures and patterns of management.

The case studies have clearly shown that leadership is a crucial factor in the management of technological change and one of its important roles is to build up, within the firm, a community of employees with shared values and beliefs.

The discussions on the issue papers and the case studies have led to two sets of recommendations; one, which is for consideration by government in the formulation of policies, and the other, which is relevant for the management strategies of firms.

Only those papers which were basically prepared for the Workshop and had neither been presented at any other forum nor published elsewhere are included in this document. However, the Overview chapter at the end also covers discussions on papers which were not included in this document.

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SUMMARY PROCEEDINGS OF THE INAUGURAL SESSION ON MANAGEMENT OF TECHNOLOGICAL CHANGE

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The Indian Council for Research on International Economic Relations (ICRIER) hosted the UNIDO-ICRIER Workshop on Management of Technological Change, held at New Delhi, on May 16 and 17, 1988.

The Workshop was inaugurated by Mr.Hiten Bhaya, Member, Planning Commission, New Delhi, India. Welcoming Mr. Bhaya and the participants, Dr.S.P.Gupta, Director, ICRIER, expressed concern regarding technological obsolescence in Indian manufacturing which was reflected in low factor productivity. The technological gap was getting wider not only between India and the advanced Western countries, but also vis-a-vis many other developing countries. Dr.Gupta emphasized the need to focus on the welfare implications and efficiency impact of technological change, and observed that there were quite a few studies in India which showed that the benefits of technological change, however small, had not been passed on to the consumer through price decreases. They had mostly been absorbed either in factor payments in the form of wages or profits, or had been absorbed in the idle capacity and unused capital in the country, and, therefore, price competitiveness had not improved in many areas.

The next important issue to which Dr.Gupta invited attention was the whole question of the supply and demand for technology, and the management problems associated with them. Technological change per se may indeed be a micro problem but it had macro inter-sectoral implications. It was difficult, for example, to bring into the picture the supply side of technology without going into many of the aspects of manpower, quality of training, the labour laws, fiscal measures and so on. There were also problems associated with the organization in industry. It had been observed that in Indian industry there were poor relations on the supply side between those who were working on the design board and the production managers, and on the demand side, between those who were working as the sales manager and the production manager, and there was so much insensitivity that it led to obsolescence.

In situations where the sources of supply of technology were different from the sources of demand, several issues arose with respect to the transfer of technology, for instance imports of technology; buying of patents; patent laws. Hence, discussions relating to the management of technology would have to go also into such related areas.

Dr.Gupta further stated that the Directorate General of Technical Development had been influenced by the past strategy of import substitution and indigenous technological developments; restrictions were placed on foreign collaboration agreements and royalty payments; some fiscal incentives, including tax exemptions for R&D, were given, but they had only a marginal effect on development, and commercialization in some cases was very ineffective. Yet another area which was weak and ineffective was the information network of private industry regarding alternative technologies, their sources and means of tapping them.

Public research institutes, like the Council for Scientific and Industrial Research; Machine Research Institute, where nearly 85 per cent of the research and development expenditure was concentrated, had inadequate orientation for need-based research of immediate and commercial value for industrial enterprises, specially covering the private sector.

Finally, Dr.Gupta explained that the Workshop had two major objectives: first, to formulate the issues involved in the management of technological change, and second, to provide a feed-back to Government to facilitate consideration of different relevant issues and the required changes in policy, so that the policy environment enables firms to bring about a rapid change in technology, economically and efficiently.

Delivering his Inaugural Address, Mr. Bhava observed that the subject of 'Management of Technological Change' had been in the forefront for the last ten years, and he had attended a number of Seminars and Workshops on this topic; but this Workshop was different because it had Case Studies with rich data.

With the passage of time the topic had not lost its significance; on the contrary, it would assume greater importance in the future. Mr. Bhava expressed the view that Management of Technological Change needed to be discussed at two levels; one, at the policy level, that is at the national level; and the second, at the enterprise level. The enterprise level was important, because it was the operative level, and a number of issues arose, because there were differences in perceptions in regard to the rationale for technological change at the national and at the enterprise level. In general terms technology change was not a change which can be justified for its own sake. It had some benefits by way of reducing the inputs of national resources; materials; energy and capital. Technology also resulted in quicker ways of producing larger quantities; economies of scale; improved quality; and increased value added. At the national level, the criteria were lower cost of domestic resources and lower range marginal costs for each unit of production, but at the enterprise level, cost was not the only consideration. The enterprise was further concerned with factors such as prices, markets and profitability. From the national point of view prices could be administered in such a way that they covered the costs and generated profits, or in the case of the public sector revenues for the budget. If prices did not cover economic costs then there are losses and the need arises for subsidies.

At the root of the policy debate, or even policy mistakes that might possibly occur, is the adoption of a particular technology or change in technology; for example, a look at the jute industry showed that despite financial incentives, modernization and change of technology was tardy; other examples were the textile industry and the coal industry before nationalization. Again, if one took the case of an entrepreneur who was making profits with old and inefficient equipment and boilers, it would be difficult to convince him of the need for further investment. While it may be in the national interests to modernize, an entrepreneur would take action towards modernization only if he found that it was in his interests. Hence, it was necessary to create the appropriate environment through various policies. It was also necessary to harmonize the sets of policies, such as tariff; import licensing; and taxation, to ensure that the private goals and national goals were congruent, as far as possible.

Mr.Bhaya emphasized that considerable action was required to be taken in this respect. First of all there was the question of the choice of technology which would serve the national interests as well as the objectives of individual enterprises. This was an area in which there was not enough knowledge even on the part of the public sector despite meetings of experts, debates and discussions. Secondly, forecasting of technologies and information for future choices of technology had recently generated considerable interest, but nevertheless it was a weak area. The third area of weakness was that India did not have its own technology base in the sense of its own design capability, although it had successfully adopted, though not adapted, many technologies over a wide range of industry and also, that the country had very competent manpower, technicians, managers and analysts.

In the private sector, finance is crucial for the choice of technology, and the ultimate decision rests with development institutions like the IDBI. With his experience of several years on the Board of IDBI, Mr.Bhaya observed that the development institutions hardly consider the technology angle; they are basically concerned with the viability of the enterprise and its ability to service the debt. They do not appraise the technology to find out whether it would keep the enterprise competitive for about ten to fifteen years, and whether it would reduce prices and hence give relief to the consumer.

Looking at the current scene and the future from the national point of view, the order of priorities, sector-wise in industry, appeared to be: capital goods; intermediates like steel and copper; fertilizers, wage goods, and lastly, the consumer durables, which went to the more affluent sections of the market. However, from the private point of view, the order of priorities would be exactly the reverse, and this was really where the problem arose and where policy guidance became necessary.

Very often with hindsight, a criticism was made that one of the reasons for technological obsolescence in Indian industry was a dogmatic insistence on import substitution and entering into a number of uneconomic ventures.

Looking back at policy, it was found that between 1950 to 1962 there were absolutely no restrictions in terms of foreign equity holdings or technology transfer - and what was the outcome? A lot of foreign companies went into areas such as petroleum refining, pharmaceuticals, dye-stuffs, fertilizers, batteries, and commercial explosives, because it was in the interests of the foreign companies to do so. Their interest did not necessarily coincide with the national interest subsequently, but it did initially. Then there was a period in which there was no bar on foreign collaborations; and a number of collaborations were made in many areas, such as PVC, synthetic fibres, nylon tyres, and some petrochemicals. However, inspite of the open policy, no interest was shown at that time by foreign companies on long-gestation infrastructural projects like the exploration of oil and gas, steel, non-ferous metals, heavy engineering, basic organics, ship-building, and a host of similar areas. These were the very areas which to-day were suffering from technological obsolescence, and therefore required technological imports in order to enable technological change.

Dr.Bhaya observed that technology import was an area which required serious consideration, both from the national point of view, as well as the enterprise point of view. In India patents had operated as a negative force and prevented the development of industry, and this was because an extraordinary kind of protection was given to holders of Indian patents. Those patents were naturally held by foreign technologists and foreign companies, particularly in the drugs, pharmaceuticals and the chemical industry. However, this policy has been changed and protection for process patents has been reduced from 16 years to 7 years and for design patents to 5 years. This had led to the growth of a number of industries like chemicals, drugs, pesticides, catalysts, and dyes. There was a lot of pressure on India to join the Paris Convention, but this could be useful only at a time when India is able to take patents out in other countries and export technology.

After 1968-69, a number of incentives were given for R&D work, and a number of establishments set up R&D Departments, but there had been no major advances in any of the industrial technologies or at best very few: and this constituted a major area of weakness.

In regard to the terms of transfer, the transfer fee in the past included the whole package, the basic process, basic engineering, procurement and inspection, construction, some commissioning assistance, and guarantee fees. Over the years, in many industries technology had been un-packaged, and detailed engineering, procurement, and inspection of construction, was all being done by Indian companies, but the basic process and basic information leading to optimal design was still not available to Indian industry. This still remains one of the areas where the transfer fee was an important issue. As far as royalties were concerned, in the earlier days they were based on the Indian selling prices which were usually about three times higher than in the developed countries; that was subsequently changed and the royalties are now based on the international prices.

The use of brand names was another important area for consumer goods, particularly drugs. India permits the use of brand names, but countries like Japan, Republic of Korea, and Brazil have a very open policy in contrast with India's inward-looking policy, which had always refused the use of brand names.

Mr.Bhaya was of the opinion that the approach to technology policy should be reconsidered and the approach that only high technology should be permitted and low technology should not be permitted should be reversed. The whole range of agro-industries, such as food processing and food packaging are the major industries for mass employment, and should not be considered as low technology and the flow of technology should be different from what it is today. In China, for instance, there was tremendous use of food technology and food processing.

Mr.Bhaya drew attention to the technology-driven industries like bio-technology, information technology, the whole range of electronics, and the area of renewable energy. The basic problem here was that they were already being commercialized in the developed countries, but that range of commercialization need not necessarily be the one India could adopt, and this was where policy was necessary for the development of endogenous parallel technology.

Mr.Bhava stated that he was particularly concerned about renewable energy. Technology for renewable energy had been developed in U.S.A., and these technologies were seeking markets in Africa and India at a very high cost. this may have been alright if they were to serve a small sector or a very specialized sector. but if it is to serve the decentralized rural sector. then it would become necessary to provide a subsidy. Technological change needs to be considered not only in the organized large industry sector but across the board. This means a different set of problems with regard to labour. choice of technology. and dissemination and adoption of technology. The whole area of management of technological change will extend beyond the organized sector. but the organized sector would continue to be the core. Technology could make a considerable difference to the rural and social service sectors. but the issues in the management of technological change in these areas need to be identified.

Mr.Bhaya drew specific attention to the fact that when foreign companies withdrew from industries like plantations. jute and textiles. they were bought over by Indian capital and these were the industries which had languished for want of technological change. The industries which came up with collaborations in the sixties and seventies were also being bought over by Indian companies in a big way and the question was whether they would also languish and become ailing industries for want of technological change and then left to be saved by the Government.

Mr.Bhaya recognised that the Workshop would not find it possible to discuss the vast range of issues which he had raised. since the focus was on issues relating to enterprises. But if there was the need for harmonization of all policies relating to national interest and enterprises. then some of the issues regarding choice of technology and relevant policies ought to be better understood.

The Director of the Industrial Technology Development Division extended his greetings on behalf of UNIDO. He stated that UNIDO was charged with the promotion of industrialization of developing countries. It had become a specialized agency since the beginning of 1986 and had already been playing an important role in India. particularly in the field of technical assistance. in a number of important sectors like computers. the steel industry. and the sponge iron industry. The role of UNIDO was not only to provide technical assistance but also to highlight the important issues governing the nature and speed of industrialization. It was in this context that UNIDO had taken an interest in the question of technological change. because the pattern of industrialization depended very much on the kinds of technologies supplied and the speed of technological change.

He made a distinction between technologies which were directed towards changes in a product or process and technological developments in fields such as micro-electronics. information technology. genetic engineering. and bio-technology. He observed that technological changes in products were also leading to changes in manufacturing practices. such as the introduction of flexible manufacturing systems.

The compulsions of technological changes were leading to the emergence of new styles and patterns of management. made heavy demands on leadership qualities and required a perceptive response of management to the ever-changing requirements of technology. It required an equally perceptive response by governments, so that economic policies created the appropriate external environment which would enable firms to successfully accept the challenges of management of technological change.

The Director hoped that this Workshop would serve as a prototype for a series of similar workshops in other developing countries.

Dr.N.K.Sengupta, in his vote of thanks, observed that consideration of technological change should not be limited only to the enterprises level but should be extended to the macro-level and the environment. He pointed out that it was indeed important to discuss technological change, but it was also necessary to conceptualize the experience. He hoped that the Workshop would provide a useful starting point for meaningful discussions which would lead to some conclusive results.

CHAPTER I

THE ROLE OF IMPORT OF TECHNICAL KNOW-HOW IN THE MANAGEMENT OF TECHNOLOGICAL CHANGE RESULTS OF A SURVEY ON INDO-GERMAN JOINT VENTURES

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I shall begin with a short story about my first experience of management of technological change in India. About 1 1/2 years ago, when I came for the first time to India, I met at a party a businessman who told me that he had problems with his machinery which he bought in Germany, second-hand, around 1955. His problem was that these machines in his production are still running very well without any problems. He knows that the technology of his product is from the mid 40's and he would like to b·.· some new equipment after 40 years of technological change, but as long as he is making good profits by selling his outdated products to the Indian market he does not like to take the risk to introduce new machines when he does not know how they will run.

Of course this might be an extreme example but it seems to be still true for at least some branches of industry in India that management of technological change is not required. Nevertheless the sinking profit rates of the Indian industry in the last few years indicate that there is a change going on for more competition in the Indian market. There is no doubt that, for example, the new policy of de-licencing of certain branches will lead or has led to more competition, which forces the Indian entrepreneur to react to technological changes. And also now-a-days more and more Indian companies are willing to export and to do business with the international markets. Their ability depends on how they are able to adapt new technologies for their products and production. Management of technological change will become necessary.

After this introduction let me come to my topic: "The Role of Import of Technical Know-how in the Management of Technological Change", which I base on a survey carried out by the Indo-German Chamber of Commerce last year on Indo-German Joint Ventures. First question: What have joint ventures - companies founded together by an Indian and a foreign businessman - to do with our workshop topic?

I want to demonstrate in the following that technical import in general and joint ventures in particular are instruments in the hands of entrepreneurs who want to or who have to react to technological changes with a view to being competitive.

Technological change can be made mainly by developing through the nation's R&D or by purchasing know-how abroad. The choice is dependent on a number of factors such as how much time is available, what resources are available, and relative costs. Once a decision is taken to import from outside the country it can be done by:

- Licensing agreement;

- Joint venture agreement, which means licencing plus capital participation in the new company by a foreign firm (in India normally restricted up to 40%).

We asked in our survey of the Indian partners in Indo-German Joint Ventures what primary factors motivated them to form the joint venture. The result is given below:

Main reason for joint ventures:

Reason	%
Acquisition of know how	63.8
Expansion of the production programme through hi-tech	14.2
Market potential	8.6
Acquisition of capital	2.4
The reputation of goods made in Germany	2.4
India's import policy	2.4
Improvement of the company's image	1.5
Export: Production of export quality products	0.8
Other reasons	4.1

The overwhelming majority was interested in getting technological know-how from their West German partners. Only a very few were also interested in German capital.

Immediately the next question arises which we ask the Indian parties: Why were you then interested in a joint venture, when a licensing agreeement is much easier to get approval by the government and has the advantage that you don't have to share your influence with another party?

The clear answer we got from about 76% of the Indian partners was that they wanted to ensure long-term building, that means a long-term technical involvement of their German partners. In India a licensing agreement normally ends after 5 years. About 48% of the Indian businessmen believed that the possibility to transfer know-how is easier and better in a joint venture that in a simple licence agreement.

So the specific character of a joint venture is the long-term and easier technical know-how transfer, which makes it valuable for the management of technological change.

In the following I want to bring some results of the survey regarding technology and know-how transfer in Indo-German joint ventures.

Altogether more than 250 licences were given by the German partners to their Indian joint ventures. In some cases they were even given general licences which were not restricted to a particular item.

The licences given related mainly to sophisticated high technology as is evident from the industrial branches to which the joint ventures belong.

20% of the joint venture companies are producers of primary goods (chemicals, construction material, semi-finished metallurgical products etc.), 70% produce capital goods and machinery parts (electrotechnik, automotive parts, optics and pumps etc.), 5% manufacture consumer goods (mainly for exports), 1% produce food stuffs and 4% provide technical services and consultancy.

To our question whether they were satisfied with the German technical contribution and also whether they consider that the German partners adhered to the terms of the agreement, 93% of the companies answered with a clear yes. We as a Chamber wanted to know whether the technology required by the Indian businessmen was for the development of their existing joint ventures. The answer was that it was a step for diversification and there was no connection between their existing product and the product to be manufactured in the joint venture. This shows, in my opinion, again that there was no necessity for technical updating of the existing products in the joint venture. It was more for upgrading the production line by taking a high-technology product in their production line. The German firms not only brought technology from their country but also set up R&D centres in the joint ventures. Almost 70% of the joint venture companies have their own R&D department and employ a total of about 2000 persons. About 58% of these departments have been set up in order to improve existing products and adjust them to Indian conditions, and 46% of the R&D departments were engaged in developing new products.

When asked about their future plans, the firms stated that in the coming years they wanted to introduce about 430 new products into the market and plan 32 new projects for this purpose. They estimated that this would call for an additional investment to the tune of Rs. 7.1 billion and that it would generate additional employment for about 10,000 persons. The setting up of R&D departments together with the foreign partner and inflow of technology on a long-term basis shows that establishment of joint ventures is a strategic decision with several options in the management of technological change.

The survey also showed which of the partners in the joint ventures had the biggest responsibility for the areas of technology, production, marketing and finance and how the share of responsibilities changed afterwards. It is natural that the German partner, as the provider of the know-how, was at the start of the joint venture responsible for the area of technology (92%). But later the management of technology shifted to the Indian side and at the time of the survey 42% of the Indians were responsible for the technology. It is astonishing to see that in the setting up phase only 38% (later on 14%) of the Germans took the main responsibility for production. In more than 90% of the cases finance and marketing were in the hands of Indians.

The employment of foreigners by the foreign partner in the joint venture should be seen also as a kind of technology transfer. The survey showed that only 16% of the Indo-German joint ventures employed German nationals. This has something to do with the high costs of secondment by foreign countries but mostly it is due to the restrictive visa policy of the Indian government. In contrast to this low number of German employees in the joint ventures each year 390 Indian employees are sent to Germany from the 92 joint ventures either for training or assignment with the German parent company.

For a good product it is also necessary to have skilled labour. Altogether 63% of the surveyed joint ventures have an in-house training system. 44% have special training facilities, e.g. at training centres.

The selection of the production technology is a strategic decision and has to be decided in connection with the price and quality of the product and flexibility. Some 58% of the joint venture companies described their production technology as semi-mechanised in the beginning while 34% described it as mechanised and only 8% described it as automated. However, after establishing themselves in the market they introduced a change in their production technology in the direction as seen below:

Period Production Technology	Start	Interview	Change
Half mechanised	67 (58.2%)	49 (42.6%)	-27%
Mechanised	39 (33.9%)	50 (43.5%)	+28%
Automated	9 (7.9%)	16 (13.9%)	+78%
	115 (100%)	115 (100%)	

Before I conclude let me introduce you briefly to the survey and some general information about the Indo-German joint ventures.

For the last 20 years the Federal Republic of Germany has been India's second most important partner for technology transfer in the form of joint ventures.

	1984	1985	1986
USA	17	66	71
Fed. Rep. of Germany	19	36	40
UK	16	26	23
Japan	5	15	15
France	5	8	9
Italy	5	10	8
Sweden	4	4	7
Other countries	26	38	51
Non Res. Indians	34	36	8
Total	**151**	**239**	**240**

Developments in the last three years (1985-87) have seen a further significant increase in all forms of technical cooperation, particularly of joint ventures.

In the context of this remarkable development more and more German companies interested in cooperation with Indian firms have been seeking information on this form of collaboration and have expressed eagerness to know about the experience of firms already engaged in joint ventures.

This is why the Indo-German Chamber of Commerce and the DEG (German Finance Company for joint ventures in Developing countries) embarked on a comprehensive survey of all operative Indo-German joint ventures. This could only be done by personally contacting each joint venture company know - or thought to exist - and bombarding them with a barrage of questions. Anyone who knows the average businessmen's abhorrence of questionnaires would have considered our undertaking as doomed from the start. The compilation of the material for the survey involved some 20 pages of tightly packed questions presented to 184 Indian and 170 German firms.

It was very surprising to receive such an overwhelming response (84% in India and 60% in Germany), making this the first truly representative study of Indo-German joint ventures.

Altogether, today, about 200 Indo-German joint ventures are operating in India and they are more or less evenly distributed over all major industrial regions, according to their industrial importance.

The study of the company size and structure show that Indo-German joint ventures cover the entire spectrum from small firms to market-dominated large undertakings. Six firms may be categorised as small companies (with a turnover less than Rs. 1 million) while 3 firms number among the 101 largest undertakings in India and 7 others belong to the group of the 150 so-called "Mini Giants" of the Indian private sector. As is to be expected, the chemical industry is dominated by large undertakings, while in the engineering sector one finds mostly smaller and medium-sized joint venture companies.

The 16% responding Indo-German joint ventures have directly created some 80,000 jobs, while indirectly they have been responsible for an immeasurably high number of job openings. According to the study, high quality products with a sales value of Rs. 31.6 billion and a value added amounting to Rs. 15.17 billion were manufactured.

In the face of India's unfavourable balance of payments situation, expenditure of foreign exchange in connection with technology transfer and especially payment of dividends by joint ventures in India is very closely scrutinised. It is, therefore, an important result of this study that it shows that Indo-German joint ventures earn considerably more foreign exchange through exports than they give out in terms of profit transfers, payment of licence fees and royalties. As compared with the transfer payments of Rs.144.1 million the export earnings amount of Rs. 1.61 billion. Even if one were to add the costs of products imported by the Indo-German joint venture companies from their German partners (1985-86 totalling Rs. 577.1 million) to the foreign exchange costs, there would still remain a foreign exchange surplus of Rs. 888.8 million.

This means that the technology transfer of the Indo-German joint ventures is not only "foreign exchange-neutral" from the Indian point of view, but instead directly contributes to the improvement of the Indo-German trade balance.

Apart from the economic advantages just mentioned, I hope I was able to demonstrate to you that import of technology in general and joint ventures in particular are potential instruments in the hands of businessmen for the management of technological change.

CHAPTER II

ACCESSING INNOVATIVE CAPABILITIES : THE STRATEGIC IMPORTANCE OF TECHNOLOGY IN POST-MODERN STRATEGY

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I. Introduction

This paper focuses on the current transformation of the strategic management field and the rise of a significant new era in strategy. This new phase, called "Post-Modern", has key features which distinguish it from previous periods of strategy thinking. In particular, it is characterized by the rising priority, and in some cases dominance, of innovation as a major strategic variable. As can be seen in Figure 1, Post-Modern Strategy represents a significant change in top-level decision-making in the postwar era and increasingly characterizes the cutting edge of strategic practice today. It blends certain features of general management and strategic planning thinking while also exhibiting new concepts of its own. Moreover, it is both less universal and less elegant than its predecessors. It is more varied, contingent, and complicated in the way its diverse parts have been both disaggregated and reintegrated. It stresses such strategic matters as implementation, the creation of multiple organisational strategic support systems, processes, and pressures, the role of a firm's unique culture and history in setting and influencing strategy, internal entrepreneurial units, the increasing use of inter-organization networks and linkages, the growing importance of what is now termed global strategy, advanced and targeted analytical strategic approaches, and the relationship between corporate strategy and various functional strategies.

A major challenge for large corporations belonging to the Post-Modern age is to develop the capability to generate simultaneously a number of diverse, and perhaps seemingly contradictory, strategic management approaches. What is the cause of such a major change in the configuration of strategic management? The answer clearly lies in the current transformation of competition in much of the world. Today competitive success increasingly requires achieving higher value objectives, which often means satisfying a range of complex and often changing demands by the customer throughout the value chain for greater innovative capability in products and services. Consequently, the key strategic objectives are shifting. In the 1970s, extending and maintaining a product line via market-share dominance, for example, was as important a goal as creating new products and services. With the arrival of Post-Modern Strategy there is a move away from simply the extension of value and toward the creation and transformation of value. Strategic actions that encourage value-intensive differentiation, such as increasing the importance of internal research and development, entering into joint ventures to design and create new products, disaggregating structure (to allow for flexibility and freedom of action in order to encourage innovation), and reintegrating structure in complex ways, to permit appropriate economies of scale and scope assume higher priority.

Figure I

The Postwar Evolution of Strategic Management

Phase I : 1950s - late 1960s

The General Management Era

- The importance of leadership
- Universal managerial characteristcs
- The universal professional manager
- View the firm as a whole
- Optimism
- Top management oriented
- Implicit strategic management

Phase II : Late 1960s-1980s

The Golden Age of Strategic Planning

- The rise of analysis
- Strategic approaches
- Strategic portfolio
- Incorporation of industrial organization and micro-economic approaches
- Viewing the firm as made up of component business that have different strategic roles
- The rise of support industries and institutions, e.g. strategic consulting firms, business schools, and strategic databases
- The emergence of a new function, profession and unit: The strategic planning staff
- Formulation oriented
- Staff oriented
- The centralization and growth of power of strategic planning
- Explicit strategic management

Phase III : 1980

Post-Modern Strategic Management

- Reaction to strategic planning
- Renewed interest in implementation
- Emphasis on the role of culture and history in determining a firm's strategy
- The rise of global strategy
- Targeted and advanced analytical strategy
- The concurrent use of multiple kinds of strategic support systems, processes, and structure
- The elevation of technology to a strategic variable

- The use of interorganization networks and linkages in strategy
- The simultaneous deployment of multiple strategic approaches-blending implicit and explicit strategy

This important reorientation of major objectives is a key factor in the elevation of technology as a strategic variable and the creation of "new linkages" by corporations for technology acquisition. For technology-intensive firms in practically all parts of the world, therefore, incorporating technology into corporate strategy is probably the greatest challenge now facing top managers in all functions of an enterprise.

II. The Practice of Post-Modern Strategy: Technology Strategy and Value Creation Networks as Cases in Point

A major indicator of overall Post-Modern Strategy and perhaps the most distinctive feature of this new wave of top management behaviour is the rise of what may be termed Technology Strategy in the mid-1980s. The recognition of technology as a top-level strategic concern for a corporation and technology's elevation to a strategic variable are due to the convergence of many of the same forces that, by the 1980s, had created the need for Post-Modern Strategy management as a whole. The full impact of such historical trends -- including the negative reaction to strategy planning, the success of the small hightechnology firm, the increasingly strategic importance allocated to technology by foreign competition (particularly the Japanese), the related rise in status of manufacturing as a strategic weapon, and the supportive relevant thinking and research in the fields of strategic management and the management of technology -- is visible, widespread, and powerful. Technology Strategy has now emerged as an important and pace-setting management activity in the modern corporation.

Technology Strategy is part of the growing concern for creating and maintaining increasingly higher-value strategic actions. Technology Strategy also focuses on the design and implementation of novel kinds of structures. Technology Strategy confronts continuously the critical tradeoff between the benefits of large-scale-oriented economies of size, scope, and synergies and the benefits small-scale-oriented individual or decentralized entrepreneurialism, flat organizations, and fast response to users and the market. A key part of Technology Strategy also involves the challenge of creating the requisite set of "new linkages" with organizations external to the firm. Finally, in developing a way to put these and possibly other elements together, Technology Strategy must cope with the probable need to manage concurrently inherent contradictions for the long-term strategic success of the enterprise.[1/](see footnotes at end of chapter)

Technology Strategy is characterized first of all by disaggregation the purposeful fragmentation, decentralization, and flattening of an enterprise in order to promote risktaking and innovation. In part, the new emphasis on disaggregation was a somewhat delayed reaction by large corporations to the dramatic and successful experience in the U.S. of small-firm high-technology entrepreneurialism and the continuing vigour of medium-size companies, which tended to highlight thebenefits of

decentralized, small, and flat organizational structures.[2/]
Disaggregation actually represents a significant change of emphasis in the evolution of the large corporation. Instead of continuing to internalize transactions through coordination and administered hierarchies where appropriate, as large firms had been doing since the late nineteenth century, by the early 1980s these entreprises were seeking ways to loosen up and operate in less coordinated smaller units.[3/]

At the same time, however, Technology Strategy does not neglect the benefits of large size and the economies of scale and scope, when they can result value-intensive strategic success. Clearly, in many instances such traditional advantages of market power as volume production, mass marketing, and large industrial R&D facilities can lead to significant strategic achievement. A process of complex reintegration is also occurring, and this new method of assembling a high value critical mass is particularly effective in the current competitive environment. This type of action essentially permits not only the effective mobilizing of internal resources but also the selection of external sources for achieving strategic advantage. Complex reintegration allows make-versus-buy of high value resources, especially technology. Therefore an important distinguishing feature of Technology Strategy today is a growing use of fluid and network-like interorganization structures-- such as strategic alliances-- as well as better and varied use of the traditional hierarchical corporate form.[4/]

Consequently, a key aspect of Technology Strategy is that it is working to modify the shape and structure of the modern corporation by actually promoting the externalization of transactions where appropriate. The whole matter of procurement and make-versus-buy is becoming increasingly critical because of the ever-growing requirement for accessing innovative capabilities.

Modern Technology Strategy demands that top managers throughout the enterprise balance concurrently disaggregation (in order to capture the benefits of flat organizations and an entrepreneurial zeal) and complex reintegration (in order to exploit the advantages of particular kinds of critical mass). Therefore, implementation of Technology Strategy often requires the kind of action that permits the continuous blending and coexistence of seemingly opposite kinds of behaviour and strategies. This crucial quality in Technology Strategy is termed Simultaneity, the simultaneous incorporation of diverse and often seemingly contradictory elements in order to achieve a larger set of strategic objectives. The ability to demonstrate Simultaneity on an ongoing basis is increasingly critical for strategic success today.

It is important to realize that key characteristics of Technology Strategy today are quite different from salient features of private-sector technological innovation that existed through the 1970s. In that earlier era, at least in the U.S., private-sector technological innovation was segmented between small and medium-size firm innovation and the traditional industrial R&D done in the large corporation. These two types of innovative activity operated according to different rules and priorities and the U.S. benefited from their coexistence.[5/] By the early 1980s, however, as technology became increasingly strategic, the boundary between the two major forms of private-sector technological innovative activity -- small-firm and large-corporation innovation--began to fade. This blending of these previously distinctive modes is a salient feature of modern Technology Strategy.6/

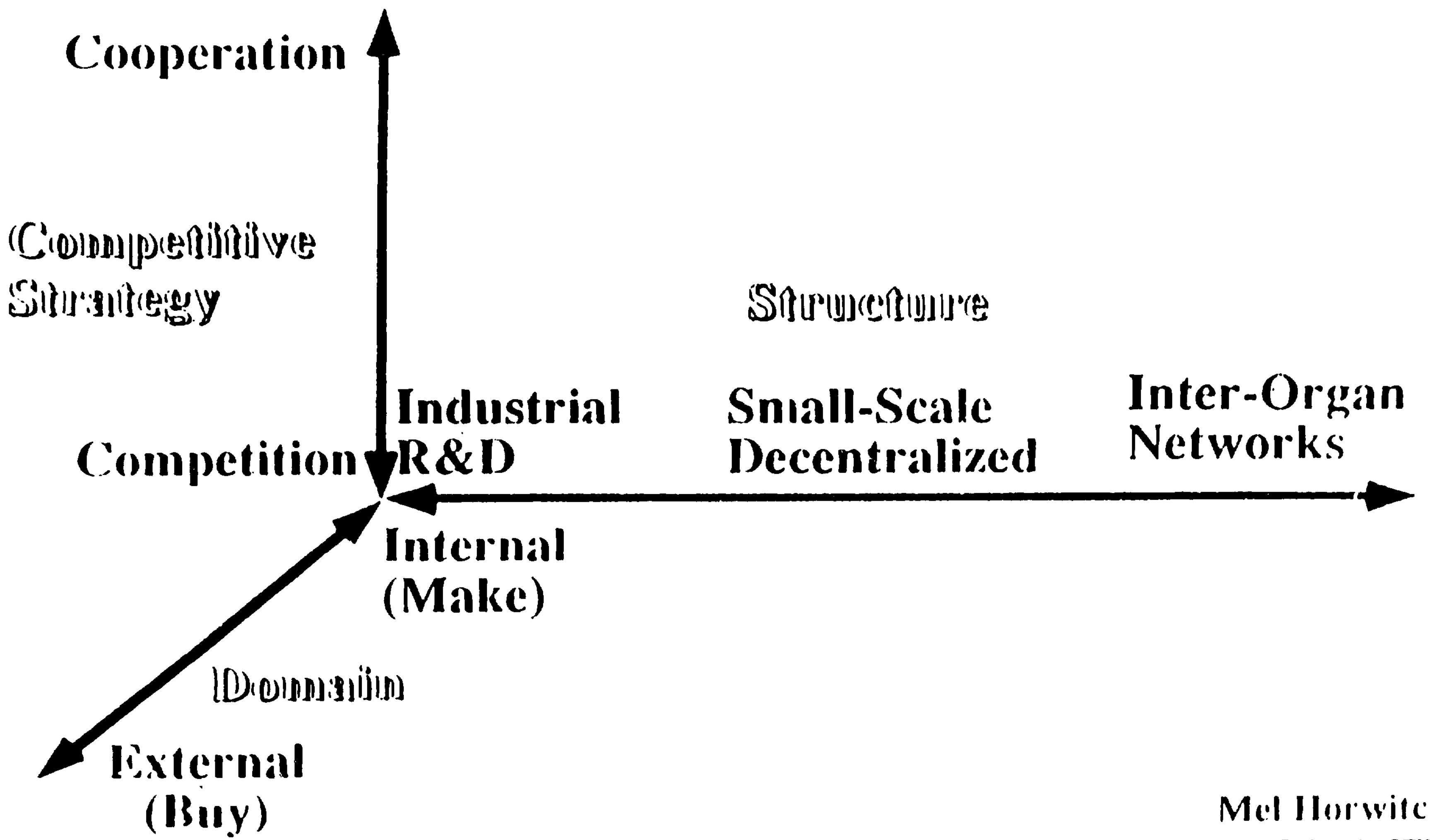
Focusing now on the needs of the large corporation. Technology Strategy can be viewed as a complex array of trade-offs. relationships, and linkages that must be managed in a highly sophisticated fashion. The specific nature of these tradeoffs are depicted in Figure 2. Three key aspects of Technology Strategy are presented. According to this framework, large modern technology-intensive corporations are making Technology Strategy decisions along three dimensions: competition vs. cooperation [competitive strategy]: internal (make) vs. external (buy) technology [domain]; and traditional large corporation industrial R&D vs. decentralized, small, entrepreneurial units vs. interorganizational networks [structure]. Achieving the appropriate set of multiple trade-offs and locations along these dimensions is one of the major tasks in Technology Strategy today.

There is a substantial, varied, and ever-increasing empirical database that supports this general notion of Technology Strategy. One study examined the Technology Strategy of a representative set of firms from the population cohort consisting of those 97 U.S.-based Fortune 500 companies that had spent at least $80 million on R&D in 1982.7/ Several methods for technology development and acquisition were identified R&D laboratory or in entrepreneurial subsidiaries represent the fruits of internal techniques of development. The remaining techniques can be considered external methods of technology development or acquisition. A review of both the Wall Street Journal Index citations and an indepth survey found that for the 1978-83 period there was a substantial increase in the practising of modern technology strategy methods generally and, especially, in employing non-traditional decentralized structures and in using all the methods identified for external technology acquisition. Companies that have strong inhouse research capabilities have been using, at the same time, more of and a greater variety of internal and external sources for accessing technology, which is a clear illustration of simultaneity in action.

Similar trends can also be seen when viewing technology strategy from the perspective of specific technology-intensive industries. Such practices are increasingly common in a diverse set of technology-intensive sectors, including the personal computer industry, which experienced a prototypical evolutionary development, from a large number of small firms to competition among fewer large players, the permanently turbulent medical diagnostics industry, the restructured manufacturing technology sector, and the immediately strategic biotechnology industry.8/

To take a specific and startling example, Technology Strategy can even be documented in an industry that does not yet truly exist, the optoelectronic communication switching and computer industry. In fact, the advent of modern Technology Strategy in this industry is probably the most dramatic manifestation of technology's strategic importance. Optoelectronics still consists mostly of intensive R&D efforts by a host of U.S. and foreign firms and some government-sponsored programs. It is still more a vision based on assumptions and extrapolations of technical and market trends. Even without viable and accepted products, however, Technology Strategy is being vigorously practised.[9]

Elements of Modern Technology Strategy



Mel Horwitch

Figure 2 a)

Figure 2 b)

Technology Development and Acquisition Approaches

Internal

1. Technologies developed originally in the traditional industrial R&D facilities, including the central or divisional laboratories.

2. Technologies developed using internal venturing, entrepreneurial subsidiaries, independent business units, etc.

External

3. Technologies developed through external contracted research.

4. External acquisitions of firms for primarily technology-acquisition purposes.

5. As a licensee for another firm's technology.

6. Joint ventures to develop technology.

7. Equity participation in another firm to acquire or monitor Technology.

8. Other approaches for technology development or acquisition.

To pinpoint this industry is a particularly difficult task. The Japanese Optoelectronic Industry and Technology Development Association defined the general optoelectronic field as one "targeted at an effective use of various characteristics of light, such as high frequency, space information processing and phase information processing capability."10/ A leading expert at Bell Laboratories defined the industry as including devices that emit or detect light, rather than using light simply for illumination. The foundation of this industry was the invention of the laser in 1960 at bell Labouratories. The laser made possible the generation of a pure and strong light signal. Optical technology in theory offers several intriguing potential advantages over-traditional electronic technology, having greater "band-width" and speed capacity for the transmission of information, possessing electronic immunity and thereby avoiding electronic tapping or jamming, and employing lighter and smaller transmission media using optical fiber instead of copper. Some of these charateristics have already led to a growing and increasingly commodity-like optical fiber market for long-distance telecommunications and information transmission.

There is also the potential for higher value uses of optical technology in information processing and telecommunications when fused with electronics and related technologies. The use of optics in such a fashion could accelerate the processing rates and capacity in these sectors. Ultimately, optical technology could be used inside telecommunications switching equipment and computers to replace electronic integrated circuits, other semiconductors, and computer wiring. At least in theory, this kind of innovation could lead to mass markets for advanced video and information services and to a huge demand for a host of new products, including optically integrated chips (the so-called "optical chip"), the optical computer, and photonic telecommunication switches. It is this potential sector, defined by the use of optics in electronics, computers, and telecommunications switches -- not solely for long-distance transmission -- that is emerging as a rich domain for intense high value competition and modern technology strategy practices.

By the late 1970s, the possible application of optoelectronics in computing and telecommunications devices was already recognized. Bell Laboratories was researching integrated optoelectronics, dozens of other U.S. research laboratories were spending a total of about $50 million on optoelectronics; and MITI in Japan established in 1978 a joint $90 million optoelectronic research project with 13 companies. Also, several companies and small firms were exploring segments of this field.

By the mid 1980s, however, the set of industry participants had changed. A dual structure had emerged with three major Japanese computer companies heavily committed to optoelectronics as well as several other firms, mostly small ones, still staking out niches. Figure 4 shows this evolution. In order to understand better this change and the strategic decisions being taken, two important and contrasting firms will be discussed, AT&T and NEC.

AT&T has been the clear leader in optoelectronics research. In 1985, at Bell Labs out of a total of 18,000 employees and 120 laboratories, about 225 scientists and parts of six laboratories (three wholly dedicated) were working on photonics research. At that time, Bell Labs spent a total of about $45 million annually on optoelectronics, $25 million on research and $20 million on development. However, Bell Labs' efforts in optoelectronics are rather unfocused and fragmented, reflecting the broad, and science-oriented research tradition of that organization. In 1985, its optoelectronics research budget had allocated 33 percent to lasers, 33 percent to detectors, switches, and bistable optical devices (for optical computing), and 33 percent to systems. But, meanwhile, the nature of competition had changed.

NEC is a formidable rival to AT&T in optoelectronics. Ten percent of its sales are invested in R&D (2 percent more than AT&T) with about 10 percent of its R&D budget allocated to optoelectronics, about $50 million in 1985. Optoelectronics R&D has grown about 10 percent annually since 1980. Optoelectronics R&D at NEC is consciously structured according to three categories: basic research, device research, and applications research. Research activities are given priorities within each category. Applied research is linked closely to production and marketing. NEC is already committed to produce efficiently small optoelectronics devices, the first plant of its kind in the world. Clearly, NEC is much more explicitly strategic, coordinated, and integrated in its commitment to optoelectronics than AT&T.

Figure 3

Participants in the Optoelectronics Industry

Type of Institution (Year)	1978	1984
Integrated Computer on Communications Company	AT&T Bell-Northern Research IBM	AT&T ($33 Billion-Total sales) NEC ($9 Billion-Total sales) Fujitsu ($8 Billion-Total sales)
Transmission Systems Supplier or Non-Telecommunications Integrated Company	Hewlett-Packard Texas Instruments RCA ITT	Boeing Electronic Company Sumitomo
Vendor	Galileo Electro General Optronics Spectronics Times Fiber Valter	Hitachi Galileo Electro General Optronics Spectronics Times Fiber Valter
Multi-Firm Research Programs	MITI	MITI Battelle Memorial Institute

Source : Anne T. Fox, Strategic Decision-Making in a Global Technology-Intensive Environment : A case of the Optoelectronics Industry, Unpublished Master's Thesis, MIT Sloan School of Management, June, 1986, pp.26-30.

Other Japanese firms are also strongly involved in developing an optoelectronics capability, including the computer company Fujitsu, which has a general strategy of entering the high growth segments of telecommunications, and the cable firm Sumitomo, which is a leading producer of optical fiber and semiconductors. This company has also made a strong commitment to optoelectronics as part of its overall strategy to move into high-technology and international markets. Sumitomo is targeting high value components like optoelectronics modules. In the U.S., Boeing also has R&D activity in optoelectronics. The firm established the Boeing Electronics Company in 1985, as part of its strategy to diversify somewhat out of aerospace. In 1986, Boeing also created an optoelectronic research laboratory in its High Technology Center. This laboratory has received about $20 million in funding or about 20 percent of the Center's total budget (which, in turn, represents about 25 percent of Boeing's overall R&D allocation). Boeing's activities are more focused than either AT&T or NEC.

It is extremely hazardous to perform an assessment of the corporate strategies in this industry, where practically no truly significant products have been marketed. Still, certain trends and evaluations can be done. As seen in Figure 4, one comprehensive analysis of this industry concluded that both NEC and Fujitsu would maintain their high strategic position during the next decade, that Sumitomo and Boeing would improve moderately, and that AT&T would decline somewhat in relative strategic position due especially to its lack of explicit priority-setting within optoelectronics and the absence of strategic coordination and integration. Clearly, AT&T has excellent technology but not necessarily superior Technology Strategy.

Multi-firm activities are also an important aspect of the optoelectronics industry. In Japan, the nine-year, $90 million MITI joint research program on optical measurement and control systems, which started in 1979, still exists with 13 companies parpticipating. In 1981, MITI also formed the Optoelectronics Joint Research Laboratory to conduct basic research on optoelectronics devices for short-haul uses. MITI is also funding optoelectronics R&D at NEC, Fujitsu, Hitachi, Toshiba, and Mitsubishi. These firms, along with Sumitomo and three others, are also participating in the MITI optoelectronics laboratory. NEC is working with several Japanese materials and chemical firms and a U.S. firm on optoelectronics R&D. In the U.S., an optoelectronics research consortia was established by Battelle Memorial Institute in 1985 and had seven corporate sponsors, Boeing, Hewlett-Packard, ITT, Allied, Litton, AMP, and Dukane. Each firm contributed $600,000 for three years of research. Battelle ideally is aiming for 16 corporate members and a $12 million program. The U.S. Department of Defence also funded $20 million for optoelectronic research in 1985.

The remarkable aspect of the optoelectronic communication switching and computer industry is how strategic it is even before there are significant products on the market. A massive long-term R&D commitment is in place, a global perspective dominates, evaluations of long-term strategic capabilities and advantages are carried out, and a web of new linkages already exists. Amazingly, explicit Technology Strategy has preceded the actual establishment of an ongoing industry.

Figure 4

Strategic position of Major Optoelectronics Firms

Company	1986	1995
AT&T	High	Medium
NEC	High	High
Fujitsu	High	High
Sumitomo	Low	Medium-low
Boeing	Low	Medium-low

Source : Anne T. Fox, Strategic Decision-Making in a Global Technology-Intensive Environment : A Case of the Optoelectronics Industry, Unpublished Master's Thesis, MIT Sloan School of Management. June, 1986, pp.94.

Among the general lessons to be derived from a discussion of comparative Technology Strategy patterns at the industry level are, first, that a similar pattern of strategic decision-making seems to have emerged, mostly without regard to the specific technology-intensive industry. Technology itself has become an increasingly important strategic concern in stereotypically high-tech sectors like personal computers, ultrasound medical diagnostic equipment, biotechnology, and optoelectronics and in seemingly mature industries like manufacturing technology. In addition, there is also clear evidence of coexistence of multiple internal structures (such as industrial R&D and venturing), of large and small firms, of multi-firm research efforts, and of new kinds of linkages in all of these industries, whether they are established (like manufacturing technology, personal computers, and ultrasound), new (like biotechnology), or not yet truly in place (like optoelectronics). Moreover, Technology Strategy methods are obviously being vigorously practised on a global basis, particularly in the advanced economies. Finally, all these lessons point to a more general implication that such practices are similarly not limited to either a small set of industries or countries.

The global character of Technology Strategy can also be discerned by studying specific representative firms. One increasingly significant feature exhibited by many of these companies is the growing importance of diverse kinds of strategic alliances and inter-organizational relationships, termed value creation networks, for the purpose of gaining access to needed technology.

The prevalence of strategic alliances on a global basis can be demonstrated by briefly reviewing the strategic configuration established by three representative technology-intensive large corporations: the linkages with a biotechnology focus of the Swiss-based pharmaceutical company, Hoffmann La-Roche; selected strategic alliances formed by the Japanese electronics giant, NEC; and the constellation of external relationships established by the U.S. automobile maker, General Motors.

All three firms are now clearly at the center of a hub of a vast and complex network of relationships.

The functions of these networks are clearly multiple. They include simply extending value for ongoing business activity and, increasingly, creating new value or radically transforming current value. Also, it is worth mentioning that the kinds of participants in these webs of linkages are extremely diverse. Large firms, small firms, multi-firm consortia, and governmental agencies or programs are all represented.

The actual types of linkages identified are also quite varied. They include licensing agreements, marketing or research contracts, acquisition, and minority equity holdings. With regard to this last type of linkage, for example, it is clear that General Motors has a strategy for using a portfolio of minority equity investments at least partially to keep abreast of technological developments in such fields as vision systems, artificial intelligence, and expert systems.

Finally, it is obvious that these interorganizational relationships often cut across international boundaries and some of these linkages are truly global in scope. Hoffmann La-Roche has biotechnology-related agreements with three U.S. universities. NEC has ties with several U.S. firms and foreign governmental bodies. General Motors has foreign joint ventures with technology development objectives. GM's partners include Fanuc, Isuzu, Alfa Romeo, and Toyota.

These remarkably similar patterns of strategic-alliance structures by such different corporations as Hoffmann La-Roche, NEC, and General Motors are not simply due to coincidence. Instead, they indicate a kind of convergence in the practice of Technology Strategy by technology-intensive corporations. Many such firms are intensively searching for effective higher value strategies, which often involve the consideration of technology as the critical strategic variable. Increasingly, firms are willing to "buy" such value-creating capability as well as investing in an internal capability to "make" high value creation.

III. Generalizing : Technology Strategy and the Value-Creating Post-Modern Corporation

A major implication of Technology Strategy, particularly with its penchant for both novel anti-hierarchical forms within the firm and for interorganizational linkages outside, is that it signifies the emergence of at least partially a new corporate form.

What might be the configuration of this quasi-new entity? It is not simply a rational hierarchical institution, which was documented by

Chandler and which was a supportive home for strategic planning methods.[11/] Nor is it the smaller, flatter, and more informal organization and style of either the general management school or high-technology entrepreneurialism.[12/] Instead, it possesses features of both--with decentralized smaller units and continuing large-scale hierarchies, divisions, and functions.

In addition, a major part of such a corporation's strategic repertoire is a diverse set of external relationships that are established for the purpose of capturing still more value. In particular, the employment of interorganizational collaborative value-creation networks are a key distinguishing feature of the strategic behaviour of the corporation practicing Technology Strategy today. Such moves can be viewed as essentially attempts to establish pipelines to outside resources that can enhance the value creation capability of an enterprise. The various types of linkages can be delineated in Figure 5, and it is argued that the emphasis is shifting to the second and third columns where the creation of value is largely occuring.

Figure 5

Alternative External Collaborative Arrangements
Possible for the Large Corporation

Strategic Objective of Large Corporation

Type of Partners/ Sponsor Chosen	Extension of Established Value	Creation or Transformation of Narrow or Targeted Value	Creation or Transformation of Broad Value
Another Large cooperative	Licensing, Joint Venture for Manufacturing or Marketing	Joint Venture for New Product Development or New Manufacturing Methods	Joint Venture for New Sector Development
Small Firm	Distributor for Limited Market	Contracted Research Joint Venture for New Product Development	Portfolio of Minority Equity Positions in Selected Small Firms
Multiple Firms			Multi-Firm Consortia
Government Programs		Governmental Research Program	Governmental Research Program
Others		University-Industry Association	University-Industry Association

The job of strategy has changed. Previously the emphasis was on recognizing the opportunities and threats in the competitive environment and establishing within the firm the appropriate structure, systems, and processes. With the increasing importance of strategic networks, which have associations that pierce through the formal boundaries of a firm, the tasks of scanning, facilitating, and coordinating external entities assumes greater significance. In addition, the old make-vs-buy tradeoff, found originally in purchasing and manufacturing, takes on greater general meaning. The creation of strategic networks can encourage a policy in which external entities play a higher value strategic role, and the notion of shrinking or "de-massing" the internal structure gains enhanced legitimacy.

To repeat, as we have seen, both novel internal structures and external value-creation strategic alliances, which make up much of sophisticated Technology Strategy today, are part of the broader transition toward Post-Modern Strategy that is now underway. This development requires a significant change of views concerning the fundamental conceptualization of strategic management. Defining the domain of corporations is no longer simple. The inside structure is quite complex. The outside environment is no longer merely competitive. The distinction and boundaries between organization and environment are blurred. There are now a variety of ways to join forces with external actors. At least some of the linkages themselves can be changed or cancelled. The growing diversity of enterprise certainly presents new difficulties for strategic managers. But it also can mean enhanced strategic degrees of freedom and choice. The rising strategic importance for firms of constantly acquiring innovative capabilities means that now there are new paths available for achieving meaningful strategic success.

NOTES

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CHAPTER III

MANAGEMENT OF PRODUCTION TECHNOLOGY

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Introduction

To define 'technology' is not easy with its denotative and connotative usages. Derived from the Greek root 'Technologia' it originally embraced systematic treatment of an art. In modern context it envisages all aspects of applied sciences for achieving a practical purpose - a totality of the means employed to provide objects for human sustenance and comfort. A widely used definition is that it is the practice, description and terminology of any or all of the applied sciences of commercial value'. The buzzword here is the value or rather the commercial value. It would imply that a certain applied scientific practice which has no commercial value presently or for the future will be treated as obsolete and such practices find no mention in this paper. However, they too serve, for they form the basis on which future technologies are often built up. It has also to be kept in mind that what is obsolete for a certain country is probably the current practice very much in use in another country. Thermionics valve theories and steam engine technologies etc. are probably obsolete in terms of 'technology life cycles' but they are very much in use and practice not only in the teaching establishments but even for commercial purposes in some part of the world.

Technology being obsolete, the terms 'current' or 'modern' and 'high-tech' are relative to a great extent. What would identify them in their correct perspective is the environment is which references are made and discussed, relative to the industrial and commercial standards and state of development of the state or country. When discussing management of technology, the guiding factor will be the position of the technology in its life cycle pattern as applied to the country under reference. For example semiconductor and IC technology are at a different stage in their life cycle curve in the most developed countries but in most of the developing countries they are very much current technologies.

Another term that is normally or almost synonymously used with technology is innovation. Probably this term has wider applicability for it denotes the sum total of activities from creating new technological concepts, skills to implementing them in industrial and commercial applications. Management of innovation calls for such aspects as technology life cycles, technology 'S' curves, sources of innovation, innovation in service as well as marketing and technology and production strategies.

Management of technology would also imply that the concept role and contribution of the R&D infrastructure at micro and macro levels are kept in view. In terms of overall competitiveness, irrespective of the radius of the action arena of the organisation, R&D of the organisation plays a critical role. It may not sound convincing when one is used to borrowed technology through and through and competitiveness may not ring a familiar bell. It is often said that managing technology is taking risks on novel products and developing new markets and managing technological change is the crux of high-tech strategy.

The competitive situation in the national and international environment of commerce and industry need to be touched upon for, that is the key trigger for all innovativeness and the catalyst to developing better and better technologies. In an unfriendly environment where 'live and let live' is not the title to the theme song, no one can afford the luxury of being complacent and hang on to the relics of technology old and obsolete. The focus will therefore be on competitiveness and management of production technology.

Global Competitiveness and Challenges

Stories concerning the loss of market share and jobs to competitors in various industries are frequent news items in newspapers around the world. Examples are far too many to be picked and quoted here. Japanese supremacy in most industries particularly electronics and automobiles are two outstanding instances which shook a number of other developed countries. The decline and fall in the position of their manufactured products and services in the international market have been a great awakening to managers around the world.

Stress on matters of competition and technology are uppermost in most industrial organisations' plans. Strategic decision-making considers these two aspects as vital inputs. Be it the industrialised or the industrially developing nations, the writing on the wall is there for those who can get the message - to survive in the highly competitive industrial environment of tomorrow, the choice and adaptation of appropriate technology is the most vital need. The right technology and the effective management of such technologies. Real challenges for the managers.

Technological choice and adoption for its own sake will serve no useful purpose. If the management is convinced of a reasonably good chance of success in the competition by adopting new technology, the venture will be justifiable but it has to be remembered that technological or innovative changes may not be the panacea for all problems in competitiveness. The scientific rating or the sophistication of the technology as understood internationally has less significance than the appropriate technology to match strategic decisions of production or manufacturing management.

Technology in Industry

Passing through various phases of human civilisations covering spans of centuries, world trade in manufactured goods and products developed and kept pace with human ingenuity and innovative skills. Technological progress from the Renaissance period to the start of the Industrial Revolution came in the shape of enhanced knowledge and improved skills. Gradual changes from manual technology to mechanisation took place with the growth of competitiveness, technological progress, production process, and management skills. Better products, improved services with greater stress on quality reliability consistent with customer needs with cost effectiveness resulted. Constant efforts at improving technologies brought out the need for specialised agencies charged with the specific responsibilities in this area. The R&D departments became an essential element of all industrial organisations. Scientist and technocrats working together have created technologies that were outside the dreams of ordinary people. Isolated inventions were no more the trend. The last few decades have probably seen more and greater innovativeness in the areas of both products and services than we had in the whole century. Production technology the world over has gradually changed and continue to change. Starting with the age-old systems, the shift to mechanised systems was very gradual in some countries but rather fast in some of the highly industrialised countries. Process industries, mass-produced standard products and mass-produced assembly lines were the first to go into the mechanised technology stage. The great strides made by the electronics industries and the advent of computers and their availability to most types of organisations opened up new vistas for the innovative entrepreneurs and risk-taking managers in different parts of the world dealing with different types of products and services. The shift to the automated strata of production technologies became a reality almost a decade ago. The shape of factories of tomorrow is already in the minds of the visionaries and creative leaders of industries, particularly in the developed countries.

PRODUCTION TECHNOLOGIES

Some of the most important technologies that are adopted by most of the industrialised countries and their industries are discussed in the following paragraphs. Production and manufacturing managers in developing countries are aware of these technologies and most of them might even have had short term exposures to such technologies as part of their training programmes in the developed countries. In our industrial environment, bits and pieces of such high-tech are in use, and in a number of organisations some of the major technological disciplines are already an established fact with some limitations. Three major technologies are discussed below:

Computer Integrated Manufacturing System.

The system known by its acronym CIM is in the higher class of high-tech production technology. An apt and precise definition is not yet available but in general it reflects the growing convergence of systems in the business and technological areas within the overall area of manufacturing concept behind this pattern of technology is that the total process of manufacturing should be viewed as consisting of three sub-systems:

- design
- production
- coordination

Within each of these subsystems, both technological and organisation, there is a gradual move towards integration of activities. Design activity has been moving from the concept of a few discreet activities to closer interface with manufacturing. As the technology in use gets to be more and more sophisticated and elaborate, use of computer in design function has become inevitable and thus the present trend and use of computer aided design or computer assisted design, popularly known as CAD.

Manufacturing organisations find more and more need for new techniques and integration. Use of established systems such as EMS, NC, CNC, DNC, CAM, CADMAT etc. are accepted methodologies in the industrially developed countries. Where the necessity of adopting such production technologies have been found suitable and economically viable, even a few of the developing countries have resorted to the use of such technologies.

CIM in its full configuration will effectively bring together all the three sub-systems of design, manufacture and coordination into a highly integrated system. When fully developed and implemented it is expected that this system is likely to establish active links with such technology as JIT (Just-in-Time) an accepted and widely-practised advanced system of inventory management.

The suitability of CIM technology for adoption in the indigenous industries of the developing countries need to be assessed for its overall cost effectiveness. The system is capital intensive for its introduction and various factors associated with the smooth and efficient function of the system need careful study before production managers decide to select this technology. Mass production lines involved in production of standardised products or components being produced to order and stock with assured marketing outlets with sufficiently experienced personnel to operate the system would find it viable and profitable.

Flexible Machining System.

This is in extensive use in most large-scale industries even in the developing countries. An integrated system of production, specially suitable for the machine tools division, this modern technology calls for the use of a number of advanced sub-systems such as NC (numerical controlled) machines, with or without data record and play back facilities, CNC (computer numerical controlled) machines, DNC (direct/digital numerical control) machines etc. Flexible manufacturing systems generally involve the bringing together of such activities as component handling in the close proximity of the machines, cutting, shaping and milling bearing in mind overall production and quality considerations. By the combined use of micro-electronics and best technology in machine design, FMS, brings considerable economy to large batch and mass production with considerable improvement in quality as well as quantity. An on-line control computer constantly controls the entire operations at all work stations including the transfer of components, tools selections and even a few dimensional checks. A number of new systems similar to FMS, both in technology and even in their names such as AFMS, VMMS and FMLS etc. are now in use at a number of production establishments with minor variations in the configurations of the sub-systems applicability and are to a certain extent more need-based to specific production purposes.

The generally accepted FMS should comprise of:

work stations. Usually machine tools which can be NCs, CNCs, and special-purpose machines, in-process measuring devices and special finishing devices including LASER devices and final washing devices.

handling systems. Ranging from simple roller conveyors towed vehicles, overhead cranes, manipulators and, where special demand exists, even robots.

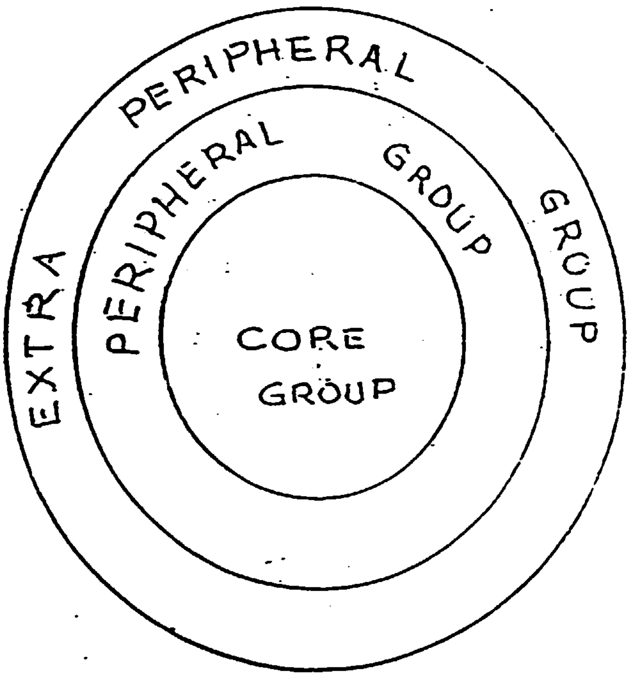
supervision system manual, direct numerical control local networking with linkages to central control and storage cell.

It may be noted that the sub-systems mentioned above are not mutually exclusive and are more often a combination of the units on an as desired basis to suit the particular production plans.

Flexibility in manufacturing could often be misconstrued or misunderstood. Flexibility itself needs to be defined as the ability to yield to influence or capable of responding to changing situations. Considering the overall capital cost of setting up a modern production line incorporating new high-tech practices, the need for these set ups to be flexible would almost be mandatory and warrants no special emphasis. However, flexibility relating to four main aspects need elaboration.

(a) Labour Flexibility: Flexibility conditions to this vital resource area are concerned with numerical and functional aspects. It is generally concerned with the readiness and the mutual understanding involving the labour force and the management of the continual or frequent changes in work force that need to be effected from time to time. Such demands might become necessary due to the changes or fluctuations in the market demands. This sort of situation is generally accepted in the industrialised countries, at least in some of them but with the explicit understanding of both parties - the industry and the labour force - to the benefit of all. A situation of this nature is not easily conceivable in the developed countries where pressures on the labour and the management often are of a non-complementary nature. It is, however, presumed that an organisation that can go into production using modern high-tech systems may be in a position to implement such flexibility with an awareness of the need and an assurance of fairness to the work force illustrated in a convincing manner. Functional flexibility associated with labour is concerned with the readiness and understandings by which changes in functions performed by labour can be altered in order to meet changes in process as well as products. There is yet a third area in which flexibility is accepted in some organisations and related to labour flexibility. This is financial flexibility and it deals with adjustments in the remunerations package that would be necessary at times and are acceptable to the labour force. The labour force generally consists of two main groups: the core group and the peripheral group. Where labour flexibility is an accepted norm, each of the groups mentioned earlier is subject to one or more of the flexibility conditions. It is essential to note that the working group in organisations consists of the core group, peripheral group and the extra peripheral group.

A simple model indicating the composite group in an organisation is indicated below:



While enjoying a certain amount of security of tenure and other conditions, the core group in the centre has and must have the readiness to accept flexibility of utilisation. The peripheral group, who are also direct employees of the organisations but not subject to career status and such other conditions of service in terms of continuity, are subject to the numerical flexibility conditions. The peripheral group generally consists of specialists and represents the under employment periods: they are entitled to higher remunerations which, to a certain extent, are compensatory factors and these are probably the main conditions under which the flexibility is accepted. The core group are generalists and subject to functional flexibility only where they could be expected to do more than one task and are expected to be trained for such changes in the job and functional matters; functional flexibility can only be achieved where achievement of multiple skills on the part of labour exists and is encouraged. A multiple skilled work force is the basis of functional flexibility. Labour force flexibility can also be achieved by the extraneous deployment or utilisation decisions. As widely practised, the policy and practice of sub-contracting and purchase of sub-systems and parts gives an opportunity for labour flexibility - a method that is probably the most applicable in our environment.

(b) Production Flexibility: The most common way of distinguishing between different types of production systems is to group them into three:

- batch production

- mass or assembly line production

- flow or process production

Batch production systems are associated with specific orders and are often quantity and time-bound operations. A good deal of sub-contracting from the assembly line or mass production organisations are batch production tasks. Batch production technology has an inherent flexibility attached with it. Mass or assembly line production systems, on the other hand, tend to be inflexible under normal conditions unless the need for flexibility has been built in at the planning and implementation stage of the facility. As it requires a high level of investment and uses a considerable number of machines of specific functioning with dedicated tooling and other detailed arrangements, flexibility in this system of manufacturing is not easy to achieve. Generally conceived as inflexible, new developments in innovations and technology are aiming at inducting flexibility to the extent possible in this system of manufacture. Flow or process production systems have distinctive characteristics of their own. Primarily it has only very limited interactions from the human element or the work force. High volume of market demands and very high capital investment needs are features of this system. Flexibility in this type or system of production is not anticipated, outside the normal limits.

(c) Technical Flexibility: This implies primarily or is concerned with the readiness or ability of an organisation to absorb new technologies which by themselves are likely to be flexible. Multiple programables, user friendly are some features of such flexible systems. Modern technology using Numerical Control (NC) and Computer Numerical Control

(CNC) systems are all examples of flexible technology that are becoming more and more common in major manufacturing organisations. As investment cost of such sophisticated systems are very high it is almost imperative that they must be flexible to a very great extent.

(d) Structural Flexibility: This is concerned with the extent to which the structure of an organisation is assisted or hindered by changes. For example, based on a decision to introduce a batch or number of new generation product, it might be necessary to close down some departments or make necessary changes in the organisational structure itself. Unless flexibility requirements have been built into the organisation itself the introduction of new technology or changes for the good of the organisation may not be easy to implement. All rank and file in the organisation must be free and willing partners and be flexible to accept changes. To cope with such fast changing technology in manufacturing and operations management scenario, organisations which are flexible surge ahead of others which are not.

(e) Advanced Manufacturing Technology: There is a school of thought which claims that such a name could be substituted by 'High Technology' on the plea that these technological innovations are applicable in the areas of manufacturing only and as such, this word or function needs no repetition. AMT basically consists of computer controls and high capital intensive machineries. Another explanation or a definition is that it is the application of the most up to date production methods and machinery. Examples of industries adopting this system fully are not easily available but it is expected that most high-volume manufacturers of electronics products and services are currently using the system or are likely to adopt the system soon. In the opinion of some of the leading technologists of the industrialised countries, AMT happens wherever people work or on the boundary of yet unknown processes, materials and methods and even in some areas of accountancy and financial disciplines. Information technology use of expert system and the presence of all other paraphernalia which are supposed to make up the enterprise of the future may indicate that the organisation is practising a high/advanced manufacturing technology approach to production.

MANAGER'S CHALLENGES

+Choice of Technology: Process technologies can be classified in many ways, in terms of the nature of or the manner in which transformation is brought about on the materials: Chemical process, machining process, information process and assembly line process are some of the common examples. Generally, classification is done by keeping in mind the historical progress of the product. Such classification helps in assessing a number of vital factors such as cost, flexibility and quality. Process Technologies classifications that are generally accepted are as follows:

+Manual Technology: Advantages of manual technology are low cost for low volume of production, low capital investment and a certain inherent flexibility, both financial and operational, which make this most suitable for most developing industries and enterpreneurs. For low or very low volume of products such as custom-made machinery manual technology is undoubtedly the most appropriate. Capacity can usually be increased or reduced without great difficulty resulting in overall cost and scheduling facility. Since the human factor is fully involved. sustained quality of products or quality control is one of the inherent problems or disadvantages of this system. This point may. however, be refuted by citing the age-old quality aspects of Rolls Royce - where, it was claimed, every component was handmade. Longer production cycles and uncertainty in delivery schedules are the other disadvantages of manual technology.

+Mechanised Technology: With the establishment of factories for regular manufacturing and production substitution of human power for mechanised power, became an established fact of life. Fully or semi-mechanised manufacturing systems were prestigious and efficient until a few years ago, although it has yet to catch up with industry in the developing countries, particularly in the low-volume low investment sectors. If low cost is required and product designs are stable, the use of special-purpose machines and technology are suitable. Larger volumes of product of standard designs would make this a suitable choice though investment cost is high and there is need for higher maintenance costs with the added disadvantage of loss of production time due to factors such as non availability of power etc.

+Automated Technology: Automation in its industrial or even domestic applications is nothing new. Use of thermostats with refrigerators and airconditioners, float valves in the domestic plumbing systems for toilets, traffic control systems using self timers etc are some examples of automation which have been in use for some time. Chemical industries have been using automatic control systems for quite some time. But automation in manufacturing industry as we visualise it, with the introduction of computers and associated technology and gadgets, is new and its use limited to the industries of most developed countries and a few industrializing countries. By this we mean the extensive use of such systems as NC, CNC, AMT, and Robots etc.

+Use of Robots: It may be appropriate to make a brief mention of Robots, their development and uses. Industrial robots are gaining great attention and applicability the world over. In certain spheres and in industry the robot has come as a great boon for its ability to replace man in and around vulnerable and hazardous situations and it has helped industrial development at a much greater pace. Robots seldc ask questions and are capable of steady productivity performance irrespective of the working environment and the length of time they are put into use. It is of interest to note the definition of 'ROBOT' as defined by the ROBOT INSTITUTE OF AMERICA which states that 'a Robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialised devices through variable programmed motions for the performance of a variety of tasks'.

The selection of appropriate technology has to be a joint responsibility shared by heads of associated disciplines, and not left to the product or production managers alone. Often specialists are inducted in and the task undertaken on the basis of project management.

Technology and Human Factors: Selection, adoption and maintenance of Technology (AMT) in any organisation presents considerable challenges to the managers. That is particularly true of those organisations and industries which have grown in a traditional semi-orthodox manner and find even minor changes difficult to accept. A feeling of threat seems to hang over them.

The self development of managers and others at the top to look ahead creatively and plan every operational activity, including production, in order to appreciate decisions and their overall influences on the organisation as a whole, ought to be the foremost requirement. Decision making/taking and their implementation calls for true skills in these areas which, among other things, can come through the learning processes.

The conceptual and professional skills of the managers and personnel involved will be an important contributory factor for the successful implementation of programmes and plans. The saying that it is the man behind the machine that matters more has never been truer. The success of a flexible manufacturing system (FMS) is largely dependent on the flexible learning system that exists in the organisation. Senior management must understand that the evaluation and implementation of any type of modern technology as a part of the corporate strategy must be tied to the decision of suitable personnel policies which must include training and motivation. Any plans to adopt modern technologies in the production and operations management area must cater for the selection training and motivation of suitable professionals in their respective areas of specialisation. Changes in attitudes, expectations and foresightedness at all levels of management are essential. Advanced technologies give ample opportunity to deserving and persevering professionals. An inquisitive mind and a challenging attitude on the part of personnel are vital in acquiring new skills through an understanding of modern technologies and practices. Enlightened management must initiate actions and provide the necessary inputs that the potential leaders can identify and be prepared to act and associate themselves with the factories of the future, the 'automatic factory'.

The Automatic Factory: Although nothing like an automatic factory exists today, there are small islands and patches of such in a large number of industries abroad and probably in our area too. It is said that the watch assembly line of SEIKO has no human association at all as none is required. The wheel manufacturing line of the General Motors in their West Coast Plant are in good shape without the influence of human hands. Imagine raw materials in the form of strip steel and coiled bars entering at one end to be automatically cut, formed, welded, punched, assembled, painted and dried and the wheel emerging at the other as a finished product - all an example of the Automatic Manufacturing Technology.

Technology and Service: A paper of this nature dealing with modern technology and production will be incomplete without a reference to the service industry which is more customer oriented and where the majority of the workforce of the world are engaged in today. Banks, travel and fast-food departments are undoubtedly leaders in the area of adopting new technology for the purpose of providing better and faster service to the customers. An indepth study in service sectors of the developing countries would be beneficial to identify modern technologies that could be adopted for overall efficiency and better and faster service. Most departments in the service area which would probably embrace almost every government agency seem to have abundant scope for absorbing or adopting better technologies.

SUMMARY

The central theme of all management development and the central task of all managers are productivity and profitability improvement. In the back-drop of national and international competitiveness, the adoption of new and newer technologies and innovations has become an absolute necessity. A few industrialised nations are considering radical changes in the management development curriculum and the introduction of full-time programmes entitled 'Advanced Manufacturing Technology Management'. The thinking and the priority are significant.

Choice of appropriate technology to match the competition market and economic viability have to be the central concerns of the organisation. Each departmental head has his own role to play.

The most important factor that needs consideration is the human element and the technology choice. The best of technology may falter and flounder unless the people behind it have the skill, commitment and motivation to be a party to decisions and management functions.

CHAPTER IV

MANAGEMENT OF TECHNOLOGICAL CHANGE ISSUES AND CHALLENGES

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Introduction

We are concerned here with the management of technological change in the corporate sector. The decisions relating to this change typically are taken in a market setting which provides the motivations as well as he constraints. For purposes of our analysis we may distinguish between the management for change and the management of change. The former is concerned with the choices and decisions relating to the evolution of technology or to the obtaining of already available technology through negotiations. Clearly the management issues raised by these two ways of obtaining technology are different and need to be considered separately. Once technology is available, its introduction brings us into the areas of management of change.

The prime concern of a firm is excellence in business performance and, therefore, skillful management involves a keen perception and sensitive response to technological change. As emphasized by Peter Drucker in the "Practice of Management", an enterprise cannot be a mechanical assemblage of resources. In other words, technology cannot, by itself, bring about a change; it has to be supported by appropriate organisational changes as well as changes in human skills and training.

Management of Research and Development

The most important single motivating factor for R&D seems to be the nature of the product which a firm produces and markets. In products which are not subject to frequent technological changes "a company necessarily operates in a stable environment, eschews change and adopts a reactive attitude to market requirements. The manufacturing operations associated with relatively unchanging products are concerned with the attainment of highest possible efficiency and this they achieve by giving attention to automation, group technology, rationalisation and other production engineering procedures. If research and development or design is carried out it is normally evolutionary and defensive in character".1/ On the other hand "the innovative company accepts that the future is likely to be uncertain and the process of corporate planning must itself generate new insights and be dynamic and reiterative. One aim of a marketing function in an innovative company will be to disturb a stable environment in order to create new opportunities. Manufacturing operations will thus need to be designed with a view to the possibility of introducing new production. Research, design and development will be important activities and will be aggresive and innovative rather than reactive".2/

The attitude to uncertainty is crucial for the management of R&D. "The problem is of human attitude to uncertainty itself. Not merely are the human reactions to situations of this character apt to be erratic and extremely various from one individual to another but the normal reaction is subject to well reorganised deviation from the conduct which sound logic would dictate".3/

"The distinction among R&D outlays as to whether the results are :- (1) uncertain (2) risky within a probability range and (3) known or reasonably predictable is clearly of considerable importance for economic analysis of the R&D decision".4/ and for taking decisions regarding an R&D project.

In addition to the attitude to risk and uncertainty research leadership is extremely important in the management of R&D. We may take here an example of William Coolidge as a research manager at General Electric. "In terms of management style. Coolidge combined the firmness of expense control with the leadership of technical excellence. He interacted with the staff and was accessible. He walked around the lab, looking more like a scientist than a 'laboratory manager'. Because Coolidge maintained his interest in research, he inspired his researchers. He encouraged them with words like: "This is fascinating, anything we can do to help?' One of his colleagues was quoted as saying of Coolidge: 'That man oozes optimism of an inspiring brand. You feel in his presence that if all things are not possible, many are. Yet he has plenty of circumspection, with a verifying, sagacious mind that readily isolates what is either impossible or extraneous".5/

It is important to recognise that "the research manager must "span the boundaries between the worlds of business and technology, managing the interface between the economic and technical aspects of the corporation. Within the corporation research managers must contribute (1) to product creation and maintenance and (2) to productivity improvement and cost reduction. Outside the corporation, research management must contribute (1) to the corporation's competitive ability, and (2) to the corporate safety and environmental responsibilities, and (3) to the corporate ability to respond to changes in the availability and costs of resources".6/

The issue which arises here is: What is the correct balance between the economic and the technical corporate values? Each firm would indeed have to find its own answer recognising the fact that. "The discipline of innovation (and it is the knowledge base of entrepreneurship) is a diagnostic discipline. A systematic examination of the areas of change that typically offer entrepreneurial opportunities. Specifically systematic innovation means monitoring seven sources of innovative opportunities".8/ Drucker goes on to state that four sources arise within the firm : they are unexpected success or failure; the incongruity between the actual and the assumed reality; innovation based on process need and changes in industry and market structures that catch us unawares. The outside sources are sources identified as demographic, 'changes in perception, mood and, meaning' and new knowledge either scientific or non-scientific.

"The lines between these seven source areas of opportunities are blurred and there is considerable overlap between them. They can be likened to seven windows each on a different side of the same building. Each window shows some features that can also be seen from the windows on the other side of it. But the view from the centre of each is distinct and different".[7/] "How then are these different views to be reconciled? What is the role of personality in conflicts or solutions?"[9/]

Acquisition of Technology

When technology is not generated by a firm it has the option to acquire it from firms where it is available. There is considerable literature on the international transfer of technology. Issues relating to the mode of technology transfer, such as subsidiaries, joint ventures or licences, and payments for technology in the form of equity, royalty or fees, and issues relating to transfer pricing have received considerable attention. Our concern here will be with the nature of the technology markets and their implications for the competitive status of the firm which imports the technology.

The technology is available on a market in the relatively later stages of its product cycle, and while the product is advertised the technology is not advertised. On the contrary, there is considerable secrecy about the technology and the terms on which it is sold. The purchaser of the technology cannot, therefore, really make an informed choice by comparing the possible alternatives. In the market for technology the seller of technology has absolute control over his technology and, therefore, occupies a dominant position and the negotiations for technology, therefore, are negotiations between unequals. Governments of most developing countries do scrutinize and examine the terms on which technology is sought to be acquired and then accord their approval to technological collaborations. But the question which arises here is, how adequate is the system of review and how can it be strengthened?

Regardless of whether the terms on which technology is acquired are favourable or adverse, the technology which is available for acquisition generally applies to the later stages of a product cycle when product competition is already keen.

A firm in a developing country which acquires this technology is likely to be at a competitive disadvantage in domestic as well as international markets. Does this mean that technology imports require tariff protection or quantitative restrictions or both in domestic markets? What is the effectiveness of export promotion measures such as duty drawback and cash assistance? Under what conditions, if any, will a technology importing firm be able to assume competitive postures?

Managing for technological change is not only a question of making available the relevant technology but also deciding on the pace of change. There appears to be widespread concern that technological change is not taking place fast enough. For example, the UK Advisory Council for Applied Research has observed that "the rate of technological innovation in the United Kingdom industry will have to increase if its products and manufacturing process are to match those of its major competitors. This is a necessary condition of our future survival as a trading nation ... we have no option but to attempt to match the productivity and product quality of our overseas competitors, to concentrate our efforts on those industries where we have most chance of success. and to adopt. as fast as possible. technical innovations from abroad. as well as those developed at home".[10/]

The same concern that technological change is not fast enough has been expressed in U.S. in the Report of the President's Commission on Industrial Competitiveness. "We have been slow and ineffective in some areas in translating research into new technologies and in recent decades we have suffered a notable lag in applying our science and engineering to process technology and manufacturing".[11/] The Report further states, "Today the role of technology in our everyday lives and in the functioning of our institutions is greater than ever and is still on the increase. In the years ahead, it will be the primary factor in determining our economic vitality, national strength and general well-being. It will

+ Accelerate advances in productivity;

+ Help us manage an increasingly complex economy;

+ Generate products and services to fill new market needs;

+ Create a net increase in employment; and

+ Raise our standard of living".[12/]

It is the pressures for introducing technological changes with a competitive speed which poses a challenge for management.

The speed with which technological change can be introduced depends upon the possibility of maintaining a balance between what Valerie Stewart calls the technical system, the economic system and the people system. "A key to successful management of the systemized phase is to recognise that there are three systems and that each system needs to be managed on its own terms; in addition, the three systems interact and this interaction in itself needs managing. A good deal of the mismanagement associated with the systemized phase comes about because people try to get the economic system and the people system to conform to the same rules as a technical system. It may make sense to subdivide a technical process into its component parts, and to base the manufacturing system on this breakdown; but one should not be surprised if bits of the economic system or the people system refuse to give comparable benefits from similar treatment".[13/]

The 'people system' possibly poses the greatest challenge for management. "Frequently, firms confront conflicting pressures in connection with work reorganisation. On the one hand, the prospects for achieving substantial product vity gains through improved development of human resources is a powerful spur for encouraging efforts towards reorganisation. Despite the paralyzing grip of convention, pressure from the workforce and the rigours of competition in the long run can lead firms to be more alert to opportunities for adjusting work conditions and to be more active innovators. On the other hand, devising specific kinds of changes in work organisation to capture these prospective gains has proved elusive and difficult and may raise all those issues concerning power and the maintenance of authority that firms would rather not face.

Firms are thus uneasy about proposals for work change: the potential benefits are attractive. but the uncertainties make them pause.

The net result of these conflicting pressures is that. from time to time. firms have had to adjust to strong prevailing winds of change and surrender some prerogative they would have dearly preferred to retain. Firms may have had to accommodate to powerful forces affecting the nature of the matching process in labour markets, but their strategic position has been sufficiently strong to enable them to effectively retain their presumptive essential authority. Work organisation does respond to pressure for change but not quickly enough".14/

The greatest challenge of technological change for management is to minimize the insecurity, stress and psychological resistance to change to bring about a synthesis of conflicting view points and to create an environment which generates a positive response to technological change.

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CHAPTER V

MANAGEMENT OF TECHNOLOGICAL CHANGE IN THE PUBLIC SECTOR ENTERPRISES IN INDIA

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Technological progress is universally acknowledged as the single largest factor contributing to the economic development of a country. At enterprise level, technological input, besides capital and labour, is again said to explain half of the increase in production efficiency.

In the case of India, where nearly half of the total planned investment is in the public sector enterprises, it is important from the policy planning point of view to examine the nature of management of technological change in these enterprises. In fact, the Indian experience in the last forty years since independence has been quite unique in many respects.

India has been a pioneer among the (post Second World War period) newly independent countries to adopt the path of planned economic development for building a socialistic pattern of society. It recognised the role of state public enterprises in fulfilling their national development objective. While the country was influenced to a large extent by the functioning of the state enterprises in the socialist countries, it kept its options for a model public sector enterprise (PSE) to itself. The mixed economy model that the country adopted admits the co-existence of both public and private sector enterprises. The latter included those with equity participation by foreign firms or subsidiaries of wholly owned foreign firms. This made the economic environment of PSEs quite competitive.

With its inception in mid fifties, the PSEs have grown to a towering height with Rs.7,597 crores in 1984-85 as the contribution to the public exchequer by way of taxes, duties and dividends. The export earning in the same year amounted to Rs.4,827 crores. In 1984-85 there were 207 public sector enterprises under Central Government of which 57 were in the service sector and the rest in manufacturing. In addition there are a large number of enterprises under state government jurisdiction.

The PSEs employed 21 lakh people in 1984-85. Despite its social obligations which affect the profitability, the PSEs earned in the said year a gross margin (surplus before depreciation) of Rs.7,398 crores on a capital of Rs.36,33990 crores which is 20.33 per cent, or 12.7 per cent in terms of gross profit as a percentage of capital employed.

The size of PSEs in terms of investments vary from a mere Rs.5 crores in Central Electronics Limited to giants like ONGC with Rs.5800 crores. Quite a few of India PSE's appear in the list of world top 500 companies of Fortune Magazine, and many are the largest of their kind in the Asian continent.

Although PSEs were primarily created to build the industrial base of the economy by manufacturing the capital goods, they are not prevented from entering the consumer goods sector. PSEs enjoy a monopolistic power in certain capital goods industries and strategic sectors in India. Whereas in the case of copper, lead, ships and railway coaches PSEs have a 100 per cent share of the product, in the case of steel equipment of metallurgical industries, mining equipment, electricity, oil, oil products, etc. its share ranges from 78 per cent to 99 per cent. In this respect the PSEs have helped the country achieve a broad-based well diversified industrial structure and much of the economic growth is based on it.

All this does not mean that all PSEs are doing very well. In fact, that is far from the truth. The break up of profit-making and losing units give a better picture - only 115 enterprises made profits while 90 incurred losses more or less regularly over the years 1980-1985. Of course, the losing PSEs include 44 ailing units taken over by government and which had a loss of Rs.346.92 crores out of Rs.1095 crores in the year 1984-85.

What ails the PSEs is a complex problem and would require a separate treatment altogether, and is outside the scope of the present theme. It may be useful to categorise the process of management of PSEs in the country into three distinct historical phases of development as follows:

Evolution of Public Sector Enterprises in India:

Phase I:	Nature of management of technology	Remarks
Late fifties-early sixties	Assimilation, technical/adjustments/modifications	Transfer of international technologies
Phase II:		
Late seventies-early eighties	Technological change arising from in-house R&D	Incremental process/product innovations and/or diversification of product lines
Phase III:		
Late eighties-nineties	Modernisation/technological upgradation	Introduction of new high-tech and capital replacement

The paper is accordingly organised into three sections. The first section deals with the problems of management of technological change in the context of international transfer of technology at enterprise level. In the second section, the technology management problems of incremental change and diversification are mentioned. Finally, the last section deals with some current and future problems relating to management of technological upgradation.

From the point of view of management, aside from management of change and even less from management of technological change, the PSEs have fared far below expectations. The importance of management as an extra input into the production of goods and services was either not properly visualised or not given due attention in the first phase.

An important feature of the PSEs in India has been that in almost all cases in the first phase the technology was imported from advanced countries, both the capitalist and socialist blocs. There are also many cases where the PSEs have imported technologies from multiple sources and are examples of hybrid technology. It would be evident that in the first phase of development, corresponding to the period of the late fifties through early seventies, the Indian PSEs were still coping with the management of international transfer of technologies. The problem of management of international transfer of technology is, generally, a fairly challenging one. In the Indian context it is even more complex due to the several super-imposed governmental considerations. As the PSEs were intended to help in treating national socio-economic development objectives and were an integral part of the national planning, the decisions on choice of technology, selection of the suppliers lay ultimately with the respective Ministries.

Described below are the management issues related to

- selection of technology
- foreign collaboration agreements
- research and development
- technology utilisation

There were the usual problems that any country would face initially owing to a lack of expertise and, to a considerable extent, its dependence upon the supplier of technology to help identify the need for the technology.

Thus, there were in use six different ways of selecting a technology for an enterprise:

(i) Government directed the companies to implement the agreement already entered into with the foreign firm by the Government.

(ii) Government would conduct initial surveys for collaboration for certain products and then directed the companies to follow up.

(iii) Government directed the companies to follow up project reports of foreign companies prepared for Government.

(iv) With the approval of the Government, the companies sometime signed fresh agreements with an existing collaborator for new products.

(v) The companies sent out global tenders to seek collaboration.

(vi) Negotiations were conducted with prospective suppliers to obtain know-how.

Which of these six options was actually used in different cases depended much upon the prevailing circumstances, i.e. the importance of the supplier of technology, the attitude of the bureaucracy in the concerned Ministry and the influence that the Chairman cum Managing Director of the concerned company could exercise. In cases where the concerned Ministry appointed an expert committee, much depended, again, upon how forceful the experts were. Very often there were differences of opinion on technical decisions between the Indian experts and those of the prospective suppliers but more often than not, the Ministry would favour the foreign experts' views.

Thus, it can be said, that generally speaking, most Indian PSEs had little say in this crucial aspect of management of technology, namely, the identification or selection of technology in the first phase of their development.

On the related issue of clauses describing the terms and conditions of the foreign collaboration agreement, the individual companies had little to contribute - concerned Ministries and the supplier worked it out jointly.

PSEs in India made a departure from the practice of private sector firms that invariably entered into financial cum technical agreements with foreign collaborators, by making only technical agreements. However, their efforts to obtain design know-how was controlled by the number of restrictive clauses imposed upon them by the Ministry. Thus, these conditions not only posed restrictions on the capability building of the PSEs but even, in some cases, made the task of operationalising the technology difficult. Where the altered production conditions demanded change in the designs of equipment which could not be made by the Indian managers, special arrangements had to be entered upon with the collaborator to permit sub-contracting of various spare parts and ancillary equipment.

The collaboration agreements usually did not have any time constraint to ensure that the said technology was transferred within the specified period. There were usually delays in the approval of the detailed project reports, in obtaining loans or shipment delays, all adding to the gestation period. Not only would these escalate the project costs substantially, but in some cases it could be embarrassing since the guarantee period for plant equipment would elapse by the time they were actually put to test. The top management of such enterprises were trying hopelessly to work against time. The poor project management of most PSEs could be ascribed to lack of proper process engineering.

To ensure effective assimilation and development of imported technology, the management of technology and that of technological change require the PSEs to have their own R&D establishment. In practice only a section of them had R&D units; most of them had design development cells only. The PSEs that had R&D laboratories were actively engaged initially in conducting R&D activities relating to import substitution of costly imported items by cheaper alternative material which was locally available. Like-wise there were a series of small incremental design alterations along with process improvements carried out by these units. Other PSEs, that did not have their own R&D, collaborated with the national laboratories.

The management of R&D in the PSEs had to face special problems. There was no independent budget for R&D; it was tied up with the production performance, and the latter being poor, the R&D scientists were starved of funds.

Likewise, there was no provision for the purchase of sophisticated equipment for R&D from advanced countries. With limited funding facilities for R&D only limited technology capability building could take place. One noteworthy feature of the Indian PSEs has been that they were free to horizontally transfer the technology to any enterprise - usually a state public sector enterprise. In managing technological change, not within the company but without, in establishing new enterprises, the Indian PSEs have been quite successful.

In the second phase of management of technological change, corresponding roughly to the late seventies and early eighties, most of the Indian PSEs have not only mastered themselves with respect to the technology imported but built a small R&D base of their own. By this time most of the PSEs had come up with a large number of technologies to offer for exports.

But how many buyers came forward is altogether another issue. Even the few cases where joint ventures were entered, the experience was not too encouraging. What has been exported mostly are the technical consultancy services by PSEs like Engineers India Limited (EIL), National Industrial Development Corporation (NIDC), Rail India Technical and Economic Services (RITES) etc.

The problem now was not with the technology but convincing the top management to introduce change. PSEs like Hindustan Machine Tools (HMT), Bharat Heavy Electricals Limited (BHEL), Electronics Corporation of India Limited (ECIL), etc. that had by now built a certain reputation of technological competence and of managing the business in general, could afford to go ahead with their plans for introducing new products and processes and even diversify into new areas. Thus, HMT has not only introduced the use of computer aid numerically controlled (CNC) machines, but diversified long ago into consumer products viz. wrist watches and electric lamps. BHEL has, likewise, ambitious plans for diversification into telecommunication EPBAX and defence items like tanks. The majority of the top twenty PSEs have drawn up their own corporate plans and introduce changes accordingly, but the majority of the other PSEs do not have this practice and have not planned any major change. Yet another set of problems encountered by management of PSEs in the second phase are of a different nature, namely, convincing their own managers who have grown with the company and struggled hard enough with one technology to go in for the new one. In fact a major managerial problem that faces most of the PSEs is that of human resource development. Maintaining high motivation level of its R&D managers is an all the more difficult task.

Innovating new products also requires market acceptance. The marketing set up of most PSEs is quite poor and cannot compete with those of the private sector units, especially the multinational corporations.

All PSEs, that have been recurring losses for years or, to put it more appropriately, have never been out of the red since inception, are obviously under the close scrutiny of the concerned Ministry. They have, thus, to convince their super bosses of the need for technological change for, after all, they are dependent upon them for finances to bring about the change.

Another major problem is the existence of the administered prices. With the average price formula worked out by the Bureau of Industrial Costs and Prices, the PSEs, have hardly any incentive to undertake R&D for incremental innovations as they would not be in a position to add the extra cost to their price until a given period.

The third phase of development of the PSEs has commenced since the middle of the eighties. The new government policy towards liberalisation of import of a fresh round of technology has set in a new shock wave for many PSEs, for they had been hoping all along that the policy of technological self reliance would protect them as envisaged in the first technology policy statement of the Government in 1983. At the same time, it is also true that there is a need for major technological upgrading of PSEs if they are to catch up with the technological advances made by the developed countries. Not only has the Indian PSEs been unable to come up with any major technological breakthrough, but their level, pace and capability is such that, at the present rate, it would take them at least a decade and a half to reach the present levels of technology of the developed countries. Besides, the economy of the country is so positioned that it is essential for its select products to capture international markets. This, in turn, necessitates the purchase of the latest technologies in respective fields.

It is therefore, necessary for the PSEs to get ready and organise themselves to synchronise with a higher level of technology. This also includes technological change outside the production wing, such as office automation, use of export systems in decision making etc.

A major development in 1987-88 has been the conclusion of a Memoranda of Understanding (MOU) between a few PSEs and their respective Ministries. This gives greater authority to the PSEs while assuring the Ministries of certain time-bound results.

A cheering feature of recent times that concerns PSEs has been the issue by a few of them of public bonds. Their acceptance speaks not only of the confidence they enjoy with the investing public but also of a new channel for raising financial resources. If they perform well they can expect to plan change by raising resources on their own and not always depending only upon the uncertain allocations from the concerned Ministries.

Perhaps, the most persuasively argued aspect of managerial change in PSEs today is that of reorganisation of its Board structure. Today, with organisations like the Standing Committee on Public Enterprise (SCOPE) the PSEs heads are voicing their views for radical reforms.

To conclude, the PSEs' problems of management of technological change have undergone transformation over the three distinct phases of their evolution which has been for the better. They are demanding greater autonomy, a clearer direction on technology from the government and public cooperation to help them to introduce and manage effectively technological changes that are essential for their survival and growth.

CHAPTER VI

SWARAJ TRACTORS - A CASE STUDY OF THE CREATIVE MANAGEMENT OF MODERN TECHNOLOGY

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Introduction

A feature of the development process - both in the developed and developing countries - since World War II is the deliberate assumption by the State of the function of regulating the pace and pattern of socio-economic development. In a large number of developing countries the State is, in addition, playing an active role in promoting and managing these enterprises.

Without a clear insight and understanding of the problem of public sector decision-making, it is hardly possible to suggest any solution. This process is complex even in the private sector and is inevitably much more complex in the public sector, as it is an integral part of the process of socio-economic evolution.

The enterprise selected for this case study is Punjab Tractors Ltd. (PTL). This enterprise is modest in its financial and economic dimensions but has much greater significance for this Workshop as it illustrates the multiple facets of the problem and enables some general inferences to be drawn on the creative management of modern technology.

The study aims at providing an understanding of the nuances of decision-making at several levels, both institutional and hierarchical.

The plan of the case study is as follows. The brief introductory section provides some information on the characteristics of the tractor industry. The narrative on Punjab Tractors is presented in all its richness in the second section. The concluding section illustrates some of the problems in the decision-making process and the shortcomings in institutional behaviour.

Background of the Tractor Industry

Before presenting the Swaraj Tractor case, it is essential to give some background with regard to the tractor indusrty. In North America, tractors replaced draught animals - usually horses - around 1900 and this substitution process was completed before World War II. In Europe, this substitution occurred during the first decade after the war as small versatile tractors and government support for tractor purchase became widely available.[1/]

Most of the technical developments in tractor design had taken place by World War II and much of it occurred in the USA. However, the truly revolutionary development of the pre-war period, the "Ferguson System", came not from the USA but from the UK and was introduced in the USA in 1939. By this time tractor technology was more or less established and there has not been any major change in this technology. The introduction of power-steering and automatic transmission are perhaps the only two significant additions.

By comparison with an automobile, a tractor is a simple machine. While a car typically has 15,000 parts, a farm tractor has a mere 2,000; of these about 60 percent are seldom or never actually manufactured by tractor manufacturers themselves. These characteristics of tractor technology and manufacture are worth noting; for they indicate that the management of technology change for new entrants is relatively easier. This point is relevant for the Swaraj Tractor case.

There is another relevant characteristic of the tractor industry that should be noted. In the tractor industry, there are economies of scale both in production as well as distribution. It has been estimated that in the US, economies of scale of around 20 per cent would accrue as a result of production expansion[2/] from 20,000 to 90,000 units. This is part of the reason why the industry in most countries is dominated by a few firms, resulting in oligopolistic competition as well as collusion.[3/]

In a durable item like a tractor, the farmer essentially buys tractor services and hence is concerned in his purchase decision with after sales service and parts availability. Farmer's loyalties or preferences thus are dealer-oriented and sales of tractors depend crucially on the quality of distribution and service. As seems to have happened in other countries, this dealership network can reduce competition and work against the interests of the farmers; for farmers generally, all over the world, do not have adequate information to judge the quality of a tractor, except through the marketing structure. These characteristics of the tractor market suggests the need for public policy in the interests of the farmers - the group in a weak bargaining position vis-a-vis the production-distribution system.[4/]

This background has been given as it is essential to understand the Swaraj Tractor case in India. Tractor production and imports are controlled and regulated by the government as are all industrial investment and imports. Public sector-decision making, thus, plays a crucial part with regard to the nature and characteristics of industrial evolution. One would expect, therefore, the decision-making organs to be aware of the characteristics of the tractor technology and industry, mentioned earlier.

Farm mechanisation in India started only after the War. In 1946-47 there were about 5,000 tractors, the number sharply rose to 20,000 in 1956-57 and by 1965-65, where our story begins, there were about 40,000 tractors. This was the year when the new agricultural strategy - the so-called green revolution - was formulated. The domestic production of tractors started in 1963-64 with a licensed capacity on a two-shift basis of 8,500 units by two firms - Tractor and Farm Equipment (TAFE) and Eicher Tractors India Ltd. (Eicher), the former with a capacity of 7,000 units and the latter with a capacity of 1,500 units. TAFE was permitted foreign collaboration with Massey-Ferguson, UK in 1961 and Eicher with Eicher of the Federal Republic of Germany in the same year.

This domestic production capability was consciously created as it was estimated that the demand for tractors would increase substantially as a result of the adoption of the new agricultural strategy in Punjab, Haryana and Western U.P - areas in India where wheat grows on irrigated land. With large increases in land productivity, farmers were facing a farm power shortage during the peak season; further, and even more important, the cost of animal power was rising sharply. The adoption of high yielding varieties of wheat improved the productivity of land, especially irrigated land. This, in turn, raised the opportunity cost of using draught animals, as fodder competed for the highly productive irrigated land. Mechanisation - task-wise - thus was expected to be an inevitable complement to the green revolution.[5/]

However, in view of relatively small holdings - 68 percent of holdings in Punjab were below 9 hectares, accounting for about 20 percent of the stock of tractors in 1971 - the problem which the Planning Commission faced was: what type of tractors would suit the budget and the needs of small-medium farmers?[6/]

Origin and Development of Swaraj Tractors

The story begins in 1965. A new team of members had been appointed at the Planning Commission and it was busy formulating the Fourth Five Year Plan. As a part of this Plan, several new projects were identified which could be set up with financial and technical assistance from Russia. One of them was a 20 HP tractor project. The Planning Commission had estimated the demand for tractors to be 40,000 units per year by 1968-69 and of this, half the demand was expected to be for tractors in the HP range of 20 HP and below. The Government of India's delegation, headed by the Deputy Chairman of the Planning Commission, visited Russia in May 1965 to discuss with the Russian Government the nature and magnitude of assistance for this and the other projects. The Director of the Central Mechanical Engineering Research Institute (CMERI), a part of the national chain of research laboratories, was one of the members of this delegation.

The Russians were reluctant to commit themselves to the tractor project. In any case, the Director, CMERI felt that the project, as formulated, had excessive foreign exchange content and required a large number of Russian experts. As the Russians were unable to assist this project, the Director suggested to the Deputy Chairman that CMERI could develop an indigenous tractor design that could be produced without external assistance or even imported parts. The CMERI thus started the work on the new tractor design under direction of a Committee of Technical Experts; comprising representatives of the industry, agricultural universities, farmers and the Tractor Training & Testing Station (TTTS), Budni.

A team of engineers studied in-depth the relative merits of the available designs of agricultural tractors, keeping in view the local manufacturing facilities, skills, raw-materials and agro-climatic conditions and developed a tractor component by component.

Since the availability of standard hydraulics was considered as the key requirement for a good tractor, the CMERI engineers successfully developed an original design for a single lever automatic depth-cum-control hydraulic system, patents for which were accepted in Federal Republic of Germany, France, India, Japan, Poland, UK, USA and Yugoslavia.

The first proto-type tractor was assembled in November 1967 and was put to extensive endurance tests at CMERI on specially designed test rigs simulating field conditions. These tests were carried out for 1,200 hours of non-stop running with 10 to 30 percent over-load during the hottest summer months. With the experience gained on this proto-type, three more units were assembled in March 1969 for extensive field trials and performance evaluation at the TTS, Punjab Agricultural University, Ludhiana and the UP Agricultural University, Pant Nagar.

As a result of these tests, a number of modifications were incorporated in the hydraulics, steering gear, front axle, engine and its cooling system and the modified tractor was again tested at TTTs in May/June 1971. These tests indicated that its performance was better than most of the imported tractors in the 20-25 HP range in regard to drawbar pull and ratio of the drawbar HP to the power available at the Power Take Off (PTO) - which are the primary concerns for cultivation. The tractor passed the TTTS test. Thus was born the Swaraj Tractor - the product of local technological competence.

The design for Swaraj 30 HP was built around the four-stroke, twin cylinder air-cooled Kirloskar engine, that was being produced in the country. Some of the salient features of the Swaraj were:

- a dual range four speed transmission so as to cover a wide variety of jobs ranging from heavy duty ploughing to fast transport;
- provision for an independent PTO which could be engaged or disengaged when the tractor was in motion and could be used as a prime mover for pumps and other similar equipment;
- hydraulics with finger tip control both for positioning and draft control of the three point linkage for operating implements;
- foot operated differential lock to improve traction in slippery and muddy spots; and
- adjustable front and rear axles, manual steering and vertical exhaust.

Lack of Sponsorship by Central Government

Thus by 1971, the Swaraj Tractor was ripe for commercial production. But the question was: who would adopt this innovation? Earlier, the proto-type was constructed with the assistance of a public sector concern - the Mining & Allied Machinery Corporation (MAMC) and it was expected that MAMC would be able to undertake the tractor project with the addition of only some balancing equipment. But in the period of industrial recession in the country - 1967-71 - the MAMC had incurred financial losses and was not willing to take any additional risk involved in the production of the tractor.

Because of industrial recession and decline in its sales of machine tools, the Hindustan Machine Tools (HMT) - another Central Government concern - wanted to diversify its output by going into tractor production. However, it wanted to use its unutilised capacity immediately by first going into CKD assembly of Zeteor tractors with parts imported from Czechoslovakia. Further, it thought that Zeteor was a proven production model, while Swaraj was only a proto-type. In this decision, it was supported by the National Industrial Development Corporation (NIDC), a consultancy organisation sponsored by the Central Government.

Thus, at the Central Government level, there was no strong support for the Swaraj Tractors. There was a change in the members of the Planning Commission in 1969 and the then Director of CMERI, the driving force behind this project, also left the Institute in 1969. The NIDC and the Council of Scientific & Industrial Research (CSIR) considered Swaraj a risky venture.

State Government Unit Becomes a Promoter

It was at this stage that the Punjab State Government decided to produce the Swaraj Tractor. The Punjab State Industrial Development Corporatiaon (PSIDC) had been familiar with the development of the Swaraj Tractor: its field trials in the Punjab and the farmer's favourable response to the Swaraj. Three characteristics of the Swaraj attracted the PSIDC: its indigenous design, its employment potential in the Punjab and its likely acceptance by the Punjab farmers as a sound dependable tractor. The PSIDC hence obtained an industrial licence to manufacture the Swaraj Tractors in 1970.

The PSIDC contacted the CMERI and requested the latter to release the five engineers who had worked on the Swaraj design for its newly set up company - the Punjab Tractors Ltd. (PTL). Simultaneously, it appointed a local consulting firm to prepare a detailed project report and undertake the entire installation and commissioning of the plant along with the company's engineers (the CMERI Group). The detailed project report was completed by the middle of 1977. The next problem was: how to finance this project?

Industrial Development Bank of India (IDBI)

The PSIDC and the Punjab Tractors Ltd. approached the Industrial Development Bank of India (IBDI) for funding.

PTL were not completely confident of obtaining financing to the tune of 85 to 90 per cent of the project cost due to the lack of sponsorship by the Central Government and the skepticism about its success expressed by both the CSIR and the NRDC. They, therefore, suggested only a modest project (capacity of 5,000 tractors in the 20-30 HP range) with a capital cost of less than RS.40 million. They were able to reduce the project cost by liaising with Kirloskars for the supply of the motive power unit and ancillarisation of about 80 per cent of total component requirements from established and new firms - largely small-scale engineering firms from Punjab - and concentrate on the manufacture of only 15 to 20 per cent of the key components.

IDBI Appraisal Process

Somewhat apprehensive about indigenously developed technology, IDBI wanted to satisfy itself about the commitment to the success of this innovative project by PSIDC, PTL and the technical consultants; for this, a single factor, was to their mind, crucial to the success of any project and more particularly for this one - a motivated team spirit. They found this present in full measure. They were also impressed by the following characteristics of this project:

a) it was specially designed to meet local conditions, and had passed the TTTS test;

b) it would support a large number of engineering ancillary industries in the Punjab - known for its entrepreneurial and mechanical talent - and thus have a large employment impact.

c) the project envisaged an efficient distribution and service system; a factor crucial from the point of view of the farmer's response;

d) it had already started with the establishment of its own tool room to manufacture jigs, fixtures and inspection gauges; this tool room was also to be used for training its personnel, developmental work and research to improve technology and design other tractor models;

e) about 10,000 tractors in the HP range of 20 to 25 were currently imported and there was no domestic production of tractors in this range. This demand was also expected to grow.

f) It was expected to produce and sell Swaraj tractors at a competitive price and, its capacity expanded to 12,000 tractors, after the initial pilot phase, it would be in a position even to export its tractors abroad.

IDBI Approves the Project for Financing

The technical evaluation committee appointed by IDBI approved the project, as in their view, it was technically sound and would be able to produce and sell a good quality tractor at competitive prices. However, they felt that it would possibly take longer than expected to complete the project and, in any case, in view of its small size and government control on tractor prices, the project would not be able to generate an internal rate of return of 15 per cent - one of the two IDBI selection criteria.

The IDBI then prepared a memorandum for its Board, recommending more than 85 per cent financial assistance (in collaboration with the other financial institutions) for the project: the memorandum argued that the exchange rate criterion was met - the domestic resource cost was less than Rs.9.50 per US$ - and this showed that the project was efficient. Obviously, an innovative project of this small size would not be able to have an internal rate of return of 15 per cent or more; but this rate was not very much lower than the cut-off rate - it was 13 per cent. The Board approved the project and sanctioned the required financial assistance - partly by way of long-term loan and partly as equity - in February 1972. The technical research for designing this tractor had started only in late 1965 and was completed in May 1970; the PTL was formed in 1970, the project report was completed in September 1971 and was submitted to the IDBI for assistance in November 1971.

Performance of the PTL 1972-77

The construction work as well as the installation of plant equipment started immediately after the IDBI sanction of financial assistance in March 1972. The performance of the PTL since 1972 has been remarkable with regard to both its cost and time schedules, as well as the manner in which it faced and tackled the problems as they arose:

a) The project was completed in 105 weeks by the end of March 1974 as was projected.

b) The actual project cost was more or less the same as expected - in fact it was somewhat lower - with regard to the total cost as well as the cost under each head.

c) PTL started manufacturing its Swaraj Model 724 tractor from 1 April 1974 and more or less achieved its full capacity as per schedule in 1977 in spite of raw-material shortages, inflationary pressures and financial stringency.

For the IDBI, this performance was unique. There was hardly any project, financed by it until then which had been completed without time or cost overruns. Again, there was hardly any project that had reached its capacity output within the planned time frame. Even the way in which the PTL identified its problems and tackled them reflected competant management.

During the first fifteen months (April 1974 to June 1975), as was expected, PTL suffered from irregular supplies from the ancillaries and rising costs due to acute inflationary pressures in India. The company suffered a cash loss of Rs.7.8 million as a result.

The top management of PTL was aware that it would have to face this problem but until November 1973, the company had almost no inventories and its relationship with its ancillaries had still not been formalised. At this stage, PTL could not afford more than one source of supply for each component; the initial production was inevitably limited by the available supplies of components, and to develop new sources required intensive technical inputs from PTL.

From November 1973, PTL concentrated on developing multiple sources of supply for each component. It promoted new ancillaries near the plant location and provided technical assistance to new entrepreneurs. Thus its materials pipeline improved and it was able to increase its output to full capacity level before the end of 1977.

But its production costs rose steadily as input prices rose. Unlike the other manufacturers, its output had no import content; others imported their inputs to the extent of 20 to 30 per cent of requirements and the prices of imported inputs were significantly lower than those of the domestic inputs. For example, HMT had started the production of Zeteor Model 20 tractor by this time with an import content of more than 45 per cent. A study by the Ministry of Finance indicated that the cost of its inputs was lower by about RS.4,000 per tractor as compared to that for the Swaraj. Even this figure does not accurately reflect the Zeteor advantage. For Zeteor, all imported inputs did not require further processing as the HMT was doing mainly assembly operations. Yet the Swaraj price was comparable to that of the Zeteor; but its margin was much lower. It may be mentioned here that the cost of inputs rose from 77.5 per cent in June 1973 to 93 per cent of the ex-factory selling price by March 1975.

Hence, PTL suggested to the Government of India that Swaraj should be exempted from excise duty of 10 per cent (about RS.3,000 per tractor) to offset its higher input prices of domestically-bought components. This exemption was granted by the end of 1975 and thereafter PTL's financial performance improved.

In addition, PTL took several measures to reduce its costs and diversify its products through intensive R&D work. It developed a new design - Swaraj 735 (35 HP) - during 1974-75 and introduced it by the end of 1975 - the second year of its operation. For this 35 HP tractor, the additional costs were only Rs.2,000 per tractor, while the price advantage was of the order of Rs.4,000 per tractor; because of historical reasons, it appears that farmers regarded a higher price product as a superior product (they were used to the Massey-Ferguson tractor of 35 HP - a tractor which had not only passed the TTTS test but was the most popular tractor for its ease of operation).

By 1977, PTL's output was composed of 4,200 "Swaraj 735" and 800 "Swaraj 724". It had started work on developing a third model and expected to start its production by the end of 1977. No other tractor manufacturer had given such attention to R&D work for product planning - developing new designs and models in response to local conditions and farmers' preferences.

However, it suffered from a major handicap. It was not included as an eligible tractor in the World Bank line of credit under which finance was provided to farmers at a concessional rate through the Agricultural Refinance & Development Corporation (ARDC). However, it got over this problem by working out a financing arrangement with commercial land mortgage banks in various states.

Problems and Conjectures

Such is the story of the Swaraj Tractor. It raises several problems for analytical inquiry - problems relating to the behaviour of the various 'actors'.

The following questions arise with regard to the Swaraj story:

a) Why did the Central Government not sponsor this project?

b) Why did the Punjab Government take the risk of undertaking this project? What were the nature and characteristics of its decision-making that accounted for its success?

c) Why was this experiment in the creative adaptation of modern technology fruitful?

Let us proceed to examine these questions and try to draw some inferences - conjectures - about the public sector decision-making process.

Central Government Behaviour

One part of the Government - the Planning Commission - took the deliberate decision to develop an indigenous tractor design.

The CMERI successfully evolved the Swaraj tractor which passed the TTTS test.

HMT - a Central Government enterprise - wanted to diversify its product range as it was facing demand recession in its main line of business, ie. machine tools; it wanted to undertake a tractor project to use its surplus capacity and thereby improve its financial results.

NIDC, also a Central Government enterprise, considered Swaraj a risky project and advised HMT to take up the assembly of Zeteor - which had also passed the TTTS test.

This suited HMT as Swaraj would have involved a gestation lag of two to three years, while the assembly of Zeteor could start immediately. Doubtless, the HMT decision was a rational one from its own point of view. But then the question is: Why did the Central Government not sponsor another public sector enterprise to manufacture Swaraj?

One answer could be that the bureaucratic apparatus had no technical knowledge of the tractor industry and probably considered an enterprise based on mere research a risky venture. However, this explanation does not seem to be valid as the Central Government had adequate technological competence in NIDC, and DGTD. More importantly, it was CMERI, a national research institute, which had developed Swaraj.

It could be that government technical experts, and hence the bureaucracy, did not have confidence in the competence of the CMERI personnel specifically or in indigenous technology and consultancy generally. After all, it was much less risky to accept overseas help than to undertake an enterprise on the basis of commercially unproven indigenous know-how. It appears from available evidence that such indeed was the case.

Another explanation could be inter-institutional rivalry. The Director of CMERI, the record shows, did not have a favourable equation with government technologists.

This project suffered in the absence of an active technology policy that could raise policy issues above the field of inter-personal and inter-institutional rivalries and jealousies.

In this connection, the role of the World Bank mission is worth mentioning. In 1971, the World Bank sent a mission to study the growth and structure of the tractor industry in India in order to make policy recommendations to the Central Government and find out the nature and magnitude of financial assistance that the World Bank should offer. It is somewhat ironical to find that this World Bank study recommended improved product planning to upgrade designs by the domestic producers with the technical assistance of their foreign collaborators. Strange to note is the following recommendation:

"Indigenous capabilities will grow through collaboration agreements but, in addition, firms should initiate cooperative programmes with indigenous universities and engineering research centres (such as, for example, the Central Mechanical Engineering Research Institute) aimed at developing tractor features especially suitable for India".

Decision Making at the State Level

In spite of the skepticism - for whatever reasons - about the Swaraj project on the part of the various Central Government agencies, how did it come to pass that another unit of the government - the Punjab State Government - decided to undertake this project in 1970?

The Punjab Government and the Punjab farmers were familiar with the whole process of the evolution of the Swaraj. After all, the field trials were largely undertaken in the Punjab. The farmers had, in a sense, become a part of this venture, and they had approved this new product which was expected to save on both capital and operating costs. They were, thus, able to judge Swaraj on its merits.

The other factor was the considerable potential employment impact of the tractor project, as Swaraj was to purchase more than 80 per cent of the components from the ancillaries - mostly from the Punjab.

For the Central Government agencies, Swaraj was an abstraction; it did not have such a direct visible impact on them as it had for the Punjab Government and its agencies. Only a well-thought-out technology policy integrated with the general development strategy of the country could have induced the Central Government to sponsor this project; but it did not have such a policy then, nor did it have confidence and pride in domestic technological competence. But the Swaraj success has probably taught some lessons. In 1975, the PTL was awarded the Gold Shield for successfully implementing a project based on domestic technology and know-how by the Central Government; this is probably an indication of a new awareness of the role of indigenous technological competence in the developing strategy.

How do we account for the remarkable performance of the PTL? The completion of the construction phase without any cost overrun, the timely realisation of capacity output, the ways in which the top management tackled problems as they arose (the problem of sources of supply and the liquidity and financial problems), the new models developed through continuing R&D work - all these characteristics of project performance were indeed unique in the financing experience of the IDBI.

Creative Management of Modern Technology

This case has relevance for the decision-making process not only with regard to the Swaraj project but also with regard to the process of creative management of modern technology. How do we explain the success of this experiment?

The organic and sequential relationship among the following tasks and functions seems to be the crucial factor:

a) Identification of a project idea was the critical first stage. This was done by the Planning Commission.

b) The identification of available technological choices for this was the second. This was the function of a Technical Consultancy Service Centre (TCSC), in this case, the CMERI performed this function.

c) Identification of a research problem by TCSC - in this case, the CMERI - was the third stage.

d) The research on the problem by a Technological Research Centre (TRC) - in this case, the CMERI - and the transmission of this research result to the promoters - in this case, PTL - was the fourth stage.

e) The preparation of the detailed project report by the promoter and its analysis by the financial system (IDBI) was the fifth stage.

f) The association of not just one, but a team of highly motivated technologists with the top management for project implementation was the final stage.

In this organic sequential relationship, the critical functions were performed by PTL and the IDBI - the functions of identifying relevant research problems, embodying the research results meaningfully into a concrete project, and facilitating its implementation. Without PTL implementation, neither the relevant research problem nor a concrete project would have been identified; and without the link between PTL and the IDBI, the project would not have become an operational project. It appears from a priori reasoning as well as from this case study that the critical links in the process of creative management of modern technology are the promoters as well as the technical team and the financial system (FS); these two provide the essential links between the production system and the technological research system. Without these two functional agencies, the production system and the technological research system are likely to evolve on parallel lines.

Notes

1. Robert T. Kudrle, Agricultural Tractors: A World Industry Study (Cambridge, Massachusetts: Ballinger Publishing Co., 1975). To quote; "It appears that the improvement in farm machinery before World War II, so much admired by Schumpeter, has continued apace with some types of equipment while tractor design virtually stagnated. Once the Ferguson system was completely diffused, however, informed opinion has not been able to point to important areas of design neglect...; the lack of advance is usually assigned to the rather simple nature of the product and the limited number of areas of possible design improvement. Continuing refinement of the hydraulic system has probably been the single most important area of advance".

2. Ibid pp.208

3. Ibid pp. 4 to 8

4. Ibid, Chapter 13. To quote: "If the farmer could be made aware by his own organisations of the persistent and substantial discrimination practised against him in the past, it is not unreasonable that he would become at least somewhat annoyed (his counterparts certainly did!), and the trust which is such a large part of the product differentiation barrier carefully nurtured by companies over the years would be diminished thereby. Fully comparable tractors have been sold for up to two decades in other parts of the world for vastly lower prices than offered to the U.S. farmer should help convince him that a bargain tractor price is something to be carefully considered and not necessarily a sign of inferior design or manufacture".

5. See Inderjit Singh and Richard H. Day, 'Factor Utilisation and Substitution in Economic Development: A Green Revolution Case Study', The Journal of Development Studies, Volume II, (April 1975).

6. The capital and operating cost of a tractor is a function of its horse-power; These costs are lower for tractors in the HP range below 3 than those in the HP range above 35. The horse-power requirement depends on the size of the farm, the cost of animal power and labour, and the characteristics of the soil and terrain. In North America and the U.K., in 1970, only 10 percent of tractors sold were units of less than 35HP, while this proportion was 33 per cent in Germany and 23 per cent for Italy. In East European countries and Japan, this proportion is even higher than 50 per cent. See Robert T. Kudrle, op. cit., pp.21-25, 87 and 90.

7. See A. Besant, C. Raj, Public Enterprise Investment Decisions in India (Bombay: The MacMillan Co. of India, 1977), pp.115-117.

CHAPTER VII

CASE STUDY OF BAGASSE-BASED NEWSPRINT

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(Study undertaken with the assistance of the Industrial Development Bank of India, Seshasayee Paper Boards Ltd. and the World Bank)

Historically, the state has played a significant role in stimulating and accelerating the process of socio-economic development. The public enterprises in India are an important and integral part of this process.

This case study of the bagasse-based newsprint project is undertaken to illustrate the rationale for public enterprises as well as the determinants of their performance. This is a fairly large and complex project, based on commercially unproven and new technology - and hence with considerable potential risks as well as direct and indirect benefits, arising from adaptive technological research not only to India but to several other LDCs growing sugar cane. It is directly linked and interrelated with agriculture as well as the sugar industry. Thus, no private enterprise was willing to select, implement and operate a project of such complexity. Such was the rationale for public enterprise in this sector.

This case study also illustrates the several preconditions essential for the success of such a public enterprise. First, it indicates the significance of having plurality of public enterprise promoters or sponsors; this generates healthy competition and makes experimentation with new ideas possible. Second, it pinpoints the importance of high level support and commitment, which makes it possible to institutionalise the decision structure and processes, essential for the effective and efficient functioning of a public enterprise. Third, it indicates the type of partnership relationship, essential in a mixed economy, between the public and the private sectors. Fourth, it draws attention to the nature and characteristics of functional interlinkages, essential for identifying and selecting an appropriate technology as well as identifying and undertaking technological research for improving such technology.

In particular, it emphasizes the role of technical service centres (TCSCs) and financial institutions in providing the vital link between modern technology and technological research centres (TRCs) on the one had and the production system on the other; without these two vital agencies, quite often, technology choice is not rightly made and research problems are not identified. Fifth, it shows the nature of partnership relationship that needs to be established between domestic TCSCs and TRCs and financial institutions on the one hand and the foreign TCSCs and TRCs and international financial institutions on the other. Finally, it illustrates the vital significance of entrepreneurial ability - the ability to identify a project idea and the will power, tenacity and drive to implement it in spite of obstacles of all types.

The plan of the paper is as follows. The introductory section deals with the raw material base of the paper and newsprint industry in India, the urgency of using bagasse as the principal raw material and the evolution of the bagasse technology. The narrative on the evolution and implementation of the project is presented in all its richness in section II. The nature and characteristics of the decision structure and processes, which accounted for the successful implementation of the project, are discussed in section III. Based on this case study, some conjectures are made with regard to the determinants of public enterprise performance in mixed economies in the final section.

I

Introduction

Before we present the bagasse newsprint case, it is essential to give some background relating to the paper and newsprint industry in India, its raw material base and the evolution and current status of the bagasse technology.

Paper and Newsprint Industry: The paper and paper board industry was started in India by the Christian missionaries in the nineteenth century. By 1950, total annual production was approaching 110,000 tons. In the ensuing three decades, domestic production of paper and paper board, based almost exclusively on bamboo and indigenous hardwoods, expanded to over 1 million tons annually, predominantly in the private sector. The new capacity since then has been built predominantly in the public sector.

The demand for paper and newsprint has been growing at more than 5 per cent per annum since 1974 and is projected to increase at a somewhat higher rate in the next two decades or so, with an income elasticity of demand of around 1.7 to 2. By 1979, - the year in which this project was conceived - the domestic production of paper and paper board met only 80 per cent of domestic demand and the rest was imported. Even currently, more than 10 per cent of domestic demand for speciality papers is met by imports - even after the implementation of this project. At the same time of the identification of this project, domestic production of newsprint was only about 15 per cent of demand; even after the increase in domestic capacity partly as a result of this project, imports still constitute about 40-50 per cent of domestic consumption. It is worth noting that India's per capita average consumption of paper is still only 2 Kg. per annum - among the lowest in the world.

The raw material base until 1980 for the paper industry has been bamboo (65 per cent) and indigenous hardwood (20 per cent). Both materials are scarce, with other high priority uses. The area under forest has declined from 33 per cent to about 11 per cent in the last 30 years and afforestation would require more land. Besides, wood is required for fuel, heating and construction. The unutilised bamboo resources are in relatively remote areas, where the cost of establishing mills is very high. Bamboo, again, has alternative uses, particularly in house construction. The bamboo plant of any given species flowers on an unpredictable schedule (10-40 years) and then dies. There is, therefore, understandable reluctance to make major investments in new large plants, where there is a risk of bamboo flowering and thus result in a cessation of supply.

However, India is the world's largest producer of sugar cane and therfore has ample supply of bagasse. If all of the cane produced were crushed, and the bagasse made available for paper production, this fibre could support an output of about 7 million tons annually or almost six times the present domestic consumption. However, only one-third of the available sugar cane is delivered to the organised sugar mills, the balance being processed in small village crushing units.

About six tons of bagasse yields about one ton of pulp; on this basis, even the bagasse available with the organised sugar mills can produce 3 million tons of paper pulp, as either newsprint grade or fine paper grade. The Seshasayee Paper Boards Ltd. (SPB) was one of the first integrated pulp and paper mills in India to produce pulp out of bagasse for manufacturing fine paper in 1963-65. About 16 paper mills have been constructed in India with the intention of using bagasse for at least part of their fibrous raw material. However, only one is using bagasse on a large-scale at present, the Mandya National Paper Mills Limited in Karnataka, which produces about 11,000 tons per year of printing and writing paper from 95 per cent bagasse pulp. SPB continues to use a small quantity of surplus bagasse. Bagasse pulp production as a proportion of total pulp production throughout the world has increased from 0.57 per cent in 1968 to about 1.50 per cent in 1986, mainly for the production of paper. This project, the Tamil Nadu Newsprint and Papers Ltd., (TNPL) is the first in the world to use bagasse successfully for producing newsprint out of 75-80 per cent bagasse pulp.

For India, with dwindling forest resources, the paper and newsprint industry has to rely on bagasse as the principal raw material. From a national-social point of view, it is much more economical to use bagasse than to bring new land under forests. One hectare of land, if used for pulp, can make only paper out of the pulp, while one hectare of land under sugar cane would produce both sugar and paper. Even if new land is to be brought under the cultivation of sugar cane, one hectare of land would be six times more productive than it would be for producing pulp.

For these reasons, the Government of India has been encouraging the use of raw materials other than bamboo and wood from the early seventies. In order to promote the use of bagasse, in April 1979, Government announced that a mill producing paper containing at least 75 per cent bagasse would be exempted from excise duties and also from production and sales controls; further, there was a reduction in import duty on equipment required for newsprint production and a levy of import duty on imported newsprint. These incentives made newsprint production, and particularly a composite project (producing both newsprint and paper based on bagasse) financially and economically viable, in spite of the additional cost incurred in the procurement of bagasse from sugar mills.

The additional cost arises for the following reason. The sugar mills use bagasse as their in-house fuel, and they have hardly any incentive to release it for paper making. They have to be supplied with coal - of which India has large reserves - but transportation of coal is costly. So the sugar mills have to be supplied with coal and coal-fired boilers. Not only that. The project has to take the responsibility of operating coal-fired boilers as sugar mills have no experience in the operation of coal-fired boilers. Further, because of the uncertainty of procuring coal on time - due to transportation and other problems - the boilers have to be capable of firing lignite, bagasse pith, etc. To use bagasse pith for boilers, it is essential to have centralised depithing on the site of the paper mill, instead of having satellite depithing stations in various sugar mills. This increases the cost of transportation of pith from sugar mills to the centralised location. Of course, the installation of multi-fuel boilers - instead of coal-fired boilers - reduces the risk arising from the uncertainty of coal supplies.

Procurement of bagasse thus links a paper or newsprint project directly with the sugar mills and requires complex negotiations with them for the procurement of bagasse at additional costs. The private sector mills, hence, are reluctant to take responsibility for these additional investments and coordination with sugar mills, which a bagasse-based project requires. A public enterprise, thus, becomes essential.

However, it became difficult to arrange financing for these two projects as the financial institutions had doubts about their financial and technical viability, in view of the uncertainty relating to bagasse technology. Thus no commercial installations were built, based on this process. After spending several million dollars on this development, the Crown Zellerbach Corporation and the Hawaiian Sugar Planters' Association made an irrevocable decision in about 1966 that they would not devote any further time, energy or money to bagasse newsprint. Thus, no actual test runs were carried out to prove the viability of this process.

It was this mechanical pulping approach that required further research and the Beloit Corporation was working on it for several years at their Jones Division, Pittsfield, Massachusetts, USA. Further research was done after 1982 by the Beloit Corporation in collaboration with SPB-PC, which resulted in the Beloit-SPB Process, developed fully in late 1984. And this technological research has been the vital element in the success of this project, Tamil Nadu Newsprint and Papers Ltd. (TNPL).

A similar approach has also been developed by the Cuban Research Center for the industrialisation of sugar cane bagasse, commonly referred to as Cuba-9 and at the P.N. Kertas Letjes Bagasse Newsprint Mill in Probolinggo, East Java, Indonesia. The Cuba-9 project has been only a demonstration plant, started in 1981, while the Indonesian project, started in 1985, has sufferred from shortage of bagasse. The capital cost per ton, however, in both these projects has been higher than in the TNPL project. Thus far, the only successful project for manufacture of newsprint based on 75-80 per cent bagasse has been the TNPL project, which succeeded in producing newsprint on this basis on October 31, 1985.

With this background, it is now possible to narrate as well as appreciate the nuances of the bagasse newsprint story, to which we now turn.

II

Bagasse Newsprint: Decision-Making Process

The Seshasayee and Paper Board Ltd. (SPB), was started in 1960 for producing writing and printing paper with a capacity of 20,000 tons per year; in 1966-68 it expanded to 35,000 tons and further expanded to 55,000 tons in 1976-78.

Genesis of the Project

S. Vishwanathan had conceived the idea of a newsprint project based on bagasse of 300 tons per day capacity as far back as 1963-65, for which a feasibility study was completed in 1966. Forest-based raw materials are scarce in the Tamil Nadu state, but the state has 23 prosperous sugar mills, as it is the third largest sugar cane producer in India. Further, newsprint production has been accorded priority by the Government of India. Thus, it was quite natural for the Chief Minister of the Tamil Nadu Government to accept Mr. Vishwanathan's suggestion and his offer of technical and consultancy services without any fee, and he announced the government decision to undertake this project in the State Legislative Assembly in February 1979. On April 6, 1979, a separate public limited company - Tamil Nadu Newsprint and Papers Limited - was formed to implement and operate the project with Mr. Vishwanathan as its chairman and C. Ramachandran - a state official - as executive director (who later became its managing director). SPB along with SPB-PC were then engaged by the TNPL as its project consultant to provide all technical and consultancy services.

Even before the formation of TNPL, the Tamil Nadu government approached the Government of India to obtain the industrial license. The Government of India approved and supported the project idea; however, it had certain reservations about the financial and technical viability of the project. So the Government of India asked the Development Council for Paper Pulp and Allied Products to constitute a subcommittee with Mr. Vishwanathan as one of its members to evaluate the techno-economic aspects of such a project. This sub-committee approved the project idea of bagasse newsprint; but it recommended certain fiscal incentives like exemption from excise duties and production and sales controls for projects based on bagasse (up to 75 per cent) and reduction of import duty on equipment essential for newsprint production. (There was no excise duty on newsprint; such duties related only to paper production). In April 1979, the Government of India took the decision to provide these fiscal incentives and these were crucial in modifying the original project idea so as to make it financially viable.

Evolving Project Design:

The SPB had realised at quite an early stage that a newsprint project may not be financially viable because of the additional cost of procuring bagasse, the prevailing newsprint prices and the uncertainty relating to bagasse technology. The fiscal incentives, however, induced the SPB to evolve a concept of a composite project - that is a project that can manufacture both paper and newsprint, 50,000 tons per year of newsprint and 40,000 tons per year of writing and printing paper or some viable mix of the two. With the fiscal incentives and prevailing prices of paper, a composite project appeared to be much more viable - financially and from the economic point of view. The concept of a composite mill was further modified by going in for a single machine - a dual-purpose paper machine - which can manufacture both newsprint and writing and printing paper on the same machine. This concept of a dual purpose machine reduced the risk of the project more or less completely; if bagasse technology did not prove viable for the manufacture of newsprint, the project could concentrate on paper only - for which the bagasse technology was already well developed.

The problem that still persisted related to technology. To understand the problems faced by similar projects in Mexico and Peru, Mr. Vishwanathan, along with his team and the Chief Minister, visited Mexico and Peru projects some time in 1979 and also discussed their problems with Cusi as well as other experts, in Europe, Latin America and the United States. From these discussions, the SPB drew the following lessons: (1) Since the pulping was the critical area in the manufacture of newsprint, the project should be conceived in such a way that the entire process of preparation of fibre, pulp manufacture and paper machine up to rewinding should be offered as a package and the responsibility for successfully implementing this package should be entrusted to a well-known manufacturer of paper/pulp machine in the world; and (2) bagasse technology for newsprint can be improved with technological research relating to mechanical bagasse pulp. Thus the concept was conceived of a single consortium and one leader who will take the responsibility for the success of the entire project as well as for the essential technological research. After detailed discussions with four consortia -

(a) German consortium headed by M/s Voith

(b) Finnish consortium headed by Metex Corporation

(c) Swedish consortium headed by M/s Elof Hansson and

(d) American consortium headed by M/s Beloit -,

the final choice was made to entrust the package to M/s Beloit Corporation Inc.

The Beloit Corporation was familiar with the evolution of the bagasse technology for newsprint and was already doing research based on the mechanical pulping approach as indicated by the Hawzell process. The TNPL, thus, entered into a preliminary agreement with the Beloit consortium in December 1980 on condition that the final agreement would be made by June 30, 1981. This preliminary agreement induced the Beloit Corporation to concentrate its research on improving the process for bagasse based newsprint. Thus, intensive technological research started at the pilot plant facilities of Beloit Jones Division at Pittsfield, Massachusetts (USA) in 1980.

Beloit had considerable research experience in the field of mechanical pulp out of non-wood fibre. The SPB scientists were, however, more familiar than others with the behaviour of bagasse fibre. Hence, in the latter half of 1982, SPB deputed two scientists to reinforce the Beloit team. This collaborative research resulted in the Beloit-SPB Process, perfected in October 1985. The printed newsprint samples were presented at an international conference held at Hollywood, Florida in November 1985. All the delegates were quite impressed with the achievement and the quality of the newsprint. Thus, the era of non-wood newsprint began.

The SPB and TNPL were quite confident about developing suitable technology for bagasse-based newsprint even before April 1980 in view of their negotiations with the Beloit Corporation. However, the other problems of procurement of bagasse had to be faced. The five sugar mills with which they were negotiating for the procurement of bagasse were reluctant to release bagasse, unless the SPB-TNPL assured them of the alternative fuel and took responsibility for installing, maintaining and operating the coal-fired boilers to supply steam to the sugar mills. The TNPL took responsibility for installing, maintaining and operating coal-fired boilers in the five sugar mills. However, the TNPL was not certain of procuring coal to the extent of more than 50 per cent of the requirement. Hence, the concept of multi-fuel boilers was conceived: such boilers can burn coal, as well as raw lignite, leco ch fines, bagasse pith, rice husk, wheat husk, etc. Thus, the dependence on coal was substantially reduced with this concept of multi-fuel boilers, and this improved the viability of the project.

The project design was modified in the light of all these considerations and a draft project report was formulated by the early part of 1980. However, the informal negotiations for the financing of the project with the IDBI had started right after the formation of TNPL. And we must now turn to these financial negotiations, which appeared to SPB to be critical for the implementation of the project.

Financing of the Project

The TNPL had informally approached the IDBI for arranging the financing of the project in April 1979. It may be noted that an official of the IDBI was a member of the sub-committee of the Development Council for Paper Pulp and Allied Products; thus the IDBI was already aware of the project by early April 1979. In August 1979, the IDBI approached the International Finance Corporation for the latter's judgement on the techno-economic feasibility of the project; the International Finance Corporation expressed serious reservations concerning the financial and economic feasibility of the project. This made the IDBI hesitant and even reluctant to finance the project.

However, the SPB and the TNPL persisted in their negotiations with the IDBI as well as the Government of India. By April 1980, the SPB prepared a preliminary project report and informally submitted it to the IDBI. At that time, the SPB wanted the Indian financial institutions to provide finance for the rupee cost of the project and intended getting the foreign exchange financing from a consortium of foreign banks, headed by Manufacturer's Hanover Trust, with whom discussions were at an advanced stage by April 1980.

It was at this time that the project came to the attention of a World Bank mission, visiting India for other purposes. This mission was attracted to this project for several reasons. The bagasse technology, if developed, could make India self-sufficient in both paper and newsprint. Further, it could be of significant benefit to other developing countries producing sugar cane and sugar. The developed countries had no interest in developing this technology, as they depended largely on wood as raw material; and thus, the initiative for developing the technology had to be taken by a developing country like India. Finally, with the compo ite nature of the project, the risk of failure was greatly reduced as the project could manufacture paper, if newsprint production did not materialise.

So the mission, on its own initiative, approached the SPB and the TNPL and obtained the preliminary project report. The mission found the logic of the project design quite sound and promised the TNPL as well as the Government of India to consider providing resources to finance a part of the foreign exchange cost of the project, if the World Bank appraisal of the project established its economic viability. Mr. Vishwanathan was somewhat sceptical about timely assistance from the World Bank; however, the mission gave assurance that it would take a decision to finance, within eleven months, that is before February 1981.

This was quite critical for the project. The World Bank's favourable view of the project convinced the IDBI and the Government of India of the soundness of the project design. The Government of India, hence, requested the Indian financial institutions and the World Bank to appraise and evaluate the project in detail.

The World Bank sent a mission in September 1980 to Mexico and Peru to observe their newsprint project. Further, the mission also visited Dalton, Massachusetts and Beloit, Wisconsin to monitor pilot-scale pulping and paper-making trials specific to the project and carried out by the Beloit Corporation. All these convinced the World Bank mission of the feasibility of developing bagasse technology and the soundness of the SPB project design. The World Bank appraisal mission visited India in November 1980 and in collaboration with the IDBI conducted a detailed appraisal of the project. This appraisal was updated by another World Bank mission which visited India in February 1981 and as a result promised an assistance of $100 million to cover 87 per cent of the total (direct and indirect) estimated foreign exchange cost of the project or about 47 per cent of the total cost, excluding taxes and duties, after the IDBI and the Indian financial institutions had taken the decision to support the project.

Meanwhile, in June 1980, the TNPL made a formal application for assistance to the IDBI, along with a revised project report. The IDBI along with the other institutions began appraising the project thereafter and on January 28, 1981 submitted its preliminary appraisal for comments and suggestions to the Inter-Institutional Meeting (IIM). This is an informal institution, devised by the IDBI with the Industrial Finance Corporation of India (IFCI) Industrial Credit and Investment Corporation of India (ICICI), Life Insurance Corporation of India (LIC) and, the Unit Trust of India (UTI) as members to meet and discuss every month all the project proposals requiring consortium financing at the highest level. After the IIM approved the appraisal report, the IDBI submitted it in February 1981 to its Executive Committee for its views. Thereafter, the IDBI began a detailed appraisal of the project. A team, headed by S. A. Dave, the Executive Director of the IDBI, visited Europe, the USA and Mexico for an on-the-spot study and assessment of the technological aspects of the project; an industrial adviser to the Directorate General of Technical Development (DGTD) of the Government of India was also a part of the team. The team also observed the trials of the on-going process development programme at Beloit's R & D Center at Dalton, USA. All these convinced the team of the soundness of the project design as formulated by the SPB.

Meanwhile, the TNPL submitted its revised and detailed project report to the IDBI on May 12, 1981. On the basis of this report, the IDBI prepared an appraisal report for discussion with the Ad Hoc Group of Advisors (AGA) for their comments and suggestions. AGA is a body of experts, selected by the IDBI for each project that it is considering for financing. At these discussions, the project promoters are confronted with the experts for responding to the comments by the experts.

At this particular meeting, the representatives of TNPL, SPB, State Government and Beloit Group participated in order to provide clarification and additional information regarding the project. The AGA was generally satisfied with the responses of the project promoters and consultants and approved the project as creditworthy. However, the AGA felt that the gestation period was underestimated by the TNPL and would be longer by about a year or so; in their view, this would mean a 46-50 month-interval instead of the 36 months envisaged by the TNPL. Further, in their opinion, the cost of the project was underestimated: in view of the fact that the technology was still to be firmed up and some of the cost estimates were on the basis of not so firm contracts, the project cost would exceed the estimated cost of Rs.1800 million - or $225 million - by about 25-30 per cent.

The IDBI then submitted its proposal for sanction of project finance to its executive committee on June 20, 1981 on the assumption that the World Bank would grant assistance to the tune of $100 million to the project through the Government of India.

The committee approved the project for financial assistance to the order of Rs 645 million, of which Rs.118 million in the form of equity and Rs.527 million in the form of term loans was to be provided by the Indian financial institutions on the assumption that the World Bank assistance to the Government of India would be available to the tune of $100 million or Rs800 million. The World Bank assistance would be to the Government of India, who would transfer it to the Development Assistance Fund of the IDBI and the latter would provide the resources to the project out of this Fund - Rs.192 million in the form of equity and RS.608 million in the form of a loan.

The Development Assistance Fund is constituted by the IDBI out of the resources obtained from the Government of India; the IDBI manages this Fund on behalf of the Government for providing assistance to large sophisticated and risky projects, which do not meet IDBI criteria for assistance. Thus the risk of non-payment of interest and principal is borne by the Government of India. The Government passed on the World Bank assistance for the project to this Fund. The exchange risk relating to the debt servicing with regard to the World Bank assistance is also borne by the Government of India.

This project had an integral rate of return of only 12.1 per cent per year, while one of the criteria for IDBI assistance is an internal rate of return of at least 15 per cent per year. Further, this project was considered by the IDBI as quite risky in view of its complexity, and the fact that assistance had to be provided even before the technological research was completed. If decisions were not taken with regard to financial assistance by May 1981, the Beloit Corporation would not adhere to the details of its preliminary agreement with the TNPL of December 1980. For these reasons, the Government of India agreed to provide the World Bank assistance to the project through the Development Assistance Fund. It may also be noted that the World Bank, for the first time in its history, agreed to let the Government of India, through the Development Assistance Fund of the IDBI, provide a part of assistance in the form of equity to the project. This shows the importance, which the World Bank attached to this project for the reasons mentioned earlier.

Subsequently, the World Bank formally sanctioned its assistance of $100 million for this project in September 1981, with the provision of retro-active assistance of $10 million in order to cover the initial down payment for the consortium package (Beloit Corporation) essential for the project to be implemented as scheduled.

Project Implementation

After the financial assistance was secured, the TNPL finalised its agreement in June 1981 with the consortium led by Beloit Walmsley, Ltd., UK; the consortium included also the Beloit Jones Division of the Beloit

Corporation Ltd (USA). Site preparation commenced in August 1981 and preparation for procurement in January 1982. Start-up of paper machine with purchased pulp was achieved in September 1984. eucalyptus pulping line was started in February 1985. the chemical bagasse line in May 1985 and the mechanical bagasse line in October 1985. Thus, though the TNPL started manufacturing newsprint with imported pulp in September 1984 (that is within 36 months after the World Bank assistance was sanctioned) the newsprint production based on internal bagasse started only in October 1985 (that is, 48 months after the World Bank assistance was secured). This additional gestation period of a little more than a year was due to the additional time taken for completing the technological research; the technological breakthrough in the manufacture of mechanical pulp out of bagasse was achieved during late 1984. A part of the additional time-lag was due to an initial delay in making down payments to Beloit - a three-month delay. The port strike and diversion of ships carrying consignment to the plant held up the delivery of certain critical equipment and delayed the project to some extent. It is the finalisation of process parameters which has contributed to the major part of the time overrun.

This research resulted in the modification in the process configuration and a change in the design and layout of the factory buildings; consequently the cost estimated for buildings increased by Rs.14.60 million, for land by Rs.10.50 million, and some increase in cost (about Rs.135 million) for plant and machinery. Thus about Rs.286 million of additional cost was due to the redesigning of the project as a result of technological research. The rest of the increase in project cost was due to exchange rate fluctuations and increase in import duties (Rs.203 million) and additional cost as a result of an increase in domestic prices (Rs.22 million). In all, the project had a cost-overrun of Rs.500 million - an increase of about 27 per cent over the original estimate. In terms of US dollars, however, the cost increase was of the order of only $5 million ($230 million as compared to the original estimate of $225 million).

In view of the fact that project implementation had started and financial arrangements had been made well before the completion of technological research, this additional gestation lag and the additional cost were quite understandable and reasonable. The AGA of the IDBI had already anticipated this outcome.

The World Bank was satisfied with the outcome. To quote Mr. Ray Chalk of the World Bank, who was associated with this project since April 1980: "At the World Bank, we all feel now that this project is definitely a technical success. We were very happy that it came in within the scheduled time - depends a little bit on when you start counting the start of the work. Basically, we are very happy with the implementation period and certainly with the capital cost. This project has come in basically within budget. The 100 million dollars that the Bank loaned to the project was used very efficiently and did not overrun. So I think that is all I need to say. We at the World Bank congratulate Mr. Vishwanathan and all his colleagues, and we think this is a very successful project. one in which we are very pleased to be part of".

As a result of this experimental project, it is possible to improve the design of such future projects in India and elsewhere. If an integrated sugar/paper mill project is conceived there could be substantial economies in steam and power balance and in rationalising equipment to be employed in both the sugar and paper industries. This integrated complex could be tied up, wherever possible, with captive sugar cane plantations. The project cost, in such a case, can be reduced by 5-7 per cent with considerable saving in transportation cost. Such projects can now be thought of for countries like Argentina, Brazil, China, Colombia, Cuba, Egypt, Indonesia, Iran, Mexico, Pakistan, Peru, Thailand, Venezuela, the Sudan and others in Africa - all of which are now large consumers of newsprint. Thus the TNPL project is likely to have a world-wide impact - as anticipated by the World Bank.

The SPB is currently engaged in advising the Government of India and three state governments on establishing such bagasse-based mills. It is also promoting the idea of an integrated sugar-cum-paper mill complex and the Government of India has come to realise the importance and significance of such an integrated approach. The World Bank has assured its continued and keen support and assistance for two other similar ventures, which, it is hoped, will improve upon the technology and design of the TNPL. Towards this end, the SPB is already taking effective steps.

It may be noted that this was the first project in India which was based on collaborative research between an Indian firm and a foreign multinational, just as the Swaraj tractor was the first Indian project, based on indigenous research.

III

Strategic Factors in Public Enterprise Performance

Such, then, is the story of evolution and implementation of this bagasse newsprint project, based on adaptive technological research to improve commercially unproven bagasse newsprint technology. This research has resulted in the development of Beloit-SPB Process, and the project has successfully adopted this new technology well within the anticipated time even though there were cost overruns due largely to factors which were not within the control of management such as fluctuations in the rupee-dollar exchange rate, rise in import duty, the re-designing of the technological process as a result of research and the time taken for semi-commercial trials of the new research results. In view of the fact that the project was formulated and its implementation was initiated much before the final research was completed, the successful implementation of the project within the anticipated time and cost parameters appears to be an achievement, unique at any rate in the context of the Indian and the IDBI experience - and probably the experience elsewhere in the world.

How, then, do we explain the causal or strategic factors behind this success story of a public enterprise? One can make some tentative conjectures relating to the nature and characteristics of the decision structure and processes, that resulted in this success story, and these conjectures or hypothheses appear to be valid for public enterprise performance in the developed as well as the developing countries.

(a) Plurality of public enterprise promoters and competitive promotion: For identifying new project ideas and stimulating a competitive learning process relating to economic development, it appears essential to have a plurality of project sponsors or promoters in the public sector as well as a plurality of various institutions - and in particular financial institutions, TCSCs and TRCs - for the success of both public and private enterprises.

(b) High-level commitment: The Tamil Nadu Chief Minister was not only keen on restoring the position of his state, but was also committed to whatever action was necessary for the purpose. He was willing to consult a private enterprise (SPB) and his managing director and to delegate full responsibility for the project to a [illegible]te-sector enterprise, simply because he was committed to the succe[illegible] effectiveness and efficiency - of his public enterprise. The success was not merely due to the commitment of the state government; it was also due to the commitment, at the highest level, of the central government, which had already taken several measures to promote the use of bagasse for paper as well as newsprint production.

(c) Partnership relationship with the private sector: The high-level commitment by itself would not have been enough. There was, in this case, a non-ideological pragmatic approach; if the public sector required assistance from the private sector, there was no inhibition or ideological constraint in obtaining such support.

The partnership link was not merely between public and private sectors in India; it was established among Indian and international financial institutions - IDBI, IFC and the World Bank - between Indian TCSC (SPB and SPB-PC) and the Beloit Corporation and its affiliates and finally between the central and the state government.

(d) Critical role of a TCSC: The SPB had long experience in the paper and newsprint industry since 1960 and its two expansions of capacity were made possible by developing and nurturing a team of experts in design engineering - a team which later on, probably, in 1977, was formed into a separate TCSC - (-SPB-PC), a natural evolution for a TCSC from an expanding enterprise.

It was this TCSC, which identified the project idea, initiated the search for technology, identified the areas for research and selected a foreign consortium which could undertake research as well as assume full responsibility for project implementation and successful operation of the project. A TCSC of such a type is essential not only for the choice of technology but also for identifying problems relating to adaptation and improvement of modern technology - whether commercially proven or otherwise.

(e) Critical role of entrepreneurial ability: But this TCSC (SPB and SPB-PC) was not an ordinary TCSC. The managing director of SPB was also the chairman of SPB-PC. He and his team had an aspiration - a dream - of developing a newsprint project based on bagasse as early as 1963-65. This dream was still alive in 1978, and it is this dream, which prompted him to suggest this new project to the Chief Minister of Tamil Nadu.

But the managing director did not merely suggest the project idea. He was so possessed by his dream that he wanted to make it a reality. And he worked at it with passionate zeal, ardour and drive - the characteristics of a Schumpeterian entrepreneur. He convinced the Chief Minister of the viability of the project idea and the necessity of having this project in the public sector in view of the risks, costs and external benefits associated with a project of this type. Through the Chief Minister, he tried to persua[illegible] the

Central Government to take essential measures in order to make this project financially viable. It is worth noting that he was one of the members of the sub-committee of the development council - referred to earlier - that recommended to the Government of India certain measures for the application of bagasse technology and which the latter adopted in April 1979 - and which resulted in the concept of a composite project with a dual-purpose machine - a concept developed by the PSB.

It was again the managing director and his team which, through personal visits and discussion in Mexico, Peru and elsewhere - in Europe, Latin America and the USA - identified the problems relating to research as well as implementation an selected a leader of the consortium of foreign companies - the Beloit Corpor on with its affiliates - to tackle these problems.

The managing director and his team, again, provided the expert personnel and trained others directly and indirectly through the Beloit Corporation -- the personnel responsible for the formulation, implementation and operation of the TNPL project.

The technological research too, would not have been undertaken by the Beloit Corporation without the assurance by the TNPL - through the SPB - of obtaining their assistance as equipment and know-how supplier as well as the major coordinator with the responsibility for the successful implementation of the project. This type of research, as the World Bank had recognised, would not have been undertaken in the developed countries - which lacked sufficient interest in bagasse - without the active support and promotion of such research by a developing country; the Beloit Corporation undertook this intensive research because the TNPL had entered into a contractual obligation with them for the success of this project. Again, this research would not have been fruitful but for the scientists of the SPB-PC actively associated with this research since 1982 - the persons who knew the characteristics and eccentricities of the bagasse fibre.

The managing director and SPB were the entrepreneurs not only for all these but also for persuading the Indian financial institutions under the leadership of the IDBI and the World Bank to provide the necessary financial assistance.

This financial assistance from the IDBI was principally due to the Central Government support and commitment to bagasse technology; and this was obtained partly by the persuasive presentation of the case by the SPB as well as because the ex-industries minister of Tamil Nadu - Mr. R. Venkataraman, the architect of the industrial development policies of Tamil Nadu - happened to be the finance minister of the Government of India. Institutional mechanisms are, indeed, important; but the spirit in which they are operated depends critically on the entrepreneurial ability of the persons who man them. How true this has been vis-a-vis SPB, the Tamil Nadu Government and even the Central Government.

(f) Vital role of financial institutions: It is worth noting that, initially, this project was considered to be risky and not creditworthy by the IDBI as well as the International Finance Corporation (Washington). While the discussions were going on between TNPL and the IDBI for financial assistance, it was a very fortunate coincidence that a World Bank team of experts happened to be in India in April 1980 and came to know about this project. The World

Bank team, on their own, initiated a discussion with the TNPL and SPB and assured them in principle of World Bank support - to the tune of $100 million after a detailed appraisal of the project to be completed by February 1981, just ten months after the first identification of the project by the World Bank team. It may be mentioned that the World Bank was familiar with the newsprint projects in Mexico and Peru and, in fact, was probably also conscious of the lack of mechanical pulping approach with regard to the bagasse newsprint technologies and the lack of coordination among the various suppliers to these projects - views which were later confirmed by the reports of the World Bank consultants, who visited Mexico and Peru in September 1980.

This World Bank support to the project was of critical significance; for it inspired confidence with regard to the project in the IDBI and other financial institutions and induced them to actively support it in an imaginative manner. The World Bank support also strengthened the conviction of the Government of India with regard to the viability of this project. Why did the World Bank support this project so actively and with such initiative and enthusiasm - somewhat unusual in a conservative international bank?

First, bagasse technology, if successful, would make it possible for India to be self-sufficient in its requirements of both paper and newsprint. Second, such a technology would be a considerable benefit to developing countries with sugar cane cultivation - and in particular the African countries - as it would enable them to improve the profitability of agriculture as well as sugar mills and at the same time make it possible for them to develop agro-industrial complexes by linking sugar-cane cultivation with sugar and paper mills. Third, the developed countries have no incentive to develop and commercialise such new technology; India, being the largest sugar cane producer in the world and with its technical and scientific personnel - the third largest in the world - was one of the few developing countries that could develop and commercialise this new technology. Fourth, because of the risks involved and the complexity of the project, it was essential to promote and support a public enterprise. And finally, even if the project could not develop bagasse newsprint technology, it could manufacture paper based partly on bagasse, as the project was so conceived as to produce either paper or newsprint or both; thus, because of the composite nature of the project and the dual-purpose single paper machine, the risk of the project was considerably reduced. Such were the explicit reasons for the World Bank support of the project.

The role of the TCSC - in this case SPB and SPB-PC - and the financial institutions, including the World Bank, was therefore very critical and crucial in providing a vital link between modern technology and TRC (Beloit Corporation and its affiliates) on the one hand and the production system (TNPL) on the other.

(g) Quality and motivation of the top management team: The selection of the top management of TNPL was, of course, the most vital factor in its success. The Chairman of TNPL was Vishwanathan during the period of implementation and the managing director has been, since the beginning, C. Ramachandran. The chairman and his team had a powerful motivation to make the project a success; after all, it was their idea, their dream and creation. They had identified the idea, formulated the project design, identified the research problems, selected the foreign consortium for promoting research, manufacturing, and supplying equipment and taking full responsibility for the implementation of the project. Both SPB and C. Ramachandran were associated with the project right from its inception and both had a powerful non-economic motivation to make it a success - a case similar to that of the Swaraj Tractor. SPB had charged fees for its consultancy service which were much lower than the conventional standard for the tasks involved; SPB was more interested in the implementation of its cherished idea than in making money from this project.

The wise selection of the top management team, its association with the project right from its inception and its powerful non-economic or non-pecuniary motivation were all factors of critical significance.

The Tamil Nadu government was far-sighted and prudent in agreeing with the financial institutions to keep its share of equity below 50 per cent; this was done explicitly to maintain the professional character of the management and provide it with operational autonomy, thus restricting the scope for ad hoc political and bureaucratic interference with the implementation and operation of the project.

Such, then, were the strategic factors which accounted for the success of this public enterprise; and these factors are relevant for public enterprise performance anywhere in the world. This case study demonstrates the critical significance of these strategic factors for effective and efficient functioning of a public enterprise and as such, has relevance for all countries with mixed economies and probably also for centrally planned economies, which are in the process of reforming the management system for their industrial enterprises - or undertaking, to use the popular Russian word, perestroika, a thorough restructuring of the economic system.

IV

Concluding observations

This case study has demonstrated the rationale for a public enterprise particularly in the developing countries.

Further, it indicates the pre-conditions essential for successful implementation and operation of a public enterprise project. These pre-conditions are: (a) Plurality of project promoters or sponsors; (b) Partnership relationship between public and private sectors; (c) Existence of an appropriate TCSC for the search of relevant technology, identification of research problems for adapting and improving technology, identification of a foreign TRC/TCSC for joint research and implementation of a public enterprise project, and establishing the vital link between modern technology and TRCs on the one hand and the production system on the other; (d) Existence of development banks with development orientation and with capacity to forge partnerships with other domestic banks and international institutions and with domestic and foreign TCSCs and TRCs; (e) High-level support and commitment on the part of the Government to ensure effective and efficient functioning of the enterprise and its operations autonomy for the purpose; and (f) Existence of institutional and policy framework that creates a favourable climate for the emergence and functioning of entrepreneurial talents and impulses in both the public and the private sectors.

Emergence of these pre-conditions is an evolutionary process; but that can be set in motion only if the political and bureaucratic structures are committed to the objective of socio-economic development, and decision structures and processes have built-in mechanisms for learning from experience with a view to ensuring creative adaptation to a changing environment.

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CHAPTER VIII

MANAGEMENT OF TECHNOLOGICAL CHANGE IN MACHINE TOOLS

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The case of PMT Machine Tool Automatics Ltd.

Machine tools are power-driven machines, used for cutting, forming, shaping or pressing metals or other materials into desired forms. They are appropriately called mother machines, since they are used to manufacture both machine tools and other machines. For this reason, developments in machine tools are critical for the development of industry as a whole.

It is not incorrect to say that there has been a revolution in the machine tool industry in the last few decades. Introduction of new materials and improved understanding of the machining process have been responsible for a part of the change. The prime mover, however, has undoubtedly been progress in control technology, which has led to large-scale automation and integration of machine tools.

It was in the machine tool industry that the computer was for the first time used outside the pure date processing environment. In 1949, not long after the invention of the electronic computer, a series of research projects were started at the Massachusetts Institute of Technology on automatic machining. In 1952, paper tape output from a computer was used to control a milling machine, which was the first numerically controlled (NC) machine. Computer applications in machine tools, therefore, have a long tradition.

In 1976, when microprocessors were still fairly new in the market, Fanuc introduced inexpensive microcomputer-based controls, which resulted in very large growth rates worldwide. The large, general-purpose machine tool manufacturers in the advanced countries have more or less stopped making non-CNC (Computer Numerical Control) machines. Some manufacturers - for example Traub in West Germany - entered the CNC field as late as 1979, and have had to almost completely switch over in less than a decade.

Reasons for the shift in favour of CNC machines in manufacturing are:

- The ability to machine difficult parts cost efficiently, for which the human operator would require a lot of skill or produce a high percentage of rejects.

- Speed is much higher on a CNC machine for several reasons. CNC has high positional accuracy, and is able to dispense with many intermediate cycles that a human operator adopts in metal removal. A CNC machine with automatic tool and work piece changers can be set up much faster than a conventional one. Repeatability is higher on a CNC machine, finished parts have to be checked less frequently. Modern computer-controlled machines store a lot of knowhow on tool and work piece materials, i.e., they resemble expert systems, and allow programming with powerful graphical and other sophisticated means. This reduces rejects and saves time, particularly during prototype manufacture. It has been estimated that for relatively simple parts, machining time on a simple CNC machine is considerably lower: on the average, 76 per cent lower for a motor coupling with a 2° bore taper 1/ (see references at end of Chapter).

- Higher accuracy of parts machined on CNC machines decreases assembly time and ensures interchangeability of spares.

- Quality control: the quality of CNC-machine products does not fluctuate as much as can be the case with human operators. Controlled speeds, pressures and feeds result in better finish. CNC machines can maintain tolerances of a few hundredths of a millimetre running almost 24 hours a day.

- The computer maintains an uninterrupted watch on the machine in the monitoring of those faults for which it has been programmed and equipped, and sends out alarms speedily. Its record of the events preceding the fault is always honest.

- CNC-machines are a prerequisite for flexible manufacturing systems (FMS).

- In the industrially advanced countries, the reduction in manpower obtained through introduction of CNC has also played a major role.

There are, certainly, exceptions to the rule, and for many parts conventional machines are still more cost-effective than CNC. However, the markets for these have either been captured by the Republic of Korea and the Taiwan Province of China, or are not large enough to interest the machine tool manufacturers in the advanced countries.

Flexible Manufacturing

A multi-purpose machine (or a combination of simple machines), together with equipment for automatic loading and unloading of work pieces, an automatic tool changer and a gauging system (to measure the dimensions of the finished part) would be an example of a Flexible Manufacturing Cell (FMC). Such a cell is capable of working a complete shift unattended. For the controls, in addition to the CNC, a programmable logic controller (PLC) is needed to coordinate and interlock machining, tool and work piece changes.

The next level of technological development is the Flexible Manufacturing Systems (FMS), obtained by coupling several CNC-machines or FMCs via a bus, with a central computer for overall coordination. FMS includes a centralised, automatic work-piece and tool management system. This seeks to ensure that all necessary tools and work pieces are available and the manufacturing programs downloaded to the CNC machines at the right time.

Factors contributing to the growth of FMS in the developed countries are:

- It requires considerably less manpower than stand-alone CNC machines.

- The trend towards "just in time" manufacturing, popularised by the Japanese. To reduce inventories and associated costs and improve cash flow. parts are manufactured or obtained from sub-suppliers just when needed in the small batches required then.

- In today's fiercely competitive world markets, manufacturers try to keep one step ahead of the competition by continuously developing products to reduce manufacturing costs and add new features to meet the tastes of more affluent and fastidious customers. In a six-month period, Japan's Sony, for example, expects to launch 101 new audio, television and video products in Britain alone - in an average of one per working day - and new electronic products are unlikely to remain in production for more 2 than three months2/. FMS are essential for manufacturing the large variety of small batch sizes just in time that such a market demands.3/

- With increasing competition, delivery periods have become shorter, increasing the demand for systems that can quickly be reconfigured to manufacture the desired part.

Increasing attention is now being paid in the developed countries to Computer Integrated manufacture (CIM). Implied by this term is the integration of marketing, design, fabrication, inventory management and dispatch through a network of computers in a fully automated plant. Advantages expected include increases of 40-70 per cent in productivity and 100-200 per cent in machine utilisation.4/ However, this technology is still in its infancy.

The Indian Machine Tool Industry

The basic strategy of development planning in India, especially since the Second Five Year Plan, has laid considerable emphasis on the development of and relative self-sufficiency in capital goods industries. Capital goods comprise non-electrical machinery (including machine tools), electrical machinery and transport equipment.

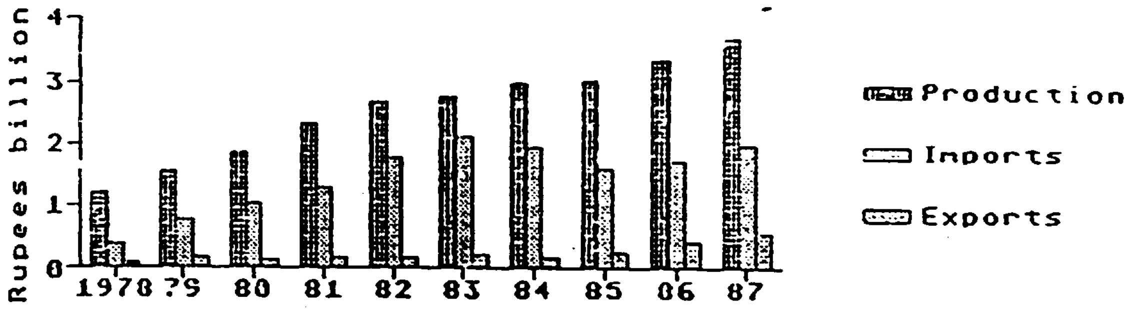
Starting with three large units making machine tools in the early fifties, today there are between 140 and 150 machine tool manufacturing firms in the organised sector. In addition, there are a large number of mechanic-workshop type small machine tool shops in Pubjab, Gujarat and Tamil Nadu, specialising in the production of simple machine tools.

A few large firms - Hindustan machine Tools, Perfect Machine Tools (PMT), XLO, Bharat Fritz Werner, Mysore Kirloskar, Praga, Godrej and Boyce, Heavy Engineering Corporation, Premier Automobiles (Walchandnagar) and Ameteep to name a few - dominate the industry in volume of production, technological collaborations, innovations and exports.

Clearly distinct from the large firms and the mechanic-workshops is a class of new entrants. Small partnership firms have been set up by engineer-entrepreneurs who were working at companies like HMT or Godrej and Boyce or were trained at the Central Machine Tool Institute (CMTI) and have now started out on their own. Skilled in the design and production of modern machine tools, they operate with low overheads and are rapidly establishing themselves successfully in the domestic and export markets.

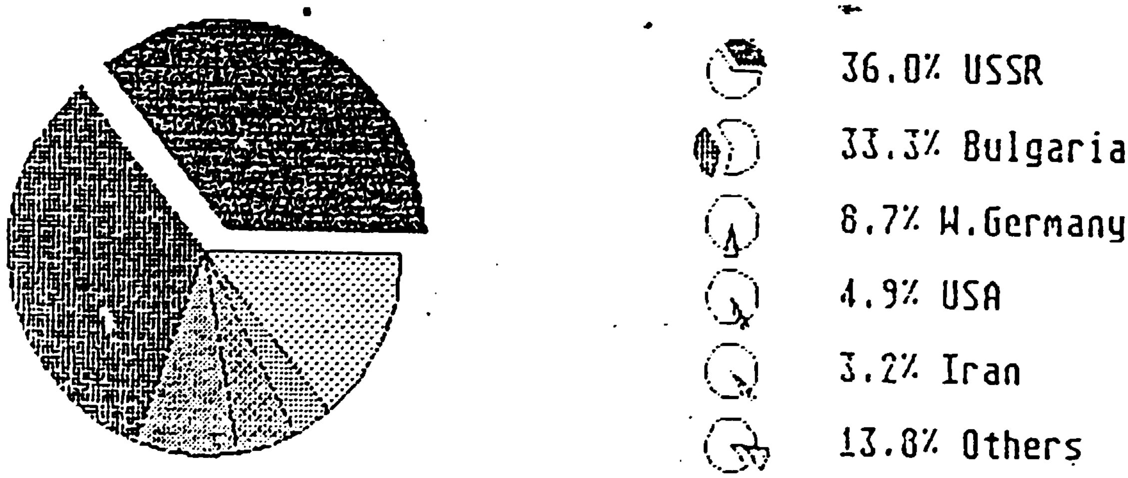
Indian production, imports and exports of machine tools between 1978 and 1987 are shown in Fig.1.

Fig.1: Production, Imports and Exports of the Indian m/c tool industry



With almost 70 per cent of the exports in 1986 being made to the Soviet Union and Bulgaria (Fig.1a), the hard currency component in exports is low.

Fig.1a: Direction of Indian Machine Tool Exports in 1986

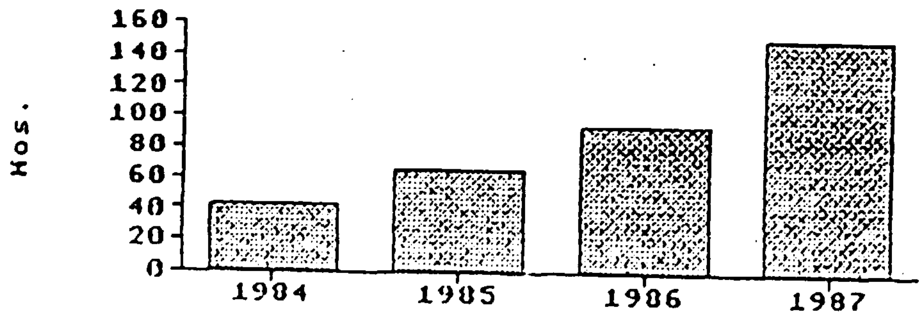


The value of output of machine tools and accessories was Rs.2.86 million in 1950, Rs.58.6 million in 1960 and Rs.372.3 million in 1970, Rs.1859.5 million in 1980 and Rs.3,361.2 million in 1986. However, the increase has been much less spectacular in real terms, i.e. from Rs. 372.3 million in 1970 to Rs.755.9 million in 1980 and Rs.844.2 million in 1985.

As can be seen from Fig.1, exports of machine tools stagnated between 1978 to 1984, and even though they have been increasing since then, they continue to remain a small fraction of imports. The self sufficiency ratio decreased from 86.1% of total value of machine tool requirement in 1978 to 58.2 per cent in 1985.

This is a result of the fact that user industries, especially automobiles, railway workshops and defence, have invested heavily in setting up new production capacity and in expansion and modernisation programmes. The stress on fuel efficiency has compelled narrower tolerances and more stringent quality control. There is a resultant shift in the demand pattern, with a clear preference for high-tech, precision CNC machines. This is reflected in the fact that 160 CNC machines valued at Rs.32 crores were cleared for import in 1985. As per the Machine Tool Census of India,[5/] less than 0.1 per cent of the installed base of 13,35,000 machine tools in India in 1985 were CNC machines. 88.5 per cent of the 1200 CNC machines were imported. The small installed base coupled with increasing demand have resulted in an extremely high growth rate for CNC machines in India. Current demand for CNC machines is about 250 per annum, of which about 150 (worth approximately Rs.150 crores) are from indigenous production (Fig.2). In contrast, Japan manufactured approximately 45000 CNC machines in 1985.[6/]

Fig.2: CNC-machine tool production in India



Source: CNC Machine Tools - Problems and Prospects, IMTMA, January 1988

Indian Machine Tool Firms and Technological Change

Indian manufacturers have seriously lagged behind international developments in the industry, particularly in CNC. This has led to burgeoning imports of CNC machines. Given the new technological developments abroad - FMC, FMS and CIM - their ability to compete in the hi-tech export market is shrinking. The Indian market for machine tools is segmented. While the bulk of the user industry lacks the sophistication necessary to use CNC machines, there are several large organizations manufacturing to international standards that need to purchase CNC machines. Relative to the industrially advanced countries, however, the market for CNC is still limited. Meanwhile, in the shrinking export market for conventional machine tools, India has been out-competed by the Republic of Korea and the Taiwan Province of China.

India has not had a manufacturer of CNC hardware, so that the close cooperation and mutual stimulus between CNC and machine tool manufacturer, characteristic of the Japanese and German industries, has been lacking in India. Manufacturers for several other critical components, such as high-precision bearings and sensors, are also not to be found in the country. Skilled manpower, particularly in the programming of CNC, is hard to find.

Raw material prices are substantially higher here than those prevailing on the international market. In addition, the quality of several key raw materials is also not upto international standards, making costly and time-consuming inspection and testing of incoming materials a must.

The Indian machine tool industry must regain competitiveness in international markets and simultaneously allow Indian users of machine tools to manufacture products that are competitive in hard currency markets. One area that could offer very interesting export possibilities is in conventional machines which foreign manufacturers are phasing out. Some of these are still and will continue to be cost effective with respect to CNC in manufacturing certain parts. Even though the demand for them is small by international standards, these volumes would be large for Indian manufacturers. If such niches could be identified in time and machines for them manufactured both for the domestic and the imported markets, the necessary economies of scale could make it possible to successfully compete with the Republic of Korea and the Taiwan Province of China. An example of this are automatic lathes, discussed below.

However, the requirements of several Indian users of machine tools needing to manufacture to international standards for import substitution and to compete in international markets can only be met through a concerted entry into CNC technology. In this, it would certainly be advantageous for a computer manufacturer to start manufacturing CNC hardware. More complex, however, is the problem of the manufacturing technology for sophisticated machine tools and the machining know-how that goes into the manufacture and programming of a CNC machine tool.

It is in this context that technology management by the Indian machine tool industry and the large number of foreign technical collaborations, into which the industry has recently entered need to be viewed.

Foreign technical collaborations - some advantages and disadvantages

Some of the issues raised in the literature pertaining to foreign technical collaborations are:

Cooperation agreements with foreign machine tool manufacturers are necessary initially to speed up the growth of the machine tool industry and as an essential component for the training and development of engineers, technicians, designers, planners, managers and skilled operators.7/

From the point of view of the licensee, the purchase of a license reduces otherwise heavy R&D expenses. Technological know-how as well as product design may also be included in the provisions of a licensing agreement. The brand name of the licensor may in addition be an indispensable selling point for the licensee, even if the quality of the licensee's own brand of machine tool is equal to the more familiar one. Finally, local producers in LDCs may obtain from their government the guarantee of protection against competitive imports if they produce an allegedly technologically sophisticated product under license than otherwise.8/

The interests of the buyer and seller of technology are complementary as long as they do not compete in the Indian or the international market. Government restrictions on imports prevent conflict of interest as long as the Indian producer limits himself to selling in the domestic market. But once he wants to become a substantial exporter he is liable to run into the competition of potential technology suppliers.9/

Therefore, attention needs to be drawn to provisions in foreign licences which affect the freedom of licensees to export. This is especially critical in the machine tool sector because machine tools are a widely traded commodity and it is rare that a successful machine tool producer does not engage in exporting. Thus, one must be doubly wary of licences in the machine tool branch which prohibit exports outright or which do not provide the latest designs (however simple the technology) so that exporting is effectively impeded since the latest designs are necessary to compete internationally.10/

The PMT Machine Tool Automatics Ltd. (PMTMTA) has, during the last decade, acquired technology primarily through entering into foreign technical collaborations and so is illustrative of the above. Since the company has been fairly successful in the management of technological change, their example is worth looking at closer.

History of PMTMTA

The Perfect Machine Tools Company (PMT) was established in 1947 as a marketing organization for machine tools. The decision to manufacture machine tools was taken in 1963. What is today known as PMTMTA was originally set up as Traub India Ltd., a joint venture formed in 1963, with Hermann Traub Maschinenfabrik (HTM), Federal Republic of Germany, holding 60 per cent of the equity and Mr.D.L.Shah, founder of PMT, holding 40 per cent. In 1964, Traub India started manufacturing single spindle automatic lathes and acquired considerable expertise, know-how and trained personnel in the process.

Not willing to reduce foreign equity in accordance with the Foreign Exchange Regulation Act (FERA), HTM withdrew financial investment totally in 1978 and sold their share to their Indian partner. The company was renamed PMT Machine Tool Automatics Pvt. Ltd. (PMTMTA). However, a close technical and trade relationship continues between PMTMTA and HTM. Since then the turnover of PMTMTA has increased from Rs. 15 million to Rs.96.5 million in 1986-87.

With the exception of 1984, in which a large export order from Iran was executed, company sales have depicted a steady increasing trend. The company's share in Indian production increased from approximately 1.56 per cent in 1983 to 2.76 per cent in 1986.

Today PMTMTA manufactures:

i) Automatic lathes, continuing the Traub India Line.

ii) Automatic lathes with six-station turret, in which the machine can simultaneously hold six tools, any one of which can be used for machining, with rapid switchover to one of the others. Technology for the product was obtained through a technical collaboration with HTM in 1980, for which a technical know-how fee was paid, and production started the same year.

iii) 3mm-80mm internal grinding machines under technical collaboration with Voumard Machine Co., Switzerland, signed in 1983. Production started in 1984 and about 75 per cent indigenisation has already taken place. Payment terms were lumpsum for drawings and know-how, and royalty at the rate of 5 per cent of sales for a period of 5 years from commencement of production. 100 machines have been produced so far.

iv) 2-axis CNC turning centres (lathes) and 3-axis turn-mill centre (i.e. a lathe with limited milling capability). With 2-axis CNC, only the tool position is controlled, whereas in 3-axis control, the rotary motion of the workpiece is synchronised with tool motion, allowing the machining of sections other than cylindrical. For these machines a technical collaboration with HTM was signed in 1986, on payment terms similar to those mentioned above for Voumard. Production started in 1987, and so far 10 machines have been delivered. CNC for these machines has been developed by HTM, with hardware from Mitsubishi, and is a part of the collaboration agreement.

PMTMTA exports automatic lathes through PMT to hard currency areas such as Japan, the Federal Republic of Germany, Iran and South East Asia. In 1986, 186 automatic lathes were exported by PMTMTA.

Technology management by PMTMTA

Licensing agreements have a variety of special benefits associated with them such as short-cut in obtaining ready made design; training of local skilled manpower; technology updating; entry into more sophisticated product ranges; building up higher technological capabilities; development of own design on the basis of experience gained from the design of foreign collaborators and marketing advantages.11/

PMTMTA has succeeded in obtaining most of these benefits in technology transfer. That this has raised PMTMTA's technological capabilities is demonstrated by the fact that they have made changes in the machines based on their knowledge of local market conditions that have been approved and even partly adopted by the foreign collaborator. The reasons for PMTMTA's success are discussed below.

Product line - marketing nexus

PMT is a marketing organization for machine tools that has served as agents not only for foreign manufacturers of sophisticated machine tools, but also, starting in the sixties, of small Indian manufacturers of simple machines. Many of these have subsequently grown and started making sophisticated machines. Clients for the imported machines include defence plants, the railways, and the automative and steel industries. PMT had an annual turnover of Rs.380 million in 1987, with exports of approximately Rs.25 million (a significant proportion being PMTMTA products).

The decision to start manufacturing machine tools in 1963 was based on PMT's marketing experience, in particular the identification of the products which sold well. Good relationships with their foreign manufacturers eased tie-ups. PMTMTA's current product mix clearly reflects this. PMT has been selling Traub machines since the fifties (much before domestic manufacture of the Traub lathes began in 1964) and Voumard machines for more than 25 years, whereas the technical collaboration with Voumard was signed in 1983.

Increases in the licensed capacity of and the new collaborations entered into by the two-wheeler industry in the early eighties triggered the decision to manufacture the Voumard machine. Using PMT's marketing know-how to identify the machine tools that the rapidly growing two-wheeler industry would need, PMTMTA diversified its product range into internal grinders, required for grinding bores in critical components such as connecting rods, crankshafts and gears. Manufacturing began in 1984.

Competitors in internal grinders are XLO, HMT and Mysore Kirloskar. PMTMTA was, however, the first to develop this product and to rapidly indigenise it, thereby partly counteracting the price disadvantage on imported components when the value of the Rupee fell against European currencies. Their use of the Voumard brand name in a market in which it was already established helped.

Therefore, choice of product, timing, identification of collaborator and a strong marketing base, all contribute to PMTMTA dominance in the market for internal grinders. A similar strategy has also been successful in the case of Traub automatic lathes, with the additional advantage that these are also used by small manufacturers in addition to the medium and large ones, so that PMT's role as an agent of small manufacturers also works to PMTMTA's advantage.

Entry into the market for CNC lathes has been dictated by the switch in favour of CNC machines by large Indian users. PMTMTA is a relative latecomer in this field and competes with HMT and Mysore Kirloskar, with whom it has caught up already. The PMTMTA strategy appears to be an attempt at differentiating its product from that of the other Indian manufacturers by offering single-source responsibility for the machine as well as the control system.

Most foreign firms collaborating with Indian manufacturers purchase controls from Fanuc or Siemens. PMTMTA. on the other hand, is collaborating with HTM for the manufacture of CNC lathes and turn-mill centres, and HTM have developed their own software for their CNC system, components for which are purchased by them from Mitsubishi, tailored to the specific requirements of their lathes. HTM's biggest strength is their expertise in the field of turning, acquired through decades of advising users on how to "program" the manufacture of parts on their automatic lathes. They were therefore, very clear on what features they wanted in a CNC. Not finding these in standard systems, and given the lack of flexibility in the large CNC manufacturers, HTM decided to develop their own system based on Mitsubishi hardware. This has the added advantages in that they are able to meet special customer requirements in the software, and also avoid dual responsibility in the servicing of their machines.

PMTMTA's tie-up with HTM has obvious advantages in that both machine tool and CNC technology is available from one source. However, this could prove to be a competitive disadvantage should HTM notbe able to keep up with Fanuc and Siemens in new developments in CNC. With system software becoming an increasingly significant component in the price of CNC and the relatively small volume of HTM CNCs, HTM might not be able to keep up in software features and still stay competitive in price with the larger CNC suppliers.

Internationally, automatic lathes are in the lower-middle range of technology, and the large machine tool manufacturers are phasing out such products in favour of CNC machines. On the other hand, automatic lathe manufacture involves considerable knowledge of how the final part is to be manufactured, and newcomers have not found it easy to enter this field. Besides, world demand is not large enough to make the effort worthwhile. PMTMTA has thus found a niche here. Their machines are well received because they meet HTM standards, and are given a make-or-buy decision, it is cheaper for Japan and the Federal Republic of Germany to buy PMTMTA automatic lathes, especially when the Rupee is weak relative to the Yen and DM.

Internal grinders and CNC lathes are as yet relatively new products for the company and are not yet exported. This is planned for internal grinders, where a niche similar to that for automatic lathes may exist. In the case of CNC lathes, the company will find it difficult to withstand Japanese and the Republic of Korea competition in the foreign market, unless prices are reduced to less than half.

Transfer of design methodology and the indigenisation process

Technological change certainly cannot be managed on the basis of design drafts and bluprints alone. However, while design methodology is usually mentioned in the formal licensing agreement, a survey of the Indian capital goods sector by UNCTAD found that the foreign licensor hardly transfers it in practice, and that normally the licensor only provides the design drafts and blueprints.[12/]

PMTMTA has nonetheless managed to imbibe design methodology, as is indicated by their ability to further develop the machine to suit local requirements. Technological developments made by them on the machines manufactured under collaboration, include:

- Automatic work-piece loading, including transfer from one machine to another.

- Change in turret design of the lathe to incorporate the facility of doing threading on the machine.

- Increase in internal grinding speed from 20-35 m/sec to 50-60 m/sec using a higher powered spindle, special fully enclosed guards and a high pressure coolant system.

As far as automatic work-piece loading is concerned, this is a useful addition to any machine, but is by now considered fairly routine in the machine tool industry. With regard to changes in the turret, HTM has accepted the redesign, and such machines are now being exported by PMTMTA to HTM subsidiaries in Singapore and Japan.

The modification in the internal grinder to almost double the machining speed has similarly been accepted by Voumard, and is a remarkable achievement reflecting PMTMTA's successful absorption of the imported know-how and quick understanding of the grinding process.

That PMTMTA is today able to transfer design methodology through licensing agreements, make technological developments on the machine, indigenise and launch new products is because it started out as an HTM subsidiary, getting in-depth know-how and training for its workers in FRG and at the domestic plant. This helped develop a strong and sound technology base on which PMTMTA has built further through licensing agreements. While it took some ten or twelve years to properly assimilate the design and manufacture of automatic lathes, the company is today already developing a simple CNC lathe based on its own design, just one year after obtaining CNC lathe technology.

In PMTMTA's case, design methodology is transferred as part of the training of their personnel by the foreign collaborator. Managerial and technical staff receive training at the domestic plant as well as for 8-12 weeks at the collaborator's plant. The objective is to let them familiarise themselves with the methods, fixtures and equipment for assembly, sub-assembly, etc. This gives design engineers, for instance, the opportunity to pick up the finer details that cannot be or are not adequately conveyed through the drawings and other technical documents. These are best learnt through hands-on experience or through talking to people actually involved in the manufacturing process, who are, as a rule, more frank and less secrecy-conscious than marketing personnel. Therefore, full use of the training offered by the collaborator of personnel already experienced in machine tool manufacture is a must if the new technology is to be successfully absorbed.

Indigenisation plans are, in general, such that initially, 70 per cent of the components are imported, and 30 per cent procured domestically. Non-critical easily-manufactured parts like guards, and standard components like switchgear and cables come under the 30 per cent. Within five years, more than 85 per cent indigenisation is planned, so that only a few critical components that are not available domestically and are very difficult to manufacture continue to be imported. However, in the case of internal grinders, more rapid indigenisation has taken place, because the declining value of the rupee made it uneconomical to import components. At the same time. the company has used the currency fluctuation of the rupee to its competitive advantage by increasing exports.

Conclusion

The large-scale application of controls technology to machine tools. initially in developed countries like Japan and the Federal Republic of Germany and now in the Republic of Korea and the Taiwan Province of China, has left India facing a substantial product technology gap. The quality and sophistication of machine tools in use affects the international competitiveness of products produced by the industry itself, and in addition has ramifications on the competitiveness of most other industries as well.

Therefore, the Indian machine tool industry needs to rapidly absorb a sophisticated and fast changing technology, in particular CNC, if it and its customer are to be able to compete in domestic and foreign markets. In this, manufacture of CNC hardware by Indian computer manufacturers would help considerably.

The volume of domestic demand in the variety of CNC machines needed is not likely to be large enough to justify investments unless exports are possible. Hence, while signing such collaboration agreements, it must be ensured that they do not, formally or informally, curtail exports of CNC machines.

At the same time, however, Indian manufacturers must not neglect the opportunity for increasing exports provided by the pullout of most foreign manufacturers from conventional machines.

PMTMTA is a case of a company that has used this strategy to its advantage. It has successfully absorbed foreign technology, is a regular exporter to hard currency markets and has, in the 80's, diversified its product mix to include more complex and sophisticated machine tool technology. Its success is in large measure due to the fact that it started out with a strong technological base, built upon it and benefited substantially from the PMT network in terms of identifying domestic product need, timing, choice of collaborators and target markets at home and abroad.

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CHAPTER IX

MANAGEMENT OF TECHNOLOGY AND CHANGES

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Goods, people, information and technology are moving across the globe at ever increasing speeds. Technology, in particular, is cutting across all political, economic and trade barriers. The automobile is a conglomeration of virtually all industrial technologies and products from basic raw materials like steel, copper aluminium, zinc, rubber, plastics, natural and man-made fibres to sophisticated alloys and ceramics. Aerodynamic factors dictate body design and modern manufacturing methods use computer controlled robots. Today micro computers fitted on the vehicle monitor important aspects of performance and control the engine and braking systems to a high degree of efficiency.

The major automobile manufacturers compete worldwide with manufacturing centres in dozens of countries. This has led to a greater stress on transfer of technology than perhaps for any other product that we can think of. Product standards and specifications travel with the product and over a period of time merge as they interact through the component suppliers. There is also a constant pressure on upgradation of technology.

The Indian automobile industry was insulated from the technological progress taking place in the rest of the world until three years ago, with the introduction of the Maruti-Suzuki. Since then, the growth of the industry has been dramatic. Other foreign tie-ups have materialized for Light Commercial Vehicles (LCV)s, 2 wheelers and established manufacturers have scrambled to upgrade their products or introduce their own new vehicles. The component suppliers have also been busy responding to new entrants who have come in with the latest technology. A host of new tie-ups have emerged, and industry capacity is being rapidly increased to meet the demand.

The challenges for the Indian automotive ancillary industry are seen on two fronts.

- meeting the quality and volume requirements of the new generation of vehicles in the domestic market

- absorbing the latest techniques of manufacturing to upgrade efficiency of production to world levels and export at competitive prices to the developed countries.

The two challenges are interlinked in many ways. Although the new vehicles bring with them some of the most stringent specifications, which are being met by the vigorous effort of the ancillary equipment suppliers, the high cost of production is a serious bottleneck to exports. This cost is not only due to the high cost of the raw materials e.g. steel, but also due to high wastages since our manufacturing processes and, in fact, our thinking processes have to catch up.

We present here a case study of Rs.80,000,000 (about US$5 million at 1988 exchange rate) project set up by us in 1980 for the manufacture of thin wall engine bearings, as a Division of Gabriel India Ltd. There was financial and technical collaboration with one of the top bearing manufacturers of the world, Federal-Mogul Corporation, U.S.A. The project was designed to be a fully integrated facility from the start, making copper lead alloy powder, sintered bimetal strips and fully machined and plated bearings, bushes and thrust washers. The plant was located in a backward area of Himachal Pradesh. Currently, it has a 25% market share, competing with two established indigenous manufacturers and imported bearings.

Our experience with this project has been mixed and has brought out some important factors that govern the management of technology and changes in the Indian context. We give below the aspects which appeared at different stages of the project and which required new sets of approaches to handle the technology management challenges.

1. Absorption of Technology

   - training of technicians
   - manufacturing equipment
   - raw materials
   - technical discipline
   - in house R&D

2. Adapting imported technology to Indian conditions
3. Locational problems
4. Management insights
5. Change

1. <u>Absorption of technology</u>

<u>Training of technicians</u>

The absorption of new technology takes time. It must also be done before the product is sent to the market, otherwise, an inferior product will ruin the reputation of the company at its most vulnerable stage. Several cases where this has happened are well known in the Indian industry.

In some cases, this difficulty can be met by SKD/CKD imports and a phased manufacturing program. This is however, not possible in the process based industry. Technicians therefore have to be trained at collaborator's plants well ahead of the planned start of production and for periods of time sufficient for them to fully grasp the basic nature of the technology.

We started our technician training program almost three years before start of trial production. The training period for each technician ranged from four to eight months. We found that a minimum of six months was required for a well qualified and skilled technician to gain a proper insight into a new process. We also continued to send technicians for shorter periods once production started. to study particular aspects of the technology which required closer attention, as well as study new manufacturing processes as we expanded our range of manufacture. In the period of eight years, over twenty technicians were sent for training of which four are still at the plant. More on this later.

It is also well understood that the training received by the technicians at collaborator's plants is not quite adequate for independently starting on their own. The collaborator's operations look deceptively simple, but it is to be realised that they are being run by seasoned personnel with a combined experience of hundreds of years.

We had technicians from our collaborators during the commissioning of each stage of our operations and subsequently more technicians were invited for short periods to review and streamline our working. More important, it served to ensure acceptable product quality from the process point of view right from the start.

This of course did not mean that we were anywhere near mastering the technology. Productivity was low, rejections were very high. Apart from the learning curve of the technicians, other important factors were responsible.

Manufacturing equipment

The collaboratoring company, over the years had automated its production facilities and had established different manufacturing lines for each type of product. Its large volumes justified this investment. In the Indian market, only manual all purpose equipment was affordable, especially at the start up stage.

The downsizing/multitasking of the equipment from high volume/automatic to low volume/manual naturally meant lower productivity and more rejections due to more frequent machine set ups. These conditions will remain until production volumes rise over the years to justify additional investment in automation.

But what is infinitely more important is that this placed an additional load on the Indian technicians to fully grasp the technology so that they could produce the variety of products from the limited equipment. This ability to innovate cannot be developed at the collaborator's plant, because these conditions do not exist there now.

We were faced with this problem as our collaborator had divided his product range into two separate plants located in different cities altogether. Equipment and process parameters were naturally different and some forced commonality had to be effected in the equipment. This required very many trials after installation in India to establish the new process parameters.

This brings out one of the most important lessons of our experience, that experimentation and development of the imported technology to suit the Indian conditions is a must. This necessity appears again and again in many forms as we look at the other factors and is something of which Indian managements need to be much more aware.

Raw materials

The imported technology assumes that raw materials are available to certain specifications. This can be a source of acute problems. In our case we needed extra deep drawing steel to make flanged type bearings which were manufactured by press forming. This grade of steel was not readily available and our rejections for this type of bearing due to cracking of the steel during the cold forming operations were above 50%. The situation is not very much improved today and we do have instances when supposedly the right grade of steel is supplied, only to have the entire production lot rejected on account of steel cracking.

We feel that any improvement in the quality and grading of steel manufactured in the country will provide immediate economic benefits to the entire industry.

Technical discipline

In the supplier's market which exists in India with some notable changes being seen only now, technical discipline in terms of strict quality control, and equally important, the development of manufacturing methods to reduce rejection and wastage has been notable by its rarity. Customers, of course, have had to accept whatever was available. Imported goods generally enjoyed a premium due to their better quality. There was a general feeling that higher quality meant an additional expense which should be avoided to whatever degree possible.

It required the japanese 'miracle' to convince us that the opposite was true. In pursuing the goal of a quality product, improvements in manufacturing technology to increase productivity and reduce wastage become an unavoidable part of the working of the organization. This naturally leads to better market acceptance and market share, larger volumes, more automation, lower costs and so on.

In our case, we were manufacturing a critical product in that a failure resulted in consequential costs to the user for exceeding the cost of the product. Due to this reason, users were exceedingly sensitive to product quality. We did experience a few instances of defective product inadvertantly reaching the market due to labour trouble. The market reaction was immediate and we had to ensure that dealer stocks suspected of defects were returned to the plant for re-inspection.

This enforced sensitivity to quality is substantiated by the high rejection rates experienced by the plant until very recently when we have turned our attention to the second part of the technical discipline, i.e. to improve the manufacturing technology for better control of the process. Undoubtedly, as competitive pressures increase domestically and we aim at export markets, this part of the management of technology will receive more importance. It is greatly overdue.

In-house R&D

A brief mention has been made of the necessity of experimentation to adapt imported manufacturing process technology to Indian conditions. This is actually the tip of the ice-berg. The concept goes much deeper and in fact determines the success of a technological enterprise.

Let us begin the examination of this concept with the training of technicians. The "how to do it" is the first part of the learning. Up to now, this has been considered as quite sufficient, given stable technology and a supplier's market. What is now beginning to be understood is that the rate of change of technology is accelerating. A process or design which lasted for decades is now obsolete in a few years. The computer industry, where product life is now measured in months rather than years is a good example of how fast technology can change. Secondly, importing technology is no longer cheap. Thirdly as will be elaborated in the next section, the imported technology may not always suit the Indian market. It is, therefore, required that the technician also understand the "why is it done" of the imported technology so that if the need arises to meet a local condition, say the nature of the raw materials, he can confidently modify it. This part of "why" is much harder to get from the training at the collaborator's plant since here, experimentation is required and both time and opportunities are limited. This part is therefore best carried out in-house.

The collaborator is also not standing still and will continue to develop his technology to survive in his competitive environment. If this knowledge is not absorbed on a regular basis, then after some time the gap will again widen.

The other vital area where in-house R&D can contribute is in upgrading the technical discipline of the operations so that the learning curve continues to operate to reduce the cost of production, by productivity improvements and reducing wastage. If the learning is allowed to get stuck at the point of start of commercial production, the enterprise is also likely to be left high and dry over a period of time.

The absorption of technology is, therefore, a continuous process and can only be done if an ongoing technology development activity is maintained in-house.

2. Adopting technology to Indian conditions

It has been our experience in the automobile industry that Indian conditions are significantly different from those existing in the North American/European/japanese environments from which the bulk of our technology is obtained. the major differences are :

- High ambient temperatures
- Dusty atmosphere
- Uneven roads or no roads
- Overloading of vehicles
- Improper maintenance practices

Imported designs which have been optimized and value engineered to suit the collaborator's environment may not work in India. This is a particularly dangerous area for the Indian high technology project as the knowledge and experience of the technical and marketing teams is generally low in the beginning. A mishap on this front can lead to the untimely demise of the project unless very quick corrective action is taken. The collaborator can provide some guidance if he has experience in similar environments, but ultimately the answer has to be provided locally.

We have also found that the fitment practices followed by overhaul garages in the replacement market do not, in many cases, conform to the specifications laid down by the original equipment manufacturers. There are a variety of reasons for this, including inadequate training of machanics and a lack of awareness among users.

These factors place an additional requirement of sturdiness on the product for the Indian market.

Vehicles in India are also operated for a much longer life than in the developed countries. Parts are reconditioned again and again whereas they would be normally replaced. This brings up the requirement on the Indian component manufacturer to incorporate design features in his product that would assist in the reconditioning to the extent possible.

When we launched our product, we found that our design which had been approved by our collaborators and which also passed all the requirements of the original equipment manufacturer (OEM), had an unacceptably high failure rate in the replacement market. The collaborator, not having experienced this problem , was unable to provide an answer. A study of the problem locally soon showed that an improper but widely followed fitment practice was resulting in overloading of the bearings. Steps were immediately taken to strengthen our design and a major problem was averted.

Similarly, there are very many component design features required by the replacement market which are meant for ease in reconditioning. These are naturally of no use to the original equipment manufacturer. In order to carve our a share in the engine bearings replacement market dominated by existing manufacturers and imported bearings, we produced with great success, bearing designs exclusively for the replacement market which were different from those being supplied to the OEMs.

This responsiveness to customer needs was possible because of the availability of senior technical personnel in the marketing function so that accurate and timely customer feedback could be provided to the plant. The role of the collaborator was naturally limited to advising whether a proposed design change would adversely affect the functioning of the component or not. Clearly, the collaborator has limitations in advising what design features would be most suited here. A strong technical link with the customer for the success of a technology is a must.

3. Locational problems

Our experience has been that setting up a medium scale unit in a backward area has been a major problem.

In the course of erection, installation and commissioning of equipment, we experienced numerous delays because of unavailability of simple erection materials, tools, etc. locally. Today, this problem applies to spare parts for the machinery since all possible spares cannot be maintained in the plant. The utilization of the equipment is affected and consequently the productivity.

Communications is the other source of delays. It is not possible to have direct communication with the plant from even the head Office at Delhi. We therefore operate an office in Chandigarh for relaying messages.

By far the biggest problem has been to provide a stable environment from the personnel point of view. We had trained over twenty technicians at the collaborator's plants, of which four remain today. As discussed throughout this paper, it is the people who make technology work, not machines. The high turnover of personnel at the plant, we believe, is the single most important reason for the mixed performance observed.

4. Management insights

We believe that the successful management of technology requires attention to the following key areas:

Quality of the human element

The technology is really held in the heads of people, not in the machines, manuals or drawings. The latter are only a means for the people to effectively utilize their knowledge.

Workforce stability

An organization must have workforce stability in order to flourish. Our exposure to collaborator's plants revealed that most of the people from machine operators to departmental heads worked in the same plant for most of their careers. A substantial number had been on the job for 20-30 years. This most certainly did not lead to stagnation as their interest in their work was maintained by the rapid pace of process/equipment/product development going on all the time to maintain their competitive edge. There were also parallel ladders for growth of technicians in that it was not required for a skilled technician to become a manager with adminsitrative duties in order to get higher remuneration.

In-house R&D

A consistent ongoing in-house R&D effort is required for absorption of technology, adopting it to Indian conditions, responding to customer demands and advance in the learning curve to improve producrivity and reduce costs.

Human resource education and training

The involvement of the entire workforce is required to get the maximum benefit of the talent, energy and experience available with them. This can only be done if they are trained and motivated. We have initiated several training programmes on quality and wastage control with very encouraging results.

Systems

Systems are administrative procedures for management to ensure that the integrity of the technology does not deteriorate with passage of time and no short cuts are taken. This part of the absorption of technology has generally been neglected and most projects are set up and left to develop their own systems. All too often, the systems do not get developed due to the low priority given to them and over a period of time important parts of the imported technology are forgotten. The result is a deterioration in the performance of the project with time whether in terms of quality or wastages, rather than an improvement.

It should be noted that the systems used by the collaborators have been refined over a period of time and would form the best base to start with in the Indian project.

Systems therefore, should be considered an essential tool in the management of technology.

6. Change

In the last eight years, we have seen many technological changes taking place in the engine bearings industry.

A number of new engines of current designs have been introduced into the country which demand new bearing materials and manufacturing methods.

Exports in very large volumes to the rupee payment countries have begun, opening up the possibility of investing in high volume automated equipment.

The exposure to world standards and specifications is a good opportunity to upgrade our ability to handle technology. Again, it is people who are the key resource in managing technological change. There is nob doubt that we have the talent. We must now create an environment of awareness, co-operation and the will to respond to change.

CHAPTER X

CASE STUDY OF ONGC

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The corporate environment has undergone dynamic changes over the years in response to internal and external factors. There are no sure-fire strategies or models to copy for definite results. The straight line strategy has become a casuality in this fast-changing corporate environment. There is increasing pressure on an organisation to adapt itself to new environment.

Management of Change

The management of change has emerged today as a crucial factor for ensuring corporate growth. The enterprises which do not grow will gradually stagnate and perish. Therefore, the success of an enterprise largely depends upon its capability to manage change and reorient its strategies to the internal and external factors for continuous growth with stability and continuous improvement in productivity.

Management of change has been influenced by changing times. The organisations which have failed to adapt themselves have gradually perished. Today, world economy is growing at a sluggish pace with increasing elements of protectionism, with the rise of Japan as a major economic power, with the emergence of newly industrialised nations and with international trade being fiercely competitive. Technological breakthrough has led to decrease in costs and increase in competition. Advanced technologies have ushered in a new society with increasing sophistication, diversification and differentiation of products and services and a better quality of life.

Public Sector

Today the public sector in India has about 226 enterprises with a total investment of Rs.6160.3 million. Despite the increasing importance of public enterprises and their expanding role in the social and economic development of developing countries, there is growing concern about their performance levels. With government facing increasing resource constraints, it is all the more an urgent necessity for the public sector to improve its profitability. Technology is one such factor, for any public sector to adapt to being competitive and increase its performance.

Industrial production during 1980-87 increased at a compound rate of 7.6 percent per annum compared with 4.2 percent between 1971-80. Industrial production grew by 9.1 percent in 1986-87 while exports grew by 10.4 percent in US dollar terms. In the current decade, India has adopted an outward oriented approach, a welcome departure from industrial controls and bureaucratic approach of the past along side efficient import substitution policies. A broadening and deepening of initiatives both in trade and industry is in progress. There is all-round keenness to absorb industrial technologies and given its low wage rates, India should be self reliant in core sector and export more goods competitively.

Modernization

Technology assumes critical importance not only for competitiveness but also for industrial progress. Today, India cannot afford to produce steel at Rs.8000 per tonne, coal at Rs.240 a tonne, aluminium at Rs.24,000 a tonne and a unit of electricity generated at Rs.7.00 for any socio-economic justification. Modernization is the key to efficiency.

It is prudent for the professional management of any enterprise, be it in public or private, to cope with the change and adapt to changing environment through technological change, process-technology upgradation and modernisation.

Management Focus

To my mind, there are three basic elements involved in managing an enterprise: (a) the scientific part of the management; (b) the human relations part of management (leadership); and (c) managing the environment-pressure groups, politicians, bureaucracy.

The scientific part of management deals with infrastructural support systems, procedures, long term plans, technology support and upgradation, research & development process and the human relationship aspect deals with man-management, motivation and morale, innovation and creating right environment conducive for generating ideas. This is one of the most crucial elements in getting the results. The leadership and top management in an enterprise is crucial in this process. Lastly, managing the environment-the corporate image through effective communication strategy assumes importance.

I would like to draw attention to the success of the oil industry in the Indian context and the role of technology in the process.

Petroleum Industry

Oil is perhaps the most important energy source in terms of its contribution to economic growth in the industrial era. Despite appreciable variations in the price of crude oil, all energy forecasts indicate that by the year 2000, oil will meet one third and hydrocarbon will meet more than half of the world's energy demand. Future reserves will largely be found in traps that are increasingly difficult to map and logistically difficult, due to terrain. Worldwide upstream ventures have necessitated the development of new technologies for the lowest possible cost options both for addition to reserves and development activities of this vital sector.

Technological developments

The accumulation of hydrocarbons is the outcome of a sequence of physical, chemical and biological processes that have acted on the crust of the earth through geological history. Comprehensive data analysis forms the basis of all seismic resolution techniques. In data acquisition the trend has been to sample the seisimic signal at ever increasing density to improve resolution and the signal to noise ratio. ONGC has introduced 3-D seismic surveys with more channels for the recording of each shot. Information on subsurface geometry and lithology through data processing has been more refined by using state of the art computers for seismic data processing. Today, ONGC is equipped with possibly the most sophisticated seismic data processing facilities in South Asia region. 3-D velocity determination by travel time inversion, 3-D migration and 3-D modelling are being developed to understand the subsurface and its history. Vertical seismic profiling, a technique used for more detailed subsurface mapping ahead of the drill bit and around the bore hole is being attempted. With interactive work stations introduced in ONGC, analysis of subsurface has become more refined with seismic, petrophysical and geological data bases. Reservoir simulation and modelling has paved way for planning and optimising of all phases of appraisal and development of oil and gas fields.

Prices of oil being volatile, improved oil recovery from existing reservoirs is being pursued all over the world with Enhanced Oil Recovery (EOR) techniques. Today, ONGC has initiated nine EOR projects of which four pilot projects has been successfully commissioned. Improved EOR technology is expected to make significant amounts of oil available at prices in the $25 to $40 a barrel range when oil markets are expected to tighten in the forseeable future.

In drilling operations, new concepts such as horizontal drilling have been successfully applied in two wells by ONGC out of 17 such wells drilled worldwide. Horizontal drilling offers considerable scope for cutting drilling costs and increased production rates specially from thin oil columns and basement oil. ONGC is in the forefront of this technology which promises improved offshore production in India.

During 1971-85, the world has witnessed major developments in fixed platform structures. The floating production system, a phenomenon of the 80's, has succeeded in creating new economic opportunities. ONGC has planned for four floating production systems in the Bombay offshore for taking advantage of this contemporary technology. Another area where large - cost savings is being attempted is through reduction in weight of top side structure which has resulted in substantial savings in North Sea operations. Sub-sea completion and development involving rational use of existing structures and equipment is being implemented by ONGC which offers considerable scope for cost savings.

Initiatives

Having discussed the technological developments in the oil sector, I would like to highlight the initiatives at our organisational level for keeping abreast with contemporary technology which has not only helped ONGC to be self reliant but also become a net exporter of technology to industrialised nations.

Technological developments involve improvement in existing concepts. development and application of new concepts which offers considerable potential for hydrocarbon exploration and development with reduction in cost of operations.

Long Term Plan

The enterprises should develop long-term plans for technology development based on "State-of-Art" reports. This has helped ONGC in identifying technological challenges and thrust areas for our institutes.

R&D Units

Research and Development is a cornerstone for success in any growing concern on a sustained basis. In line with this, ONGC has set up five research and development centres covering exploration, reservoir studies, drilling technology, ocean engineering and technology and production technology. Also centres for environment and safety and geo technic research have been planned to cater to the needs of the South Asian region.

Profit centre concept

Today, ONGC has identified R&D institutes as profit centres. This is a novel concept which has led to considerable improvement in the functioning with elements of time, cost and resource framework defined and generating profits.

Industry-university interaction

A dialogue has been initiated with leading institutes/universities for joint collaborative projects in the field of oil operations. Also basic research has been farmed out to these institutes with application of concepts being developed by the industry.

Farming out low technology

ONGC has identified through a careful planning process, key thrust areas for technological development with farming out low technology areas to the small cooperative sector and development of ancillary units. This has resulted in the management time being devoted to the business of oil exploration. We have been able to experiment this with success with several fold increase in productivity.

Historically the public sector has brought under its control a variety of technologies ranging from the lowest to the highest. This had an adverse effect on growth opportunities for the enterprise.

Human Resource Development

The approach to human resource development is based on an explicit recognition that every individual can make a positive contribution to the organization. The best of equipment and facilities, including technical libraries for scientists and engineers, are provided. But more important than the physical facilities is the work environment and work culture in which there is a constant striving for excellence. There are two significant features of this environment and culture: firstly, there is the 'freedom to operate' which provides the opportunity for the exercise of skills and judgement and, secondly, outstanding performance is recognized by giving awards and by publishing the work of the 'pace setters'.

Strategies

A multipronged strategy has been adopted for technology development in all areas of operations for cost reduction and application of new concepts in oil operations.

Technology Scanning

Technology scanning is being done on a continuous basis through desk research and also by attending conferences worldwide to keep abreast with developments in entire chain of oil operations. 'State of-the-art' reports are published for identifying technology challenges and accordingly the R&D programme is firmed up.

Technology upgradation

A deliberate policy for technology upgradation is being pursued through joint ventures and foreign collaboration in all areas of oil field equipment, material and services to ensure adequate flow of technology with firm commitment of transfer of technology.

Joint working groups

ONGC has formed joint working groups with the confederation of Engineering Industry and CHEMEXIL for promotion and development of technology in the oil sector with an objective of self reliance in technology through a phased indigenisation programme.

Conclusion

In conclusion, it may be added that keeping pace with technology is the only way to stay competitive and achieve productivity improvement for sustained growth which is extremely vital for the very survival of the organization. Organizations both in private and public sector have to keep abreast of the technological developments and suitably adapt them to the Indian conditions.

CHAPTER XI

CASE STUDY OF A CEMENT PLANT

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Introduction

In any industry it is necessary to adapt a process in keeping with changes in the quality of raw materials. In a study on a cement plant, presented here, the kiln was designed by a foreign multinational (FLS Smidth with their Indian tie-up with M/s Larsen & Toubri) on the premise that the heat value of coal used/charged in it would be 5,500 to 6,000 kilo calories per kg. Unfortunately, on commission, it was observed that the heat value of available coal actually charged was in the range 4000 - 4500 K-cal/kg. The quality of limestone, on taking to consideration the source of supply also appeared uncertain. Technological innovation was an imperative in order to tackle the situation.

The paper incorporates a study done jointly by the Society of Management Science and Applied Cybernetics and the Cement Corporation of India (the latter are the owners of the Cement factory at Rajbans) in 1981, after the factory was commissioned.

The paper presents a systems approach in studying a complex system like a cement factory. An important problem in most of the production units is the necessity to apply adaptive technology to cope with changes in qualities of the raw materials. For the setting up of units on the basic industries, it is necessary to keep in view certain constraints of the Indian situation, viz., existence of high ash in coal, high ferrous content in iron ores, certain features of limestones, etc.

Energy economy in the kiln

The Cement industry is energy-intensive by nature: not only does it require considerable amount of fuel (mostly coal in India) to burn the raw meal in the kiln but it also requires substantial amount of power for grinding purposes at various mills in a cement plant viz. raw mill, kiln, cement mill etc. For most of the plants in India the triumvirate - coal, power and transport - plays a significant role. In the case of Rajban Cement Factory there is no major problem in transport either in transporting raw materials to the plant or in despatching the finished products from the plant. Accordingiy coal and power form important inputs in the production process.

a) Power consumption

The relationship between the amount of power consumption and production of clinker at the kiln was studied. It clearly points out the fact that the two are positively correlated - increase in production in clinker is always accompanied by increase in total power consumption and vice-versa. There is, however, an indication that when production of clinker at the kiln increases, there is lowering in the power consumption rate (KWH) per tonne of clinker). This correlation similarly holds good for other equipment like crusher, Raw Mill, Cement Mill, etc.

b) Coal consumption

The pattern of coal consumption in the kiln has been studied. The present requirement of coal is of the order of 0.21 tonnes per every tonne of clinker produced. The kiln has been designed for a quality of coal of heat value in the range 5500 to 6000 K.Cal/Kg. of coal. Unfortunately, sample studies indicate that heat value of coal obtained is of the order of 4,500 K.Cal/Kg of useful heat value. The heat value of coal can be predicted with precision from the knowledge of ash and moisture from the following formula:

$$H = 8900 - 138 (A+M) \text{-------}$$

of HEAT VALUE = 8900 - 138 (ASH+MOISTURE) ......

where A is the ash content and M is the Moisture and H is the heat value in terms of K.Cal/Kg. From the above formulae, therefore, the maximum value of A+M, in order to get heat value of 5500 Kc/Kg., (as per Kiln design) should be 24% Kcl/Kg. It should be 32% with inherent coal moisture around 5%.

c) Variation in Quality of Coal and Benefication

A detailed study of variation of ash and moisture in non-coking coals was undertaken. In this context, it has been observed from studies of samples at various collieries in India - that the quality of coal from Raniganj Coal-Field may vary anywhere between 14 and 40% in terms of ash and 1 and 9% in term of moisture in spite of the fact that the nominal grade allotted to a group of collieries is grade A (e.g. AAAA+M ranges between 19 to 24). Similar variations are noted among coals of South Karanpura, North Karanpura, C.I.C. Coalfield, Pench Valley etc. Such variation is due to the fact that the standard deviation of A+M is exceedingly high due to the occurrence of shales in different parts of the same seam.

Consistent quality can be ensured by two ways:

a) By employing by expert hand-pickers at the loading and by the colliery;

b) By resorting to the washing to non-coking coals;

While hand-picking can be easily done by employing labour in the cement plants for the CCI at the coal gantry, the washing of coal can be done only if washeries are established either at the site of the collieries or near producers. However, the setting up of washeries for non-coking coal can be done only by a centrally operated autonomous body which would decide on the optimal location of washeries and would supply washed coal to major consumers like thermal power station, cement industry etc. An advantage of washing of non-coking coal is that the standard deviation of gloat at a specified specific gravity would be very low so that consistency of quality would be ensured. From a long term perspective, washing provides the most reliable remedy.

d) Energy economy

Practices followed in several countries like the USA, Japan, and West-Germany were studied for suggesting energy economy measures. Apart from implementing measures which would ensure adequate supply of coal and power, inconsistency in quality of coal and the problem of the use of low grade coals will have to be tackled. There are certain latest techniques by which heat requirement in the kiln itself is reduced.

i) Use of salt additives

The US Patent No.4.115, 138 (September 19, 1978) provided a method by which calcination of the raw meal can be done at a substantially lower temperature. This is provided by addition of calcium chloride in the raw meal in proportion between 6 to 100% by weight, so that calcination is formed at a temperature of 1000 C. in the conventional kilns. The clinker thus produced is ground with an additive of gypsum dihyarate (3% by weight of clinker) to produce cement of sufficient strength. US Patent Nos.4.130.441 (December 18, 1978) 4179.302 (December 118, 1978) etc. give further modifications of the process.

ii) Development of Precalcining Processes

In Japan, Germany and the USA development of precalcining is being done at a fast rate. With the complete disappearance of wet kilns in the USA it has been decided that almost all the new kilns started since 1977 will be precalcined. In Japan, the market and transportation structure created the need for very large production units which are only practicable with precalciner technology. The interest in burning low grade fuels led to the first industrial precalciner operation in 1968 in Germany. These and other advantage which were derived from these developments are listed below:

i) improved brick life
ii) reduced alkali and sulphate build-up (ring formation)
iii) improved control and kiln stability
iv) ability to burn low grade fuels
v) possibility of very large production uits
vi) reduction in NoX emissions

Precalciner systems have one common basis - the degree of decarbonation of the raw mix entering the rotary kiln is increased by burning a portion of the total fuel requirement in a precalciner vessel which is part of the preheater and the raw mix enters the kiln 20 to 30% decarbonted, since the rate of heat transfer is vastly superior in the precalciner than in the rotary kiln. The volume of the precalciner is very small in proportion to the rotary kiln volume it replaces. In all configurations the raw mix is fed at approximately 700 C to the precalciner vessel from cyclone.

The precalciner process offers the possibility of using low grade fuels (e.g. coal) which are high in ash content for efficient rotary kiln firing. Besides, precalciners are less susceptibie to ring formation than in conventional preheater systems.

Technological details about precalciner systems and experience in the USA, Japan and Germany can be obtained from the existing literature. (Cooke, 1979).

It is imperative that from a long-term perspective there is a case for introducing precalcining system in cement plants in India; however, the case of each plant has to be looked at both from technical and economic points of view by doing an exercise in cost benefit analysis. Nevertheless, since the future cement plants will have larger capacities and since the existing plants like Rajbans will have to increase their capacity, introduction of precalciner process may help in forward planning because it permits the use of inferior grade coal and also reduces the incidence of ring formation. Besides, precalcination technology improves brick life in the kiln. (Brick lining is a major cause of stoppage of the kiln for "maintenance and repair").

However, some technological changes are necessary for introducing pre-calcination. These will also have to be taken into consideration.

Problems of Maintenance in the Kiln

The kiln comprises the following components:

i) Kiln shell
ii) Supporting Rollers
iii) Preheater Cyclones
iv) Cooler tubes
v) Main and Auxiliary Drive

A detailed study of stoppage times is required to make an assessment of reliability of each component of the kiln.

It appears from the experience of most cement plants, including Rajbans, that the most important factors contributing to the stoppage of the kiln are:

a) Maintenance and Relining Work
b) Ring Formation

Occasionally, cyclone jamming also take place: stoppage due to power shortage at Rajbans has not been significant.

Preventive maintenance (PM) can be characterised as maintenance work carried out prior to actual repairs being required. A PM programme should aim at:

i) Short-term reliability
ii) Long-term reliability, meaning no gradual reduction in efficiency.
iii) long life time of the equipment with special emphasis in wear and corrosion.

For the kiln, a PM programme should be applied to all the equipment. However, a PM programme has also to take into account the nature of raw materials used in the manufacturing process. Accordingly, reliability of the prototype of a kiln design for using coal of heat value 6000 K Cal/Kg would be different from the one specified when coal of significantly less heat value is applied. The same applies to variations in chemical constituents of the raw meal.

It has been observed from the experience of large plants in West Germany, Japan, etc. that use of precalcination technology distinctly reduces the problems of frequent maintenance.

Quality of Limestone

An important factor of uncertainty, lies in the fact that the quality of limestone at present charged in the plant does not represent the quality of the limestone of the hill-top quarry. While chemical analysis data of limestone as charged at present are available, detailed analysis of hill-top quarry data are not available. Nevertheless a confidence range has been estimated from the data of limestone and they are given below in table 1.

Table 1

Confidence Interval of quality constituents of (Weekly data)

Quality Constituent	Mean	Confidence		Interval 95%
LOI (Loss on Ignition)	35.86	35 .76	-	25.96
SiO2	12.76	12.76	-	12.76
AL2O3	3.26	3.18	-	3.32
CaO	44.87	44.77	-	44.97
MgO	.79	0.76	-	0.83

It appears at present that the quality charged is greatly consistent in the matter of various constituents. In the absence of detailed data for the drilling at the hilltop quarry we may not be unjustified in assuming that the same will hold true for the hilltop quarry also. However, it is imperative that a quality monitoring device will have to be installed in the plant as soon as possible. This would consist in installing an automatic sampling device as well as an automatic chemicals analysis device. This would ensure advance information regarding the quality of new material mined to the raw mill personnel who can monitor the quality of raw meal accordingly. However, an off line X-Ray analyser has been installed in the laboratory.

Concluding Remarks

Though the study was done for a particular cement plant, a few remarks, as given below, may be relevant in the context of industrial decision-making in developing countries:

i) While designing a plant in a developing country, the quality and nature of the raw materials should be considered.

ii) For the future policy regarding new cement factories, there is a case for introducing pre-calcination technology. Introduction of pre-calcination in existing plants may not always be cost-effective.

iii) Since cement factories are energy-intensive, it is necessary to apply energy-saving devices.

iv) It is necessary to introduce preventive maintenance schemes, because PM helps in increasing the life-time of equipment and reducing stoppage time.

v) The quality of Indian coals (e.g. high ash and high moisture) makes pre-calcination all the more necessary.

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CHAPTER XII

CASE STUDY OF THE DRUGS AND PHARMACEUTICAL INDUSTRY

Usha Dar

Introduction

Technological change in the drugs and pharmaceutical industry is taking place at an ever increasing pace, making available new drugs or new routes to production. The management of technology in the pharmaceutical industry falls into distinct stages - (1) Research and Development; (2) establishment of proprietary rights over the technology; and (3) commercialisaton of technology which has two aspects, namely; (a) commercial production of the basic drugs or pharmaceuticals; and (b) international transfer of technology.

Management of R & D*

In order to provide an analytical structure for the management of R&D we view it in terms of clearly defined sequential stages. The first phase of R&D is the chemical phase in which new substances are identified and isolated. Either the new substances are extracted from a natural substance or synthesized artificially. Innumerable molecular variations may then be produced for further testing.

The chemical phase is followed by the biological phase. In this phase the samples of the substances which are available are subjected to a number of screening tests to find out whether the substance has the expected pharmaceutical action or possibly some other action which may turn out to be useful. It is important to emphasize the fact that very small molecular differences in a substance can lead to tremendous differences in its effects. For instance, the original Penicillin G, which was a combination of Penicillin notatum culture and phenydacetic acid, had to be injected because the stomach acids inactivated it. When phenoxyacetic acid was used it resulted in Penicillin which had a different side chain and was also able to resist gastric juices and, therefore, could be administered orally.

This case study is based on a larger study by the author on the "International Competitiveness of the Drugs and Pharmaceutical Industry" sponsored by the Indian Council for Research on International Economic Relations, New Delhi.

*This section on the phases of R&D has greatly benefitted by discussions with the Pharmaceutical Manufacturers Association, Washington, the Association of the British Pharmaceutical Industry, London and the laboratory of the Government Chemist, London.

When the substances are found to be potentially useful then they have to go through a series of pharmacological, toxicological, bio-chemical and microbiological testing. The objective of the pharmacological tests is to find out the effects of the substance on the different systems of the body in different animal species. The toxicological tests are carried out on the cells of different animal species and reproductive toxicology investigations of animals. When a substance passes these rigorous tests, which generally take about two years, then tests are carried out on human beings.

In the clinical phase of research, the new drug is tested on a small group of volunteers. This test is to determine whether the drug is well tolerated and whether in fact it does have the expected results. If it fails to meet either of these requirements then the drug is rejected. In case some unexpected results are observed then it is returned for further pre-clinical biological testing. When a drug passes all the requirements then it is tested on a large group of patients who volunteer to have the tests carried out on them. However, it is necessary to explain to them in as much detail as possible the known direct effects and side effects.

After the substance has passed the biological research phase it moves into the galenic phase. In this phase it is tested for composition, purity, stability over time and in different environmental conditions. These tests provide the basis for setting production specifications and standards for quality control. After the final specifications have been developed, work can begin on the setting up of a pilot production plant.

This brief description of the various phases of research shows that a high level of risk is associated with each phase and, therefore, the management of risk is crucial in the management of technology.

Table I shows the pharmaceutical R&D expenditures by country and Table II shows the number of new substance developed by inventor countries.

TABLE I
PHARMACEUTICAL R&D EXPENDITURES BY COUNTRY

COUNTRY	1964 LEVEL ($ Million)	WORLD SHARES (Percentage)	1973 LEVEL ($ Million)	WORLD SHARE (Percentage)	1978 LEVEL ($ Million)	WORLD SHARE (Percentage)
United States	282	60	640	34	1159	28
Germany	40	8	310	16	750	18
Switzerland	38	8	244	13	700	17
Japan	27	6	236	13	641	15
France	28	6	166	9	328	8
United Kingdom	29	6	105	6	332	8
Italy	15	3	82	4	147	4
Sweden	9	2	33	2	72	1
Netherlands	9	2	26	1	72	1

Source: OECD Directorate for Science, Technology and Industry "Impact of Multinational Enterprises on National Scientific and Technical Capabilities", Mimeograph, Paris, 1977 quoted in "A Competitive Assessment of the U.S. Pharmaceutical Industry"

TABLE II

NUMBER OF NEW SUBSTANCES BY INVENTOR COUNTRIES

	Country	1961-1983	1981-1983
1.	United States	377 (29.6%)	24 (21.0%)
2.	France	284 (22.4%)	13 (11.8%)
3.	West Germany	217 (17.0%)	16 (14.5%)
4.	Japan	196 (9.0%)	41 (37.3%)
5.	Switzerland	115 (6.6%)	6 (5.5%)
6.	United Kingdom	84 (6.6%)	10 (9.1%)

Source: Office of the Technology Assessment, Commercial Biotechnology, An International Analysis, Washington, DC. 1984. Quoted in "A Competitive Assessment of the U.S. Pharmaceutical Industry"

United States ranks first both in terms of R&D expenditures and the number of new substances developed, but the percentage share of U.S. has declined from 60% in 1964 to 28% in 1978. The R&D expenditures, relative to world R&D expenditures, have also declined for France, United Kingdom, Italy, Sweden and Netherlands. The R&D expenditures have increased for Germany, Switzerland and Japan.

Table III shows the world's leading companies in the development of new drugs.

TABLE III
LEADING COMPANIES IN THE DEVELOPMENT OF NEW DRUGS SUBSTANCES
FROM 1961-1980

Company	Country	Number of Substances*
1. Hoechst-Roussel	West Germany	50(2)
2. Sanofi	France	44
3. Sandoz	Switzerland	38(2)
4. Rhone-Poulenc	France	40(1)
5. Johnson & Johnson	U.S.	37
6. Boehringer Ingelheim	West Germany	36(2)
7. Bayer	West Germany	35(4)
8. Ciba Geigy	Switzerland	33(3)
9. Roche	U.S.	29(2)
10.Pfizer	U.S.	26(4)
11.Upjohn	U.S.	25
12.Lilly	U.S.	23(2)
13.Warner Lambert	U.S.	22
14.Schering	West Germany	22(3)
15.Merck Sharp & Dohme	U.S.	21
16.L"Oreal	France	21
17.Montedison	Italy	21(1)
18.Glaxo	Great Britain	20(1)
19.Dow	U.S.	20(1)
20.I.C.L.	Great Britain	17
21.Bristol	U.S.	16(1)
22.Pechiney Ugine Kuhlman	France	16
23.Merck	West Germany	16
24.Squibb	U.S.	15(1)
25.Degussa Pharma	West Germany	15(2)
26.Syntex	U.S.	15
27.Servier	France	15

*Figures in parentheses indicate substances developmed simultaneously in two countries.

Source: MM&M - 1983; Quoted in "A Competitive Assessment of the U.S. Pharmaceutical Industry" Washington 1984.

Many of the new "drugs of the future will be products of the new knowledge obtained from recombinant DNA research".

It is visualised that "Biotechnology will give rise to a vast array of new inventions. the inventions may be placed into two general categories, products and processes. Products will include organisms. such as genetically modified micro-organisms. cell lines. hybridomas. plants. and possibly even animals. Products also include parts of organisms and related material such as high expression plasmids, viral vectors. synthetic genes. probes. and restriction enzymes. Finally. there will be products of organisms. such as drugs. chemicals, biologics, and monoclonal antibodies (MABs). Processes will include various ways to make new organisms or parts thereof or to use an organism to make some product such as insulin. Other examples of processes include various bioprocessing techniques. regeneration of plant tissue culture, breeding techniques. and methods of treating the human body".

According to the Bristol-Myers Report, in applied use the development of genetically engineered vaccines is seen as the most promising area of research. Genetically engineered vaccines will also have the highest impact on medical treatment and much or some of the improvement in the prevention or treatment of AIDS by the year 2000 are seen as a result of the products of biotechnology. The greatest improvement is expected in the treatment of hepatitis and malaria. Some improvement through biotechnology is also likely to take place in the treatment or prevention of cancer and leukemia.

"The era of successful commercial application of products developed by new biotechnological techniques is in its infancy. Major breakthroughs in genetic engineering techniques have only occured within the past decade. The first biotechnology products have just entered the market or are undergoing clinical trials. In the United States, only one product of human consumption, Genetech and Eli Lilly's rDNA-derived human insuln, has been approved for marketing, and several others (including an analogue human growth hormone, three interferons, proinsulin, tissue-type plasminogen activator, interleukin-2. and bovine (GH) have been approved for clinical trial. Diagnostics for human diseases, based on moloclonal antibodies and DNA probes, are being marketed. Ganex has introduced an enzymatic drain cleaner and is selling the phenylalanine component of aspartame. A broad spectrum of products are in the development stage, and the design and construction of manufacturing plants for large-scale production has begun" (see reference No. 4 at end of chapter).

"There are two levels of problems in producing genetically engineered substances; at the basic research level and at the production level. With regard to problems at the basic research level, there are many unknown concerning the structure, organisation and expression of genes. chromosomes, proteins and other substances. For example, the genes of many industrially useful micro-organisms have yet to be identified. A major barrier exists with respect to a lack of knowledge and understanding of the mechanisms and regulation of multi-chromosone expression and of germplasm delivery systems for plants and animals.

Technical barriers to be overcome during the scale-up process include optimising micro-organism growth conditions and optimizing equipment and production techniques. These problems are usually attacked in the intermediate-stage pilot plant, working with culture volumes of a few hundred liters. Pilot plant studies add two or more years to the development process -- often at the cost of a few hundred thousand dollars -- but they are essential before several to tens of millions of dollars are invested in a full-scale facility" (see reference No. 5).

At present USA is the leader in biotechnology and there are a number of collaboration agreements between US firms and firms of other countries such as Japan, West Germany, the Republic of Korea, Sweden, Belgium, France, Italy and Denmark. According to the studies, made by the US Department of Commerce which has surveyed the biotechnology developments in a number of countries, Japan is a very strong competitor to USA . The biotechnology drive is spearheaded by establishment firms such as Takeda and Shionogi. By 1984 at least 25 pharmaceutical firms were engaged in research in biotechnology.

TABLE IV

Joint Ventures for Research & Development in Biotechnology for Pharmaceuticals

U.S. FIRM	FOREIGN FIRM	AGREEMENT
Abbot Laboratories	Dainippon Pharmaceutical (Japan)	Joint Venture firm set up in Japan to carry out research in monoclonal antibodies.
Advanced Genetic Sciences (AGC)	Hilleshog AB (Sweden) Tienen Sugar Refinery, Radar N.V. (Belgium)	Joint Venture set up in Belgium called Plant Genetic Systems to carry out research and development in plants and micro-organisms for European agricultural applications.
Applied Molecular Genetics (AMGEN)	Kirin Brewery (Japan)	AMGEM and Kirin have set up a 50/50 joint venture, Kirin-AMGEN, for the worldwide production and marketing of RDNA-derived human erythoropoetin (EPO). Kirin will invest $12 million; AMGEN will provide additional sums and the technology for producing the EPO.

Biosearch	Toyo Menka (Japan)	Toyo Menka will act as agent to import and sell Biosearch biotechnology process equipment.
Biotech Research	Ajinomoto (Japan)	Biotech has an agreement with Fujirebio to develop viral diagnostic kits. Fujirebio will handle the marketing in Japan.
Biotech Research	Shanghai Cancer Institute (PRC)	Biotech has an agreement to develop monoclonal antibodies for the diagnosis and treatment of cancer.
Calgene	Rhone-Poulenc (France)	Calgene has a research contract to develop new herbicide resistant varieties of sun-flower for Rhone-Poulenc Agrochemie.
Centennial Corp.	Nippon Reizo (Japan)	Centennial and Nippon Reizo have agreed to a joint venture in Tokyo which will import Centennial's calf serum, used in cell fusion operations, for resale in the Japanese market.
Cetus	Roussel-Uclaf (France)	Cetus is doing research on a vitamin B12 producing micro-organism.
Chiron	Nordisk (Denmark)	Chiron has a research contract to develop an rDNA-derived Factor VIII antihemophilia product. A second research contract covers a process for producing rDNA-derived human insulin.
Collaborative Research	Sandoz (West Germany)	Sandoz will market Collaborative Research's kidney plasminogen activator (KPA).
DuPont	Sanyo Co. (Japan)	DuPont and Sankyo are carrying out joint research through their joint venture, DuPont-Sankyo Pharmaceutical K.K., set up in Tokyo in 1983.

Enzo Biochem	Meiji Seika (Japan)	Meiji Seika has worldwide marketing rights for reagents developed with Enzo's monoclonal antibodies.
Genetech	Boehringer Ingelheim (West Germany)	Agreement provides BI with exclusive marketing rights outside the U.S. for Genetech's tissue-type plasminogen activator. Genetech receives contract/revenues and bulk sales/royalty revenues. BI has European marketing rights to Genetech"s gamma interferon.
Genentech	KabiGen AB (Sweden	Agreement provides Kabi with worldwide rights to produce and market human growth hormone currently undergoing clinical testing. Genentech has right to supply a percentage of Kabi's needs, and retains right to market produce in U.S. and Canada.
Genentech	Kyowa-Hakko Kogyo (Japan)	Agreement to produce and market tissue plasminogen activator (TPA) thrombus dissolving agents in Japan.
Genentech	Mitsubishi Chemical (Japan)	Joint venture established in Japan to produce serum albumin using rDNA techniques developed by Genentech and Mitsubishi's manufacturing capability.
Genetic Systems	Daiichi Sesiyaku Co. (Japan)	Joint venture to market Genetic System's monoclonal antibodies in Japan.
Genetic Systems	Institut Pasteur	Joint venture to develop and market a diagnostic to detect the virus that causes AIDS.
Genex	Pharmacia (Sweden)	Research agreement to develop a bacteria capable of producing a protein with potential therapeutic applications.

Genex	Green Cross (Japan) and Kabi Vitrum (Sweden)	Research agreements for the production of human serum albumin using Genex's rDNA technology.
Genex	Mitsui Toatsu (Japan)	Genex has contract to develop human urokinase using rDNA technology.
Genex	Pierrel S.P.A. (Italy)	Joint research project to develop a process for L-Phenylalanine (used in the manufacture of aspartame) through an enzymatic route. Pierrel will have exclusive production and marketing rights for the product, using the process under development, in Europe and the Middle East.
Genex	Schering AG (West Germany)	Genex has 2 research agreements with Schering. The first calls for the development of an rDNA product to treat heart disease. Under the second, Genex is to improve an rDNA strain for amino acid production, and develop process technology for scale-up purposes. Both agreements involve exclusive and non-exclusive licensing arrangements.
Genex	Yamanouchi Pharmaceutical Co. (Japan)	Joint venture calls for collaboration in development of fibrinolysis agents through rDNA techniques; marketing agreement will allow Yamanouchi to produce and sell the product in the U.S., France, West Germany, U.K., and Japan for 15 years and pay Genex licensing fees.
Genex	Yoshitomi Pharmaceutical (Japan)	Genex has research contract to develop an rDNA strain to produce human interleukin-2.

Hybritech	Teijin Ltd (Japan)	Teijin will provide $7.5 million over a three year period to develop human monoclonal antibodies. Teijin gets marketing rights in the Far East. Hybritech gets marketing rights for North America; both will share joint rights for the rest of the world. Hybritech gets access to Teijin's proprietary immunochemistry methods.
Hybritech	Toyo Soda (Japan)	Agreement to jointly develop and produce diagnostic test kits based on monoclonal antibodies. Hybritech will receive $2 million in contract revenues over a three-year period and retains marketing rights for North America; Toyo Soda has rights for the Far East; the two firms share joint marketing rights in the remaining countries.
Integrated Genetics	Serono (Italy)	Integrated Genetics has a US$ 3 million contract to carry ou research in unspecified areas.
Molecular Genetics	Roxane, Inc. Subsidiary of Boehringer Ingelheim) (West Germany)	Molecular Genetics has agreement to produce unspecified rDNA products.
E.R. Squibb	Novo Industri (Denmark)	Squibb & Novo formed a joint venture which will market Novo's insulin in the U.S.

Based on information in High Technology Industries: Profiles and Outlooks - BIOTECHNOLOGY. U.S. Department of Commerce, International Trade Adminstration, Washington DC. July 1984.

Given the collaboration in R&D by pharmaceutical firms and the very strong felt need of these firms to secure property rights in the inventions, some management problems may arise due to differences in the perceptions of the home countries of the firms collaborating in joint ventures in R&D as well as the actual patent protection given. The issue is, would the emerging system of patent protection be on the lines of the European Patent Convention (EPC) which went into force on October 7, 1977? In other words, would the same substantive law patents emerge for the countries collaborating in pharmaceutical research?

The significance of joint ventures in technology at the stage of R&D is that the collaborating firms are seeking technological leadership with the objective of gaining competitive advantage. The advantages of technological leadership are sought to be further strengthened and sustained by building in marketing agreements in R&D agreements. There is thus a clear move in the direction of linking technology strategy with marketing strategy, and in time different forms of linkages are likely to evolve.

Yet another way to maintain the technological and competitive edge would be to effectively manage the transfer of technology. A possible approach to management would be to have a close group of firms which would share the technology. In the first place, therefore, technology may be transferred to firms participating in the R&D joint venture and later the technology may be transferred to their subsidiaries and affiliates. Thus the technological edge of the pharmaceutical multinationals and the resulting competitive advantage in national and international markets will further strengthen the power of the multinationals in an industry which they already dominate.

The tendency towards increased technological and market dominance of pharmaceutical multinationals may evoke different policy responses from countries desirous of importing the pharmaceutical products and technologies, but there is a possibility that a set of policies specific to pharmaceutical multinationals, as distinct from other multinationals may eventually emerge. The consideration of these policies, however, is outside the scope of the present paper.

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CHAPTER XIII

MANAGING INTERNATIONAL TRANSFER OF TECHNOLOGY A CASE STUDY OF IDPL

B. Joshi

International transfer of technology is one very effective way of ushering in technological change within an enterprise. Yet it is seldom realised that the process of international transfer of technology is a very complex one and its management requires high skills, team work across borders, clear understanding of the entire process and strategic management. This paper presents a case study of a technologically successful though financially non-viable firm, from the view point of management of change, namely, Indian Drugs and Pharmaceuticals Limited (IDPL), a public sector enterprise, that has accumulated over years of losses far exceeding its initial capital investment, and, with success out of sight after 25 years of existence.

Before one describes the managerial problems in transplanting the drugs and pharmaceuticals technology, it is necessary to briefly sketch the main characteristic of this enterprise and the background against which it was established.

Soon after Independence, the Indian planners of the health sector visualised that, to fight the then prevalent diseases in epidemic forms, on a war footing, required, among other things, supply of essential life saving drugs in large quantities. It was, therefore, decided to establish large plants in the public sector to fulfil this need, and manufacture from the basic stage vital antibiotics drugs like Penicillin, Streptomycin, Tetracycline, Vitamin B, folic Acid, Analgin, Phinobarbitone and a wide range of sulfa drugs on a gigantic scale, namely 300 tons of antibiotics and another 290 tons of sulfas. Thus in all, IDPL was the largest drugs plant in Asia with Rs.92 crores of investment that was one third of the entire Indian drug industry.

The selection of the supplier of technology, it may be mentioned, was made more on economic considerations than on technological. Not only the Soviet Union was willing to supply the complete technology and also provide a cheap loan at 2.5 per cent interest rate (in contrast to 10 per cent with royalty as in the case of Western drug firms) but also there was a general reluctance on the part of Western firms to transfer the drugs know-how in the fifties when they were busy making profits on their innovations. It was hoped that with the establishment of IDPL in 1962, the era of self sufficiency in drugs would come in a decade. It has not come. Should management alone be blamed?

The complexity in the management of international transfer of technology arises from the co-relation of a number of variables such as, the technology in question, its scale of transfer, the partners in transfer, the technical agreements, transfer environment, and other different factors. The specific transfer of technology characteristics cast their own influence and the expected shape of things could well have been anticipated by the process (transfer of technology) engineering design group only if it existed.

Technology adaptation is the first step in the management of transfer of technology. It includes adjustments alterations/- modifications arising out of technical and/or economic considerations. In an international transfer of technology these are inevitable, for, technology is system specific: the conditions of production operations are bound to differ in the supplier and recipient country. The technology has to be adopted to the local conditions. In the case of pharmaceutical industry, particularly, the antibiotics that are products of complex activity of micro organisms and hence very sensitive to many things, such as the culture media on which antibiotic is grown, the vessel containers where possible contamination could come in the diemulsifying agents added, etc. That is why, despite the fact that high antibiotic yields had been obtained in the suppliers' country, the joint technology management team of experts of the two countries had to struggle long enough to get similar level of yields. A series of technical changes had to be made on economic conderations, such as whale oil being substituted by ground nut oil or Lactose by sugar cane in the preparation of antibiotic culture broth. Likewise, in the case of Vitamin B1, the entire Bromide Hydrobromide process was replaced by Chloride Hydrochloride process and by undertaking other simplifying steps. Antibiotics being high technology products with a fast rate of obsolescence, almost every two years improvements in the antibiotic strains were made by the collaborator and were passed on. This required continuous readjustments of technical parameters by the technical management teams.

The design and size of the equipment must match the antibiotic process at each of its steps in fermentation, recovery and purification. Thus, it was found that the size of Butanol recovery equipment was inadequate and would affect Penicillin production by 50 per cent. Likewise the carbon treatment plant was also under-designed, and drying capacity of Rotary driers was below the requirement. In process technologies, one also has to often substitute one set of chemical inputs by another, and this was done. All these need proper planning, for, the technical adaptation process does go on indefinitely.

The second step in the management of technology transfer is that of managing and stabilising the production operations. The main problem in the IDPL case was in establishing the performance norms, for the one supplied by the collaborator were not valid under the changed conditions. This required monitoring the production operation for very long periods before realistic norms could be set. The other usual problem of plant operations of procuring raw materials, spare parts, inventory control, quality control etc. were also present but only in a much magnified manner. Attracting skilled manpower was also a problem as expected, not many were familiar with pharmaceutical production at the basic stage.

The technological innovation is complete only after the product has been successfully marketed. IDPL faced several problems at this stage of technology utilisation. The Indian pharmacopical standards that were close to the British and American were higher than the Soviet standards. Thus, drugs could not be marketed till their standards were brought at par.

The decision to enter into drug formulations for financial viability led IDPL enter the major war between brand names and generic names. The drugs in the market were better known by their brand name like Novalgin of Hoechest and Analgin of IDPL would not sell although the same bulk drug sold to Hoechest would get marketed under the brand name.

Yet another kind of marketing problem arose from the inability to vary the drug prices that were fixed by the Government. The firms in the private sector, particularly the MNC's, could manage a higher profit margin because of their lower costs.

Then, certain drugs that were transferred under the agreement such as Chlorotetracycline, Phimdopyrine, Piprazine, Phenacetin, Sulphadizine, were either not in use or replaced by drugs of higher efficacy. IDPL had to make considerable product mix alterations to the produce that had a market and which could utilise the existing plant equipment. Strategic management was essential, keeping the surprise moves of the MNC in mind while fighting the technological management battle IDPL did emerge as successful in a limited sense. However, the time taken along with a host of factors common to all public sector enterprises, brought IDPL into financial difficulties. In reality, although one of the three plants of IDPL did break even and make net profits, the total scene owing to mounting depreciation and interest dues was always bleak and the company only crossed break-even point once or twice.

CHAPTER XIV

MANAGEMENT OF TECHNOLOGICAL CHANGE
AN OVERVIEW

Usha Dar

Introduction

The relationship between technological change and economic and social change is complex, and because of continuous interaction among them, it is not easy to distinguish between cause and effect. While the pressures for technological change are set by international competition, it is the domestic environment of a country, determined by various economic policies which re-inforces or dampens the need felt by firms for technological change. Hence the management of technological change involves a continuous, perceptive and sensitive response to environment and change both by firms and government policies.

We shall now consider the various issues in the management of technological change. While for analytical purposes these issues have to be separated, it must be emphasized that management has to be considered as a total process.

Management of Risk

Risk extends right from the stage of R&D to the marketing of the product, and is crucial for the management of technological change. Dar, in her case study, identifies the different phases of research in the drugs and the pharmaceutical industry and shows how risk is associated with each phase. In general, she endorses the view that, given competing claims on corporate funds, the commitment of funds to R&D will be influenced by whether the results of R&D are uncertain, risky within a range of probability, or fairly predictable. Nath and Misra, in their paper on "Case Studies on Indigenous Industrial R&D Utilization" also emphasize the existence of risk but 'risk is not a concept which excites the research worker' and can become a source of conflict between the researchers and management.

Col.Wahi points out, in his case study of the Oil and Natural Gas Commission, that their approach to resolving this conflict was to make R&D as a profit centre. This concept of profit centre generated considerable interest among the participants. An important issue which was raised related to the orientation of R&D. Was it to achieve problem-solving results or money results? It was clarified that the focus of R&D in ONGC was certainly on the technological answers to problems, but there was management audit of materials. The profit and loss account was notional in as much as it was not maintained in accordance with the requirements of Company Law, but it did bring about considerable psychological pressure and it made the people conscious of the financial implications of R&D.

The various case studies gave empirical support to the view that innovation is the chief mechanism by which a firm can distinguish itself from its rivals and gain a competitive edge. Innovation is a powerful weapon which on the one hand demolishes established barriers to entry, and on the other hand creates barriers to entry. But a distinction has to be made here between a firm which is first or among the early innovators and hence among the early entrants to the product market and a firm which innovates when other firms have firmly established themselves in a particular product market.

The case study on Rifampicin by Nath and Misra shows that the technology for Rifampicin was developed by Themis Chemicals, a medium sized firm, but the firm could not market Rifampicin because the import prices were substantially lower than the prices at which Themis could sell. Thus technical success, instead of leading to commercial success, was associated with commercial failure.

Transfer of Technology

When technology is imported, quite often it may be alien to the environment of the developing country, and therefore, it is important not only to absorb the imported technology but also to adapt it to local conditions. Mathur's case study of "Engine Bearings" clearly brings out the need to adapt technology to the local environment. He points out that there are major differences between the American, Japanese and European environments from where the bulk of the technology is imported to India. The major differences are high ambient temperatures; dusty atmosphere; uneven roads or no roads; over-loading of vehicles; and improper maintenance practices. Mathur's observation that the imported designs which have been value engineered for the collaborator's requirements may not work in India, is highly significant. Since the knowledge and experience of the technical marketing teams is generally low in the beginning, it may be a major factor in an untimely demise of the project, unless almost immediate corrective action is taken. It may be possible force the collaborator to share his experience provided he has some in similar environments, but ultimately the answer needs to be provided locally.

Another local problem which called for adaptation, arose from the fact that the fitment practices which were followed in India by the replacement market did not in many cases conform to the specifications laid down by the original equipment manufacturers. The two most important reasons, among others, for this situation were the inadequate training of mechanics and a lack of awareness among users. The vehicles in India are also operated for much longer periods than in developed countries. Parts are repeatedly re-conditioned whereas they should normally be replaced. Thus, in adapting the imported technologies to the Indian conditions the major requirement was sturdiness, which in turn required the Indian component manufacturers to incorporate design features in the product, which would assist in re-conditioning to the maximum possible extent.

The need for adapting imported technologies to local consumer requirements is also clearly underlined by Laroia in his case study of Swaraj Tractors. Production of tractors in India started in 1963-64 by two firms, namely Tractor and Farm Equipment (TAFE), which had a collaboration with Massey-Ferguson, U.K.; and Eicher, which had a collaboration with Eicher of the Federal Republic of Germany. However, given the relatively small size of farm holdings in India, an important question for consideration was the kind of tractor which was most likely to suit the budget and needs of the small and the medium farmers.

A team of engineers of CMERI made an in-depth study of the relative merits of the available designs of agricultural tractors, keeping in view the local manufacturing facilities, skills, raw materials, and agro-climatic conditions, and developed a tractor, component by component. While research started with a very careful study of imported technologies, CMERI engineers successfully developed an original design for a single lever automatic depth-cum-control system, and patents for this were accepted in India, U.K., Japan, West Germany, U.S.A., France, Poland and Yugoslavia.

The first prototype tractor was assembled in 1967 and was put through extensive endurance tests, on specially designed test rigs, which simulated field conditions. These tests resulted in a number of modifications which were incorporated in the cooling system. Further tests showed that the performance was better than most of the imported tractors in the 20 - 25 H.P. range.

A new design, Swaraj 735 (35HP), was developed and introduced. For this model the additional cost was only Rs.2,000/- per tractor, but the price advantage was of the order of Rs.4,000/- per tractor. The psychology of the farmers played an important part in the acceptance of this model. The farmers were used to the Massey-Ferguson tractor of 35HP and, possibly they regarded a higher priced product as a superior product. The process of adaptation of technology to local conditions, had as a result of dedicated and sustained effort led not just to modifications but to the development of new designs and models in accordance with consumer preferences.

The two basic factors for successfully adapting technology to suit local conditions, namely, familiarity with the markets and dedication to research, are also very clearly brought out in the case study of PMT Machine Tools Automatics Ltd. by Kapur Mehta and Mehta. PMT MTA was a marketing organization that served as agents for foreign manufacturers of sophisticated machine tools. It began the manufacture of machine tools in 1963, and this decision to commence manufacturing was based on its market experience of which product sold well. Good relations with foreign manufacturers facilitated the tie-ups, and this is reflected in the current product-mix of the firm. PMT has been selling Traub machines since the fifties, and Voumard machines for more than 25 years, but the technical collaboration with Voumard was signed only in 1983.

Given PMT's experience in marketing, PMT MTA took the opportunity provided by the expansion of the two-wheeler industry in the early 80's, to identify the machine tools which the expanding industry would require and diversified its product range into internal grinders, required for grinding bores in critical components, such as connecting rods, crankshafts and gears and manufacturing began in 1984.

The competitive advantage of PMT MTA was derived from three factors (a) They were the first to develop the product and they rapidly indigenised it. (b) The indigenisation helped the firm to partly counter-act the price disadvantage on imported components when the value of the rupee fell against European currencies, and (c) their use of the Voumard brand-name, which was already known, helped in the marketing.

The key factors which contributed to PMT MTA's dominance in the market for internal grinders was an effective technology strategy coupled with a strong marketing strategy.

We have seen the competitive advantages of early entry into a market, but the case study of CNC lathes shows how the disadvantage of a late entry can be turned into a competitive advantage. PMT MTA was a late comer in the field of CNC lathes and faced competition from Hermann Traub Maschinenfabrik (HTM) and Mysore Kirloskar.

The two questions facing the firm were : what should be their strategy for competition; and who would be the right collaborator to help implement this strategy. The main focus of PMT MTA was on differentiating their products from that of the other Indian manufacturers by offering a single source for machines as well as systems. They collaborated with HTM for the manufacture of CNC lathes and turn-mill centres. HTM had developed their own software for their CNC system, and they purchased the components for this from Mitsubishi, tailored to the specific requirements of their lathes. HTM had acquired considerable expertise in the field of turning, as a result of long years of advising users on how to 'program' the manufacture of parts on their automatic lathes. HTM had developed its own system, based on Mitsubishi hardware, and were therefore able to meet special customer requirements in the software. The advantage which PMT MTA had in collaborating with HTM was that it was able to get both the machine tools and the CNC technology from one source.

The case study of a cement plant by Ghosal and Ahuja stresses the need for adjusting and adapting the imported technologies to the kind of inputs available in the host country. Qualitative differences in inputs make it virtually impossible to achieve the technical norms of the transfer of technology, for example, the quality of limestone and coal are crucial considerations.

Born's paper on "The Role of Import of Technical Know-how in the Management of Technological Change" is based on a survey of about 180 Indo-German joint ventures. He observes that in the management of technological change it is the attitude of the firms to technological change which is important. This attitude, in turnm, is conditioned by the environment created by government policies. If the environment is such that it is possible to continue with dated technologies, and not only be able to market the product, but also make profits, then there is hardly any motivation to adopt technological change, or in other words, take the risks associated with change.

The survey showed that 63% of the Indo-German joint ventures were for diversifying into products which required sophisticated technology. and there was hardly any relationship between what a company was actually manufacturing before the joint venture and the product manufactured with joint venture. Born finds this to be an indicator of the fact that it was not felt necessary to update technology of the existing product.

The German partners not only brought in the technology but also set-up R&D centres in the joint ventures. About 70% of the Indo-German joint ventures had R&D departments and of these 58% were set-up to improve the existing products and over 40% were engaged in developing new products.

The case study by Dar on the Drugs and the Pharmaceutical industry shows that the whole approach to technological collaborations was tending to change in high-tech industries, such as bio-technology. Joint ventures began at the R&D stage and the significance of joint ventures at this stage is that the collaborating firms are seeking technological leadership with the objective of gaining competitive advantage. The advantages of technological leadership are sought to be further strengthened and sustained by building in marketing agreements in R&D agreements. There is thus a clear move in the direction of linking technology strategy with marketing strategy, and in time different forms of linkages are likely to evolve.

Yet another way to maintain the technological and competitive edge would be to effectively manage the transfer of technology. A possible approach to management would be to have a close group of firms which would share the technology. In the first place, therefore, technology may be transferred to firms participating in the R&D joint venture and later on, the technology may be transferred to their subsidiaries and affiliates. Thus the technological edge of the pharmaceutical multinationals and the resulting competitive advantage in national and international markets will further strengthen the power of the multinationals in an industry which they already dominate.

The discussions on these case studies brought out a number of factors, which were crucial to the management of technological change. We shall briefly focus on them.

Factors in the Management of Technological Change

1. Excellence in technology and its application is of vital importance for the competitive strength of firms. Technology opens up opportunities, but these opportunities are not without their threats. To perceive the opportunities, to take the risk as well as responsibility of facing the threats is a function of leadership. The motivations, attitudes, morale, and values of the leader permeate right through the firm.

2. One of the lessons which came out loud and clear from the case studies was that technology and innovation were too important to be left to the scientists and engineers. On the one hand scientists and engineers need to understand that they have to work with the functional managers in the enterprise. At the same time, general managers and non-technical people should ask hard questions that relate to technological decisions.

3. New technologies mean new skills and this can lead to resistance to change from those persons who do not have these skills, or who think that it is not possible for them to acquire the requisite skills. Thus, the knowledge and experience of the existing personnel, or in other words the human capital within firms, may act as a barrier to technological change.

4. No two firms are the same in terms of attitudes, search for sources of technology, adoption of technology and innovations. The inter-firm differences can be related to the different capacities of individuals to manage technology and to the effects of the organizational structure.

5. All firms have to make strategic decisions relating to the allocation of funds between R&D and other activities, but there is a distinct relationship between efficiency, market shares, the resources to improve efficiency, and the organizational structure of the firms.

6. The ability to innovate is not by itself sufficient for commercial or competitive success. The timing of the innovation when a firm is not among the early innovators, the inter-firm differences in the trade-offs between the costs of innovation and the timing of the product development are crucial to the link between innovation and competition.

7. The technology obtained from the collaborator makes demands for various inputs. It is essential to have the same quality of inputs as specified by the collaborator.

8. The changing technological and economic environment shapes the pattern of demand for technology. Different environments are likely to be associated with different patterns of demand for technology and different patterns of adapting to local requirements. Hence an appropriate environment is a pre-condition to the successful adoption, adaption, and development of technology.

9. The management of public sector firms faced more constraints than the management of private sector firms. These constraints arose from the fact that the time perspective for corporate plans usually gets limited to five years, and this made it difficult to formulate a long-term corporate strategy. Yet another management problem of public sector firms arose from the need to seek government approval for major financial decisions, and delays in according government approval, adversely affected the correct timing of corporate decisions, which was crucial for the management of technological change. These constraints dampened motivations and cramped management styles.

10. The financial institutions evaluated projects from the point of view of the magnitude of investments and the cash flows, which these investments were likely to generate. The underlying assumption was that technology was reflected in the cash flows. The approach to project evaluation by the financial institutions should be broadened to include assessment of technology.

11. The universities and the institutes for technology are the source of supply of manpower for the management of technological change, but the curricula and syllabi had not kept pace with the requirements of management of technological change. It was necessary to appropriately revise the curricula and syllabi as well as the teaching material, and also upgrade the laboratory equipment.

12. The change in the curricula with emphasis on technology should actually begin at the school level. The speed with which these changes could be brought about at the school level would depend on the availability of teachers with the necessary teaching skills and also the availability of teaching materials.

13. The relationship between technological change and industrial structures clearly brought out the need for an integrated approach to the industrial and technology policy.

Approach to Management of Technological Change

Mel Horwitch in his paper on "Accessing Innovative Capabilities: The Strategic Importance of Technology in Post-Modern Strategy" observes that the post-modern strategy represents a significant change in top-level decision making, and blends certain features of general management, with concepts of his own. The source of change in the approach to management was the transformation of competition in the modern worlds where competition becomes a strategic variable and the greatest challenge for top managers was to incorporate technology into corporate strategy.

In the strategic management of firms, a very important part of technology strategy involves the ability to manage the traditional business and at the same time discover in other parts of the corporation high value innovative niches. Because innovation is important and firms cannot remain limited by their own internal capabilities, the need arises, therefore, to go out and buy innovative capability; this is the externalization of technology strategy.

The technology decisions by firms are normally made along three dimensions: first, competition versus cooperation - this is in effect the competitive strategy; secondly, external versus internal, that is the 'buy or make decisions'; and thirdly, the traditional large corporation R&D versus organizational net-works. The main task of technology strategy is to achieve an appropriate set of multiple trade-offs.

An essential requirement of technology strategy is that top managers should balance concurrently disaggregration in order to capture the benefits of flat organizations and complex re-integration. Thus the implementation of technology strategy enables the blending and co-existence of seemingly opposite kinds of behaviour and strategies. This crucial quality of technology strategy is 'simultaneity'.

A significant observation by Horwitch that the pattern of strategic decision-making is not specific to any technology intensive industry and technology strategy has acquired a global character. It has been observed that inter-organizational relations cut across international boundries and some of the linkages forged are really global in character.

There is a remarkable similarity in the patterns of strategic alliances in different industries. and this could hardly be a matter of confidence. as a matter of fact they indicate a kind of convergence in the practice of technology strategy by firms.

The linkages which are being formed by firms. Horwitch explained. could possibly be of two kinds. Some relation could be strong and durable and difficult to break. because they may be legally bound for a definite period or until some goal is achieved. The other kind of relationships may be easy to break. One of the ways in which it could be done was for the large corporation to sell stock or withdraw funds arbitrarily.

The focus of the discussion on Horwitch's paper was on broadly two issues. In the description of technological innovation and development one is looking at the future. but in this context one has also to look at the experience of other countries in the management of technological change and, to the extent possible, learn from them. The Japanese experience had shown the method of taking a technology from elsewhere, and then producing a product cheaply, efficiently and free of defects. A major challenge was to take a look at what was being done, and then do it in a way which makes the firm competitive in terms of cost and quality.

Three related questions were raised on the issue of breaking of linkages: (1) under what conditions would a firm want to break a link; (2) if a company sells out the stock, then from its point of view it had made a break, but what were the implications for the firm from which it had made a break, particularly if it was a small firm? It might possibly be shaken to such an extent that it may have to go into liquidation; and (3) should this happen, what would be the likely effects for the future pattern of linkages?

Responding to these questions, Horwitch observed that it was enough to be just good at buying technology, at being adaptive; at least one had to be a partner in being creative.

As regards the question of linkages, they were being forged between the large and small companies because of the experience of small high-tech companies. The small company has indeed to be very careful of the large corporation. The small companies are, however, getting increasingly professionally managed and they are also likely to consider various aspects before establishing links with large companies. However, Horwitch had looked at the problem from the angle of the large companies and had not considered the problem of linkages from the point of view of the small companies.

The papers and the discussions on Management of Technological Change brought out clearly the broad directions in which action should be taken by firms and by the Government. Since official policies create the environment to which the firms respond, we shall first consider action required to be taken by Government.

Recommendations

A. Action by Government

1. The industrial and technological policies should be carefully reviewed and an integrated policy formulated;

2. The collaboration policy for industry needs to be reviewed and revised in the light of the technological changes in the developed world and the emerging forms of joint ventures;

3. Government should examine how industrial firms can be encouraged to strengthen their R&D capabilities;

4. Technological change has a number of implications for the organization of education and training at schools, universities and technical institutes; Government would assess the short and long term changes which can be introduced at different levels of education and formulate an appropriate education policy;

5. The relationship between government and public sector management should be reviewed and changed in order to enable the management of public sector concerns to take timely decisions relating to technological change and make such organizational changes as may be considered necessary.

6. Circulars may be issued to financial institutions asking them to indicate how best they can integrate technological and financial considerations in appraising projects for funding, and after meetings and discussions, a uniform approach to project appraisal, with a focus on technological change, should be adopted by all financial institutions.

B. Action by Firms

1. Firms should assess the market potential for a product before seeking technology from international sources;

2. Firms should strengthen their negotiating capabilities in the field of technological collaboration;

3. Firms should make appropriate arrangements for the training and re-training of workers, engineers, and managers;

4. A minimum in-house R&D capability should be established;

5. The suitability of the existing organizational structure of the firm, for the management of technological change should be examined and relevant changes introduced.

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GLOSSARY OF ACRONYMS

Acronyms	Name
A F M S	Advanced Flexible Manufacturing Systems
A G V S	Automated Guided Vehicles
A I S	Automatic Identification System
A L D E P	Automated Layout Design Programme
A M T	Advanced Manufacturing Technology
A R D C	Agricultural Refinance & Development Corporation
A T & T	American Telephone & Telegraph
B E C	Boeing Electronics Company
B E L	Bharat Electricals Limited
B G M L	Bharat Gympsum Mines Limited
B H E L	Bharat Heavy Electricals Limited
C A D	Computer Aided/Assisted Design
C A D E	Computer Aided Design Engineering/ Control and Design Engineering
C A E	Computer Assisted Engineering
C A M	Computer Aided Manufacturing
C A T	Computer Aided Testing
C C I	Cement Corporation of India
C E O	Chief Executive Officer
C I M	Computer Integrated Manufacturing
C K D	Completely Knocked Down
C M D	Cordinate Measuring Devices
C M E R I	Central Mechanical Engineering Research Institute
C N C	Computer Numerical Control
C R A F T	Computerised Relative Allocation of Facilities Techniques
C R P	Capacity Requirement Planning/Computerised Resource Planning

C S I R	Council of Scientific and Industrial Research
D E G	German Finance Company for Joint Ventures in Developing Countries
D F M S	Dedicated Flexible Manufacturing System
D G T D	Directorate General of Technical Development
D N C	Direct/Digital Numerical Control
D S S	Decision Support System
E I L	Engineers (India) Limited
F A S	Flexible Assembly System
F M C	Flexible Manufacturing Cells
F M L S	Flexible Manufacturing Line System
F M S	Flexible Manufacturing System
F S	Financial System
H A L	Hindustan Aircraft Limited
H M T	Hindustan Machine Tools
I C	Integrated Circuit
I C R I E R	Indian Council for Research on International Economic Relations
I D B I	Industrial Development Bank of India
I D P L	Indian Drugs & Pharmaceuticals Ltd.
I D S	Industrial Development Services (Private) Ltd.
I M B	International Business Machines
I O C	Indian Oil Corporation
I P C L	Indian Petrochemicals Corp. Ltd.
I S F	Inventory Status File
I T D C	India Tourism Development Corporation
I T I	Indian Telephone Industries
J I T	Just in Time
L C V	Light Commercial Vehicle
L D C	Least Developed Countries
M A M C	Mining & Allied Machinery Corporation
M I T	Manufachusetts of Technology
M I T T	Ministry of International Trade and Industry

M O U	Memorandum of Understanding
M P S	Master Production Schedules/Master Process Sheets
M R I	Machinery Research Institute
N C	Numerical Control
N E C	Nippon Electric Company
N I D C	National Industrial Development Corporation
O N G C	Oil & Natural Gas Commission
P B I T	Gross Profit Before Income Tax
P B T	Profit/Loss Before Tax
P L C	Programme Logic Controller
P M T	Perfect Machine Tools
P M T M T A	PMT Machine Tool Automatics (Pvt) Ltd.
P S E	Post Second World War Enterprises
P S I D C	Punjab State Industrial Development Corporation
P T L	Punjab Tractors Limited
P T O	Power Take Off
R & D	Research & Development
R E C	Rural Electrification Corporation
R I T E S	Rail-India Technical and Economic Services
S	Technology 'S' Curves
S A I L	Steel Authority of India
S K D	Semi Knocked Down
S P C	Statistical Process Control
T A F E	Tractor & Farm Equipment
T C S C	Technical Consultancy Service Centre
T N P L	Tamil Nadu Newsprint & Papers Ltd
T R C(s)	Technological Research Centres
T T T S	Tractor Training & Testing Station
U N C T A D	United Nations Centre for Trade and Development
U N I D O	United Nations Industrial Development Organization
U P	Uttar Pradesh