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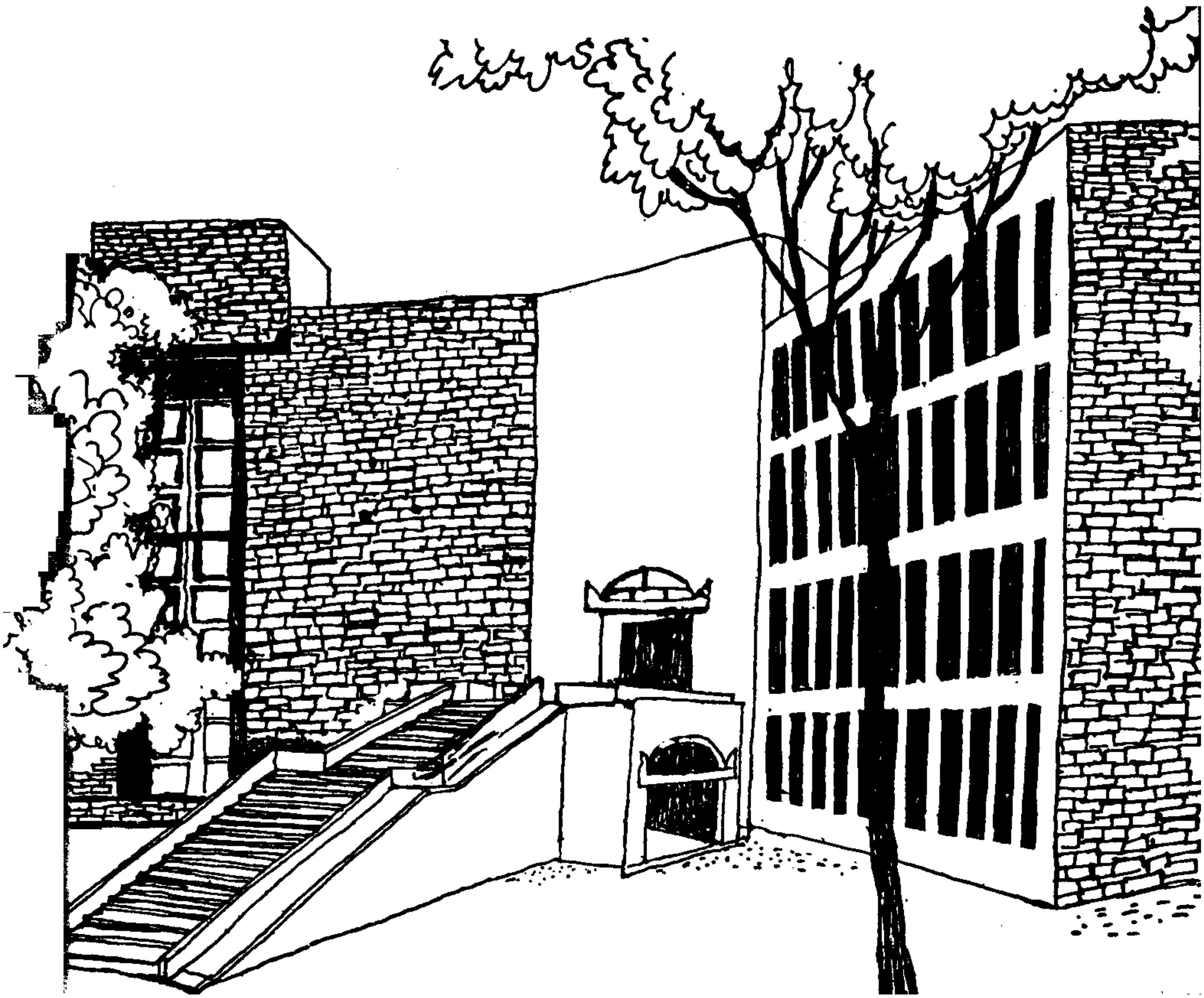

MANAGEMENT OF INTERNATIONAL
TECHNOLOGY TRANSFER

By

Shekhar Chaudhuri

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INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380015
INDIA

Abstract

The significant liberalization of the Indian government's policies towards foreign collaboration and industry in general has led to an upsurge in the annual number of tie-ups between Indian and foreign firms in industrially developed countries. While this development augers well for the technological upgradation of Indian industry it may pose enormous challenges for the technology purchasers. This paper highlights some of the problems faced by firms in* assimilating foreign technology and illustrates how they were overcome. A conceptual framework in the form of four organizational stages in the process of acquiring and assimilating foreign technology is presented, which is then illustrated with the help of two case studies. Finally, this paper also draws some implications for technology buyers in developing countries and MNCs and other technology sellers in industrially advanced nations.

*Indian industry

Management of International Technology Transfer

Shekhar Chaudhuri

Introduction

Technology seems to be one of the most critical factors in the socio-economic development of nation. Chandler's[1] study highlights the role of rapid technological development in the United States. The post-second world war development of Japan is attributable to a great extent to the massive import of technology. According to Chitale[2], between 1963 and 1973 Japan paid out in all $3.4 billion for its technology imports. Ford and Ryan[3] contend that rapid assimilation of foreign technology has been largely responsible for the emergence of multinationals from Japan.

The backwardness of a large number of developing countries is to a great extent due to their limited capabilities for negotiating technical collaborations, assimilating and using existing knowledge and generating new technology for meeting socio-economic needs. The increasing technological gap between the industrially advanced nations and the less developed ones is a cause for concern in the latter. An examination of the figures of R&D expenditure by different countries reveals the vast gap between the developed and developing countries. Most of the industrially advanced countries spend between 2 to 4 per cent of their Gross National Product (GNP) on R&D, whereas the developing countries spend anything between 0.2 to 0.8 per cent.[4]

The vast expenditure on science and technology by the industrially advanced countries represents a storehouse of technology which can be relied upon and utilized by the developing countries. By being late comers to the process of technological development, the developing countries have the advantage of being able to import directly the technologies already available in the advanced countries. This is what many developing countries have been attempting. In India there has been a mixed experience. There has been considerable success in assimilation of technology in some areas whereas in others the experience has not been too good.

Trivedi[5] cites the examples of synthetic fibre, fertilizer, synthetic detergents, etc., where the development has been lopsided because of the absence of a clear cut technology policy at the government level. Baranson's[6] study highlights the problems faced in assimilating advanced technology because of the mismatch with local conditions. Subramanian[7] pointed out that foreign collaborators assumed too many functions, extracted a very high price through a complex payment scheme and curtailed the autonomy of Indian ventures. The net result of the import of technology by the Indian firms was the increase of foreign exchange outflows on service payments and a heavier burden on the balance of payments. India's recent experience with heavy water plants is worth mentioning. The Rupees 66 crores (approximately $ 55 million) heavy water plant of the Department of Atomic

Energy (DAE) at Talcher, an industrially backward area, whose design and part of the equipment were supplied by a West German firm failed to produce even a drop of heavy water. The reason given was the very process on which the Talcher design was based proved to be unworkable or defective[8]. This is just one example. Very serious problems are being faced by DAE's other heavy water plants.

Notwithstanding the formidable problems in acquiring and assimilating technology, international technology transfer mechanisms are likely to remain the dominant route for the development of technological capability in developing countries. The Indian government has in recent times significantly liberalized its policies towards foreign collaboration. The results of the liberalization of the government's policies are already visible. During the period 1977 to 1979, 841 foreign collaboration agreements were approved. But during the next two year period the number almost doubled to 1500 and in 1985 this number touched a figure of over 1000 for that year itself[9]. It is in this context that the study of international transfer of technology to developing countries assumes great importance. Although governmental policies can play an important role in facilitating the success of technology transplants as in the case of Japan it should be recognized that it is the management of the individual firm which is ultimately responsible for successfully managing the process of acquiring and assimilating technology from its collaborator.

Some of the state owned firms operating in relatively high technology industries in India have realized the need to manage technology effectively. Consider the following:

... A great degree of success has already been attained in developing manufacturing capacity, adapting the designs to meet local material availability, modifying technological processes to suit available equipment, and putting in developmental effort to a limited extent... it is being increasingly felt that to sustain the developmental effort in quality and quantity necessary to meet our goals and responsibilities, it will be essential to pool our limited expert personnel and other resources. The 'One product, multiengineering and development centres' approach has to give way to a 'one-product one engineering and development centre' approach ...[10].

... The quality of engineering inputs during the conceptualisation and design stages of the projects would ultimately determine their performance and reliability during operation. The Technical Service Division of the company, created to coordinate the engineering work of various consultants ... has now developed into a dynamic organization ...[11].

... Quality of design, engineering, equipment, systems and services, on which depends the generation efficiency, plant availability and plant reliability, can no longer be relegated to the background...[12].

It has been recognized by practioners, researchers and policy makers that successful management of international technology transfer is a complex task. Some firms have been quite successful and others not so. Consider the following examples:

1 The Hindustan Machine Tools Limited, (HMT) a state owned undertaking in India provides, us an illustration of an Indian firm, which started in a very small way with limited technical competence and developed into an international competitor in machine tools.

... Initially HMT faced problems that confront all developing countries - lack of industrial infrastructure and a raw, untrained labour force. What followed was growth in three stages.

Stage 1: Receiving a turnkey project from its Swiss collaborators. Learning what to expect, what to ask for and how to get it.

Stage 2: Executing a duplication of the original unit in the same location with an almost identical and integrated production programme.

Stage 3: Setting up a third unit a good 2000 miles away followed by 11 other divisions.[13]

2. Eicher Tractor Limited (ETL) was the first company to commence farm tractor manufacturing operations in India. The entrepreneur decided to venture into manufacturing in financial and technical collaboration with Gebr. Eicher of West Germany when in 1957 the government banned the import

of tractors through normal trade channels due to critical foreign exchange position. The manufacturing operations started in a very small way with a capital investment of less than Rupees 1 million. Starting with a single cylinder air-cooled tractor of 24 H.P. Eicher India now has developed improved models based on the original design with minimal help from the collaborator. It has also developed a 35 H.P. and a 12 H.P. model through its own efforts and these tractors are likely to be in the market soon in a big way. The progress however was not an easy task. Beginning in 1960-61 with a production of 132 tractors per year (basically an assembly operation) the company manufactured 13,650 tractors during 1983-84. It passed through a very critical situation as a result of a poor financial condition, lack of technical and managerial expertise, poor industrial infrastructure, collaborator's inability to help because of its own problems in W. Germany, and the government's policy of discouraging import of components and pressure to indigenize rapidly. As late as 1975, about 15 years after commencement of manufacturing operations, gross block was less than Rupees 7 million and the turnover was Rupees 38.0 million. The company set up a relatively large research and development centre separate from its production facilities during 1975-76, with departments specialising in engine design, tractor design, system design, transmission design, metrology, prototype development, materials science and testing. The annual recurring expenditure is approximately Rupees 10 million.[14,15]

3 Company X was incorporated in 1973 in collaboration with company Y for the manufacture of thin plate closely pitched storage batteries. Thin plate batteries have several distinguishing features; less consumption of lead, and higher cranking power being the more important ones. The manufacturing technology however requires considerable expertise. Company Y is one of the largest manufacturers of batteries with the widest range of products in lead acid storage batteries.

Although Company X acquired the most modern production equipment, several technical problems were faced in the early years of its operations. The production was restricted to low levels and as a result the company suffered from severe financial strain for a number of years and (within 7 years the management of the company had to sell out). The sickness of the company was attributed to a lack of adequate manufacturing skills; inability of the company's management to attract and retain qualified people; frequent tripping and huge shortfall in power from the state electricity board; absence of professional management, which could anticipate all these problems and strong competition provided by a well established manufacturer which produced a superior quality product.[16]

The cases described in the foregoing paragraphs illustrate the difficulties in assimilation of imported technology. They also illustrate that some firms are more successful in managing this process than others. This article is an attempt at understanding from a managerial perspective the process of international technology transfer. Based on a study (see Appendix for brief description of the research) of six tractor manufacturing firms four organizational stages have been identified in the process of technology acquisition and assimilation. These four stages are described in some detail, and subsequently summaries of two case studies are presented to illustrate them. Finally some lessons are drawn for managers of technology importing firms and MNCs, which are a major source of technical know how for developing nations.

Stages in International Transfer of Technology:

The process of international transfer of technology has been conceptualized in this article as a four stage process. The four stages may be distinguished from one another on the basis of differences on a number of important characteristics which are tabulated in Figure 1. Before describing each of these stages in detail I shall mention a few things about the framework proposed in this article.

This framework suggests that organizations which attempt to build their technological capability through the route of foreign collaboration transit through four stages. These stages are conceptual categories on a developmental continuum defined by a combination of a number of environmental, strategic and organizational dimensions. Though they have been depicted as separate sub-processes, in reality there may be some overlap between them. For example, an organization while in the process of purchasing technical know-how from a collaborator, may have simultaneously initiated managerial actions related to the process of technology adaptation. The framework indicates that the process of transition from one stage to another is a sequential one; with the technical task emphasis changing as the organization moves from one stage to another. However, it does not imply that speed of transition will be the same for all firms. The speed of movement through one stage to another would be governed inter alia by a number of factors; a) motives of the firm's management; b) government's policy; c) existing technological base of the organization, d) investment in R&D activities; e) technological capabilities in the country; and f) financial resources position of the technology acquiring firm. The framework also suggests that the transition from one stage to another may not take place automatically but would be dependent upon a certain combination of external and internal organizational factors. With these few general comments about the framework I shall now describe the stages in detail.

Stage 1

Viewing the process of international transfer of technology from the perspective of the management of the technology importing firm the first stage is characterized by a technical task emphasis on acquiring technical know how from the potential collaborator. Broadly, the first stage includes alll the managerial processes related to the recognition of the need for foreign collaboration, searching for sources of technology, negotiating with government and the collaborators, and finally signing the agreement.

This stage is very critical in the international technology transfer process as the performance in the succeeding stages may be significantly influenced by the quality of management of stage 1. Lack of adequate analysis of the various issues may result in a choice which may have adverse impact on stages 2,3, and 4. A simple product requiring relatively low level manufacturing technology, low capital investment and know-how fee and royalty to be paid to the collaborator may seem attractive to a small company but may require a very high cost in terms of development of manufacturing technology for a large number of components which the collaborator might have been procuring from vendors in its own country. A product may be chosen because the collaborator may be having the know-how and may be willing to transfer it, but it may not adequately match the needs of the customer in developing countries. A second hand plant may be available cheaply from a developed country firm, but it may not be appropriate in a developing country because the obsolete plant may be based on a large number of general purpose machines requiring a very high degree of operator skill.

Broadly two kinds of technology search strategies seem to be adopted by Indian firms; a) problem or crisis induced, market-oriented limited search; and b) systematic and comprehensive lo ng term oriented search. The first approach is adopted by firms which face an imminent loss of say, an import business. When faced with an import ban, a number of tractor manufacturing firms in India launched a limited search to identify a collaborator whose products were already being sold in the country with a view to reduce the marketing risk. However, not much importance was paid to the technological content of the collaboration agreement. This strategy seems to be adopted by firms with a weak technological and financial base.

The second approach is adopted by firms with a relatively strong technological, financial and managerial base and in situations when they are not facing any immediate crisis.

The first approach requires comparatively less resources and depth of competence than the second approach. The study of technology transfer in the Indian tractor industry reveals that the first approach generally resulted in the choice of erstwhile tractor suppliers as collaborators for setting up manufacturing units. The second approach resulted in the choice of more advanced technology. On the basis of available empirical evidence it may be possible to hypothesize that a systematic and comprehensive long term oriented technology search strategy is better than the first approach; however, extreme care is necessary to analyse the various assumptions. The longer the time span of planning the more uncertain the assumptions. There needs to be a balanced appraisal of the technological, organizational, financial, marketing and legal aspects. In the first approach because an already existing product is sought to be produced many of the aspects and their implications are well known and hence not much effort is required to understand them. The organizational mechanism for searching for technology would be different for the two approaches. The first approach may require fewer people whereas the second would require expertise in the various areas mentioned earlier and it may also be necessary to analyse the various aspects simultaneously rather than sequentially.

The predominant sources of external influence on technical decisions are the government's policies and the collaborator. Most developing countries attempt to curb imports and encourage import substitution through tie-ups between local and foreign companies. Various policies influence decisions on a) make/buy of components; b) rate of indigenization; c) choice of plant and machinery; d) plant capacity; e) and mode of collaboration-financial-cum-technical vs purely technical. These decisions are significantly influenced by the collaborator's overall strategy, its policy for transferring technical know-how and its manufacturing practices. The technical know-how acquired by firms with none or little prior manufacturing experience in the same field tends to be "packaged", which means that there may be certain elements in the agreement which are not absolutely essential but the collaborator passes it on to extract a higher price. On the other hand in Stage 4 the developing country is able to "unbundle" the technological content, meaning thereby that it is able to separate out the essential from the non-essential part and negotiate for the former at a relatively lower price.

Stage 2

Stages 2, 3, and 4 are sub-stages in the process of assimilation of the imported technology. Technology assimilation at the level of the enterprise refers to the process by which the foreign technology becomes an inalienable part of the organization. Operationally, it would mean that once the foreign technology is assimilated by the organization, its members are capable of utilizing it and improving upon it for the purposes of producing goods and services. The process of technology assimilation consists of three stages, which have different emphases in terms of the technical tasks undertaken during each stage. In this section I shall discuss the second stage which focuses on adaptation of manufacturing technology.

Adaptation of manufacturing technology may be necessitated for a variety of reasons. Developing countries pursuing a strategy of import substitution require technology importing firms to progressively indigenize component manufacturing. For example, from the beginning of the 1960s the Government of India began to exert pressure on the tractor manufacturers to reduce the import content by manufacturing or subcontracting manufacture of as many components and subassemblies as possible. In order to indigenize the product adaptation of manufacturing technology was necessary to some extent. For example, many firms replaced the forgings or steel castings in the original design to fabricated components. In certain cases material substitution was resorted to whenever the material specified by the collaborator was not readily available. Manufacturing know-how for the items bought out by the collaborator in its own country does not form a part of the collaboration agreement since this know-how is not available with it. Development of these items is also an exercise in adaptation of manufacturing technology.

Scaling down the manufacturing system of the collaborator to a much smaller plant size as allowed by the industrial licensing policy of the government is also another form of adaptation. In the Indian tractor industry plant size was regulated by the government's licensing policy. Industrial licensing directed towards securing the national objectives had among the original aims; i) regional dispersal of manufacturing units; ii) prevention of economic concentration; iii) impetus to small industries, iv) encouragement to import substitution; v) opportunity to new entrants; vi) elimination of unlicensed expansion. The capacities allocated to each firm in consonance with the government's policy was very small compared to that of its collaborator's plant. Hence these firms were forced to adapt the mass production technology acquired from their collaborators to small volume batch production technology. Though the external factors are similar the nature of adaptation by each firm could be very different. The differences could arise because of the unique characteristics of each firm.

The proportion of bought out components and or sub-assemblies to inplant processed ones varies from firm to firm since this depends on the practice followed in the corresponding collaborator's works. The higher the proportion of inplant manufactured components, the more reliable is likely to be the quality, since the manufacturer can have better control over manufacturing processes in its own works. In the Indian tractor industry, consisting of a total number of 13 firms, 7 account for more than 95 per cent of the total production. Five out of these seven units have set up inplant manufacturing facilities for most of the critical elements of the tractor, viz., i) engine; ii) transmission system consisting of clutch, gear box, rear axles and final drive; iii) hydraulic system and linkage for control of implement depth, draft and position; iv) power take-off (P.T.O.) shaft and draw bar. Massey Ferguson uses an engine manufactured by Simpsons, an associate; and Ford uses transmission and hydraulics manufactured by Escorts Limited, a firm in the same conglomerate group. Eicher Goodearth uses transmission and hydraulics manufactured by its associated companies. However, Punjab Tractors buys the engine and hydraulics from outside, and HMT Limited purchases the hydraulics from a specialised manufacturer.

The choice of plant and machinery though influenced by the collaborator's practices may be also influenced significantly by the local firm's management. Eicher Tractors installed very cheap locally available machines and tooled them up by designing appropriate jigs and fixtures. This helped it to design a manufacturing system for producing a volume comparable with the other larger units at an extremely low capital investment. International Tractors (ITC) for its initial phase installed mostly general purpose machinery on the lines of its collaborator's plant, which relied upon very old conventional machines. However, for its expansion project ITC went in favour of more sophisticated machines to overcome problems they had faced earlier in maintaining close tolerances and consistency in quality levels.

Examples of adaptation of manufacturing and product technology received from collaborators are many and it may not serve any useful purpose in recounting all of them. In sum, technological adaptation can be of two types; a) modifying the input specifications, developing manufacturing technology for components not manufactured inhouse by the collaborator and scaling down the manufacturing technology supplied by the collaborator and b) modifying the product design and making concomitant changes in the required inputs and the manufacturing technology. During Stage 2 the emphasis of adaptation is on the former. This type of adaptation is induced by a) suppliers' characteristics, b) government's policies, and c) collaborator's products. It is also influenced by the organizations' resource position, capability base and the values of senior managers. Understanding of technical know-how is very important during this stage.

Briefly the key managerial tasks during this stage are; a) the creation of a project team with the requisite expertise; b) formulating a strategy for developing technical skills at different levels; c) detailed study of collaborator's technology and choosing manufacturing technology consistent with licensed capacity, technical base of the suppliers, and its own financial position; d) negotiating with suppliers, building contractors, technical consultants, e) and developing vendors.

Providing technical leadership is extremely critical in firms which have a weak technical and financial base because

In such cases very creative technical decisions may have to be taken to overcome the weaknesses. The critical skills and knowledge necessary to effectively manage Stage 2 are listed in Figure 1. The organization is characterized by a high degree of informality as procedures are not yet fully developed. Decision-making is more or less centralized. There is hardly any marketing activity. Products assembled from semiknocked down (SKD)/or completely knocked down (CKD) packs are assembled in relatively small numbers and sold as part of the "market seeding" activity. There is no R&D department, but most organizations have a "cell" focussing on activities related to indigenization.

Stage 3

The technical task emphasis during Stage 3 of the framework is on utilization of the capacity and technical infrastructure already created. The major objective of a firm's management during this stage is to establish production and increase capacity utilization to the highest level possible. The key managerial tasks as can be seen from Figure 1 are quite different from that of the first two stages. The tasks are more related to building up of the technical organization and institutionalizing various management systems such as production planning and control, inspection, quality control, and inventory management. The organization's leadership is required to institutionalize various norms and values related to productivity, quality, cost control, etc. Due to the increasing size of the organization, there is an increasing trend towards formalization. Co-ordination through face to face meetings become increasingly difficult; hence the need arises for formal mechanisms for coorrinating the tasks of different departments. The critical skills and knowledge required during Stage 3 are: i) ability to coordinate a fairly large number of specialized functions through formal means; ii) skills in formulating policy with the inputs from a number of departments; iii) specialized skills in managing a number of functions; iv) ability to implement a variety of management systems; v) and skills in building organizations.

Stage 4

The technical task emphasis during stage 4 is on making improvements on the original product design and developing new products. Figure 1 summarises the key managerial tasks related to the technical functions. It may be seen that creating an organization to perform the new tasks demanded by the market is very important. The predominant sources of external influence on the technical functions are no longer suppliers, or the government as in the previous stages. It is the customers and competitors who matter most. Organizations in this stage respond to the new needs of the market place by creating an R&D department which is separate (from the pproduction unit within the R&D department) specialized sections are created; which focus their attention on distinct activities such as design improvement of a certain assembly, quality assurance or new product development. Owing to increasing competition, firms develop mechanisms for acquiring information on competitor's R&D activities, new products launched in the market, the performance of their own products and emerging needs of customers. Owing to the dynamism and uncertainty in the environment more information needs to be processed and hence more integrating mechanisms are developed. Stage 4 is also characterised by a lesser degree of centralization. R&D emerges as a new power centre. Organizations in this stage attempt to develop company wide planning systems.

The critical askills and knowledge required are: i) coordination of a large organization, ii) an ability to manage organizational transition from a "production-sales" orientation to simultaneous attention to marketing, R&D and production, iii) strategic analysis; iv) implementing company wide planning and control systems, v) and organization building. The type of leadership required could be categorised as "organization builder, strategic analyst and entrepreneurial".

Two Case Studies

In this section two case studies of technology acquisition and assimilation are discussed in order to illustrate the framework described above and to highlight the problems faced in the transition through the stages and how they were sought to be managed.

Figure 1: Organizational Stages in Acquisition and Assimilation of Foreign Technology

CHARACTERISTICS	Stage 1	Stage 2	Stage 3	Stage 4
Technical Task Emphasis	Acquisition of Technology	Adaptation of Manufacturing Technology	Technology Utilization	Technology Improvement and Development
*Key Managerial Tasks	1. Recognising the need for seeking technical collaboration. 2. Search for possible collaboration opportunities 3. Evaluation of technological collaboration alternatives 4. Negotiation on: a) Products to be manufactured; b) Mode of collaboration and terms and conditions c) Make/Buy decisions at a broad level d) Plant location e) Financial scheme, etc. 5. Deciding on technical consultant 6. Final choice of collaborator.	1. Creating the project team for implementing the project 2. Formulating strategy for developing technical skills at different levels: a) deciding on whom to send to collaborator's plant. b) deciding on training methods. c) deciding on how to train people at home and in what areas. 3. Detailed study of manufacturing system at collaborator's plant. 4. Selection of manufacturing technology consistent with local capabilities of machinery and component suppliers ascertained after detailed survey. 5. Negotiate with potential suppliers, collaborator, building contractor(s), technical consultants, etc.	1. Commissioning the Plant and establishing production. 2. Creating specialized organizational sub-units for handling new tasks such as: a) production planning and scheduling, b) inspection and quality control, c) industrial engineering, d) personnel and industrial relations, e) purchase and materials management, f) sales and distribution. 3. Setting up and institutionalizing various management systems like a) production planning and control system, b) quality control system, c) inventory management system, etc. 4. Inducting managerial staff in key positions. 5. Establish systems for co-ordination of the work performed by the various departments.	1. Creating organizational sub-units for performing the following: a) Systematic analysis of feedback on product performance b) Quality Assurance c) Value Engineering d) Cost and Productivity Improvements e) New Product Development f) Research and development activities leaning more towards the 'R' end of the R&D spectrum. 2. Systematic environmental analysis for ascertaining demand for new products. 3. Locating and negotiating with potential technology suppliers for new products if technology is not available internally. 4. Developing co-ordinating mechanisms for integrating the work of the various new departments amongst themselves and also with relevant existing ones.

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		6. Search for technical know-how for components for which the collaborator may not have know-how. 7. Provide technical know-how and other assistance to develop suppliers. 8. Design manufacturing system for scaled down production volume.	6. Development of policies in inter-related functional areas. 7. Setting norms for production, quality, maintenance, etc.	5. Developing and introducing company-wide planning and budgeting systems and more sophisticated information and control systems.
*Predominant sources of external influence on technical decisions	1. Government's policies on:a) Import of technology b)Foreign Investment, c)Import of Plant & Machinery, d)Industrial Licensing. 2. Collaborator	1. Supplier 2. Government's requirement of progressive indigenization 3. Collaborator	Government's price and distribution control	1. Customer 2. Competitors 3. Collaborator (If relevant)
*Supply sources of machinery and equipment	-	Partly imported and partly indigenous.	-	Predominantly indigenous
*Supply sources of components and parts	-	Initially CKD packs supplied by collaborator.	Critical sub-assemblies and components supplied by collaborator, which was gradually reduced by developing indigenous sources.	Predominantly indigenous
*Size and nature of market	1. Small regional(catered through SKD packs) 2. Negotiable competition	1. Regional but larger(within the country) 2. Large unsatisfied demand	Geographically Diversified domestic markets 2. Little competition	1. Predominantly domestic but some overseas presence 2. Relatively high competition based on product range, quality, price and other services.

Characteristic				
*Product Range		Mostly single product	-	Additional products introduced
*Sources of know-how		Foreign Collaborator	Foreign collaborator	Foreign collaborator Local Applied R&D Institutions In-house R&D department
*Characteristic of know-how	"Packaged"			"un-packaged"
*Type of production technology		Emphasis on simple general purpose machines		Increasing trend towards more sophisticated plant & machinery
*Nature of organization	Very small team	Larger team consisting of a number of engineers for implementing the project	Functional organization Organizational sub-units created: a) Production Planning & Control b) Inspection & quality control c) Industrial engineering d) Purchase e) Sales and distribution f) Industrial relations	Functional organization Organizational sub-units added: a) product servicing b) quality assurance c) value engineering d) cost reduction and productivity improvements c) specialised sections for improvements in design. e.g. engine, transmission, metallurgy, etc. f) marketing planning
*Critical skills and knowledge	1. Skills in negotiating 2. Strategic analysis 3. Knowledge about markets and governmental policy and thinking of key people in Govt. 4. Knowledge of international trends in product/technology 5. Knowledge about funding sources and an ability to negotiate with them. 6. Knowledge about legal aspects	1. Technical assessment of plant & machinery 2. Designing manufacturing system for significantly smaller capacities than that of collaborator's plant 3. Knowledge about plant & machinery available in the country. 4. Ability to enthuse a group of engineers to take on challenging technical task of adapting collaborator's technology.	1. Co-ordination of a large number of specialised functions through formal means 2. Skills in formulating policy 3. Skills in the various functions listed above 4. Ability to implement management information, planning & control systems in the manufacturing area	1) Co-ordination of a larger organization 2. Ability to manage a shift in organizational focus from "production and Marketing" R & D simultaneously. 3. Strategic analysis 4. Skills in implementing company-wide planning & control systems 5. Integrating the work of a large number sections and departments through a variety of informal and formal mechanisms. 6. Skills in organizational analysis and building organization.

Characteristic				
		5. Ability to deal at a high level with collaborator's technologists 6. Dealing with suppliers of machine & components 7. Training a group of young engineers and workmen.		
*Some key aspects of organization structure	Team consisting of members of top management	Team with "Project Manager" as head Coordination is achieved through informal face to face discussions.	.Functional organization with dominant orientation towards production and sales, less importance to staff roles. .Little importance given to quality control and R&D .Q.C. department often reports to head of the manufacturing function. .R&D forms a part of the "engineering" department .Use of co-ordination committees, introduced with a focus on production related aspects.	.Functional organization with multiple focii: R&D, Marketing and Production .Increased importance to Staff roles .Quality control is given greater importance. Sometimes head of Q.C. department reports to head of overall operations. .R&D becomes a separate department with specialised sections under its purview .Some firms set up separate deparment for exports .Marketing & Sales function is reorganized to go closer to the customer .Greaters stress on multiple and formal integrating mechanisms.
*Type of Leadership	Entrepreneurial/ Strategic Analyst	Technical Leader	.Organization Builder	Organization Builder/Strategic Analyst/ Entrepreneurial
*Nature of Control Process	-	Informal/Personalised	Combination of informal and formal	Greater emphasis on formal
*Degree of Centralization/Decentralization		High Centralization	Lower degree of centralization	Emphasis on decentralization and lateral communication processes.
*Task Emphasis of Marketing Department		Market seeding	Selling and Distribution	Marketing
*Task Emphasis of R&D Department		Indigenization	Indigenization,Production and product related trouble shooting	Product improvement, Cost reduction New product development.

Eicher Tractors Limited

A brief summary of this case was provided in the introductory part of this paper. In this section I shall describe the technology acquisition and assimilation process in greater detail.

Acquisition of Technology:

The entrepreneur started importing tractors from Gebr Eicher of West Germany in 1952. A good workshop was set up for repairs and maintenance and training of farmers and mechanics. Import of complete tractros continued till the end of 1956 after which the liberal import of tractors through normal trade channels ended on account of the stringent foreign exchange situation. As a result the entrepreneur started exploring the possibility of collaborating with Gebr Eicher to set up a manufacturing unit to produce tractors in India. Towards the end of 1958 the government of India issued an industrial licence to the company. The entrepreneur decided to manufacture the 24 HP tractor because of a number of factors; a) it could withstand various types of use and abuse like pushing heavy loads, pushing trailers, various farm operations; b) ease of maintenance - even poorly trained village mechanics could maintain it; c) low price and d) low operating cost.

Gebr. Eicher of West Germany had started as a small venture just after World War II. Its production volume was very low - about 3000 tractors per annum. It used very simple machinery. A collaboration agreement was signed in 1959, which ended in 1973. It was a financial-cum-technical collaboration. Gebr. Eicher's share of the total paid up capital is 23.82 per cent, the remaining is held by the Indian promoters and the public. According to the agreement the collaborator was required to; a) supply the documents and drawings for the manufacture and assembly of tractors, b) supply critical components till they were progressively indigenised, c) help in establishing production and assembly operation in India, d) supply all drawings and documentation of jigs, fixtures, and d) train engineers of the Indian company at their works.

However, before much progress could be made the collaborator ran into a number of problems like sinking market share, inadequate technology, etc. In 1970 Gebr. Eicher was bought over by Massey Ferguson of Canada.

Adoptation of Manufacturing Technology:

Initially the government had issued an industrial licence to Eicher Tractors India Limited for the manufacture of 1250 tractors per year, which was later increased to 2000. A few years ago it was raised to 17000.

Compared to the usual production capacities of over 30,000 tractors per annum of the major manufacturers in North America and Europe Eicher's initial capacity was extremely small. This posed a very challenging task of designing a manufacturing system appropriate for such a small volume. Coupled with this was the problem of inadequate supply of imported CKD packs and components, and government's pressure to indigenize. Eicher India also lacked proper technical infrastructure to undertake the task of indigenisation as stipulated by the government. Its meager financial resources did not allow them to maintain highly qualified and experienced technical personnel. The company continued to lead a precarious existence till the late 60s as its production was almost entirely dependent on the availability of imported assemblies.

The critical factor which prevented the company's progress was its inability to adapt the imported know-how to the local environment. The explanation for the situation the company found itself in could perhaps be explained by the lack of a "technical leader" in the organization. The key tasks for the proper implementation of the project were the design of a manufacturing system geared to an extremely small volume, and the building up of the organization to manage the engineering and manufacturing functions. The foreign collaborator's technicians who had been sent to the Indian firm had not been able to design the system in the short period that they were there. With their departure, there was a vacuum in the technical leadership.

In 1968, when the present MD took over the charge of the technical functions a new phase began in the organisation's history. He succeeded in designing an innovative manufacturing system which helped the organisation come out of the difficult situation. The critical steps that he took were the following:

(1) Deciding to indigenise the tractor rapidly through own efforts.

(2) Identification of plant and machinery compatible with the product requirements, licensed capacity, funds position, and organisational capabilities.

(3) Providing personal leadership for solving many technical problems on the shop floor, or the drawing boards.

(4) Purchase of some critical second-hand machinery at very low prices. Though the technology was obsolete, it matched product requirements, and the organisation's fund position.

(5) Designing appropriate jigs and fixtures to 'de-skill' the operations in order that they could be performed with less skilled workmen who could be retained at wages lower than what would have been required for highly skilled operators.

(6) Designing simple material handling systems to reduce capital costs.

(7) Setting up of a team of engineers to design some of the more critical machines in-house

which were very expensive. The MD provided considerable technical help to this team. This step not only helped reduce capital expenditure but also aided immensely in the building up of technological capability within the organisation.

(8) Some of the 'frills' on the tractor were removed to reduce the manufacturing cost further.

Once these tasks were performed there was considerable improvement in overall production performance. The organisation during this stage was very informal. Formal mechanisms for co-ordination and control had not been developed. The technical leader was closely involved in performing the key tasks during this stage. He also played the role of the integrator of the various teams.

The case of Eicher Tractors India Limited brings out very clearly the complexity of the process of technology adaptation in a typical developing country like India. Lack of resources, absence of technical capabilities and a hostile environment impede the process of assimilation of foreign technology. However, simplicity of product technology and its compatibility with the host technological environment facilitate its assimilation by the technology importing organisation.

Technology Utilisation:

With the identification and performance of the key tasks during the technology adaptation stage, Eicher Tractors entered a new phase in its history. Production started increasing and within a period of three years all the accumulated losses were wiped out. However, a new set of problems emerged as production could not be increased beyond a certain level.

The company used the services of a management consultant to identify the reason for the low production levels. The consultant recommended strengthening of the organisation by placing professional managers at key positions and also improvement of various management systems. With the implementation of these recommendations there was a dramatic improvement in production performance.

Major organisation changes were initiated during this stage. To improve quality levels, the management thought it necessary to have rapid market feedback and quick action on field problems. To develop this capability in the organisation, the marketing department was restructured to develop closer contact with the customers and also to develop a higher degree of specialisation within sub- functions. To improve the coordination between marketing and other technical functions, various coordinating mechanisms were instituted.

The key tasks performed by the top management during this stage were:

(1) Induction of professional managers at key positions,

(2) Developmment of decision- making capability at relevant levels in the organisation,

(3)

(3) Creation of some specialised decision-making units within the organisation,

(4) Development of some formal integrating mechanisms,

(50 Defining a set of policies in inter-related functional areas, and

(6) Development of appropriate management systems.

Technology Improvement and Development:

With the change of the market conditions from an absolutely sellers' to an increasingly buyers' one there was a felt need in the top management for developing an increased marketing orientation. This was exemplified by the drastic step taken by the company to stop production for a month to given attention to quality problems. This was the precursor to the next stage; technology development.

With substantial improvement in its financial position by 1974-75, the top management directed its attention to improvement of existing products and development of new products. A separate R and D Centre was set up with relatively substantial investment in facilities. Sub-functional specialisation was also encouraged by including specialists in engine design, farm machinery, transmission, machine tools, electrical machines, metrology, and material science. These steps were taken to create an environment within the organisation for the development of know-how for the company's future expansion and product diversification.

In addition to the creation of a separate R and D centre the marketing function was strengthened by improving communication channels, integrating sales and service territorially, formalising links with relevant areas to look into issues related to product quality, etc., which were necessitated by the increasing competitiveness of the market.

<u>The International Tractor Company of India</u>[17,18]

Overview:

The International Tractor Company of India (ITCI) came into existence in 1961, coinciding with the beginning of the era of import-substitution. It was promoted by Mahindra and Mahindra Limited, Voltas Limited and International Harvester, each contributing 17 per cent of the equity. Voltas had long experience in marketing and distribution of imported tractors while Mahindra and Mahindra (M&M) had experience in automobile manufacture. International Harvester's (IH) subsidiary in U.K. provided the technical know-how, and IH, USA provided a large foreign exchange loan; Voltas provides sales and service and M&M took the responsibility of managing the company.

Installation of the plant and machinery was completed during 1965 and commercial production begun in April 1965. The company performed exceedingly well till 1975. In 1976 the company suffered a set back, when it made a large financial loss for the first time in its history, which finally led to its merger with M&M. It is now known as the International Tractor Division of M&M. The operations improved considerably after the merger and during the period 1983-84 it was the largest manufacturer of tractors in the country with a production volume of 15,901.

Acquisition of Technology:

The collaboration agreement initially covered the 35 H.P. tractor model. The 35 H.P. tractor was chosen as it was the lowest H.P. tractor made by I.H. in U.K., and was the most popular size in U.K. and Europe. The general practice in India seems to have been that the smallest model which was in regular production at the collaborator's works was initially selected for manufacture in India. New models of higher horsepower were added as and when the need was felt. The following services were provided under the agreement:

- Supply of CKD packs
- Technical know-how for manufacturing and servicing
- Use of trade marks
- Basic product design, part drawings, manufacturing process sheets, specification of standards, testing and quality control methods, etc.
- Help in establishing production.
- Supply of tooling
- Continuous supply of modification in product design.
- Finance for import of capital goods
- Training of Indian Engineers at the collaborator's works.

Later ITCI obtained the design and drawings for the 43 H.P. model, later upgraded to 45 H.P., from IH, UK. The collaboration agreement expired in 1971.

In 1964, one of the senior executives of M&M was transferred to ITCI to implement the tractor project. Along with him a few senior engineers were also transferred. Most of the strategic decisions had already been made by the top management. Decisions which were required to be made by the new ITCI team were:

- make/buy/import of components
- extent to which facilities of M&M could be used
- Selection of manufacturing processes
- Selection of plant and machinery
- Design of special tooling
- Procurement of jigs, fixtures and special tooling
- Design of plant layout
- Training of personnel.

The manufacturing programme had to be designed keeping in mind the phased indigenization requirement of the Government of India. Initially ITCI was given a licence for manufacturing 3500 tractors a year but subsequently the government approved their application for increasing their capacity to 10,000 in two steps. At the time of planning for the first phase ITCI had already received the letter of intent(the stage before receiving the licence) from the government. This helped

ITCI in integrating properly the subsequent stages of incremental capacity expansion.

Some of the important steps taken to transfer technology from IH, UK to ITCI were the following.

1. IH, U.K., supplied all technical documents related to product, manufacturing processes, and tooling.

2. The ITCI team studied all the technical documents and based on those drew up a plan for a phased manufacturing programme. They also prepared the process sheets finalised design of jigs and fixtures, and decided the plant nad machinery and inspection equipment required to be imported.

3. Two engineers from ITCI were sent to IH, U.K. to study their operations. During this visit, the tooling designed by the collaborator's engineers was modified. The trials of the imported equipment were also conducted during the visit by the Indian engineers.

4. One senior executive was deputed by the collaborator to the Indian partner to provide technical help in establishing production and maintaining quality levels as stipulated in the standards. This person was also member of the Board of Directors of ITCI.

In the very first year of manufacture 50 per cent of the components by value had to be deleted from the CKD packs in accordance with the conditions of the industrial licence. The components which comprised this 50 per cent were items like tyres, tubes, batteries, horns, etc., which were readily available from automotive ancillary units. Indigenization of these components required little technical input from the company.

In the second phase of indigenization sources for semi- finished components such as castings and forgings were identified and developed. A large number of sources had already been developed by the Jeep Division of M&M.

The subsequent phases of the indigenization programme were critical as the components indigenized during that period were technologically complex. There was no existing capacity for manufacturing those components, they required heavy capital investment for plant and machinery, and entrepreneurs were not willing to invest in capital equipment for manufacturing these items at low production volumes. The company decided to set up its own facilities for machining all components of the engine and the transmission.

Initially the company had problems in the development of sources for engine castings because of thin walls and close tolerances. The pattern for manufacturing the castings had to be imported as it could not be procured indigenously.

All pressed components were planned to be procured from M&M's Automotive Division.

Facilities for machining all the components of the engine and transmission were planned to be installed within iITCI's premises.

At the time ITCI was founded the Hindustan Machine Tools Ltd. had already made a mark as a manufacturer of high quality general purpose machine tools. Also at the same time the country was facing an acute foreign exchange crisis and therefore imports of general purpose machine tools were banned. The Government also banned import of special purpose machines which were proposed to be manufactured by HMT in 1966-67.

The project team studied the technical documents which included product drawings, manufacturing process sheets, production drawings of jigs, fixtures and tooling before deciding on the manufacturing process. In the 1960s International Harvester relied upon very old factories for the supply of components for their tractors. There was a general reluctance to invest[18A]. The manufacturing processes used by them for some critical components were highly time consuming. For example, for machining the cylinder head of the engine, International Harvester's plant in U.K. used a very conventional process. However, in the first stage of capacity installation of 3,500 tractors per annum, the processes adopted by ITCI more or less resembled those used in the IH-U.K. plant. For the 3,500 tractors per annum stage the machinery was mostly general purpose type. The reasons for this seem to have been; i) influence of the collaborator, and ii) the economic aspects (special purpose machinery were not economical for low production volumes). In the first stage the jigs and fixtures and special tooling were procured from foreign suppliers along with some of the machinery which was not available in the country then.

For the second stage expansion to 7000 tractors per year, the choice of plant and machinery was in favour of more sophisticated ones to overcome difficulties faced with universal and conventional machinery used in the first stage of 3,500. Problems were faced in maintaining consistency in quality levels. Rejection rates were high. Difficulties were faced in maintaining close tolerances. Some problems were faced because well trained workmen were not easily available, whereas the general purpose machinery used for the first stage required higher operator skill. The shift towards choice of more sophisticated machinery in the second stage was mainly to de-skill the manufacturing operations.

By 1969 the installation of plant and machinery for the first stage was over. Facilities included machinery capacity for heavy components - crankcase, cylinder head, transmission case, rear axle carrier, front axle support, and clutch housing. The light machine shop housed facilities for manufacturing light-weight components such as, flywheel, connecting rod, valve housing cover, etc. Gears were also manufactured in small volumes.

The engineers who formed the project team were drawn from Capital Purchase, Tool Engineering and Industrial

Engineering departments. The recommendations of this team was to adopt more sophisticated manufacturing processes and machinery to improve quality, consistency and to achieve higher production. Also it was recommended to gradually change the shop layout from a completely "process" to a "product oriented" one. In the new layout some of the components were to have separate production lines to reduce "handling" and "back tracking". Some of the changes which were made were the change over to special purpose machinery for machining the valve seat, injection bore, transmission case and cankcase. ITCI's collaborator used a conventional machine for some of the operations on the crankcase. They overcame problems encountered in using conventional machines by some adaptations in assembly techniques; for example, by using a higher torque while tightening bolts. Such techniques were not documented and could only be transmitted through verbal communication with experienced technicians. Such techniciques could be developed through trial and error and over a long period of time. Therefore ITCI decided to shift to more sophisticated processes. Additions were made to gear manufacturing capacity to cater to the volume of 10,000 which include special gears like the hypoid gear used in the differential,bevel gears and all heat treatment facilities.

Experiments were made by the ITCI engineers to convert GPMs into SPM by making certain modifications but the efforts were not very successful.

Technology Utilization:

During the year 1964-65 production was a mere 225 tractors, which were assembled completely from 100 per cent CKD packs in a makeshift shed in M&M premises. Severe shortage of building materials, and foreign exchange stringency contributed to the delay in implementation of the project. No manufacturing activity could be undertaken during 1965-66. However, during 1966-67 manufacturing activity was begun with an indigenous content of about 51 per cent. During the next few years all attention was focused on increasing production volume, more so because during 1967 tractor prices came under the ambit of the government's tractor price and distribution control policy. Total volume of profit could be increased only by increasing volume. Production increased rapidly to a little more than 9000tractors during 1971-72.

Cost of manufacturing tractors started increasing rapidly and from 1968 onwards ITCI made several representations to the government for allowing price increases. In 1970-71 the government's new finance bill imposed customs duty and excise duty on all tractors and tractor components. Earlier all tractors below 50 H.P. had been exempted from payment of customs duty. During 1971-72 the government allowed some increase in prices of tractors. But the situation did not improve much as the input prices continued to rise. ITCI's profit margins went on decreasing. Around 1972-73 the market for tractors started showing signs of saturation. So volumes of profit could not be increased by increasing sales volume. In order to improve financial performance ITCI introduced the IH-434, a 43 H.P. tractor during 1972-73. ITCI also made a beginning in exports during the same year. The net profit in 1973-74 was only Rupees 3.31 million as compared to Rs.7.55 million in the previous year. During 1973-74, ITCI produced 3009 IH -434 tractors and in the next year 3,200. However, as a result of haste in introducing the new model some problems were faced in the field which created a poor image in the market. Lack of adequate and timely feed-back from the field accentuated the problems. There was a pressure on the dealers to sell more tractors at a time when the demand was stagnating. Ultimately when product problems became very acute the new model was withdrawn. However, a modified version, a 45 H.P. tractor was later introduced very successfully.

As a result of repeated representations to the government by the tractor industry the selling price of tractors was decontrolled in October 1974. Then followed successive price increases. There was a time lag between price increases by ITCI and its competitors. At one time ITCI's 35 H.P. tractor sold at Rupees 6000 to 7000 more than comparable models of competitors, resulting in a temporary market resistance to ITCI's products.

During 1974-75 ITCI received a shock as its operations resulted in a loss of Rupees 25.38 million.

At this juncture ITCI decided to take over marketing of its tractors from Voltas. The market had become quite competitive with a number of manufacturers operating in a stagnating market. ITCI's management felt that it was necessary to go closer to the market.

A phased plan for the take over of the marketing and distribution function from Voltas was finalised. Initially a large number of dealerships had to be reactivated as many of them had gone out of business during the market slump.

The poor performance of the company during 1974-75 and 1975-76 triggered off major organizational changes. Till 1976-77 the organization was very informal. As an illustration, no organizational changes before 1977 had been documented. No formal and regular forums existed for discussion among functional heads. Most of the persons had worked together for a long period and so whenever there arose the necessity they used to meet and discuss the problems. There was no system of company-wide budgeting. Departmental heads prepared budgets on an ad hoc basis. Manufacturing and sales plans were made, but there was little systematic effort at integration of the same.

In early 1977 in a significant departure from past practice, the chairman of the company announced a number of organizational changes through an official memo. The announcement contained personnel changes as also the creation of new functions.

The person, who had earlier been responsible for implementing the project, was brought back to head ITCI from M&M where he had been transferred in between. This was done to provide strong leadership to the organization. A new position was created for the internal audit function, directly under the chairman. The function of company-wide planning was also temporarily entrusted to the person in-charge of operational and financial audit. A new position was created to manage the embryonic export operations.

Immediately after the top level changes announced by the company's chairman, ITCI's chief executive also brought in a number of changes. During the previous three years or so the company had faced problems arising out of erosion of product quality, poor coordination between manufacturing, engineering and the marketing functions. The new chief executive attended to these needs. Weekly production meetings were instituted immediately. All departmental heads were to be present in these meetings. A company-wide budgeting process was introduced. In early 1978 a separate cell called Management Information Section was created to improve the information and reporting system. At the middle management level, emphasis on value engineering, product reliability and quality control was sought to be given by the creation of separate positions of Chief Value Engineer and Chief Quality Engineer. The former's responsibilities were; product cost control, value engineering and product engineering and the latter's were product reliability, manufacturing and supplier's quality and quality audit.

The post of Production Services Manager was created to coordinate the following; a) production planning and control, b) production engineering, which included tool engineering, time standards and methods improvements, tool room, and plant maintenance. The above functions were grouped together to facilitate timely and effective rendering of all the services for production.

Technology Improvement and Development:

Till 1977 the research and development activities of the company had been conducted under the umbrella of the engineering department. R&D was clubbed with tool engineering, industrial engineering and capital purchase. However, in 1977 the management realized that the competitive market conditions required stronger emphasis on R&D and hence a separate R&D department was created through an announcement from the chairman's office. The erstwhile engineering manager was appointed as the R&D manager with separate functions under him for design and value engineering, prototype development and total product evaluation and testing. Though most of the activities of the new R&D department were already being performed, the creation of a separate R&D department gave a new thrust to the function. The personnel strength was planned to be increased substantially. Simultaneously it was planned to increase the investment in capital equipment.

After the merger of ITCI with M&M a centralized R&D organization was created at a place about 200 Km away from the manufacturing plants. This centralized department was made responsible for R&D activities related to Jeeps, light commercial vehicles and tractors. In addition the company has a separate product improvement department located at the earlier site adjacent to the manufacturing plant.

Prior to 1977-78 the thrust of the R&D activities was on trouble shooting activities related to the existing product and manufacturing problems. However, after the creation of the separate department there was some shift in orientation towards improvement in existing products and new product development.

A 50 H.P. model designed and developed indigenously by M&M was introduced in 1980-81 but as of 1980-84 it was a small component of the product mix. The first tractor, the 35 H.P. model still dominated M&M's product portfolio, accounting for almost 20 per cent of the total market for tractors. The company also claimed that the fuel consumption of the original engine had been reduced from 220 to 195 grams per brake horse power hour (gms/BHP hr.). According to the company, improvements had been made to the piston ring assembly, engine cooling system and foot accelerator. New products like industrial fork lifts, front end loader, tractor mounted road roller and a hauler tractor had been developed by the R&D department.

Conclusion

It has been mentioned previously that the liberalization of the Indian government's policies towards industry and import of technology has resulted in a significant rise in the annual number of foreign collaborations approved by the government. This fact shows that given the right policies of prospective host governments, MNCs and other firms in developed countries may be quite eager to transfer their technologies to developing country firms. Contractor's[19] study of international technology licensing shows net licensing income obtained by several U.S. firms to be very respectable, considering the much lower risk associated with it compared with direct investment. According to him several U.S. corporations are taking a fresh look at licensing and other contractual modes for generating foreign income and some firms have upgraded licensing departments in the last few years. Ford and Ryan[20] assert that using a technology solely in product sales is no longer enough. Companies in the developed countries face high R&D costs, competitive pressures from low-cost producers, capacity limitations, antitrust laws, financial difficulties and foreign trade barriers. Hence they must improve the rate of return on their technology investments by marketing techno-logy as completely as possible during its life cycle.

However, the process of transferring technology from a firm in the industrially advanced countries to one in a developing country is not without its problems. The two case studies described in the previous section amply prove this point. Eicher faced problems mostly in the technology adaptation stage. Inspite of the fact that the product and the process technology used by its collaborator were so simple Eicher India faced enormous problems. The problems were overcome only after the emergence of the technical leader who made a number of innovative decisions.

On the other hand ITCI did not face any problems during the technology adaptation stage as it had a strong technical infrastructure. M&M's prior manufacturing expertise in the automotive industry was very useful to ITCI. However, the company faced problems during the technology utilization stage because of a delay in the development of an appropriate organization structure, compatible management planning and control systems and the lack of an organization builder.

Both technology suppliers and technology receivers need to recognize that the process of international technology transfer is a complex phenomenon which requires a variety of skills at different stages in the total process. These have been discussed in previous sections and tabulated in Fugure 1.

In my experience of studying international technology transfer processes in a variety of industries, I have found firms attaching very little importance to organizational aspects. However, as evident from the case studies and the stages framework, building an appropriate organization is critical in Stages 3 and 4. In fact Stage 3 requires a leader who has skills in building and managing complex organizations. Stage 4 requires a leader who is not only an organization builder but also is a strategist and an entrepreneur. Emphasizing the need to know about "hardware" alone is not enough. Acquiring knowledge about how to integrate the hardware into the organization is equally important. Appropriate management of each of the stages is important. However, there is need for a qualification at this stage. Many developing country firms collaborating with firms in developed countries never reach Stage 4. The transition to Stage 4 may not be absolutely necessary as a firm, if the government allows it may continue to depend on its collaborator for the supply of technology from time to time. However, if the market is competitive and access to foreign technology is not very easy, developing country firms tend to move into Stage 4. It may be also possible that firms which have moved into Stage 4 may slide back into Stage 3 if the top management does not perceive the continuing need for an R&D orientation. Most top managements perceive a higher degree of risk with a Stage 4 orientation.

The significance of the "software" aspects of technology transfer suggests the need for designing appropriate training programmes for technology transfer. Apart from including technical aspects, collaboration agreements should include a specific training module focusing solely on organizational aspects. However, it does not imply that technology recipients should adopt all management practices lock-stock-and barrel. Every management tool used by the collaborator must be evaluated for its need and suitability to the host environment before being adopted.

The cases discussed in the previous section amply bring out the fact that the foreign collaborator and the technology recipient have complementary roles. Both have to play active roles. In situations where one partner is not capable of playing the proper role the other has to strive much harder. Till Stage 2 the role of the foreign collaborator may be quite strong, however, it diminishes as the organization moves into Stage 3 and Stage 4. In future with certain segments of Indian industry becoming highly competitive, it is likely that a larger number of firms will move into stage 4. New forms of collaboration agreements may then be required. Uptil now cases of Indian firms seeking guidance from the collaborators on R&D has been rather limited. However, this scenario is likely to change and increasingly Indian firms will tend to ask their collaborators to help them develop R&D facilities and organizations. The framework described in this article suggests that Indian firms are better able to choose technologies which are compatible with the small capacities allowed by the industrial licensing policy of the government. They have skills in adapting imported technology to suit local conditions and also in identifying and developing suppliers. Foreign technology suppliers should actively try to utilise these latent skills in designing their technology transfer programmes.

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APPENDIX.

The Indian tractor industry is now more than 25 years old. A beginning with indigenous manufacture was made in 1959 when the first tractor manufacturing unit was set up by Eicher Tractors Limited near New Delhi. Though indigenous manufacture was initiated in the beginning of the 60s decade there was significant dependence on imports till the beginning of the 70s. Since the mid 70s, however, the industry's production has grown fairly rapidly with some fluctuations and is now said to be the fifth largest in the world. In 1984 the tractor industry produced more than 80,000 tractors.

The farm tractor is a complex piece of machinery, consisting of an internal combustion engine, a transmission or gear reduction and selection unit to convert engine power to to torque at various speeds; and a hydraulic system and linkage for control of implement depth, draft, and position, and other accessories. Twentyfive years ago knowledge and expertise in the country about complex machinery was extremely limited. Hence, the government encouraged the setting up of companies in collaboration with foreign manufacturers.

At the time of the study during 1978-79, there were 11 manufacturers which included, a) firms of different sizes, b) firms in various stages in the process of assimilating the acquired technology, c) firms in the private as well as the public sector, d) firms which had acquired technical know-how through foreign collaboration as well as from a national laboratory, e) firms with and without a high degree of technical competence prior to entry into the industry and f) firms which had entered the industry at different stages of development of the industry. This industry because of its strategic role in the country's economy and the variety of situations offered by it provided an ideal setting for the study of technology acquisition and assimilation.

This study focused on the managerial processes involved in managing the interaction of the external environment and the organization in relation to technology acquisition and assimilation. Data was collected in during 1978-79 from six major tractor manufacturing firms, which accounted for more than 80 per cent of the total sales turnover. Technology related issues studied were: i) choice of product, ii) choice of foreign collaborator and mode of collaboration, iii) choice of plant size and process of capacity expansion, iv) choice of plant location, v) choice of manufacturing technology, vi) choice of R&D strategy, etc.

Environmental factors like competition, government regulations, capabilities of farmers, and automobile ancillary industry, and role of national laboratories were considered. Organizational characteristics like formal organizational structure, systems of control and coordination, training methodology, philosophy of top management of the firms, and their resource position and capabilities were studied in conjunction with the environmental factors.

An exploratory research methodology was adopted consisting of a) a pilot study of two firms for a period of about one and a half months, b) study of secondary sources of data, and c) re-examination of the two organizations previously studied and study of four additional organizations. Major data sources were the detailed interviews with about 60 company engineers and executives. In addition detailed study of various company documents like detailed project reports, feasibility reports, organizational announcements, etc., was also done.