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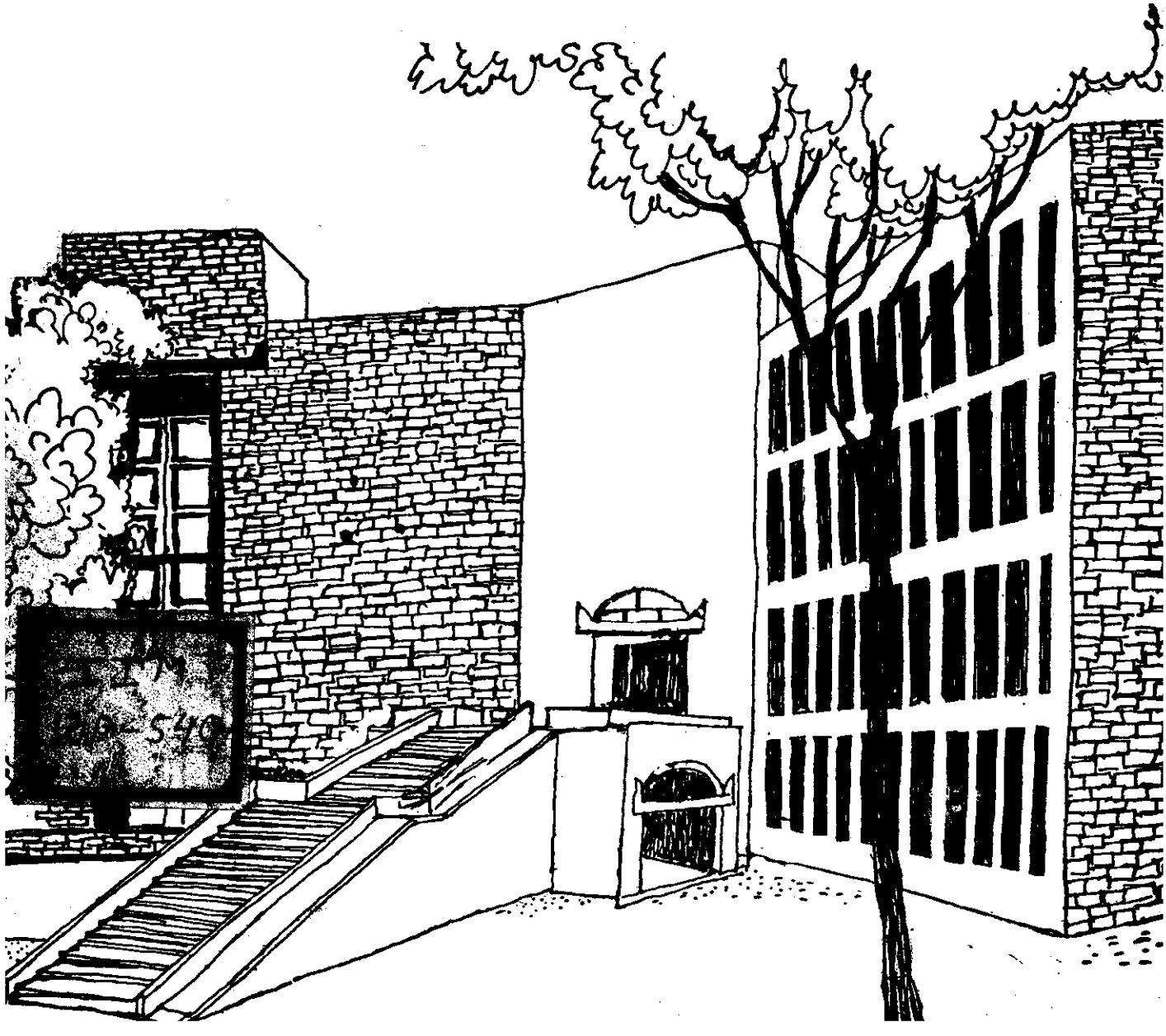
Working Paper



LEARNING BY DOING: TECHNOLOGY TRANSFER TO AN INDIAN MANUFACTURING FIRM

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W P. No. 540

November 1984

The main objective of the working paper series of the IIMA is to help faculty members to test out their research findings at the pre-publication stage.

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AHMEDABAD-380015
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Abstract

This paper presents an indepth case study of technology transfer to an Indian manufacturing firm in the tractor industry and highlights the complexities involved as a result of the interaction of a number of factors both external to the firm as well as internal to it. The total process of technology assimilation is conceptualised as consisting of three sub processes; a) technology adaptation; b) technology utilization and c) technology development, which are characterized by differences in the organization's goals and actions taken by management taken during each stage. Based on the case study and other relevant research the authors draw some implications for policy at the national level.

Learning by Doing:
Technology Transfer to an Indian Manufacturing Firm

SHEKHAR CHAUDHURI AND TUSHAR K. MOULIK

Increasing technological gap between the Western World and developing countries is one of the significant causes of the widening economic disparity between them. The less developed countries are not only much poorer than the countries of the industrialized world, they produce goods with much less sophisticated means, often using inefficient techniques. Many finished products have to be imported. The developing countries suffer both from low productivity of labour as well as of capital.

The international arena in science and technology shows a predominance of the industrialized countries of the west. A very large percentage of the world's R&D expenditure is accounted for by the advanced countries, as shown in Table 1.

One view is that the vast expenditure on science and technology by the developed countries represents a storehouse of technology which can be relied upon and utilized by the developing countries. By being latecomers 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 without having to spend time and effort in re-inventing these technologies. Therefore, what is required is a channel or conduit through which this "transfer of technology" from the developed to the developing countries can take place.

Japan has successfully implemented this policy to engineer its economic growth. The post-war development of Japan is accounted for by many factors, 1 but the most outstanding is its massive import of technology. Between 1963 and 1973 Japan paid out in all 3.4 billion for its technology imports. The government adopted a selective approach towards foreign technology; the authorities screened the contracts and approved agreements only after considerable study. They imported the latest and capital intensive technologies and successfully adapted them through local R&D programmes. The imported technologies were transformed into export capabilities, and their exchange earnings through export far exceeded the payment on account of royalties.

India has also placed major emphasis on developing scientific and technologies capabilities with the belief that science and technology would contribute to the economic, social and cultural transformation of the country.2 Various institutions have been set up like the Ministry of Scientific Research and Cultural Affairs in 1948, Council of Scientific and Industrial Research, the Atomic Energy Commission, etc. However, India has not been very successful in assimilating technology.

Trivedi 3 cites the examples of synthetic fibre, fertilizer, synthetic detergents, etc., where development has been lopsided because of the absence of a clear cut technology policy at the governmental level. The experience of the steel and diesel engine 4 industries highlights the problems faced in assimilating advanced technology because of mismatch with local conditions. Subramanian's study 5 shows 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.

Much time has passed since the above studies were conducted and one can reasonably expect that a significant amount of technological development would have taken place during the intervening period. India is now known to be one of the top industrial nations in terms of industrial production. However, the problems that she had faced in technology acquisition and assimilation immediately after independence seem to be there even today. A recent example is India's experience with heavy water plants. The Rs.66 crore heavy water plant of the Department of Atomic Energy (DAE) at Talcher in Orissa, whose design and some of the equipment were supplied by a West German firm failed to produce even a drop of heavy water. The reason being the very process on which the Talcher design was based proved to be unworkable or defective.6 This is not just one example; very serious problems are being faced by DAE's other heavy water plants in Kota, Tuticorin and Baroda.

Despite the fact that the problems in acquiring technology from foreign firms and assimilating it are formidable, international technology transfer mechanisms are likely to remain dominant for the development of technical competence. Very recently we have noticed a sudden increase in foreign collaborations. During the period 1977 to 1979, 841 foreign

Table 1

International Comparison of R&D Effort

Country	Per Capita GNP in U.S. Dollars at current prices	R&D Expenditure as percentage of GNP	Per Capita R&D Expenditure in U.S.dollars at current Prices
(1)	(2)	(3)	(4)
1. Argentine	904	0.2	1.86
2. Belgium	2176	1.3	30.20
3. Canada	3097	1.3	46.87
4. Czchoslovakia	1370	3.6	114.65
5. France	2525	2.0	50.81
6. Germany (FRG)	2238	1.8	50.16
7. Ghana	220	0.2	0.23
8. Iran	334	0.3	1.35
9. India	100	0.4	0.47
10 Italy	1439	0.9	13.96
11 Japan	1658	1.8	29.10
12 Republic of Korea	220	0.5	1.03
13 Mexico	632	0.1	0.80
14 Netherlands	2012	2.2	48.43
15 Nigeria	83	0.5	0.50
16 Pakistan	132	0.1	0.08
17 Sweden	3365	1.2	37.66
18 U.K.	1716	2.5	43.87
19 U.S.A.	4139	2.8	129.13
20 U.S.S.R.	1198	4.2	58.01
21 Yugoslavia	580	1.0	4.9

Source: Research and Development Statistics, National Committee on Science and Technology, May, 1975, P.15 quoted in V.Sriram et.al Top 300 Companies: Imports, Exports, Foreign Collaboration Agreements and R&D (New Delhi: Economic and Scientific Research Foundation, 1979).

collaborations were approved. However, during the period 1980-1982 this figure shot up to 1,500. 7 These developments are a pointer to our need for improving our knowledge of the process of technology transfer and its management.

The process of technology transfer at the firm level in influenced by both external as well as internal factors. The external environmental factors may be typically categorised into, (a)economic, (b)political, (c)social, (d)technological, (e)market related or competitive, (f)regulatory and (g)physical or ecological. The internal or organizational factors may be related to the, (a)goals, (b)leadership style, (c)resources, (d)capabilities, (e)organization structure, (f)information flow, etc. This framework has been used to describe and understand the process of acquisition and assimilation as experienced by Eicher Tractors India Ltd., now known as Eicher Good Earth Ltd. This is presented in the first part. In the second part of this paper, a model of technology assimilation process has been developed.

The third and final part of this paper draws upon the case study reported earlier and findings of other relevent research to highlight a number of policy implications.

I Eicher Tractors India Limited:** Prelude to Technology Acquisition

Eicher Tractors India Limited was floated in 1959 by The Goodearth Company. The latter had been

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** Based on unpublished doctoral dissertation, "Acquisition and Assimilation of Technology in the Tractor Industry in India: The Strategic Perspective", by Shekhar Chaudhuri. (IIMA 1980)

engaged in the business of selling imported tractors. In 1948, the founder and the managing director(MD) of the company had taken up the dealership of Ferguson tractors for a few districts each in Western U.P. and the areas now in Haryana. Tractors at that time had a curiosity value and a market had yet to be developed. The MD found the tractor distributorship to be profitable and in 1952 he decided to import tractors on his own.

In 1952, The Goodearth Company imported a few tractors from Gebr. Eicher of West Germany to test market them. The market response was good and from 1953 onwards the company started importing tractors in larger quantities. The imports in those early years were in the range of 100 to 200 a year. It never went beyond 300 a year. A good workshop was set up for repairs and maintenance, and training of farmers and mechanics. Import of complete tractors 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. Around this time the MD started considering manufacture of tractors in India. Around 1957-58 he toured West Germany to explore the possibilities of a collaboration with Gebr. Eicher, for the manufacture of tractors according to their design and specifications. Simultaneously he applied to the Government of India for an industrial licence. Towards the end of 1958 the government issued an industrial licence for the manufacture of tractors.

Choice of Product Technology

At the time when the MD had thought of importing tractors, most agriculturists in the country depended upon human and animal power. Indian farmers had not yet been exposed to mechanization of agricultural operations, and were, therefore, apt to put the tractor to abuse. There was hardly any facility for maintenance of tractors. The level of technical skill possessed by the farmer was also very low. The MD realized that a tractor was required which would withstand various types of use and abuse like pushing heavy loads, pulling trailers, various firm operations, etc, and in his European tour he looked for a tractor which had the following characteristics, ease of maintenance by even poorly trained village machanics, low price and low operating costs. The Eicher tractor fulfilled all these requirements and till recently it has remained the lowest priced tractor in the country.

The Eicher tractor was powered by a single cylinder air cooled engine and had a minimum number of moving parts. It did not have a hydraulic system for implement control, whereas by 60s almost all tractors in the developing countries had incorporated this in their designs. In other words, the tractor model selected for manufacture in India was comparatively an obsolete model.

Mode of Collaboration:

Gebr. Eicher of West Germany, started as a small venture just after world war II, had a very low production volume of about 3000 tractors per annum. Because of the simplicity of design and low production volume, the machinery used were mostly of the general

purpose type and less sophisticated. The manufacturing technology used by them was compatible with the level of technological skills available in the automobile ancillary industry in India and their production volume matched Eicher India's licenced capacity of 2000 tractors per annum.

A collaboration agreement was signed in 1959, which ended in April 1973. It was a financial-cum-technical collaboration, the collaborators were given a share in the share capital of the company and the right to nominate two of their representatives on the Board of Directors. According to the agreement, Gebr. Eicher of West Germany was required to; 1) supply the documents and drawings for the manufacture and assembly of tractors, 2) supply critical components till they were progressively indigenised, 3) help in establishing production and assembly operations in India, 4) supply all drawings and documentation of jigs, fixtures and 5) train engineers of Eicher India at their works.

A royalty of two per cent was payable on ex-works cost of components manufactured in India. Another two per cent was payable as technical knowhow fee.

The German collaborator sent a few technicians to the Indian Company during the initial phase to help set up the assembly operations, however, before much progress could be achieved, 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. The collaboration continued till 1973 but not on very satisfactory terms. Eicher India's major problems were production, import licence availability, finance, etc and the collaborator's

was basically that of marketing. The collaborator sent the drawing's and documentation and were prepared to train the engineers of Eicher India at their works. Due to lack of funds this facility could not be availed of totally. During the initial stages pilot components were sent to Gebr.Eicher for testing. But over the years Eicher India is not only supplying the collaborator some of the components but has also been highly commended by the Gebr. Eicher for their quality.

Manufacturing Policies

Plant Capacity Initially the government had issued an industrial licence to Eicher Tractors India Ltd. for manufacturing 1250 tractors per annum, which was later increased to 2000 tractors per annum. Compared to the average production capacities of over 30,000 tractors per annum of the major manufacturers in America and Europe, Eicher Tractors India's licenced capacity was very small. But because of difficulty in getting import licences for CKD packs and their lack of technical and managerial expertise, the production volume never went beyond 200 tractors per annum in the first few years.

Phased Indigenization The company started production on september 3, 1960. The manufacturing programme as approved by the government envisaged the following progressive indigenization:

Year	Indigenous Content
1st	48.6%
2nd	79.5%
3rd	100.0%

Implementation of this rapid indigenization programme was, however, fraught with numerous difficulties.

India's balance of payment situation had started deteriorating in the late 50s. Simultaneously, the

government ended the liberal import facilities to conserve foreign exchange. This had serious repurcussions on the operations of Eicher Tractors India Ltd. It had not visualized that foreign exchange availability would be such a problem. When the industrial licence was given for 1250 tractor per year, it thought CKD packs would be available to that extent. In fact Gebr.Eicher had specially produced 1250 almost complete tractors and these had to be kept in stock, in Germany as there was no licence to import them. The government allowed import of only 150-200 tractors 1 year and this continued for six years. Only on continued representation to government, Eicher India, was given an import licence of 1250 CKD packs.

Eicher India also lacked proper infrastructure to undertake the task of indigenization as stipulated by government. It lacked adequate engineering staff, tool room facilities, purchasing and vendor development staff, etc. The low production volume, because of the small import licences, could not sustain a larger personnel strength required for the rapid indigenization programme.

In 1966 the government liberalised the import policy and import licences of CIF value of Rs.51.47 lakh for the import of essential raw materials and components were issued. Another import licence of the value of Rs.38.98 lakh was expected.

During 1967-68 machines worth Rs.16.75 lakh were installed to achieve indigenisation of the tractor.

In 1968 government granted another import licence for Rs.49 lakh for the import of special steels, tools and components.

In the third phase the development of the engine

was taken up, starting with simpler parts like connecting rod, crank shaft and then finally engine housing. By 1969-70 the whole of the engine had been indigenized and only the transmission remained.

Around 1970-71 other Indian companies started manufacturing gears. Efforts for manufacturing all the gears indigenously began and by around 1974-75 the company was successfully in developing reliable sources for the same. An R&D cell specially for concentrating on developmental activities was created through which technical help was given to the gear manufacturers. A part of the suppliers' developmental expenses was also met by the company. Gears were completely indigenized by 1974-75.

Choice of Manufacturing Technology

The son of the founder, joined Eicher Tractors India Ltd. in 1968 and one of the major tasks before him was the selection of proper plant and machinery to increase production, which had remained extremely low for the past eight years.(see table 2)

Table 2

Production (July - June)
(26.5 h.p)

Year	Nos.
1960-61	132
1961-62	149
1962-63	214
1963-64	64
1964-65	225
1965-66	123
1966-67	92

1967-68	204
1968-69	346
1969-70	378
1970-71	859
1971-72	789
1972-73	854
1973-74	1081
1974-75	1232
1975-76	2142
1976-77	2719

Technically, there were options in the choice of manufacturing technology.

1. Use of mass production technology using special purpose machines for all operations.
2. Use of only general purpose or universal machinery for all operations.
3. Use of a combination of special purpose and universal machinery.

The first choice was ruled out as there were not enough funds to employ mass production technology and also the fact that production volumes of 100 or even 300 tractors per year would not have been economically justifiable.

The second option was ruled out on the ground that it required high level of skill and stringent quality control. So the management decided on the use of a composite technology, i.e., a combination of universal and special purpose machinery.

Innovative Technology Choice Acute paucity of funds was responsible for the evolution of a corporate philosophy of "low cost" in every endeavour of Eicher India. To over come the problem of financial stringency, the

management initially decided to purchase some second hand machinery from the collaborator. These machines were required for some of the critical operations, e.g. machining of connecting rod, cam shaft, etc.

Indigenous machinery avoidable from well known manufacturers like HMT or Kirloskar were too expensive which the company could not afford. So a team of engineers along with the present managing director went around small scale enterprises in Punjab to observe the machines and equipments they were utilizing and after studying their practices thoroughly the management decided to go ahead with the purchase of very simple machines called addas manufactured by the small scale industry in Ludhiana and Batala in Punjab. These machines were fitted with very simple tool carrying heads. These addas were basically universal machinery which could be tooled up for mass production of different items. The idea of the management was to design and manufacture proper jigs and fixtures by which the reliability of the operations could be enhanced. By this method the operations could be "deskilled" to a certain extent.

The layout of the shop was designed in such a way that each component could be manufactured in a part of the shop, using a combination of these addas. Combining process and product line layout for certain critical components it was possible to increase the capacity of production with low capital expenditure in plant and machinery. The addas cost them approximately Rs.3000 and the special jigs and fixtures another Rs.1,000 whereas a machine from the established large machine tool manufacturer would have cost them Rs. 20,000-50,000. Capital expenditure or fixed assets is as shown in Table 3.

Table 3

Fixed Assets (Rs. lakhs)
(at cost less depreciation)

Year	Value
1964	6.86
1965	19.82
1970	26.58
1976*	105.59
1977	154.95

* In 1976, land accounted for Rs.4.0 lakh, buildings Rs.11.0 lakh and plant and machinery Rs.71.3 lakh after depreciation. Breakup for the other years was not readily available.

Source: Annual Reports.

Strategy for Technological Skill Development:

A separate engineering team was created to cater to such needs as converting very simple universal machinery to single purpose machinery by designing proper jigs and fixtures, copying attachments, hydraulic systems, etc. Also many of the complicated machinery were designed and manufactured in the company by a specially created cell. Machines like dynamic balancing machine for balancing the crank shaft and the flywheel, fine boring and tapping machine for the cylinder head were designed and manufactured by the company's engineers.

Management Philosophy According to the managing director "what originally started as a reasoning born out of

paucity of funds has now become a philosophy of the company-the low cost approach in every endeavour. This is also in keeping with the needs of our country's developing economy where capital is scarce and therefore must be conserved". This philosophy continues even now, though the company has long turned the corner and is making handsome profits. To quote one example, the company plans to make a pressurised paint booth at a cost of approximately Rs.8 lakh, which if purchased from established manufacturers would cost them Rs.16 lakh. The new plant for the 35 h.p. tractor and the gear manufacturing which the company planned to up Parwanoo would follow the same philosophy. They planned to purchase addas of better quality which would give them higher reliability.

However, in the R&D department, their policy was to have sophisticated machines and their total investment in the R&D department was several times more than that in the production plant. Till recently the policy of the management was to subcontract as many items as possible in order to reduce the capital expenditure. This was possible till the production volume remained at around 2,500-3,000 tractors per annum. With the increase in volume the management felt that complete dependence on supplies for critical components was too risky therefore to insulate themselves from such uncertainly they were in the process of creating some manufacturing base. This, the management felt would also act as a deterrent against price increases by suppliers. The gear and transmission plant planned at Parwanoo was also part of such a policy. The engine plant a Alwar was started to cater to the increasing volume and also to cater to the needs of other industries.

A machine tool manufacturing unit was started to cater to the needs of machinery for the three plants at Faridabad, Alwar, and Parwanoo. This machine tool unit had its genesis in the early period of the Faridabad Plant when a special cell was created to convert all the universal machinery into single purpose machinery, to make modifications on the machinery bought from the collaborator, and design and manufacture machinery for replacement purposes. The addas used by the company had a useable life of about three to five years.

Sources of Funds

Initially the Company's share capital was very small and in the tractor industry the prices and distribution was controlled. The company survived this crisis only on the enormous goodwill of the dealers. It took advance-security advance-from the dealers for a period one year in advance of delivery of tractor. The prices of tractors were maintained at an artificially low level. This meant that the company had constant cash problems like paying salaries, wages, government dues, etc.

Technology Development and Product Diversification

Developmental activities were undertaken from the very beginning of the company. A design cell had been created for undertaking the following activities:

1. Indigenization of all the tractor components
2. Converting the simple addas into single purpose machines by designing suitable jigs, fixtures and other special tooling.
3. Designing and manufacturing special purpose machines required for machining critical components.

Till about 1972-73 the whole organization was

geared up to increase production. Prices being controlled by the government the only other way of generating larger surpluses was through a larger volume. By 1970 the accumulated losses after providing depreciation amounted to Rs.35.24 lakh. However, by constantly increasing production, all the accumulated losses were wiped off by 1973-74.

The tractor industry had been in a sellers' market till about 1972-73. According to the MD, "marketing" as a concept had not taken roots in the company during this time. It could be described more as "distribution". Initially distribution of tractors also had been controlled by government as the indigenous production was very small.

However, in 1972 the market started showing signs of a change. The Director's Report in the Annual Report(1971-72) said: There is now tough competition in the Tractor market. Further, overall demand for tractors has fallen, because of various reasons, such as further reduction in size of land holdings.

... on the recommendations of the Bureau, prices of all the indigenous tractors were revised in January/February this year. The price for Eicher tractors was fixed at Rs.25,200 ... The company had however kept the selling price at Rs.23,700... in order to meet competition.

In order to give more incentive to the dealers and to enable them to improve their servicing facilities, the company raised the discount to its dealers from Rs.800 to Rs.1,300 per tractor.

Product Diversification In 1973 the company added the following products to their product lines:

1. Eicher diesel generating sets
2. Stationary diesel engines
3. Trailers 3-6 tons.

No industrial licence was required for manufacturing and selling these new products.

The company's policy which guided new product decisions can be guaged from the following:

> ... the company has maintained its prime objective of economy with quality by providing sound low cost products. So much so that when the price control was lifted from the tractor industry in 1974, Eicher was the only organization which did not raise its price, even marginally.
>
> Yet another unit was set up in 1978. The product chosen was machine tools, which could fill the gap existing in the market between the high cost/high precision machines made by large manufacturers and the low cost/low precision machines manufactured by the small scale units ...

Exploratory Efforts in Export Markets The year 1973 also saw some exploratory steps in developing an export market for their products-mainly tractors. The company made efforts to develop markets in the developing countries of South America and Sudan. They also supplied samples of components for "Eicher" engines to their collaborator in which all measurements were not only within tolerance but were very close to the basic data.

Product Improvement In 1974-75 the financial position of the company was very bright, with a net profit of Rs.38.6 lakh. The company started giving its attention to areas like diversifying its tractor line, improving the existing tractor by providing automatic depth control systems and making improvements in the following areas:

1. Improved bonnet
2. Rigid axle with improved suspension

3. Improvement in electrical system
4. Improved quality for better look and greater durability.

Till 1974-75 there were no separate facilities for developmental work and existing production facilities were used. In view of the enlarged activities envisaged for the R&D department the company approached the Indian Overseas Bank for loan facilities.

Organizing for Research and Development In 1975-76 the company, for the first time, invested heavily in equipment and machinery for research and development. A beginning was made in the recruitment of personnel for manning the R&D department.

A person with 16 years experience in industrial research in Germany and several years experience in R&D management in a major heavy vehicles manufacturing firm joined the company as General Manager-Research and Development.

The department was staffed by highly qualified personnel. Two of the senior managers including the chief of R&D held Ph.D. degrees in their fields of specialization. The company has a policy of recruiting generally M.Tech. degree holders with experience in research and development as section heads and either M.Tech. or B.Tech. as Senior Engineers or Engineers below the section heads. They adopted a functional organizational structure with departments specialising in; engine design, tractor design, system design, transmission design, metrology, Prototype development, materials science and testing. The total staff strength of this department in 1978 was 90 and was planned to be increased to 150 by 1980.

The objective of the R&D department was to make constant improvements in the products, develop the 35 h.p. tractor, make improvements in the existing model in response to feedback from the field and reduce cost by making design changes. A value Analysis Cell was planned which would look into aspects of providing the customer better value for the price.

R&D Capital Expenditure Systematic budgeting in the company was a very recent phenomenon. The management was considering introduction of project costing" and turning the R&D department in to a profit centre.

The capital expenditure on R&D is given below:

Year	Amount in Rs. lakh
1977-78	85.30
1976-77	10.84
1975-76	60.25
1974-75	0.58

Major Organizational Changes

When the present MD came to Eicher Tractors India Ltd. in 1968 from Goodearth Engines Private Ltd. he did not have any official designation and it was left to him to define his bwn role. He had an engineering degree from West Germany and being a technical man, for the first few years he worked in the various technical functions like material procurement, vendor development, design of jigs and fixtures and special purpose machinery. Selection of plant and machinery, production planning and control and was later designated as Technical Adviser in charge of all technical functions.

Till 1975 the company remained small and there was nobody who could be called a good manager. By the end of 1974 the production volume had reached 100 tractors per month and it did not increase further. Some management consultants was contacted to look into the operations. They identified the source of the problem to be lack of adequate managerial personnel. So in April 1975, three General Managers were appointed in Finance, Works and Materials with three officers at the middle management level and some at the junior levels. The change was dramatic. By September the production level increased to 150 tractors per month, by December 180 and thereafter to 250 tractors per month without any input in terms of machinery and equipment.

With the increase in production it came to be noticed that the suppliers were not maintaining the required quality. In September 1976 the new MD suspended production for a week initially and then extended it to a month. The time was spent on sorting out all quality problems-vendors within the plant, deciding on critical tolerance, developing proper control systems and so on. The company lost on production for two or three months but thereafter there was a steady increase.

Changes were made in the marketing organization also. In the earlier set up "sales" and "service" operated independently and were coordinated only at the level of the Director-Marketing. However, as the market became more and more competitive and more and more reports of field problems came pouring in, the management realized that a customer oriented marketing department was essential for the organization's success.

In 1976 the marketing set up underwent a radical

change. In the new structure the sales and service representative was given the responsibility for the sales as well as service in a particular territory. In addition to reporting to his immediate superior, the Area Officer reported functionally to the service Manager. In this set up an attempt was made to integrate sales and service at all levels.

Systematic analysis of warrantly claims was introduced and coordination machanisms to look into these areas were developed. Weekly Warrantly Meeting were held between representatives of production, materials, quality control and service departments to deal with routine warranty and quality issues.

For dealing with critical issues which involved major investments to improve quality or major modification in design of product, there was a coordination mechanism at the level of senior managers, and Director-Faridabad, General Manager-Research and Development, and Director-Materials.

In view of the expanding operations the company decided to set up an Engine Plant at Alwar in Rajasthan. The registration was for manufacturing 7500 engines per year. The company decided to phase out the installation of capacity with 3,000 in the first phase.

In November 1977 there was another reorganization. A corporate office was created at Delhi to which the managing director, secretary, general manager responsible for finance and other executives concern with finance and EDP moved. Simultaneously, various senior executives were designated as Director, Faridabad, responsible for the tractor plant at Faridabad; Director Alwar Engine Plant; Director, New Project Division for setting up and operating a new plant for 35 h.p.

tractors and marketing manager for the company's agricultural marketing operations.

II A Model of the Technology Assimilation Process

Having discussed in detail various aspects of technology transfer in Eicher Tractors, we now conceptualise the process of assimilation. Technology assimilation at the enterprise level may be broadly understood to mean the process by which the members of an enterprise learn to utilise the technology to produce goods and services. This term would include processes by which organizations make decisions on; 1) Whether to make/buy/import of parts, components, raw materials, machinery, etc. 2) manufacturing technology, 3) type of plant and machinery, their sources, etc; 4) type of infrastructure required including power, water, transportation, buildings, pollution-control, etc, 5) type of manpower required and the nature of training necessary, 6) organization structure, information systems, and other management systems compatible with the technological posture of the organization, and 6) new product introduction, technology development and improvement.

The term "technology assimilation" is an all encompassing. It may be possible to conceptually identify different sub-processes which could be differentiated by the nature of the dominant tasks related to each and certain other organizational parameters. Broadly the process of technology assimilations could be conceived of as consisting of three sub-processes; 1) technology adaptation, 2) technology utilization, and 3) technology development. However, there may be certain differences in this classification depending upon whether acquisition of technical capability takes

place through collaboration with some foreign manufacturer, national laboratory, an indigenous firm, or through in-house research and development efforts.

In this paper we are concerned only with the first. In this context, technology adaptation implies minor changes in the plant, equipment and machinery to adjust to the host environment. Adaptation, would also involve possible use of indigenous raw materials, or intermediate components or technology which ultimately could result in cost reduction, better product utilization by client because of a higher degree or compatibility with their needs, improvement in quality, etc. Adaptation could be of two types; a) modifications of the inputs required for producing a product according to the design and specifications provided by the foreign collaborator, and b) modifications of the product design and the concomitant changes in the required inputs. The former type of technology adaptation could be described as input-oriented and the letter as market-oriented because of the difference in focus. Understanding of know-how is important during this stage.

Technology utilization may be described as the processes which enables the organization to utilize the technological infrastructure already established by the enterprise. It would involve the operation of the plant, organising supply of raw materials, establishing production norms, quality norms and control systems, institutionalizing production planning and control systems, setting up of monitoring and information systems, designing and operating inventory management system, and troubleshooting. It would involve a greater attention to building an organization and

its operating systems. Learning to manage the technical organization is more important during this stage.

Technology development is the last stage in the assimilation process. During this stage, the organization devotes considerable energy to self regenerative activities like updating the product technology and manufacturing technology. Technology updating may be possible broadly, through two routes; a) collaboration with foreign manufacturers, and b) in-house development. If the former mode is adopted then the activities would be more similar to those in the technology acquisition stage. It would not imply development of technological capability within the enterprise which is the essence of assimilation. For our purpose, therefore, we shall consider the technology development sub-process as synonymous with reliance on in-house research and development efforts. However, this does not mean that when a firm reaches the stage of technology development it never borrows know-how from others. On the contraty, this stage only means that an organisation which is in this stage is able to make very major technological decisions on its own. It is able to decide whether it requires help in the field of technology or not, it has a strong R&D capability, it is able to buy the technology it requires and integrate it within its own ongoing or planned R&D activities, and it is able to integrate its R&D activities with the other relevant functions because technology development in isolation may not pay dividends. For an effective technology development activity within an organization there should be flow of information from the market place to R&D, interaction between manufacturing, quality control, and R&D, etc. The focus here is on understanding "Know-why".

Technology Adaptation

Eicher Tractor India's venture into manufacturing was a response to the regulatory environment created by the government. But the organizational capabilities were inadequate to the task facing the company. The critical factor during the initial years was the ability to adapt the foreign technology to the local technological environment. This was essential because of the administrative pressure from the Directorate General of Technical Development(DGTP) to hasten the indegenization programme. The delay in getting the import licences for the CKD packa had serious repercussions on the company's financial performances as the production programme till the late 60s was almost entirely dependent upon the availability of the imported assemblies. The company continued to lead a precarious existence till the end of the 60s. Whenever, they could obtain an import licence for CKD packs, assembly operations were carried on and as soon as the CKD packs were exhausted, work came to a stand still. The explanation for this kind of situation that existed may be explained by the lack of a technical leader in the organization. The key tasks for the implementation of the project were the design of a manufacturing system geared to a small volume, and the building up of the organization to manage the engineering and manufacturing functions. The constraints of the extremely small volume and an accute paucity of funds imposed a challenge of the highest order. 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 vaccum in the technical leadership.

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

1. Deciding to indigenize the tractor rapidly through own efforts.
2. Identification of plant and machinery compatible with the product requirements, licensed capacity, funds position, and organizational 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 organization's fund position.
5. Designing appropriate jigs and fixtures to "de-skill" the operations in order that they could do 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 organization.
8. Some of the "frills" on the tractors were re-

moved to reduce the manufacturing cost further.

Once these tasks were performed there was a considerable improvement in overall production performance. The organization during this stage was very informal. Formal mechanisms for coordination 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 organization.

Technology Utilization

With the identificatification 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 level. The consultant recommended strengthening of the organization by placing professional managers at key positions and also improvements of various management systems. With the implementation of these recommendations there was a dramatic improvement in production performance.

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

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

1. Induction of professional managers at key positions,
2. Development of decision making capability at relevant levels in the organization,
3. Creation of some specialized decision making units within the organization,
4. Development of some formal integrating mechanisms.
5. Defining a set of policies in inter-related functional areas and
6. Development of appropriate management systems.

Technology 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 give 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&D centre was set up with relatively substantial investment in facilities. Sub functional specialization 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 organization for the development of know-how for the company's future expansion and product diversification.

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

III Some implication for Government Policy

The case of Eicher Tractors raises a number of issues about import of technology and industrial policy in general. This is very relevant in the context of the recent liberalization of government policy. Based on the case study reported earlier and other relevant studies we explore some implications for policy at the national level.

Policy on Import of Technology

The government's attitude towards foreign investment and collaboration was very favourable till about the end of the 60s. As a result of this, a large number of collaboration agreements were signed around the beginning of the second plan till the mid 60s. The government favoured minority foreign equity participation to provide for the foreign exchange component of

the project cost. Towards the end of the 60s, however, the government initiated a policy for selective foreign investment and collaboration depending upon the merit of each case. The change in attitude also found expression in an attempt to reduce the various costs involved.

These changes in policy towards foreign investment and collaboration were reflected in the type of foreign collaboration agreements entered into by the firms in the tractor industry. 8 Eicher Tractors and International Tractors which entered into foreign collaboration agreements in the period 1959-61 had minority foreign equity participation, the duration of the agreement was 10 years, and the managerial control was vested in the Indian firm as stipulated by the government. Escorts had a licence agreement with a polish manufacturer for a relatively obsolete product.

HMT and Kirloskar Tractors entered the industry during 1971-74. Both the firms entered into pure technical collaboration agreements and the duration of royalty p ayment was five years from the commencement of production. A significant feature of the collaboration agreements was that the managerial control over operations essentially rested with the Indian partner even in the cases where there was equity participation by the foreign collaborator. Also the Indian partner had the option to make adaptations to suit local conditions if found necessary. However, this can not be generalized with regard to all the firms in the tractor industry.

Another interesting feature was, firms like International Harvestor (IH) and Klockner Humboldt Deutz agreed to collaborate with Indian firms at the terms

and conditions specified by the Government of India. For example, when Mahindra & Mahindra Ltd. collaborated with IH, the latter was amongst the leading manufacturers in the world, having about 55 per cent of the market share in India. In fact, for IM it was the first time that they went in for a minority capital participation in a collaboration agreement. When Kirloskhar Tractors Ltd. signed the agreement with Klockner Humboldt Deutz the latter's product was acknowledged as one of the most sophisticated in terms of technical parameters, like fuel efficiency and hydraulic lifting power. However, in this case also the foreign collaborator agreed to collaborate for a shorter period of royalty payment, though with a relatively high lumpsum fee.

It is possible to conclude that for these foreign collaborators the involvement with Indian firms dovetailed into their global strategies. The maturity of the agricultural machinery industry in the advanced countries and the increasing competition faced by these firms were instrumental in their making changes in their establishee policies. One also has to see this in the light of the technological skills developed within the country and the Indian firms' technological capability.

The analysis showed that the better the match between technological decisions and the firms' environment and resources and distinctive competence, the faster is the process of assimilation. The tractor industry spanned a continuum of technological sophistication. At the lower end of the spectrum the process of technology assimilation was found to be easier even with low technological capability within the firm

whereas at the higher end the process was found to be very strenuous even with considerable technological expertise within the firm.

An important implication for public policy would be that developing nations could match their technology search process with the stage of the technology in its life cycle in advanced countries along with its own level of industrial development to have a strong bargaining position in foreign collaboration negotiations. In the early stages of development a developing nation could direct its search for technology to the more mature industries so that the process of technology assimilation would be comparatively easy. With progress in economic development the search could be directed towards more sophisticated areas.

Policy on Encouraging Innovation

The analysis in a previous section suggested that though governmental policies had considerable impact on Eicher's choice of manufacturing technology there was still much leeway for the company to develop technology strategies which could be uniquely related to its resources and cap abilities. The industrial licensing system limited plant size in the tractor industry to 1 : 25 at the minimum end of the spectrum and 1 : 5 at the maximum in relation to manufacturing capacities in the advanced countries. However, in spite of such disadvantages even the smallest firm, Eicher, could compete successfully with the largest. During the period 1973-77 Eicher India's market share increased from 4.1 per cent to 9.1 per cent in competition with the much larger companies in the industry. The critical factor in the success of the smallest firm was its innovative capability in designing a plant to

achive low manufacturing cost at extremely small volumes. Related to this was its deliberate decision to go for indigenous machines to reduce capital investment. An important issue for public policy in developing countries is how to encourage firms to be innovative in their manufacturing policy choices and at the same time aid the development of the machine building industry. 9 It seems that entrepreneurs are often blind to the range of possible technological options available to them. This may happen because of some kind of dependency syndrome vis-a-vis the foreign collaborator. The government may play an active role by providing technical help through technical consultancy services, which may be critical to entrepreurs as seen in the case study reported here. Innovative technological behaviour may be encouraged by providing some financial incentives or penalizing those who would like to depend on collaborator's technology and imported plant and machinery totally. It was observed in the case of Eicher that lack of professional management skills was a limiting factor during the technology utilization stage. Developing countries could develop institutional mechanisms to provide management consultancy services to young entrepreneurial firms. Perhaps the financial institutions and industrial development agencies could play an important role in the development of management capability. Also important is a technological orientation of the top management in firms whose businesses are based on complex technologies.

Policy on Industrial Licensing

The government's economic and regulatory policies had a pervasive influence on the development of the

tractor industry. Though from as early as the 60s, the government attempted to motivate the industry in general to commit resources to R & D through tax concession, there was little effort made by the tractor firms in that direction. However, when the tractor industry was suddenly faced with competitive forces, there was a qualitative shift in their attitude towards R&D. The behaviour on the part of the individual firms in the tractor industry under consideration show that competitive forces are essential to force the firms to make a transition to market oriented technical change. This has important implications for industrial licensing in the country.

The manufacturing performance of the tractor firms over almost two decades has shown that even though the capacities alloted to individual firms were very small as stated by the management, the capacity utilization in the industry was not high, thus creating a gap between growth of demand and supply. This brings us to the point that even if the government had allocated the total plant capacity to very few firms in order that they would be able to achieve considerable economies of scale, it is highly unlikely that they would have installed their licensed capacity at one shot because that would meant extremely high manufacturing cost at low volume. The technological behaviour of the firms reveals a process of incremental capacity installation to match perceived increase in demand. One might argue that the firms could have set up a large capacity at one shot, in order to export the larger part of their production. However, the authors feel that these firms would not have been in a position to compete with the major manufacturers in America

and Europe as they had a long way to go in acquiring technological competence.

However, an export strategy could have been formulated with active support of the foreign collaborators, which would have implied giving them considerable control over operations. It is doubtful whether managerial control over operations could have been left to foreign collaborators when one considers the political environment then existing in the country. Considering these aspects of policy making in this country, it seems that one way by which competition could be introduced would be to allow a number of companies to enter the industry to create competition.

Policy on Export of Technical know-how

Many of the multinational corporations in agricultural machinery business have discontinued manufacturer of small and medium h.p. tractors and have shifted to the larger ones. Indian manufacturers, who are operating in this range have a definite strength from the point of view of the possibility of export of complete tractors to the less developed amongst developing countries.

However, even greater strength lies in the area of technology export to the LDCs. The manufacturing technology of the Indian firms has cost efficiency at extremely low volume, and also involves substantial lower capital investment in plant and machinery and promises higher employment. Indian technologists in the tractor firms have acquired considerable skills in adapting and indigenising imported technology to local conditions and have also acquired managerial skills in operating in a highly regulated environment. Considering these aspects. Indian tractor firms are in a

very strong position vis-a-vis firms in advanced countries to export technology to less developed countries. The government and the tractor firms could collaborate in identifying such developing countries where technology could be exported. There could be considerable scope for technology export in the context of a growing tendency amongst developing nations to become technologically self-reliant.

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