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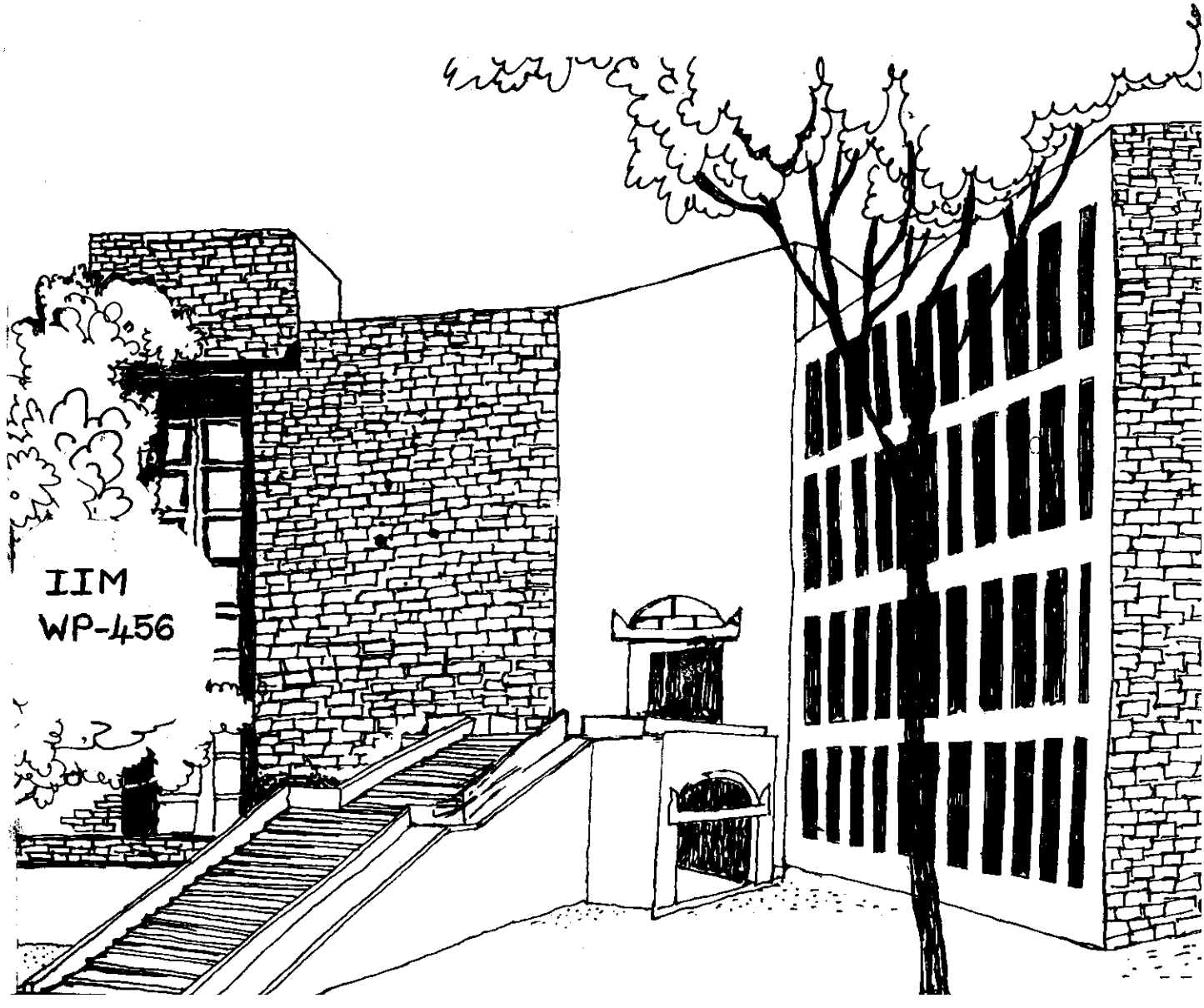

INTERNATIONAL TRANSFER OF TECHNOLOGY TO INDIA: THE CASE OF THE TRACTOR INDUSTRY

By

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International Transfer of Technology to India

The Case of the Tractor Industry

SHEKHAR CHAUDHURI

Abstract

Based on an indepth study of five major manufacturing firms both in the private as well as the public sectors, this paper discusses the process of technology acquisition and assimilation in the tractor industry and draws some implications for public policy.

The study revealed the following interesting results:

i) An increase in bargaining power during the period 1960-74 of Indian firms over their foreign collabotors;

ii) A dominantly satisficing technology search behaviour with the perceived immediate market needs as the major concern of the technology importing firms;

iii) A significant influence of Government policy on the choice of manufacturing technology to match small capacities;

iv) A change in R & D focus from production related trouble shooting and indigenization to quality assurance, value engineering and new product development with the onset of competitive forces in the industry; and

v) The importance of providing "technical leadership" in making innovative technology choices and the need for appropriate organizational structure and systems to match the technological tasks.

Major data sources for the research were indepth interviews of some 60 senior company executives and various documents like detailed project reports, feasibility reports, organizational annoucements, etc.

International Transfer of Technology to India: The Case of the Tractor Industry *

SHEKHAR CHAUDHURI

The increasing technological gap between the western world and developing countries seems to be one of the significant causes of the widening economic gap between them. The less developed countries are not only much poorer than the countries of the industrialized world, they produce with much less sophisticated means the goods they use or sell. Many finished products must be imported. Some can be produced only by using inefficient techniques.

The developing countries suffer from low productivity of labour as well as of capital. Added to this, they have large disparity between income groups. Economic and technological dualism is a characteristic feature of these countries. In the sectors where the most modern or relatively more current technologies are in use, the effectiveness of the technology transfer or the benefit to the recipients are debatable issues.

It is with the belief, that science and technology would contribute to the economic, social and cultural transformation of the country, that India has placed major emphasis on developing scientific and technological capabilities. The setting up of the Ministry of Scientific Research and Cultural Affairs in 1948, Council of Scientific and Industrial Research and the Atomic Energy Commission during the period 1948-1954, Defence Research and Development Organization in 1958, Department of Science and Technology and Electronics Commission and Department of Electronics in 1971, were all steps in this direction.

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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 store-house 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. This policy has been successfully implemented by Japan to engineer its economic growth.

According to Chitale[2], the post-war development of Japan is accounted for by many factors, 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.

The Indian experience is, however, different. Trivedi[3] cites the examples of synthetic fibre, fertilizer, synthetic

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. Argentina	904	0.2	1.86
2. Belgium	2176	1.3	30.20
3. Canada	3097	1.3	46.87
4. Czhechoslovakia	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	2.4	43.87
19. United States of America	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 e.t.al Top 300 Companies: Imports, Exports, Foreign Collaboration Agreements and R & D. (New Delhi: Economic and Scientific Research Foundation, 1979).

detergents, etc., where development has been lopsided because of the absence of a clear cut technology policy at the Governmental level.[4] The experience of the steel and diesel engine[5] industries highlights the problems faced in assimilating advanced technology because of mismatch with local conditions. Subramanian has highlighted many of the problems faced by Indian companies in collaborating with foreign manufacturers for the acquisition of technology. He wrote:

> ... As a channel for import of technology, collaboration arrangement of an enterprise to enterprise kind was found very costly. The terms of collaboration were such that by and large foreign collaborators assumed too many functions and extracted too high a price through a complex payment scheme. Restrictive clauses were invariably introduced in the collaboration agreements which in effect curtailed the independence of Indian ventures, vested technical control over production with foreign collaborator, and made the product more import dependent and export discouraging. All these added to the fact that foreign capital in a sheltered market enjoyed high profitability, raised foreign exchange outflows on service payments and imposed a heavier burden on the balance of payment....[6]

Notwithstanding the problems faced by Indian companies whether in the public or private sector, international technology transfer mechanisms would remain dominant for acquisition of technical know-how and competence.

This paper discusses the process of technology acquisition and assimilation in five major tractor manufacturing companies both in the public and private sectors and draws some useful lessons. A brief review of the mechanisms for technology transfer and the Government's policy on import of technology is given to provide perspective to the case studies.

Mechanisms for International Transfer of Technology

There are many mechanisms for supplying proprietary technology to developing countries.[7] The actual mechanism of proprietary technology transfer falls into three major groups according to the amount of foreign equity investment in the host company: 1) direct investment by multinational firms in a wholly owned or majority owned subsidiary, 2) a joint venture with minority participation by the foreign firm, where foreign equity ownership is generally less than 50 per cent, and the role of the foreign and domestic investors is clearly delineated, and, 3) pure technical collaboration agreement in which the foreign company and the local one enter into a contract for the use of proprietary technology by the latter. The last one has been more commonly used in India in recent times. Such contracts may provide for training of engineers from the host company at the collaborator's plant, visits by the technicians of the supplying company to the recipient, or for transfer of other forms of knowledge. Other conditions in the agreement may relate to the limits on the use of technology, its transfer to others, the duration for which the technology can be used, the source of key inputs of the process, and the geographical limitation on the market area of the product. Payments may be in the form of royalties, or as a lump sum fee, or a combination of both.

The above description does not do justice to the variety of possible arrangements. Some other arrangements are: 1) management contracts, 2) licence agreement, 3) "fade-out" or "fade-down" arrangements, and 4) co-production arrangements. The management contract involves an undertaking by the foreign party to provide most of the services provided by a direct

investment but leaving out the equity capital. In this kind of arrangement, the foreign firm performs over a stated period of time the essential managerial functions for a local enterprise in which it has no ownership interest. The primary purpose of a management contract, the transfer of know-how, is a feature common to the mechanisms for technology transfer discussed earlier.

Licence agreements confer upon the licensee certain rights to the use of a specific process or product incorporating inventions developed and owned by the licensor in return for an agreed-upon payment. A one time transfer of trade secrets may suffice, but generally the licensee requires a continuous flow of know-how in order to operate the licence effectively. The more complex the technology the more comprehensive the ancillary provisions of the licence agreement tend to be.

Majority-owned direct investments could be legally of indefinite duration or subject to a contractual or legislative provision for reducing the foreign equity according to a prearranged plan. This is known as the "fade-out" or "fade-down" arrangement. The co-production arrangement is usually combined with managerial contracts or turnkey projects.

Another mechanism is one that serves as a bridge between joint ventures and pure technical collaboration agreements (PTCA). PTCAs with minority foreign equity participation have become quite common. In lieu of royalty or lump sum payments, the foreign supplier receives shares in the newly floated company.

Some Principal Features of the Indian Tractor Industry

The Indian tractor industry has a major role in the country's economy in terms of a number of parametres. Direct employment in the tractor industry, its ancillaries and its distribution channels is around 50,000; and 50,000 new jobs are created annually. The direct capital investment is around Rs.70 crores. Total investment, including the investment in the ancillary industry is around Rs.200 crores.[8] Estimated contribution in direct and indirect taxes in 1977-78 was Rs.56.68 crores.

The industry is characterized by 11 manufacturing units of which seven account for over 90 per cent of the total production. In 1980 the total production of tractors amounted to 67,105 with horsepower ranging from 18 to 75. Table 2 provides data on the manufacturing units, their sources of technology and the models they produce. This industry provides an ideal setting for the study of international transfer of technology because it has a sufficiently large number of firms, which are in various stages in the process of assimilating the acquired technology in the private as well as the public sector, with and without a high degree of technical competence at the time of entry into the industry at different points in time.

Government's Policy towards Import of Tractors

Tractors were allowed to be imported by established importers who were required to provide evidence that; 1) they were accredited agents of manufacturers of imported tractors; 2) they had adequate workshop facilities and trained engineers to service the imported tractors, and 3) the makes of tractors

Salient Features of Six Major Tractor Manufacturing Firms (1978-79)

Details	Eicher Tractors India Ltd.	International Tractor Co. of India Ltd. (ITCI)	Escorts Ltd.
Year in which assembly/manufacture started	1960	1964	1962
Previous experience at time of entry	Selling Eicher Tractors and very little technical capability	Voltas (one of the co-promoters) had experience in selling IH tractors and M&M had considerable experience in assembly and manufacture of Jeeps.	Experience in selling Ferguson tractors and considerable experience in setting up manufacturing facilities for pistons, piston rings, cylinder liners, gear boxes for trucks, motor cycles and scooters.
Technical collaboration	Gebr. Eicher of West Germany	International Harvestor, U.K. (1961)	1.Motoimport of Poland (1965) 2.Ford Moto Company of USA (1968) (New company called Escorts Tractors Ltd. was started).
Mode of collaboration	Financial-cum-technical	Financial-cum-technical	1.Licence agreement with Motoimport 2.Financial-cum-technical with Ford.
Location	Faridabad(Haryana)	Bombay (Maharashtra)	Faridabad (Haryana)
Licenced capacity	Licenced capacity was 2,000 per annum till 1976 raised to 10,000 in 1976-77	Licence issued for 3,500 in 1959. Subsequently Raised to 10,000 in 2 stages of 3,500 & 3,000 in 1964-65.	Licence issued for 7,000 in 1966 Raised to 16,000 in 1972.

contd...

Table 2 (contd.)

Details	Eicher Tractors India Ltd.			International Tractor Co. of India Ltd. (ITCI)			Escorts Ltd.		
Products Manufactured currently	26.5 h.p. currently manufactured. 35 h.p. tractor being designed indigenously			B-275 (35 h.p.) and IG-444 (43 h.p.)			E-3036 (35 h.p.) E-335 (35 h.p.) E-47" (45 h.p.) E-350		
Production	1960-61	1964-65	1968-69	1964-65	1968-69	1971-72	1964-65	1968-69	1972-73
Nos.	132	225	346	225	4001	9006	155	4069	3941
	1972-73	1974-75	1976-77	1972-73	1974-75	1976-77	1976-77		
Nos.	854	1232	2719	7201	7492	2004	5117		
	1978-79			1978-79			1978-79		
Nos.	5159			7077			10277		
Approximate Value of Fixed Assets Gross (At cost in 1976)	Rs.142 lakhs			1473			Not available (N.A.)		
After Depreciation	Rs. 94 "			828					

Table 2 (contd.)

Details	Hindustan Machine Tools Ltd. (HMT)	Punjab Tractors Ltd.(PTL)	Kirloskar Tractors Ltd. (KTL)
Year in which assembly/ manufacture started	1971-72	1973-74	1973-74
Previous Experience	Considerable experience in designing, developing and manufacturing sophisticated machine tools	Key personnel had experience in designing tractors	The promoters had experience in rural marketing and manufacturing of diesel engines, compressors, pumps, electric motors, etc.
Technical Collaborator	Motokov of Czechoslovakia	Technology was acquired from Central Mechanical Engineering Research Institute (CMERI)	Klockner Humboldt Deutz of West Germany
Mode of Collaboration	Purely technical	--	Purely technical
Location	Pinjore (Haryana)	Mohali (Punjab)	Nasik (Maharashtra)
Licenced Capacity	12,000	10,000	10,000
Products Manufactured Currently	Zetor 2511 (25 hp) and Zetor 5511 (55 hp)	Swaraj 724 (26 hp) Swaraj 735 (35 hp) & Swaraj Sartaj (18 hp)	D 4006 (43 hp) and D 6006 (75 hp)
Production Nos.	1971-72: 1605; 1974-75: 6800; 1976-77: 4415; 1977-78: 7689; 1978-79: 8190 +1000 CKD packs	1973-74: 58; 1975-76: 2242; 1976-77: 3196; 1978-79: 4541	1973-74: 88; 1974-75: 744; 1975-76: 605; 1976-77: 325; 1978-79: 600
Approximate Value of Fixed Assets. Gross (At cost in 1976)	Rs.1113 lakhs (1977)	354	257
After Depreciation	N.A.	306	247

to be imported by them had obtained specific official test certificate.

Licences were given in an adhoc manner in 1951 and 1952; but in 1953 distinction was made between makes of tractors imported earlier and the new ones. The licensing policy for the former was based on a quota system whereas for the latter, applications were to be considered on an ad hoc basis and on individual merits. Imports were allowed relatively easily till 1956, though certain procedural modifications had been made because of the deteriorating foreign exchange situation. However, by this time liberal import of tractors through normal trade channels had ended. Small quantities were allowed to be imported from time to time till in 1959, when quota licences to established importers were altogether stopped.

Besides the normal trade channels, imports of tractors were made through the State Trading Corporation, largely from Russia and Czechoslovakia from 1957 onwards. During the period 1961 to 1970 Soviet Russia, Czechoslovakia, and Rumania were the major expoerts of tractors to India.

The numbers of imported tractors, which used to be around 2000 to 3000 annually, increased in the late 60s. The Green Revolution in Punjab had converted farming from a subsistence activity to a commercial proposition. There was a long waiting line for tractors and the Government responded by allowing massive imports of tractors especially from the rupee payment countries during 1966-1972. Imports were allowed in spite of the fact that indigenous production was increasing from year to year. Representatives of the industry alleged that tractors were being indiscriminately imported. The Department of Agriculture opined that though indigenous production was picking up it was not sufficient to meet the total requirement of tractors in the country. Import was arranged by the

Department of Agriculture after considering the overall demand and the estimated indigenous production. This was done from year to year in consultation with the Department of Industrial Development, Ministry of Foreign Trade and Supply, and Ministry of Finance.

World Bank Scheme[9]

In 1971, the World Bank sent a mission to study the growth and structure of the tractor industry in India in order to make policy recommendations to the Central Government and find out the nature and magnitude of financial assistance that would be required. The World Bank, including its soft loan affiliate, the International Development Association, showed interest in financing integrated agricultural projects in India. These projects included various aspects of agricultural development, such as development of land, minor irrigation facilities, farm mechinization, etc. and only those that were eligible for refinancing from Agricultural Refinance Corporation. Agreements were signed to cover the foreign exchange cost of the import of agricultural tractors for the following projects:

1. Tarai Seeds projects (World Bank Loan) 750 tractors (Over one year)
2. Gujarat Agricultural Credit Project (IDA Credit) 8000 tractors (Over two years)
3. Punjab Agricultural Credit Project (IDA Credit) 8000 tractors (Over two years)

There were massive imports of tractors under this scheme and through other channels in 1971 and 1972. In 1973 and 1974 this had died down to a trickle and from 1974 onwards import of complete tractors was stopped.

Industrial Licensing Process

Table 3 presents data regarding production capacities in the tractor industry licensed by Government in 1960-61.

Table 3

Licensed Production Capacities -Initial Position as at the End of 1961

Name of the Firm	Draw bar horse power (D.B.H.P.) range of tractor licensed	Capacity per annum nos.
1. Eicher	a) 12-18	1,000
	b) 20-30	1,000
2. Hindustan	a) 35	1,000
	b) 50	1,000
3. International	35	3,500
4. TAFE	a) 28.2	3,000
	b) 43.5	500
	Total	11,000

Source: Report on Fixation of Prices of Agricultural Tractors, (Bombay: Tariff Commission, 1957), p.6

During the period 1961-66 the demand for tractors went on increasing progressively and the need arose for higher indigenous capacity. So, the government allowed increase in the production capacity of some of the existing units and at the same time licensed one more unit in the private sector and proposed another one for the public sector. Table 4 gives the licensed capacities in 1966.

Table 4

Licensed Capacities for Production of Tractors in July 1966

Name of the firm	D.B.H.P. range of tractors	Revised licensed capacity per annum Nos.	Letters of intent issued for additional capacity Nos.
1. Eicher	20-30	2,000	
2. Escorts	25-35	7,000	
3. Hindustan a)	35	2,000	
b)	50	5,000	
4. International	35	3,500	6,500*
5. TAFE	35	7,000	
6. Proposed Public sector Project	20	-	12,000
Total		26,500	18,500

* International's capacity is to be raised in the stages of 3,500 and 3,000 reaching finally an aggregate of 10,000 tractors per annum.

Source: Tariff Commission Report, P.7

The sudden spurt of demand from 1966 onwards prompted the Government to delicence the tractor industry on February 7, 1968. This step was suggested by the Department of Agriculture to enable more manufacturers to enter the field of tractors. Nine new manufacturing projects as given in Table 5 were approved by the Department of Industrial Development during this period of delicensing:

Table 5

Name of the Party	Porposed location	Make of the tractor	Annual capacity Nos.
1. Ghaziabad Engg. Co. Ltd. N. Delhi	Lini (U.P.)	DT-148 -14 HP	10,000
2. Indian Agro-Machines, Bombay	Hyderbad	RS-09 (20 H.P.)	10,000
3. Dr. R. Keymal Hyderabad	Hyderabad	Guldner (15-45 HP)	10,000
4. Escorts Ltd. Faridabad	Faridabad	Ford (56 HP)	6,000
5. Kirloskar Brothers	Poona	D-3006,4006,6006 and 9006(27-75 HP)	10,000
6. Prem Agro-Engg. New Delhi	Hyderabad	U-650/651 (65 HP)	5,000
7. Perfect Tractors Limited Patiala	Patiala	Hanomag (32 HP)	5,000
8. Steyr India Ltd.	Hyderabad	Steyr (44 HP)	12,000
9. International Tractors Co. Ltd., Bombay	Bombay	14434 (44 HP)	7,000

Source: Company document

The tractor industry was exempted from the licensing provisions of the Industries Act, 1951 from February 7, 1968 to February 19, 1970 and with effect from February 20, 1970 the tractor industry was again relicensed.

The lure of quick profits made tractors the most sought after industry in 1968-71. Every conceivable foreign collaboration was sought and at one stage there were 18 apirants interested to enter the industry.[10] The interest of most of these seemed to lie in the profits from trading activities, i.e., sale of imported tractors which were permitted in the introductory phase of the indigenous manufacturing programmes. Along with licensing a large number of new manufacturing projects, the Government stepped up imports to meet the increasing demand. By 1971 the demand slackened and in this period the interests of these new aspirants fizzled out and only a few considered setting up manufacturing facilities seriously.

The Working Group on Agricultural Machinery and Implements recommended the manufacture of the Czechoslovakia Zetor - 2011 tractor in the public sector in view of its good design and suitability for medium and small farms. Subsequently, the Hindustan Machine Tools Ltd (HMT), a public sector undertaking was issued a letter of intent on July 27,1970 for a capacity of 12,000 numbers per annum and their collaboration agreement was approved. The Department of Industrial Development took a decision not to set up an altogether new unit in the public sector for the manufacture of tractors. This was in view of unutilized capacity available with HMT.

In 1977 the licensed capacity stood at 1,10,000, with an installed capacity of 50,150 of 11 manufacturers. The annual production and sale of tractors stagnated at around 33,000

numbers during the years 1975 to 1977, and this trend continued till early 1978. The capacity utilization of the industry was around 70 per cent of installed capacity which was itself less than 50 per cent of the licensed capacity.

II. Evolution of Government's Foreign Collaboration Policy

This section discusses the evolution of Government's policies and regulations in relation to foreign collaboration. Foreign collaboration, both financial-cum-technical and purely technical are the major channels for acquisition of technology in the tractor industry. In fact, out of 11 manufacturers who have already established production, 10 have foreign collaboration. This being the situation, it will be useful to know the process through which the Government's policies regarding foreign collaboration has evolved over time.

The Industrial Policy Resolution of 1948 recognized that participation of foreign capital and enterprise, particularly in industrial techniques and knowledge, would be valuable for the rapid industrialization of the country. However, the Government was keen to regulate the conditions under which foreign collaboration would be allowed. It insisted that major interest in ownership and effective control would always have to remain in Indian hands and training of Indian personnel be insisted upon.

An increasing need for foreign capital was felt as internal capital was not forthcoming in spite of repeated exhortations by the Government.[11]

The advantages of foreign capital in terms of its ability to graft much needed technical and managerial skills to Indian industry remained to be seen. Official attitudes gradually became more liberal. Foreign investment policy was further liberalized in 1949. Foreign capital was assured non-discriminatory treatment vis-a-vis Indian enterprise with regard to industrial licensing requirements. Facilities were given for repatriation of profits and capital as well as payment of fair compensation in the event of compulsory acquisition of the enterprises. Government would frame terms and conditions keeping mutual advantages in view and not object to foreign control over operations for a limited period provided it was in the national interest. Each case was to be treated on its merits. Employment of foreign personnel was permissible in the event of non-availability of Indian personnel.

There was an outcry against Government's favourable attitude towards foreign capital by domestic business interest. But this did not deter Government from adhering to its chosen policy. Gradually domestic business interests also veered to a more favourable stance towards foreign capital.[12]

On the basis of the Prime Minister's statement made in 1949 various qualifications for the acceptance or rejection of foreign investment projects were developed. These qualifications have been stated in different documents and, statements have been issued by various governmental organizations. No rigid criteria were laid down for screening collaboration arrangements, but the Government's approval was necessary for all proposals. In the absence of specific criteria, the government was free to judge each collaboration application "on its merit". However, the normal policy was to restrict foreign collaboration to those cases where there was potential of acquiring technical

know-how and where indigenous capability was lacking or where domestic capital was not forthcoming or was inadequate. Favourable treatment was also given to those projects which, effected a saving in foreign exchange through import substitution or earned foreign exchange through exports.

An example of the flexibility of government in approving foreign collaboration agreement is provided by the case of the fertiliser industry which is included in Schedule B of the Industrial Policy Resolution of 1956. Here Government policy was altered to meet the special requirements of this industry. Majority of foreign capital ownership was allowed for substantial expansion in the private sector.[13]

The post I dependence period saw a definite shift in the nature of the collaboration agreements signed by Indian industry In the mid 50s, when industrialization gathered momentum with the launching of the Second Plan, there was a sizeable increase in technical collaboration agreements.[14] Minority participation appeared in the immediate post-Independence period and this form of agreement became predominant during 1956-64. The foreign equity provided the foreign exchange for importing machinery and equipment. Some collaborators also accepted equity participation in lieu of royalties and technical fees. Some tax concessions were also extended to foreign enterprises which attracted foreign capital. The setting up of the Indian Investment Centre in 1961 was instrumental in making available useful information for foreign tie-ups. Another factor which attracted the foreign investor was the sheltered market created by the imposition of stringent import control, necessitated by a precarious foreign exchange situation. Between 1948 and 1955 there were only 234 foreign collaboration agreements; an average of about 41 per year. Between 1956

and 1957 the average was around 80 and between 1960 and 1965 the average was around 300.[15]

This large scale import of technology invited severe criticism. As a result, Government in 1968 distinguished three categories of industries whereas, 1) both financial and technical collaboration would be permitted, 2) foreign technical collaboration would be permitted but not foreign investment, and 3) no foreign collaboration (financial or technical) was considered necessary.[16] At the same time government established the Foreign Investment Board to cope with applications for foreign collaboration. The Secretary in the Finance Ministry was to be the Chairman of the Board and there were to be representatives from different ministries concerned with foreign investment and collaboration, and from the Directorate General of Technical Development, the Capital Goods Committee, the Council of Scientific and Industrial Research, and the Planning Commission. All applications for foreign investment/collaboration were to be submitted to the secretariat of the Board. This was done to streamline the procedures which had been very cumbersome.

In 1969-70 the Government further tightened its policy on foreign collaboration. Foreign collaboration was to be resorted to only for meeting a "critical technological gap"; it was not to be allowed at all in consumer goods.[17] In 1970 following the recommendations of the Dutt Committee, the government published a list of 121 items where significant technological gaps existed, thus offering scope for foreign technical collaboration.[18] Actual terms and conditions, including extent of foreign investment, were to be decided on the merits of each case within the framework of Government's policy announced from time to time. There was provision for some relaxation provided the projects were substantially export

oriented and or-were in the small industries sector.

The Dutt Committee identified certain industries which were crucial to the national economy. This group of industries was categorized as the "core sector", comprising of "basic, strategic and critical industries". These included all industries whose products entered into the production processes of a large number of other industries, those which were potentially capable of production for defence requirements, and those whose development was crucial for the overall economic growth of the country, including (among others) basic metals, heavy machine building, and heavy chemicals.[19] The larger industrial houses were expected to concentrate their resources on the development of complex and heavy-investment industries which mainly belonged to the core sector.

The significance of the core sector to the national economy was very large; hence the Dutt Committee recommended that detailed industry plans be prepared for this sector and essential inputs and foreign exchange be made available on a priority basis.

The agricultural tractor industry as an important component of the total agricultural inputs also came under this sector. This industry was also identified as one in which technological gaps existed and therefore foreign collaboration was possible.

The primary concern of the Government in regulating foreign collaboration in industry has been to ensure that the national interest with regard to plan priorities, prospective demand, degree of sophistication of technology needed, effect on balance of payment, self-sufficiency, use of local raw materials is subserved. Also, the Government's attempt has been

to ensure that the terms and conditions are not too onerous.

The 1975-76 Report of the Lok Sabha Committee on Public undertakings summarized the current policy.[20] Although, initially framed as restrictive, the policy permitted import of foreign technology competing with indigenous technology if there was reasonable expectation of substantial exports. Equity participation of more than 40 per cent ceiling was permitted for export-oriented schemes for the import of high technology not otherwise available. Royalty payments were not allowed to exceed five per cent of production value and were not allowed to extend beyond five years, but exceptions to these ceilings were also permitted. In certain cases, foreign equity investment up to 74 per cent was also permitted. In most cases, a tax holiday limited to a portion of the earnings was permitted up to a maximum period of five years. For encouraging backward area development, cash subsidy up to 15 per cent of the invested capital was provided in conjunction with a tax holiday on a relatively large portion of the income for up to a period of 10 years.

III. Five Case Studies

In the following sections a comparative analysis of the process of technology acquisition and assimilation in five major companies in the tractor industry is presented. These five companies comprised more than 70 per cent of the total sales turnover in the year when data for this research was collected. It also examined one more firm which developed its technology indigenously, however, reference to it is brought in only to arrive at some conclusions.

The research methodology used consisted of three phases: 1) pilot study of two major firms for a period of one and a half months approximately, 2) study of secondary data sources, and 3) a re-examination of the previous two organizations and study of four additional ones. Both external and internal

factors that influenced the technology acquisition and assimilation process were examined. The external factors were: competition, Government's policies, technological capabilities of the farmers and automotive ancillary industry, role of national research laboratories, and demand for tractors. The internal factors were related to the following organisational characteristics:

1) existing businesses if any and their relationship to the tractor industry;
2) formal organization structure;
3) systems of control and coordination;
4) training methodology; and
5) their existing resources, technical and managerial capabilities.

Major data sources were interviews of some 60 company executives. In addition detailed study of various company documents like detailed project reports, feasibility studies, organizational announcements, etc. was also done.

Nature of Collaboration Agreements

An analysis of the collaboration agreements entered into by the five major tractor manufacturing firms studied here suggests that while they were enterprise specific, they were also significantly influenced by the Government's policies toward foreign investment and collaboration, industrial licensing, and on import prevailing at the time. Tables 6 and 7 depict the differences in the collaboration agreements on various dimensions across the five firms. The firms are placed in the two tables according to their time of entry assuming that the public policies did not change considerably during the particular period.

Table 6

Terms and Conditions of Foreign Collaborations (Period of Entry:1961-64)

Eicher Tractors Limited	Escorts Limited	International Tractors
Terms and Conditions:	Terms and Conditions	Terms and Conditions
1. The collaboration was for the acquisition of technical knowhow for the manufacture of 26.5 h.p. tractors to the design of M/s. Gebr Eicher of West Germany	1. The collaboration was for the acquisition of technical knowhow for the manufacture of 22 h.p. and 35 h.p. tractors using transmission components to the design of M/s. M$_Q$ to Import, of Poland	1. Initially the collaboration was only for the supply of technical knowhow for the B-275 (35 h.p.) tractor. However, later on, knowhow for the international 434 and 444 was also supplied by M/s. International Harvester of U.K.
2. Ownership of Capital: Yes. But value not available	2. Ownership of Capital: Nil. The collaboration was only a licence agreement. Management was to be with Escorts Ltd.	2. Ownership of Capital: 17% equity shareholding for each of the promoters. Management was to be with M&M and the sales distributorship became the responsibility of Voltas Ltd.
3. Duration 10 years from the commencement of production	3. Duration 8 years from commencement of production	3. Duration 10 years from the commencement of production.
4. Export Clauses Details not available	4. Export Clauses No restrictions	4. Export Clauses ITCI was given the right to export tractors to any territories but under the condition that IH's representative would be appointed as sole selling agent.

Eicher Tractors Limited	Escorts Limited	International Tractors
5. Right to Sub-Licence: Details not available	5. Right to Sub-Licence: Details not available	5. Right to Sub-Licence Not allowed.
6. Lumpsum Payment Nil	6. Lumpsum Payment Rs.5,50,000 (pre-devaluation).	6. Lumpsum Payment Nil
7. Royalty 2% on ex-works cost of parts manufactured in India under collaboration. Another 2% was payable as technical knowhow fee.	7. Royalty No royalty payments.	7. Royalty 25 pounds sterling for each complete tractor and 3% on ex-works price of all spares.
8. Training: 2 or 3 engineers were sent to the collaborators for a few weeks each. 2 of the collaborator's technicians helped in establishing production during the pre-production period for a short time	8. Training: 2 engineers were sent for 5 months each to the collaborator's works	8. Training: Engineers of ITCI to be sent to IH's works in U.K. at ITCI's cost and also 2 of IH's technicians were supposed to be sent to ITCI to help in establishing production.
9. Regulatory Clauses: Details not available	9. Regulatory Clauses: None	9. Regulatory Clauses Concerning use of trade mark incorporation of design changes made by collaborator, right to inspect products manufactured by ITCIand the return of all drawings and information after the termination of the agreement.

Table 7

Terms and Conditions of Foreign Collaborations (Period of Entry : 1971-74)

Hindustan Machine Tools (HMT)	Kirloskar Tractors Limited (KTL)
Terms and Conditions	**Terms and Conditions**
1. Collaboration was for 3 models: Zetor 2011/2511, 4511, and 5511. Initially documentation for the 25 h.p. model was to be supplied and later when HMT desired the documentation for the other models was to be supplied. Collaborator : M/s. Motokov of Czechoslovakia.	1. Collaboration was for the unified series of 30,40,60,100 h.p. models. Collaborator: M/s. Klockner Humboldt Deutz of West Germany.
2. Ownership of Capital: No ownership of capital by M/s. Motokov. Complete managerial control was to be with HMT.	2. Ownership of Capital: No ownership of capital by M/s. Deutz. Complete managerial control was to be with KTL.
3. Duration 5 years after the commencement of the Licence agreement for the Zetor 2011/2511.	3. Duration 5 years after the commencement of commercial production
4. Export Clause: HMT was allowed to export to Ceylon & Nepal For export to other countries, permission had to be taken.	4. Export Clause: Only with prior written consent of the collaborators. Engines were allowed to be sold in any part of the world as a part of equipment other than tractors, but not separately as prime movers.

Table 7 (contd.)

HMT	KTL
5. 5.Right to sub-licence technology Allowed under conditions which were to be mutually agreed upon.	5. Right to sub-licence know-how Not allowed –
6.Lumpsum Payment: Rs.4.12 lakhs for preparing detailed project report. Rs.9.80 lakhs for the documentation for the 25 h.p. model (free of taxes)	6. Lumpsum Payment: DM 14,000 for the whole documentation (free of Indian taxes)
7.Royalty 2.5% (subject to taxes) for a period of 5 years.	7. Royalty 3% for domestic sales and 5% for exports for 5 years after commencement of production.
8.Training 36 engineers of HMT were to be trained at the Collaborator's works for periods ranging from 6 months to 1 year. 12 engineers of M/s. Motokov were to impart training to HMT engineers in their works for a period of 1 year each.	8. Training There was an agreement for training 4 engineers of KTL at a time in KHD's works. They also agreed to send their technicians for helping in establishing production.

Eicher and International Tractor Company of India (ITCI) which entered into foreign collaboration agreements during the period 1959-61 had minority foreign equity participation. The duration of the agreements was 10 years and managerial control was vested in the Indian firm. Escorts had a licence agreement with a Polish manufacturer for a relatively obsolete product.

HMT and Kirloskar Tractors Limited (KTL) entered the industry during a later period- 1971-74. Both firms entered into pure technical agreements and the duration of royalty payment was five years from the commencement of production which was exactly half that in the two cases cited above.

A significant feature of the collaboration agreements was that managerial control over operations rested with the Indian partner even in the cases where there was equity participation by the foreign collaborator. In the case of ITCI there were regulatory clauses which stipulated that the Indian company could use the foreign collaborator's trade mark on the condition that they would have the right to inspect the quality of the products manufactured. One of their engineers was stationed at the plant in Bombay as their resident director for keeping check on the quality.

The conditions regulating export by the Indian firms varied across the firms. ITCI was allowed to export to any country but on the condition that the foreign partner's representative would be appointed as sole selling agent. Information was not available for Eicher which also had foreign minority equity participation. Escorts which had a licence agreement did not have any restrictions on exporting its products. However, in the case of the other two, which had no equity participation there was some restriction on exports as seen from Table 6.

In terms of scope of the collaboration agreements those that were signed later were more comprehensive in nature. In the case of both HMT and KTL, the collaboration was for transfer of technology for a whole range of tractors which belonged to a unified series of products in contrast to those signed earlier which were for one model only except in the case of Escorts which was for two models. This perhaps was an indication of the increase in bargaining power of the firms that entered the industry later. Even in the case of IMCI and KTL it seems that the Indian partners were able to sign agreements in line with the Government's policies in which the parent company made departures from their established policies.

In the case of IMCI, the three partners, International Harvester (IH) Mahindra & Mahindra, and Voltas had 17 per cent shares each in the equity. For IH, this joint venture marked an important departure from its established policy of investing abroad only through wholly owned subsidiaries. According to Kudrle,, IH's foreign role had been quite large right from the beginning of this century. In 1912, 40 per cent of its total sales was from outside the United States. IH's foreign role became more significant with the dwindling of its domestic market share. IH had been leading in the North American farm machinery sales until the late 50s. Gradually from 1929 onwards it lost ground to Allis-Chalmers, John Deere, Ford, and Furguson. To maintain its position and to take part in the World War II boom, IH moved into manufacturing activities in France, Germany, Britain, and Australia. Around mid-50s, India began to face a deepening foreign exchange crisis and the Government's policy of import substitution posed a threat to IH's market which was about 55 per cent of the total sales in India. IH's decreasing market share in the home market and the impending loss of the Indian market pointed to the need of setting up manufacturing facilities in India. Also the protection against competition provided by the Indian Government's policies could mean a lucrative future market. This perhaps was a powerful motivating force for IH to invest in India.

When KTL signed their agreement with M/s. Klockner Humboldt Deutz, the latter's product was acknowledged by tractor experts the author interviewed, as one of the most sophisticated on technical parametres like fuel efficiency, and hydraulic lifting power. However, in this case also the foreign collaborator agreed to abide by the prevailing Government's policies. An explanation for the relatively high bargaining power of the Indian firms vis-avis their foreign counterparts is that the tractor industry had reached its stage of maturity and hence the technology was widely dispersed making it relatively easy for an interested firm to acquire it.

The development of the tractor industry is very closely associated with the automobile and automotive ancillay industries. A major part of the standard proprietary items used in the manufacture of the tractor is supplied by this industry. This constitutes about 50 per cent of the tractor by value. The apparently high bargaining power of the Indian tractor manufacturers resulted from the higher technological absorptive capacity.

Another major point that is worth noting is that all the agreements had special provision for training Indian engineers at the collaborators' plants and also for help by the foreign firms' engineers in establishing production. However, the intensiveness of the training did vary across firms which reflected enterprise-specific situations.

Choice of Product

The process of choice of the proprietary technology reflects more the style of top management of the firms and their perception of market conditions at the time of their entry into the industry

than the influence of Government's policies. The Department of Agriculture stated:

> On account of varied soil topography and crops cultivated in different parts of the country, the need for the type and horsepower range varies, and one or two makes ... cannot cope with the varied requirements. Moreoever, the requirements of the country cannot be effectively met by any one or two manufacturers. Hence, Government of India has, subject to the availability of foreign exchange, allowed import of (i) such make/makes that have a manufacturing programme approved by the Ministry of Industrial Development and Internal Trade and/or those whole manufacture is likely to be established in the ... foreseeable future;(ii) Tractors which had either been tested at Tractor Training and Testing Station, Budni and found satisfactory, or alternatively which had been imported in the past and we have had sufficient experience of their satisfactory performance under Indian conditions ...[21]

Given this policy of Government, there was considerable leeway available to the firms to exercise their choice. However, as we shall see presently, the majority of the firms did not conduct a comprehensive search for the best technology but exhibited a satisficing[22] behaviour with the marketability of the products in view. Nevertheless, there were deviations from this which were more of an exception than the rule.

When Eicher Tractors India Limited was floated in 1959 by by the Goodearth Company, it had been engaged in the business of selling imported tractors for quite some time. In 1948, M.M. Lal, the founder 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. However, in 1952, Goodearth Company started importing tractors on its own from Gebr. Eicher of West Germany to "test market" them. Imports of complete tractors went on till the end of 1956 after which the liberal

import of tractors through normal trade channels ended on account of stringent foreign exchange situation. Around this time Lal started considering manufacture of tractors in India. Around 1957-58 he went to West Germany to explore possibilities for collaborating with the same company as its products had been well accepted by the market.

The Indian farmer was not exposed to mechanization of agriculture, and was, therefore, apt to put the tractor to abuse. There were almost no facilities for maintenance of tractors and the level of technical skill possessed by the farmers was very low. Lal realised that India needed tractors which could withstand various types of use and abuse like pushing heavy loads, pulling trailers, various farm equipments, etc. Ease of maintenance even by poorly trained village mechanics, low price and low operating costs were major characteristics, which he looked for in his extensive tour of Europe for a suitable tractor. The Eicher tractor fulfilled these requirements. It was simple in design; it could be easily maintained by farmers with a low level of technical skill, and was low priced. The tractor was powered by a single cylinder, air-cooled engine and had minimum number of moving parts. It did not have a hydraulic system for implement control, whereas by the 60s almost all tractors in the developed countries had incorporated this in their designs. In other words, the tractor model selected by Lal for manufacture in India was comparatively an obsolete one. The German collaborators were no longer manufacturing this tractor. They had already brought out more sophisticated ones for the German market.

In 1959, Mahindra & Mahindra Limited, Bombay received sanction from the Government for manufacturing agricultural tractors in collaboration with David Brown and Company in U.K.

The new company was called David Brown Mahindra Tractor Private Limited. It had planned to begin manufacture with already existing facilities in the Mahindra & Mahindra Group of companies. However, this collaboration agreement failed and Mahindra & Mahindra started searching for another suitable collaborator. Voltas Limited had been the sole selling distributors of International Harvest tractors from the early 30s. In 1957, they started toying with the idea of manufacture of tractors as they realised that the balance of payments position of the country was gradually becoming precarious and that there would be restriction on imports. Their idea was to initiate technical collaboration between their foreign principals and well known Indian firms to manufacture their products which was already selling in the country. In these ventures, Voltas retained the right to sole distributorship. This strategy matched the requirements of the government's industrialization policies, the foreign firm's need to secure their existing markets, Voltas's need to diversify using foreign technology, and its own distinctive competence in selling and distribution. On August 24, 1961, Voltas International Harvester of U.K., and Mahindra & Mahindra teamed up to form the new company, called the International Tractor Company of India Limited. For Mahindra & Mahindra Limited (M & M) with its experience in the automotive industry, entry into the tractor industry was a logical step.

The demand pattern forecast by the Planning Commission envisaged higher demand for tractors in the range of 20 to 30 draw bar horsepower. In 1961, when the company was formed, Voltas was selling the B250 model of IH tractor. At that time the lowest horse-power tractor made by IH was 35 horsepower in the UK and 25 horsepower in Germany. A Government sponsored team which had visited many countries in 1962 was asked to determine the ideal range of tractor horse-power

for India. It observed a gradual shift towards higher horse-power tractors all over the world. There was a preference for tractors with engine horse power above 25. Since IH had strong commitment to "35 +"horse power tractors it decided to introduce the B275 (35 horse power) model in India. The choice of the product was not based on any systematic market research, but, on the basis of field experience and judgement.

The story of Escorts' entry into tractor manufacturing as narrated by a senior executive of the company is as follows:

> Till 1961 we were selling Ferguson tractors in the North and North-East India. We sold very large numbers of these tractors. But in 1961, our selling agency of Ferguson was terminated because they signed a collaboration agreement with Simpson for starting a tractor manufacturing plant in Madras. We had a large infrastructure of dealers and we did not know what to do. We then recommended the new company which Ferguson had set up to appoint them as their dealers.

This was the setting in which Escorts found itself in 1961. The decline in sales from Rs.43 lacs to Rs.193 lacs in that year was mainly due to the loss of their tractor business. At this time Escorts was approached by the supplier of Polish tractors to explore the possibilities of manufacture in collaboration with Messrs Moto Import of Poland. They had an Indian agent in Kanpur with whom they were dissatisfied. Escorts then became their agent for selling "Ursus" tractors. In 1962 Escorts applied to the Government for an industrial licence to manufacture tractors in collaboration with Messrs Moto Imports in which 50 per cent was planned to be constituted of indigenous components. This was possible by using an indigenous engine with a transmission imported from the collaborator. The Government issued the licence in 1966. In the meanwhile due to the limitation placed by the Government on import of complete tractors, the company designed and developed its own tractor

by utilizing an Indian made engine and other components produced by anciallary industries. Utilization of a large percentage of indigenous components resulted in a low value of imported components. The Government in appreciation of their efforts in the development of a tractor with an indigenous engine allowed the company to import CKD packs from Poland. However, all the activities were only assembly operations as manufacturing could not be started without a licence. The tractors, the company developed were the Escorts 37 (35 horse-power) and Escorts 27 (22 horse-power).

When HMT, a public sector undertaking of the Central Government entered this industry, it had two options, either to go in for a foreign collaboration with Messrs Motokov of Czhechoslovakia or to examine the proto-type model of an indigenous tractor called 'Swaraj' developed at the Central Mechanical Engineering Research Institute at Durgapur. HMT decided to go in for the former for various reasons. There were many plus points for the Czhechoslovakian tractor. Over 30 thousand of them had already been in operation on Indian fields for over ten years. Moreover, for the first five years of the manufacturing programme foreign collaborator was supposed to provide CKD packs ready for assembly. This period was considered to be sufficient for developing the capability to manufacture most of the components indigenously. The Swaraj's on the other hand was an unproven model. It would have taken roughly three years to establish the manufacturing facilities. During the financial year 1967-68, 1968-69, and 1969-70 HMT made large amounts of loss and hence its management was under tremendous pressure from Government to turn the company around. From the point of view of commercial advantage, which was most important to HMT because of the slump in its machine tool

business, the choice in favour of the imported tractor model was obvious. Though the foreign collaboration agreement was signed for transfer of technical knowhow for the manufacture of three models-Zetor 2011/2511 (25 horse power), 4511 (45 horse power) and 5511 (55 horse power) - initially technical documentation was to be supplied for only 25 horse power model. Terms and conditions for the supply of knowhow for the higher horse power models were to be decided only when HMT was ready to manufacture those.

The process of choice of product was problem oriented, i.e. firms started searching for a possible collaborator only when their existing business were in trouble. In the first two cases, the search for a collaborator and product was influenced by the top management's desire to produce a tractor which could be easily sold. Even this criterion for choice could have led to a number of alternatives. In the case of the last two companies, the firms did not have any time to undertake a comprehensive search because of the need for taking fast decisions as a result of a major slump in their existing business. The proposals for foreign collaboration in a way were offered to them and they accepted the same.

In contrast, we have the case of KTL whose top management was interested in a technology that would be far ahead of the competitors' products. At the time they entered the industry, their competitors were ITCI (collaboration with IH), Tractors and Farm Equipments (collaboration with Massey Ferguson), Escorts (collaboration with Messrs Moto Import of Poland and Ford of USA), Hindustan Tractors (collaboration with Motokov), and HMT (collaboration with Motokov). KTL's top management was on the look out for a product that would be "the technology for the next 25 years." This was the philosophy of the Kirloskar Group. In 1949, the Kirloskar

Oil Engines Limited (KOEL) had decided to go in for the manufacture of vertical diesel engines which was a remarkable improvement upon the then popular horizontal ones. The horizontal deisel engine could achieve speeds up to 750 revolutions per minute whereas vertical ones could go up to 2000 revolutions per minute and hence could develop more power. At the time KOEL introduced the vertical engine, it was a totally new concept in the Indian market and only after intensive market development the product proved very successful. Deutz tractors were designed to use direct injection air cooled engines with a very low specific fuel consumption of between 158 to 165 gms. per horse power hour. The engine was designed to run at 2300 RPM. The cylinders and cylinder heads were separated for ease of servicing. Repairs could be completed quickly as only the affected cylinders needed to be dismantled. Thermodynamically the theoretical efficiency of an air cooled engine is higher than that of the water-cooled one because higher operating temperatures are achieved rapidly. Also the optimum operating temperature for the air cooled engine can be designed to be higher than that for water-cooled engines. This enables the complete burning of sulphur present in the fuel which otherwise forms sulphuric acid in the cylinder after cumbustion thus causing corrosion and wear on cylinders, pistons, and cumbustion rings. The horse power consumption by the blower for air cooling is two to three per cent of the power generated by the engine as compared to six to seven per cent of the energy consumption by the cooling equipment in a water-cooled engine. The horse power output is, therefore, greater for any size of engine. However, there were doubts in the minds of the Indian farmers regarding the cooling efficiency of the air-cooled engines. This doubt had been generated by failure of the RS-09

tractors and the bad performance of Escorts Tractors sold earlier which had been fitted with air-cooled engines in the mid 60s. In spite of the bad name air-cooled engines had acquired in India, the management of KTL decided to use this engine, the thinking being that this would be the technology of the future.

Choice and Adaptation of Manufacturing Technology

The choice of manufacturing technology in the Indian tractor industry was significantly influenced by the Government's industrial licensing policy on the one hand and enterprise specific factors on the other. Though all the firms considered in this study largely used 'batch production technology to manufacture tractors, there were differences across the firms on various dimensions. These could be attributed to the differences in organizations' characteristics which we shall discuss later in this section.

Plant size in this industry was regulated by the industrial licensing policy of the Government. Industrial licensing, directed towards securing the national objectives had among the original aims; 1) regional dispersal of manufacturing units, 2) prevention of economic concentration, 3) impetus to small industries, 4) encouragement to import substitution, 5) opportunity to new entrants, and 6) elimination of unlicensed expansion. In consonance with these objectives, the total capacity planned/ activities were based on demand forecasts made by various governmental and non-governmental bodies. The firms were forced to adapt mass production technology acquired from their collaborators to low volume batch production technology matching the cpacity allocated to them by Government.

/for each plan period was divided amongst the number of enterprises. The planned

Eicher Tractors was initially issued an industrial licence for manufacturing 1250 tractors per annum which was later on increased to 2000 tractors per annum. In 1977 it was again raised to 10,000. Compared to the average production capacities of over 30,000 tractors per annum of major manufacturers in America and Europe, Eicher Tractors' 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 2000 tractors per annum for the first two years. One of the major tasks for Vikram Lal, after he joined Eicher Tractors in 1968 was selection of proper plant and machinery to increase production, which had remained extremely low for eight years from 1960 onwards.

Technically, there were three 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 combination of special purpose and universal machinery.

The first choice was immediately ruled out as there was not enough funds and also the fact that the production volumes of 100, 200 or even 300 tractors per year would not have been economically justifiable. Use of universal machinery alone was possible as the skill level required in certain operations would be very high and reliability of quality levels achieved would be a problem. So the management considered the use of composite technology, i.e. combination of universal and special purpose machines, a judicious solution.

The major factors that influenced the choice of plant and machinery was the acute paucity of funds which was responsible for the evolution of a corporate philosophy of low cost in every endeavour. To overcome the problem of financial stringency, the management decided to purchase some second-hand machinery from the collaborator which was available at a very low price and which were required for some of the critical operations, for example, machining of connecting rod, crank shaft, etc.

Indigenous machinery available from well-known manufacturers like Hindustan Mahine Tools Ltd., or Kirloskar were too expensive which Eicher Tractor could not afford. So the team of engineers alsong with Vikram Lal went around small scale enterprises in Punjab to observe the machines and equipments they utilised. After studying their practices thoroughly, the management decided to go ahead with purchase of very simple machines called Addas manufactured by the small scale industry in Ludhiana and Batala in Punjab. These machines were basically cast iron bases of lathes, drilling machines, or milling machines 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, and by these operations it 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 combination of these Addas. Using a combination of a 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 cost of Addas was approximately Rs 3,000/- and the special jigs and fixtures around Rs 1,000/-. The total cost of each Adda was Rs 4,000 whereas machines from the well known manufacturers would have cost them between Rs 20,000 and 50,000.

Capital expenditure was also reduced by manufacturing some of the costly machines like dynamic balancing machine for balancing the crank shaft and the fly wheel, and fine boring and lapping machine for the cylinder head in the plant. The company's philosophy had always been as expressed by their Managing Director:

> We do not wish to invest heavily in fixed assets, because we felt that we could not afford to do so without raising the prices. What originaly 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 hence must be conserved.

To quote another example, at the time the study was conducted, the company was planning to make a pressurised paint booth at a cost of approximately eight lakhs, which if they purchased from established manufacturers would cost Rs 16 lakhs. The company also had set up a machine tool manufacturing unit to cater to the needs of machinery for three expansion plants at Faridabad, Alwar, and Parwanoo.

The project team of ITCI studied the technical documents which included, product drawings, manufacturing process sheets, production drawings of jigs and fixtures, and tooling before deciding on the manufacturing process. In 1960 International Harvester relied upon very old factories for the supply of components for their tractors. The manufacturing process used by them for some critical components were highly time consuming. For example, for machining the cylinder head of the engine, international Harvesters' plant in UK used a very conventional process. The process adopted by ITCI for the first phase of their plant more or less resembled those used in the International Harvesters U.K. Plant. The machinery was mostly of the general purpose type. The reasons for this seem to have been; 1) influence of the collaborator, 2) the economic aspects (special purpose machinery was not economical for low production volumes). The jigs and fixtures and special tooling were procured from foreign suppliers along with some of the machinery which were not available in the country then. At the time ITCI was founded, HMT Ltd., had already made a mark as manufacturer of high quality general purpose machine tools. Also, at that time, the country was facing acute foreign exchange crisis and therefore imports of general purpose machine tools were banned. Government had also banned import of special purpose machines which were proposed to be manufactured by HMT in 1966-67.

In the second stage of expansion to 7,000 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. 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. The general purpose machinery used in the first stage required higher operating skill. The shift towards more sophisticated machinery in the second stage expansion was mainly due to the felt need for deskilling manufacturing operations.

The project team recommended change over of the shop lay out from a completely process to a product oriented one, to reduce material handling and back tracking. Special purpose machinery were bought for machining the valve seat, injection bore, transmission case, and crank case. ITCI's collaborator used a conventional machine for some of the operations on the crank case. They overcame problems encountered in using conventional machines by some adaptations in assembling techniques, for example, by using higher torque while tightening bolts. Such techniques were not documented but transmitted through verbal communication. These techniques could be developed through trial and error and over a long period of time. Therefore, ITCI decided to shift to more sophisticated processes.

Till 1968, all jigs and fixtures and special tooling were imported. When the tool room was established, import of jigs and fixtures were stopped. Some of the complicated ones were proposed to be manufactured within the plant and a major part was sub-contracted. The tooling was, however, to be designed by the tool engineering department. Regarding special purpose machines, their policy was to obtain them completely tooled up from the manufacturer. For the gearshop, gear cutting machines were to be imported as they were not indigenously manufactured. Later on, additional gear cutting machines were procured from indigenous sources.

The Escorts group of companies were involved in various business ventures which were highly inter-related. There was a high degree of sharing of some manufacturing facilities by different divisions. Hence it was not possible to identify the capital investments made specifically for tractor manufacturing. However, Escorts went in for relatively sophisticated plant and machinery only when its financial position had improved considerably. From its early stages it had depended upon a policy of procuring a very large number of components and assemblies from ancillaries to keep investment in plant and machinery at a low level.

In the case of HMT, the detailed Project Report submitted by the collaborators envisaged a very large capital investment (Rs 32.5 crores) compared to that of other tractor firms. Their engineers had suggested in-house manufacturing to the extent of 30 to 35 per cent. The manufacturing process suggested by them involved a high degree of automation and sophistication. HMT's project team was asked to prepare another project report considering the following guidelines:

1. As far as possible under-utilized machinery in the machine tool division had to be utilized:
2. All machinery had to be selected in consultation with the collaborator, also the number of variety of tools had to be kept to a minimum.
3. The components were to be manufactured in batches, which would cover one month's production.
4. In-house manufacturing was to be limited to those components that involve technological complexities, precision manufacturing techniques, highly skilled workmanship, and intensive supervision.

The new project report envisaged a manufacture of a large number of components by 30 ancillary units which were planned to be set up within the plants' premises on the pattern of its previous manufacturing units. In addition, a large number of standard components like tyres, tubes, fuel injection equipment, batteries, horns, rims, etc. were available from established automotive ancillary units. The major components which were proposed to be manufactured within the plant were, complete engine, main transmission housing, axle, and gears. The detailed project report projected the machinery requirement at 541 machines out of which 53 were to be special purpose machines. However, when the project was implemented, because of cost escalation, the number of machines required were reduced further to 374 out of which special purpose machines constituted 49. In comparison to the choice of manufacturing technology made by the other firms described earlier, HMT's manufacturing technology was much more sophisticated as shown by its emphasis on special purpose machinery. The project cost as calculated in the DPRI was Rs 1189.31 lakhs. One reason for their being able to go in for expensive, sophisticated machinery was the fact that a large part of the funds required was available from the Government.

As described earlier in an earlier section, Kirloskar's technology was the most sophisticated and some of the components required very high level of sophistication in manufacturing technology. Their collaborator's report envisaged highly sophisticated and mass production type machinery for achieving large production volumes, more suitable in the context of a highly industrialised nation. However, the conditions available in India required a different approach for planning manufacturing. With this in view, Kirloskar's tractor division task force analysed the various assemblies of the tractor to decide

the components which could be manufactured indigenously immediately and which would have to be developed gradually. The project team visited the collaborator's factory in Germany to study the plant and equipment required. It was found that 50 per cent of the tractor's components could be obtained indigenously as standard items. The engine constituted about 22 per cent of the total value of the tractor and the remaining 25 per cent comprised the transmission system consisting of various gears and shafts, the transmission units, and the hydraulic systems. There were two considerations involved in the decision making regarding these components:

1) whether the technology for manufacturing these components was available indigenously, and

2) whether it could be economically viable/feasible to manufacture them in-house.

The technology required for manufacturing the engine was not available indigenously. The cylinder head had to be made by special diecasting of aluminium. Aluminium had to be used because of its high thermal conductivity which allowed faster cooling. Aluminium die casting technology had been highly developed only in a few countries like Canada, Germany and Japan. But in order to reduce capital requirements, the project team explored the possibilities for its manufacture indigenously. They contacted some of the existing foundries but were told that they could develop the technology only if they promised them a requirement of one lakh engines, as the investment required in equipment was quite heavy. The pattern required for die-casting the cylinder head at that time cost $ 1,50,000 and had to be imported with a delivery time of one year. The cylinder block and grey-iron casting required a special purpose machine for machining. The piston and the impeller for the blower was

also not available indigenously. The next alternative was to have them manufactured at one of the promoter's works. Venturing into manufacture of a highly sophisticated diesel engine in the promoters works was perceived to have long-term implications on over all production strategy of the company. The general policy in the Kirloskar Group had been to create a separate company whenever, there was a major diversification in collaboration with a new foreign company. In consideration of the special factors in their situation, the top management decided to manufacture the engine in the Kirloskar Tractors works itself. It was thought that in addition to supplying the engines for its tractors, KTL could market engines as prime movers for heavy-duty, and marine applications. The larger market would then justify the heavy investment.

The foreign exchange element of the financial requirement was of the order of Rs.2.5 crores. No Indian financial institution was ready to grant such a big amount. In consultation with the Government of India, a German financial institution - KFW a West German Government institution - was approached for a foreign exchange loan. It was hoped that the West German collaborator would be able to help in obtaining the loan for KTL. However, after they studied the proposal for one year, and their team visited KTL twice, they declined to grant the loan. As had the foreign exchange situation was not good in 1970, the top management of the promoters took a decision to modify the project. Kirloskar Oil Engines, one of the promoters of the KTL had some spare capacity for manufacturing engines and with some additional plant and machinery, the management thought of meeting the situation. For KTL, the project then boiled down to manufacturing the hydraulics and the transmissions.

At one stage, it was also thought to get gears manufactured

outside. The existing gear manufacturers were mostly in the replacement market and could not supply a high volume. Anticipated uncertainties in supplies finally resulted in manufacture of gears in-house. In 1972 when the financial institutions were approached again for a grant of a long-term loan they insisted upon a fresh market assessment as the date on which the project was based was already three years old. During the appraisal, the question of market acceptance of air-cooled engines created considerable controversy. They had been until then more familiar with the water-cooled engine tractors. They wanted to satisfy themselves that the air-cooled engine tractors could withstand the extreme climatic conditions in this country. It was finally decided that the project would be reassessed by an independent consultancy firm. M/s. M.M. Suri & Associates were employed to do the job. The financial institutions suggested that they would be willing to finance the project, however, its size was revised down from 10,000 to 6,500 tractors per annum during the first phase. In the second phase KTL could increase the production to 10,000. Finally in June 1973, the financial institutions agreed to finance the project through long-term loans to the extent of Rs.500 laks. Thus it took about four years from the time the project team was created till the day the financial institutions finally agreed to finance the project.

The Organizational Dimenstion in Technology Transfer

Creation of an apporpriate organizational context for the performance of various tasks is extremely important for the successful transfer of technology. The various key dimensions would be discussed in this section under different heads.

1. Leadership

In the case of Eicher Tractors, the critical decisions

about the choice of the product and the collaborator was taken by the entrepreneur himself. However, in this company for a period of about 10 years the production remained extremely low. The fledgling organization did not possess the technical and managerial competence to formulate a technological strategy and as a result got into a vicious cycle of heavy dependence on import, low production and lack of funds. To overcome this situation, it called for a highly imaginative and bold decision to go in for crude and cheap machinery to reduce investment and increase production. Also the task of organizing a highly motivated team at a time when the organization was in the doldrums was extremely challenging. The leadership was provided by the entrepreneur's son who was a technologist by training and who later became the managing director of the firm.

A similarity is seen in the case of Escorts where technical leadership was provided by a retired expert from Massey Ferguson of U.K. He developed a strategy of rapid introduction of new models by using a highly over-designed transmissions systems with different indigenous engines. Escorts could follow this indigenous strategy only because of this leadership.

In ITCI, the need for this kind of personalized leadership did not arise as the organization was promoted by three well-known promoters. Mahindra & Mahindra, one of the Indian partners was already experienced in the automotive field and hence translation of the technology package imported from IH into a commercial product did not pose much of a problem.

Even in the cases of HMT and KTL, there already existed a pool of technical talent in other divisions or companies belonging to the same group of firms. At the time of diversifying into tractor industry, the parent company or companies provided the technical talent to carry out the tasks during the technology adaptation stage.

2. Development of the Organization and Formal Management Systems

During the initial phase of technology transfer, very few people were involved in decision making. Generally a small team of top management personnel consisting of members of the Board of Directors and possibly the would be Project-in-charge in the case of large companies got involved. In small organizations, the entrepreneur himself conducted all the decision-making on behalf of his company. However, in the case of public sector undertakings, the situation was different as evidenced by the case of HMT. In this public sector undertaking the Minister and the Secretary of the concerned Ministry, members from other Governmental bodies, and the concerned public sector undertaking were involved. However, as the production increased it became necessary to build a larger organization with officers and separate units to look after different specialized tasks. From a small project team the organization developed different functional units like production, quality control, production planning and control, accounting, finance, design and development, etc. Due to the increasing size of the organization there was an increasing trend towards formalization. Coordination through face-to-face meetings became increasingly difficult; hence the need arose for formal structural mechanisms to facilitate this process. Systems for production planning and control, inventory management, materials planning and control, quality control and cost control were introduced. Skills of developing a well coordinated organization and building systems for integrating various functional areas became important.

This is very clearly evident in the case of Eicher Tractors where production was stagnant for a couple of years, in spite of having no bottlenecks in plant and machinery, technical skills or finance during the early 70s. The problem lay in the firm's lack of managerial skills as identified by the

Managing Director and also corroborated by the consulting group retained by the firm. When the managerial inputs were provided by positioning professional managers at various levels and the organization was restructured to meet the new organizational needs, there was a remarkeable improvement in over all performance. The case of ITCI presented a situation where the development of the organizational structure and management system did not keep pace with the increasing size of the organization. This resulted in the formation of various sub-groups in the organization which were not well integrated. Lack of communication and slow response to environmental changes resulted in vitiation of performance. Top management then directed their attention to the new organizational needs and a series of announcements were made which were directed towards a deliberate formalization of integrating mechanisms through structural as well as systemic changes.

3. Nature of Research and Development Activities

Though at the time of the study all the firms had some sort of R & D department, their orientations were considerably different. In Eicher Tractors developmental activities were undertaken almost from the very inception. 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 and fixtures and other special tooling, and
3) Designing and manufacturing special purpose machines required for machining critical components.

In the beginning the orientation of developmental activities was towards cost reduction. Many of the complicated

machinery which were very expensive were designed and manufactured in the company by the specially created cell. Till about 1972-73 the whole organization was geared up to increase production. Prices being controlled by the Government, the only way to generate larger surpluses was through larger production volume. By 1970 the accumulated losses after providing profit for depreciation amounted to Rs.35.24 lakhs. However, constantly increasing production helped wipe off the accumulated losses in 1973-74. The company's financial position from 1959 till 1974 was very precarious and hence the orientation of R & D had been towards facilitating the production department to increase the production. Also the tractor had been in a seller's market till about 1972-73. According to their Managing Director, the market started showing signs of change around 1972 which called for a change in the orientation of R & D activities. In 1973 the company added the following products to their product line:

1. Diesel Engine Sets
2. Stationary Diesel Engines
3. Trailers of 3-6 tonnes capacity

These products could be manufactured and sold as no industrial licenses was required. The company's policy could be gauged from the following:

> ... the Company had maintained its prime objective of company 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 we felt could fill the gap existing in the market between the high cost/high precision machines made by manufacturers and low-cost/low-precision machines manufactured by the small-scale units ...

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 to their collaborators who commended on their quality. With improvement in its financial position the company started directing 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. Improvements 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 R & D department, the company approached the Indian Overseas Bank for loan facilities and in 1975-76 the company for the first time, invested heavily in equipment and machinery for R & D. A beginning was also made in the recruitment of personnel for manning the R & D department. At the time of the study the department had two senior managers holding Ph.D. degree and a number of them with M.Tech. and B.Tech. degrees in Engineering. The total capital expenditure during the years 1974-75 to 1977-78 was Rs.156.9 lakhs approximately.

In ITCI R & D existed almost from the very inception. However, till 1977 it formed a part of the engineering department. The activities of the R & D section up to 1977 were the following:

1. Trouble shooting and carrying out modifications for tractor components, effecting cost reduction, import substitution, and modifications based on field complaints
2. Field complaints analysis
3. Documentation of drawings and other production related information and data
4. Design and development of new products and attachments
5. Company standards and value engineering study
6. Designing and drawing
7. Components testing, fabrication of prototypes of components being indigenised

Till 1968 new product development was not given any importance. However, in the same year design and development of 17 h p was begun as there was a demand for a small tractor. On making certain estimations, the engineers realized that the cost differences between a 35 h.p. and 17 h.p. engine would not be more than Rs.1800 whereas the customer was willing to pay a much higher price for the higher h.p. tractor. On realizing this, though the tractor was designed and tested, the company did not venture into the manufacture of the product. The following statement by a senior officer of the company gives an idea about the nature of the R & D activities in the company:

> "We have not conducted any systematic market research to decide on our new product development. However, on the basis of our field experience, instincts and judgment, we were able to visualize the potential for certain types of products and adopt appropriate measures. These are reflected to some extent in our project development work as part of R & D during the last 10 years. In 1967 a domestic washing machine was taken up for design and development. This was in the nature of a contingency plan towards diversification. Again it was also meant to give training

> in design to engineers who had an aptitude for design and development work. Generally, whenever we undertake a small project, financial allocation is arbitrarily made, certain targets are also fixed and subsequently the progress also reviewed. Also the commencement of the project might not necessarily follow the preparation of a formal budget, we prepare a budget and sent it subsequently."

During 1968-70 tractor implements were developed according to drawings supplied by IH. During the period 1970-71, the company realized that it would be profitable to have an additional higher h.p. model to broaden its product change. Also around the same time Escort came out with their Ford (43 h.p.) tractor. Actually the design for a 45 h.p. tractor had been already made ready by 1969. The philosophy behind the design was maximum utilization of existing production facilities including machine tools, jigs and fixtures and other expensive special tooling. No formal permission had been taken from the top management for the design and development of this tractor, though an initial budget was made and the top management was informed of the likely expenses for development of the product. Seventy to eighty per cent of the components were of same design as used in the existing 35 h.p. model. However, the top management had doubts about the marketability of the product. Hence they decided to go in for the imported design: the international 434, a 43 h.p.tracto One of the reasons for going in for this model was the exigency of the competitive situation. The management felt that it was essential to enter the higher h.p. market segment in the early stages. The IH design was a proven one and therefore the choice. Similarly there were other new products designed and developed by the R & D department but none of them reached the stage of commercial exploitation.

One of the major contributions of the R & D department of ITCI was "the dieselization" of the "Jeep". After the oil crisis

in 1973, the cost of petrol had increased markedly and with that the market for jeeps had slumped. One of the jeeps used by ITCI was fitted with a tractor engine and tested for performance. It was found to be much more economical but not appropriate for automotive use. As a temporary measure the whole production of jeep was converted to use the tractor engine and the company (Mahindra & Mahindra) was saved from a major disaster. Simultaneously R & D effort was focused on the development of an appropriate engine for the jeep. A collaboration agreement was also signed with a French company for technical know-how for manufacturing a diesel engine for the jeep.

On March 25, 1977, a separate R & D department was created with the former engineering manager as its head. This step was taken to give greater emphsis to value engineering, product reliability and quality control by the creation of the posts of Chief Design and Value Engineer, Chief Development Engineer, and Chief Quality and Test Engineer under the R & D head. The total capital expenditure between 1973-74 and 1977-78 was of the order of Rs.47.7 lakhs. At the time of the study total personnel strength of the R & D department was 65, the composition being about 15 Engineers, 15 technical supporting staff, and about 35 in the administrative category. However, in spite of a relatively large allocation of fund in the R & D, the top management commitment towards developing new marketable products through its own R & D activities was not very strong. The top management view was that there was not much scope for R & D in terms of new product development. However, they felt that there was a scope for cost reduction through control of rejection rate. Value engineering was given emphasis through-out the company from 1976. A company-wide seminar was conducted with the experts from IH - USA plant. This seminar was held at the instance of the Chairman of the company. Within two years some

/the order of Rs.69.4 lakhs and revenue expenditure of

reduction in the cost of the tractor was achieved. This was of the order to Rs.250 to Rs.300 per tractor.

R&D in Escorts had really begun as early as 1963, under the leadership of R.C. Heath, who had joined them in the early 60s. He had earlier worked with Harry Ferguson of "Ferguson Systems" fame. During the early days the Escorts-27 and Escorts-37 tractors were developed with indigenous engines and imported transmissions. The activities were more of a developmental nature, requiring expertise in the design of jigs, fixtures, and special tooling. The backend of the Ursus - 335 (Polish) tractor was highly over-designed and could withstand stresses developed on tractors up to 50 h.p. This backend was adapted for matching with engines of different h.p. In this manner Escorts was able to produce a broad range of tractors. Escorts also gave attention to the development of various types of agricultural implements.

During the 1967 Escorts developed the Escorts-47; a 50 h.p. tractor fitted with a Perkins engine. In 1968 the Kisan tractor using a eight h.p. Kirloskar engine who developed for introduction in the market. During 1970-71 the company developed a new tractor using a 37 h.p. water cooled engine, which was introduced in the market in April 1972. Many new products based on the tractor were also developed. These were material handling equipment like cranes, tuggers, dumpers, compressors, generators, and elevators. During 1973-74, its R & D department attached to the Tractor Division also gave substantial emphasis on the indigenization of the engine, the technology of which had been acquired from M/s. Moto Import.

By 1975-76 Escorts had developed a complete line of material handling industrial equipment, based on the tractor manufacturing facilities. This line of products helped Escorts

to remain in the blue during the recession period.

In 1977 Escorts set up the Escorts Scientific Research Centre. The President of the company reported in the 1977 Annual Report:

> "... the company has expanded its employment and has doubled its design and product development capacity. A lot of unique facilities have been acquired by our Research Centre and engineers have developed more reliable and economical products for the future growth plan of the company."

The Escorts Scientific Research Centre has set-up at a cost of one crore rupees. The total R & D and revenue expenditure of Escorts for all businesses of Escorts between 1968-69 and 1975-76 amounted to 207.45 lakhs.

Till the creation of the Scientific Research Centre in 1977, the objectives of R & D had been 1) import substitution, 2) application oriented product development without going into the basic design features, 3) cost reduction, and 4) improvement of product performance in the field based on market feedback. However, with the creation of the Research Centre there was a qualitative shift in their R & D activities. In 1978 the organization structure of R & D reflected a distinct departure from the earlier policies. A deputy general manager now headed R & D and an officer of the rank of manager, headed the Engine, Hydraulic and Transmission sections - these three assemblies being the most critical part of the tractor. Two other managers directly under the Deputy General Manager looked after : 1) complete tractor implements, trailers, and special equipment and 2) industrial equipment. The objective of this structural change was to commence activities which ultimately would lead to the evolution of new design concepts and the possibility of : 1) using different fuels in the engine, 2) improvement in specific

fuel consumption and 3) improvements in hydraulic systems and transmission efficiency, etc. Highly qualified personnel with with previous experience in Combustion Engineering and Hydraulic Systems were recruited. The Research Centre was also equipped with a prototype development workshop and a full-fledged drawing office and testing facilities.

At the time of the study, R & D in HMT was in a very nascent stage. The major objective at that time was to rapidly indigenize a 55 h.p. tractor which had already been introduced into the market. The following statement by a senior officer of the company captures the essence of R & D activities at that time.

> "... we do not have basic capabilities in Research & Development. We have taken some new people and are still in the learning stage. We have to learn everything about manufacturing tractors first before we go into research and development. For Indian farmers these tractors will be good enough for the next 10 years."

HMT did not have any tractor testing facilities within its premises. The Tractor Training and Testing Station at Hissar was being used for testing new models and prototypes.

Till the end of 1975 there was no separate design department. All activities concerning the phased deletion programme like process planning, tool design and development, vendor development, etc. were performed by the planning department under the general manager in coordination with the purchase department.

The need for a separate design and development department was felt in 1975 when the indigenization programme had to be speeded up. Another factor which gave impetus to the formation of a separate design department was the crisis regarding

non-availability of hydraulic units from Chzechoslovakia.

By the end of 1975 the management of HMT had begun to realize that the quality control department had to be strengthened through technical support and field complaints had to be attended to expeditiously. Also the increasing competitiveness in the market demanded a larger product range. Under this situation the Design & Development Department came up in HMT towards the end of 1975. Some new products were also developed with the objective of training the personnel. They were Janata or Krishi tractor, Aerodrome haulers, Rice Special, 35 h.p. tractor, and Mini truck.

The Design and Development Department had about 35 persons at the time of the study. The manpower budgeted for 1978-79 was 53. Some of the personnel had been transferred from the Machine Tool Division and some junior persons had been recruited from outside.

In Kirloskar Tractors also R & D was in its very early stages. There was no separate department for R & D. However, developmental activities for indigenization had been taken up and were being coordinated by the Project Manager till 1974. The Design Cell under him looked after: 1) Conversion of drawings and standards; 2) indigenization, 3) jigs and fixtures design, and 4) engine development. The Development Section looked after: location of sub-contractors, providing technical assistance to vendors, and prototype development. Towards the end of 1974 the Project Manager was designated as Executive (Technical) and a separate position for Manager (Quality Control) was created under him. The three other departments under him were Production, Materials Management and Design Development, and Tool Room.

A number of conclusions may be drawn regarding the process of evolution of R & D in the tractor industry and character of

R & D activities in each of the firms and the forces that were responsible for the same. From the above it is clear that R & D was a significant function in each of the firms in the tractor industry. However, there was a considerable change in the nature of the R & D activities carried out over a span of 20 years which this study covered. A comparative study of R & D in the five firms shows some commonalities and some differences. The commonality is in terms of the nature of R & D activities in the early stages of the firm's history. As seen from the description above, all the firms started their R & D with a focus on production related trouble shooting activities and indigenization of the imported design. These activities were greatly influenced by the Government's import policy and its administrative pressure to gradually reduce the import content of the tractor. The character of R & D activities underwent considerable change when the market conditions changed from a seller's to a buyer's one around 1977-78. Most of the firms responded by creating separate departments for R & D and gave greater attention to activities like quality assurance, value engineering, and new product development. Though this was the general trend in the evolution of the R & D function there were a number of important differences which we shall see presently. In the case of Eicher from the very beginning developmental activities was oriented towards reduction of investments in capital equipment. As seen earlier, they created a cell to convert simple machines into single purpose machines to increase the production and also to build much of the very expensive and sophisticated machinery within the company's premises. ITCI had given importance to new product development almost from the very beginning; however, those products were not commercialised as they believed in depending upon imported technology for the same. Escorts, in contrast, gave considerable importance to new product development from the very beginning and indigenization

became important only much later when they went in for the Ford Tractor and the improved Ursus Tractor. However, with the market turning into a competitive one, value engineering, use of new fuels, quality assurances, and product improvement became more important.

IV. Implications for Public Policy

1. The study of the tractor industry shows that the choice of product spanned a continuum of technological sophistication. At one end we have the relatively obsolete product that Eicher went for and on the other, the highly sophisticated one that KTL acquired. In both the companies there was considerable strain during the technology transfer process. In the former it was because its collaborators could not help much as they themselves were facing a lot of problems and also because of acute paucity of funds, not much progress could be made towards increasing production by installing machines needed for the same. However, the choice of very simple and inexpensive machinery was the most critical decision which finally helped the firm to increase its production and improve its performance. Over a period of time Eicher acquired the technical and managerial competence required to assimilate the technology. On the other hand, the latter company possessed a considerably higher level of technical and managerial expertise. But due to the highly sophisticated nature of technology, they were not able to indigenize it rapidly which resulted in increasing costs and poor financial performance. What then is required is a match between the technological decisions a firm takes and its resources and competence and the technological enviornment around it meaning thereby the availability of supply networks and technically skilled people to use and service the product in the field. An important implication for public policy would be that

developing nations should match their search for technology with the stage of the product life cycle in the advanced countries. In the early stages of development a developing country could direct its search for technology to the more mature industries so that the process of technology assimilation would be comparatively easy and with increasing progress in development of technology the search could be directed towards more sophisticated areas.

2. The analysis in a previous section suggested that though governmental policies had considerable impact on the firm's choice of manufacturing technology there was still much leeway for them to develop technology strategies which could be uniquely related to their organizational resources and capabilities. The industrial licensing system limited plant size in the tractor industry to approximately 1 : 25 at the minimum 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 in the industry in terms of capacity could compete successfully with the largest. The critical factor in the success of the smallest firm was their innovative capability in designing a plant to achieve extremely low manufacturing cost at extremely small volumes. However, the Government had not played an active role in the process of facilitating the design of economic plants for low volume. It could, neverthless, help prospective entrepreneurs by having analysis of alternative technological choices made available to them for study at same cost. Such studies would be useful in the industrial licensing process and could be conducted by some of the Government's various agencies.

3. The objective of planned regional development has been achieved to a considerable degree in the case of the tractor

industry. The firms covered in this study were spread over three states. The remaining ones are situated in five other states. The achievement of balanced regional development however involved an initial period of difficulty in technology assimilation for some firms because of non-availability of trained manpower in the vicinity of the plant, difficulty in attracting technologists and managers to relatively small towns, and in developing ancillary units for the supply of components. Nevertheless, this policy had considerable importance in the context of the great need for diffusion of technology throughout the country.

4. 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. This has been discussed earlier. 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 lag 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 have 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 author feels 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 enviornment 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.

5. Many of the multi-national corporations in agricultural machinery business have discontinued manufacture 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 exports of complete tractors to the less developed amongst developing countries.

However, even greater strength lies in the area of technology export to the LD.C.s. 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 enviornment. 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 considerble scope for technology export in the context of a growing tendency amongst developing nations to become technologically self-reliant.

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