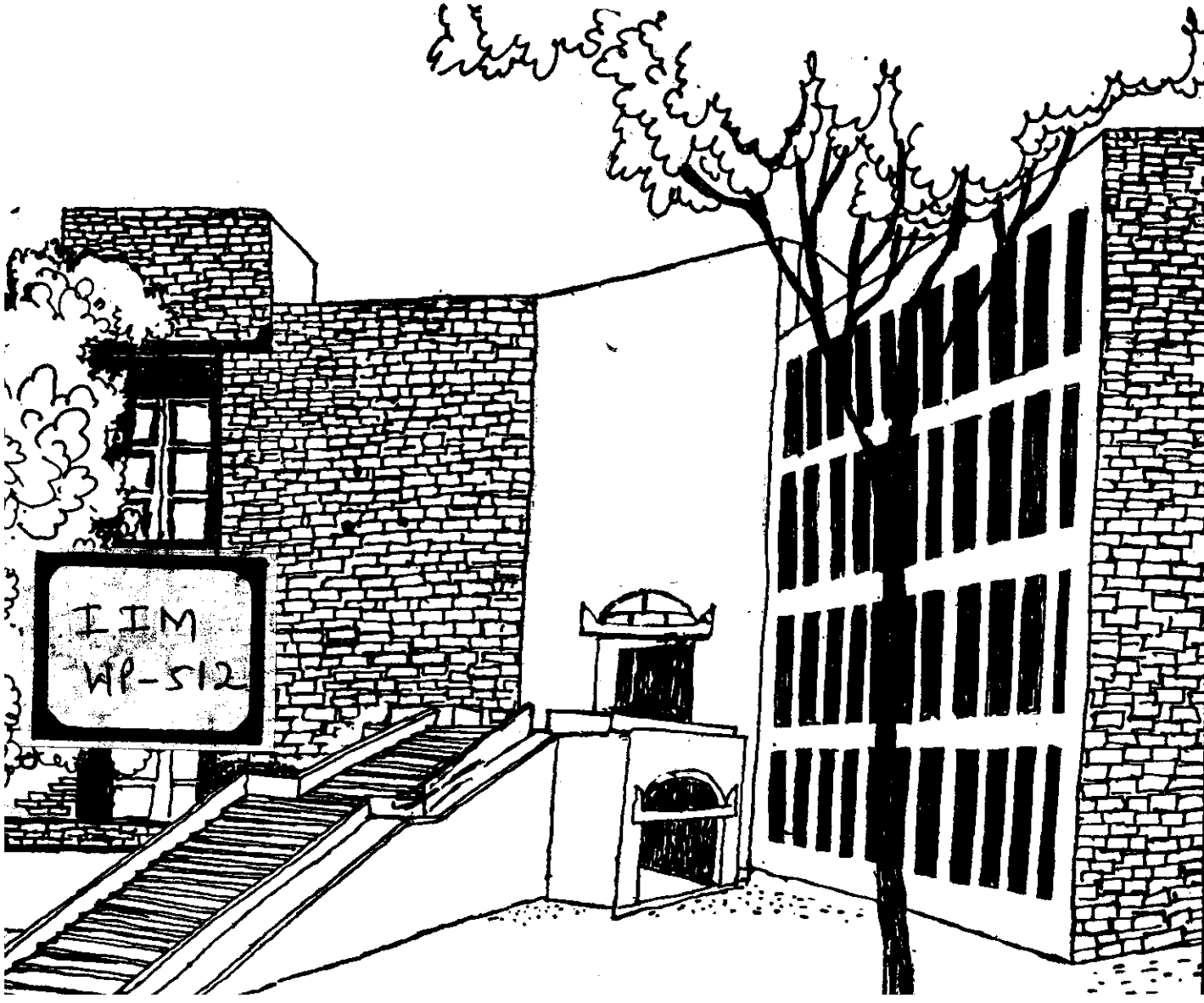
विद्याविनियोगाद्धिकाल:
IIM
AHMEDABAD

Working Paper



TECHNOLOGICAL INNOVATION IN A NATIONAL LABORATORY IN INDIA: A CASE STUDY

By

Shekhar Chaudhuri

W P No. 512

June 1984

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380015
INDIA

Technological Innovation in a National Laboratory in India : A Case Study

Shekhar Chaudhuri*

Summary

This paper gives a historical account of a major technological innovation in India. The technology was developed in a national laboratory and successfully transferred and commercialised by a public sector corporation and promoted by one of the state governments. This paper focusses mainly on the managerial processess involved in the innovation. The innovation process was found to be an extremely complex one with a large number of organizations involved in it at different points in time. The laboratory faced a number of problems as a result of a high degree of uncertainty in the government's policy towards it, a hostile external environment and a lack of credibility with its external constituencies. The total innovation process could be categorised into three stages on the basis of the dominant managerial orientation; (i) entrepreneurial, (ii) reactive-muddling through and (iii) Planned-learning. The planned-learning mode seemed to be superior to the other two. A number of factors associated with the managerial actions seem to have aided in the success of the innovation. These were : (i) the presence of a product champion during the most of the technology developmen stage, (ii) continued support of the project by the Director-in-Charge of the laboratory after the departure of the product champion, (iii) strong commitment of the technology development team based on pride in indigenous technology, (iv) effective relationships developed by the product champion with the key decision makers in government, (v) close association with the team of committed consultants for a considerably long period of time.

---

*The author is an Assistant Professor at the Indian Institute of Management, Ahmedabad. This paper draws on his doctoral dissertation entitled, "Acquisition and Assimilation of Technology in the tractor industry in India : The Strategic Perspective". I would like to thank Professors T.K. Moulik, K. Balakrishnan and G.R. Kulkarni for their comments and suggestions on earlier drafts of the case.

(vi) supportive external evaluation by funding agencies at a later stage in the overall process, (vii) an organic linkage between the technology development and productionising stages provided by transferring the development team to the manufacturing enterprises and (viii) multiple lateral linkages with organizstions in government which helped in a number of technology adaptation decisions during the phase of commercialization.

Technological Innovation in a National Laboratory in India : A Case Study

1) Introduction

The increasing technological gap between the western and developing nations 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 of sell. Many finished goods must be imported. The technology used for producing the goods that are not imported is mostly imported creating a form of unending dependence of the developing countries on the industrialised ones. This dependence is increased because of the lack of capability of the developing nations to adapt and assimilate foreign technology when it is unsuitable.

Many developing nations have attempted to build institutional infrastructures to develop technological capability. For example, 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 (CSIR) and the Atomic Energy Commission during the period 1948-1954, Defence Research and Development Organization in 1958, Department of Science and Technology (DST) and Electronics Commission and Department of Electronics in 1971, were all steps in this direction (1).

The Government of India's (GOI) support for science and technology has been based on the "... faith that somehow the infrastructure thus built will offer the foundation for growth of an indigenous technology base and will also hopefully assist in the absorption of imported technology in a variety of ways ..."(2). Research and Development in India had been a virtual monopoly of the laboratories set up under the Central Government till the beginning of the sixties (3, 4). However, the composition of the country's total R & D expenditure shifted radically during the sixties and early seventies.

By 1965 the share of CSIR and industrial associations had fallen to 70 percent, and by 1974 their share was less than a quarter. There was an appreciable increase in the share of private and public companies. But even in the beginning of the eighties there was still a dominance of the Government in the R & D scenario (4, 2).

Of the total governmental expenditure on R & D, the CSIR laboratories accounted for a share of more than 40% (4). Inspite of the large infrastructure created by the Government its performance does not seem to have been significant except for a few stray cases. Of the 1726 processes developed by the laboratories under the CSIR by 1974 and reported to the National Research Development Corporation (NRDC), which is the sole marketing agency for the CSIR and other government laboratories only 729 were licensed. Till 1977 there were only two technologies developed by CSIR which could be considered significant - television and tractors (4). Some of the reasons for this poor performance as pointed out by some researchers are, (a) lack of market information at the time of selection of research projects; (b) little possibility of economic return from the technologies developed (4); (c) preference of Indian firms for foreign technology (5); and (d) inadequate coordination between different sectors of society resulting in the failure to develop its potential for technological innovation (6).

One of the major successful innovations from one of the CSIR laboratories was the Swaraj Tractor. This case is striking because of its success in the face of a number of difficulties which the Central Mechanical Engineering Research Institute (CMERI) faced during the process of development of the technology as well as its transfer for commercialization. Some interesting case studies of this innovation have been done and reported earlier (7, 8). Both these studies, focused more on the external environment of the organization directly involved in the innovation process. The research reported here was undertaken on the premise that there may be a number of useful lessons to be learnt from this case by studying the processes by which the

managements of the concerned research laboratory and the technology using commercial enterprises overcame the difficulties and made the technological innovation a success. This research was undertaken in 1978-79 as a part of the author's doctoral research entitled "Acquisition and Assimilation of Technology in the Tractor Industry in India : The Strategic Perspective", (9). This paper describes the process of development of the technology in the CMERI and its subsequent transfer to a public sector enterprise created to commercialize it.

2) Conceptual framework and research methodology

Technological innovation is influenced by factors in the external environment of the innovating organization or organizations as well as those intrinsic to them. The external environmental factors may be typically categorised into, (a) economic, (b) political, (c) social, (d) technological, (e) market related or competitive, (f) regulatory and (g) physical or ecological. The internal or organizational factors may be related to the, (a) goals, (b) leadership style, (c) resources, (d) capabilities, (e) organizational structure, (f) information flow, etc.

The framework of Corporate Strategy (10, 11) was used to study the innovation process. Corporate Strategy as defined by Andrews (10) is "the pattern of major objectives, purposes, or goals, and essential policies and plans for achieving those goals, stated in such a way as to define what business the company is in or is to be in and the kind of company it is to be". Corporate strategy emerges as the result of a match between the opportunities in the external environment of the organization and its strengths, capabilities and resources. This framework according to Rosenbloom (12) provides an useful framework for conducting policy research at the level of the organization. It synthesizes the perspective of the economists, who are predominantly concerned with the external environment of the organization and organizational theorists who focus their attention on its internal environ

In the study that is reported here an attempt was made to map the critical interactions of the technological laboratory with its environment at different points in time during the process of the innovation. It was felt desirable to describe the total process as accurately as possible to generate new insights from which lessons could be learnt. The focus of this study being on the managerial processes in technological innovation it was decided to rely on the exploratory research methodology (13). The objective was to gain familiarity with the phenomenon and to generate new insights into the processes.

The principal sources of data for the research were the interviews with senior executives of Punjab Tractors Limited (PTL), the public sector company which was created to implement the technology. The whole design team which had worked on tractor project at CMERI had been transferred to PTL, hence no visit was made to CMERI. The executives interviewed belonged to the first two or three levels of the organizational heirarchy.

In addition to the executives at PTL, the author interviewed a large number of executives in 5 other manufacturer competitors of PTL and also one executive of a large firm which had been the sole selling distributor of an large competitor. The author also had the opportunity of discussing the project with the then director-in-charge of CMERI who had played an important role in the transfer of the technology to PTL.

A second source of data were the company documents like feasibility studies, detailed project reports, consultancy reports, corporate announcements, minutes of meetings, memoranda, R & D budgets, correspondence with Government etc. A third source was the published literature.

The research was conducted in a number of phases. Firstly, a pilot study was done, during which the author spent about 15 days at

PTL. The second phase consisted of studying the published literature to gain an understanding of the tractor industry, its historical development, various governmental regulations enforced from time to time, etc. The third phase of data collection was focussed on filling the data gaps and clarification of doubts.

Once the case study was written it was sent back to the managing director for his scrutiny to check whether it portrayed the situations described in an objective manner.

3) About CMERI

The CMERI was established in 1958 at Durgapur in West Bengal as one of the links in the chain of national laboratories under the CSIR. CMERI's activities were to be exclusively devoted to design, development and improvement of machinery and equipment, development and improvement of process technology, and evaluation methods for engineering products and materials (13).

The preliminary task of building the infrastructure of the laboratory took a considerably long time. Even in 1962, the institute professional staff was more science oriented rather than technology oriented. In that year it had only two mechanical engineers. During the period 1962-64 Mr. G.S. Chowdhury, the director-in-charge was able to create several new research units related directly to industrial problems, such as industrial design, welding, automobile production and refrigeration. This tempo was kept up when Mr. M.M. Suri became the director-in-charge in 1964. During the next three years collaboration with industry increased significantly. By 1965 it was organized under seven divisions : (i) Applied Mechanics, (ii) Applied Science, (iii) Automobile Engineering, (iv) Heat Power and Refrigeration, (v) Materials, (vi) Product Development and Industrial Design, and (vii) Production Engineering (7).

4) CMERI perceives and creates a major opportunity

The story of SWARAJ tractor began in 1965, when the Fourth Five Year Plan was being formulated. One of the projects for which the GOI was thinking of obtaining aid from Soviet Russia was the establishment of a plant for manufacturing a 20 horse power (h.p) tractor in India. However, the Russians indicated their reluctance to assist the project.

Mr. M.M. Suri, the then director-in-charge of CMERI was also a member of the delegation which visited Soviet Russia. He felt that the project as formulated had excessive foreign exchange content. Also it envisaged the use of a large number of Russian experts which was not necessary given the capabilities already developed in the country. He felt that the idle capacities at Mining and Allied Machinery Corporation (MAMC), Durgapur and Heavy Engineering Corporation (HEC), Ranchi, two public sector undertakings could be utilised to manufacture the product without substantial additional investment. He also felt that the infrastructure and the capabilities already developed at CMERI was sufficient to design an indigenous tractor. Accordingly he suggested to the then Deputy Chairman of the Planning Commission that his institute could develop an indigenous design of a tractor that could be produced without any external assistance or even imported parts. This kind of thinking was extremely novel in these days when there were strong xenophilic tendencies in the country in all quarters (15).

At that time, there was a feeling in Government, that India was very weak technologically and so it had to depend upon foreign technology for producing most products. However, there were many technocrats like Mr. Suri who believed that Indian engineers were second to none. Mr. Suri began a crusade advocating the development of indigenous technology and was successful in getting the government's approval for designing an indigenous tractor at CMERI. The thinking of

Mr. Suri and his associates, who were later to take up the project was that Indian industry was essentially foreign collaboration based. The diversity of the sources of technology imposed a great burden on the ancilliary industry.

A Committee of Technical Experts (CTE), comprising representatives of the industry, agricultural universities, farmers and the Tractor Training and Testing Station (TTTS) at Budni was constituted in 1965 at CMERI for directing the design team. When asked by the author, why the planning commission supported the project when everywhere there was a preference for foreign technology, the managing director of PTL Mr. Chandra Mohan, the erstwhile leader of the design team at CMERI replied that it was because of the persuasive skills of Mr. Suri that the Planning Commission agreed to allow them to go ahead.

The design team consisted of two production engineers, two design engineers, an industrial engineer, a foundry expert, a metrologist and two automotive engineers. At the time of their joining the team they had almost no industrial experience. The team was very young. In an interview the director-in-charge, who took over after Mr. Suri left CMERI said that the lack of sound production experience could be gauged by the fact that the team found it difficult to indicate the various machining tolerances on the production drawings. However, he mentioned that the team was highly motivated and devoted to its task. Their determination helped them learn fast from their mistakes.

5) Development of Prototypes

The design team undertook intensive studies in the comparative merits of design of various tractors manufactured in India with foreign technologies. CMERI's objective was to engineer the design specifically for the Indian environment and also compete in terms of features, efficiency and effectiveness with the very best model.

The designs were developed in such a way that capital investment in plant and equipment for producing the parts was minimum. Mr. Chandra Mohan, gave the example of sheet metal and engine casting. Tooling investments for the Swaraj's sheet metal work was about Rs.10,000 which could be made in 5 small units with about Rs.1,00,000 of investment each. In contrast, in the industrialized countries because of the need to save on labour, the minimum tooling investment was Rs.5.0 million and plant investments of Rs.10.0 million. Swaraj engine castings could be manufactured in foundries with total capital investments of Rs.0.5 million whereas in the developed countries because of the thin wall of the castings to save an material costs, the higher level of technology required an investment larger than Rs.100.0 million. CMERI's design was engineered around technologies, equipment and machinery available with potential suppliers in the country to avoid further investments as far as possible.

6) Innovation in Product Technology : Overcoming the Patent Barrier

The Swaraj 20 H.P. tractor originally designed around a 4-stroke was two cylinder , air-cooled engine that was already being manufactured by the Kirloskar Group of companies in India.

Availability of hydraulics was considered to be a major requirement of a good tractor. Providing a sophisticated system with automatic draft and position control of implements without infringement of the existing patents posed a problem. The CMERI team successfully developed an original single lever automatic depth-cum-implement control hydraulic system, which is covered by CMERI patents in India, U.K., Japan, West Germany, U.S.A., France, Poland, and Yugoslavia. All known tractor hydraulic systems in the world employed two or more remote control levers for controlling the working of the hydraulic system. The PfL executives claimed that the Swaraj was an improvement upon the existing design concepts. The entire control could be effected by a single lever which enabled (i) easier training of farmers for

handling implement operation efficiently and (ii) which reduced chances of confusion during operations.

The prototypes were extensively tested on test rigs especially designed for the purpose. During the period 1967 to 1971 prototypes were tested at CMERI on test rigs, field trials and performance and evaluation was carried out at the TTTS Budni, Punjab Agricultural University, Ludhiana and U.P. Agricultural University, Pant Nagar. Testing at Ludhiana and Pant Nagar not only covered the universities but also nearby farmers.

Initially there were a number of technical problems as could be expected. However, the learning from each prototype was incorporated in the subsequent designs and by the middle of 1971 the director of TTTS, Budni cleared it for production.

7) Swaraj on the edge of nowhere : Changes in situational context and the lack of impetus

While Mr. Suri was advocating the cause of indigenous technology the then Minister of Industries of the GOI Mr. T.N. Singh concluded an agreement with M/s. Motokov of Czechoslovakia to prepare a detailed project report (d.p.r.) for the manufacture and assembly of 12,000 Zetor 2011 tractors and some agricultural implements for a plant to be established at Ramnagar (7, 14). This d.p.r. was submitted by M/s. Motokov in March 1967 involving a capital investment of about Rs.325 million (14). Originally CMERI had obtained the financial support of a private sector company for developing prototypes but when it backed out it had been expected that the MAMC a public sector undertaking at Durgapur would be able to undertake the tractor project with the addition of only some balancing equipment. But during 1967-1971, a period of industrial recession in India, MAMC suffered financial losses and hence it also withdrew its support to Swaraj as it did not want to take any additional risk.

At this time the Hindustan Machine Tools Limited (HMT) now a very well known public sector undertaking, was exploring diversification opportunities. CMERI saw some hope of reviving Swaraj through its transfer to HMT. However, the National Industrial Development Corporation (NIDC) a public sector undertaking, which was asked to evaluate the Swaraj design and the foreign one (Motokov), recommended the manufacture of 12,000 Zetor tractors of 25 HP at the Pinjore works of HMT, thus dashing Swaraj's hopes of being commercialised.

The Swaraj project seemed to fizzle out without any support of the Government. The Planning Commission members who had shown interest when Mr. Suri had made the proposal also had left by 1969. Mr. Suri, who had spearheaded the project also had to leave in 1969 on account of some internal organizational problems.

8) Revival of Swaraj

The Punjab State Industrial Development Corporation Limited (PSIDCL), a wholly owned undertaking of the Punjab Government, set up in 1966 to promote medium and large sized industries in the state, was now approached by CMERI. The PSIDCL had been familiar with the Swaraj from the time of the field trials in Punjab, but, according to Mr. Chandra Mohan, it had not shown any enthusiasm towards Swaraj, probably because of the perceived risks associated with it. It was the first major product of indigenous technology and it was till then only a prototype model. However, the CMERI team impressed PSIDCL and convinced it of the potential benefits that would accrue to Punjab. The PSIDCL, having been convinced by the arguments of the CMERI team, promoted the PTL on June 27, 1970 at Chandigarh.

9) Technology Transfer from CMERI to PTL

The know-how and technology developed by CMERI was licensed to PSIDCL through the National Research Development Corporation (NRDC), a public sector undertaking responsible for licensing of all

technologies developed at the national laboratories. The conditions were :

1) Rights to CSIR's Indian Patent Nos.113114, 113115, 116257 and their corresponding patents in USA, UK, West Germany, France etc.

2) Right to any further developmental work done by CMERI on the Swaraj tractor and first options on work in a field allied to tractors.

3) A royalty of 2% on the net ex-factory sales price of the tractor excluding major bought-outs like the engine, tyres, tubes, rims and electricals including dashboard instrumentation would be payable to NRDC for a period of 10 years.

4) A royalty advance of Rs.1 lakh to NRDC to be adjusted subsequently.

For the implementation of the Swaraj Tractor Project at PTL, the PSIDCL obtained the services of the CMERI tractor design team. Dr. A.K. De, the then director-in-charge of CMERI agreed to second them to PTL on lien as he realized that the success of the implementation would depend greatly on the motivation and dedication of the people involved. The Swaraj project being the first indigenous effort in a relatively complex field with strong competitors already entrenched in the market with their foreign brand images was expected to face a number of problems. These could be overcome only by a committed team of people and the CMERI team had become well known for their steadfast championing of indigenous technology from 1965. They had relentlessly pursued the objective of developing Swaraj in the face of frequent frustrations and heavy odds for six years. Also this team had become familiar with all the technical details much of which could not possibly be documented. Hence by transferring the team to PTL, the technological capability was also transferred.

10) Productionising the prototype model : Role of the consultant

In the initial negotiation between CMERI and PSIDCL the former indicated that the major responsibility for translating the developmental know-how into mass production technology would have to be taken by the latter.

It was recognized that the development of production technology for Swaraj would require expertise of high calibre in styling, jig and tool design, manufacturing stores and procedures, production planning and control, material management, plant layout, etc. Two alternatives were available to PTL; (i) appointment of reputed consultants who would provide the composite engineering services, and (ii) building up PTL's own cadre of experts.

The second alternative was dropped after detailed consideration, when it was recognized that full-time services of experts of the calibre required would be extremely expensive. It was then decided to use the services of some reputed consultants for the purpose. Accordingly PSIDCL approached M/s. M.M. Suri & Associates (P) Ltd, New Delhi, a consultancy firm founded by Mr. M.M. Suri, the former director-in-charge of CMERI under whose leadership the tractor project had been initiated. In fact Mr. Suri had continued to crusade for building support for indigenous technology and particularly Swaraj even after leaving CMERI. This firm was given the responsibility with effect from September 1971 for providing comprehensive engineering services during the period of construction and six months of production thereafter at an approximate cost of Rs. 1.95 million, which was considered by PTL's management to be much less than what other consultants would have charged. An additional responsibility given was for the training on the job of the original design team as well as other engineers in all aspects of project execution, production and management.

11) Financing of the project

The detailed project report was completed by March 1971. The next problem was that of financing the project. The PSIDC and PTL approached the Industrial Development Bank of India (IDBI), and other financial institutions. The fact that they had received a lukewarm reception from various organs of the Government made it difficult for the new company to obtain financial resources. This difficulty seemed to have been instrumental in driving them to reduce project costs considerably by adopting novel concepts in building design, foundation for plant and machinery manufacturing processes, etc., which we shall see later.

The PTL submitted a project (capacity output of 5,000 tractors in 20-30 HP range) with a capital cost of about Rs.3.7 crores (Table 1). They had planned a very high percentage of (80 per cent) boughouts with only 15-20 per cent own manufactured components in order to reduce the capital cost of the project. The expected project costs were exceptionally low compared to most tractor manufacturing programmes. Plant and machinery costs could be kept low by ensuring high utilisation rates of expensive machinery. In the words of the Managing Director of PTL :

> "A very critical contribution of indigenous technology is the in-depth flexibility which it provides to the design group to adopt/innovate to bring down the costs keeping local conditions in view. This flexibility is further increased by their indepth knowledge of the production processes. We have in our own case changed designs of components to cut down capital investments any number of times. Complementarity of the production group has also shown immense flexibility in selection of machines and stretching them to

TABLE 1

Swaraj Tractors : Project Costs

(Rs. millions)

Details	Expected (March 1972)	Actual (April '74)
Land	1.162	0.985
Buildings	2.252	3.435
Plant and Machinery :		
a) Imported	3.191	3.135
b) Indigenous	15.426	13.457
Technical Knowhow	2.075	1.640
Miscellaneous Assets	0.781	2.357
Preliminary Expenses	4.480	0.583
Pre-Operative Expenses	5.050	5.187
Provision for contingencies	2.300	-
Margin for Working Capital	4.287	5.157
Total :	37.002	35.916

Source : V.V. Bhatt, "Decision Making in the Public Sector Case Study of Swaraj Tractor," Economic and Political Weekly, XIII (21), (May, 1978).

> the limits of their capabilities to conserve capital, a scarce commodity in a developing country. We are perhaps the only unit in the world wherein special purpose machines, which are normally tooled up for the production of one or two components, have been stretched out to handle 4 to 5 components. Our utilization of these expensive SPMs had 100% utilization at production levels of 4000 and as we proceed further to higher production levels, we will keep on adding SPMs. Capital investments for us will always be made as the market demands higher production levels (15)."

The PSIDCL was agreeable to contribute at the most 10 per cent of the project cost, while the IDBI's rule of thumb was that the promoters should finance the project atleast to the tune of 15 per cent of the total cost through their own resources. The PTL team suggested that Punjab Government and G.S. Atwal's* combined shareholding would satisfy IDBI's conditions. However, complications arose when IDBI took the decision that G.S. Atwal & Co. had to be dropped. IDBI was not agreeable to G.S. Atwal's becoming the managing director of the company, a condition laid down by the latter for his equity participation. However, IDBI's top management was extremely impressed by the quality of the d.p.r., the motivation and dedication of the team. It took them one year to finally decide to contribute about 90 per cent of the project cost in collaboration with other financial institutions. In February 1972 PTL was informed that IDBI in collaboration with Industrial Finance Corporation of India (IFCI), Industrial Credit and Investment Corporation of India (ICICI), Life Insurance Corporation (LIC), and

*An entrepreneur located by the PTL team who was willing to become a co-promoter.

Unit Trust of India (UTI) would provide the funds in the form of equity and long term loans. The GOI also took the decision to participate in the equity capital of PTL to the extent of Rs.0.85 million.

12) Project Implementation

The IDBI, a major partner of PTL was very impressed with the performance of the project on various dimensions : meeting target date of completion; keeping within expected project cost at a time of rising material prices, raw material shortage, financial stringency; and reaching full capacity in the expected time (see Table 2 (8).

TABLE 2

Some Performance Indicators

	Expected	Actual
Capital Cost (Rs. million)	37,002	55,916
Gestation Lag	105 weeks (March 1972 to March 1974)	105 weeks (March 1972 to March 1974)
Output/Sales of Tractors (Nos.)		
1974-75	1600	933
1975-76	3500	2242
1976-77	4500	3196
1977-78	5000	4003
Operating Profit (Rs. million)		
1974-75	- 3.656	- 8.82
1975-76	- 0.320	+ 0.57
1976-77	1.761	+11.89
1977-78	2.702	+13.34

This was achieved through management action in various areas as explained by the Managing Director.

> In Punjab Tractors Ltd. (PTL), completion within project estimates was a total commitment. This commitment in a situation where prices started rising abruptly at an alarming rate, inspired us to explore every conceivable avenue towards cost saving in all aspects of the project ...

To save on construction costs, PTL adopted a large number of innovations in building technology, some for the first time in industrial construction, even though all these technologies had been proven extensively in other fields of civil engineering. Some of them were :

i) Use of under-reamed piles for foundations through the help of the Central Building Research Institute, which reduced foundation cost by 50 per cent.

ii) Large panel suspended beam, thin section R.C.C. walls without foundation - a technology developed at CMERI.

iii) Open web steel structure - again a technology developed at CMERI

iv) Soil stabilised undersoling of heavy duty floors and internal roads.

Once the project got commissioned, the one goal uppermost in the mind of the management was to reach full capacity utilisation. Some problems arose in reaching this target were :

1) Development of reliable vendors to cater to the very steep production growth curve.

2) Technical problems on the product

3) Manufacturing problems.

12.1 Development of Reliable Vendors

By 1978 PTL had developed about 125 ancillary units out of which 60 per cent were promoted at the specific instance of PTL, the remaining 40 per cent being those existing in small units which were located and given support to manufacture Swaraj components.

Out of the 750 components, approximately 60 were made by PTL. The largest single item was the engine (about Rs.12,000 or 25-30 per cent of the retail price) which was bought from Kirloskar in Pune.

Approximately 50 per cent of the components came from large scale enterprise. Large components like Tyres, Tubes, Batteries, Wheels, Radiators, Clutch, came from suppliers all over India. Out of 125 small and medium scale enterprise supplying components to PTL, 40 were within 1 Km of the plant and another 40 were located in Chandigarh. Proximity had several advantages, ease of communication, better quality control, and greater continuity in supplies. Some 50% of PTL's components by number came from such enterprises, although in rupee value the small and medium scales share was much less.

Initially PTL found it difficult to convince potential vendors to take up manufacture of Swaraj components. It seemed that the ancillary industries considered the Swaraj project a risky venture to associate with. So during this period PTL started manufacturing a large number of components within its own premises to somehow increase production. Production facilities had been planned to manufacture only 70 to 80 components; when it was utilised for manufacturing several times this number, the production of complete tractors was naturally small. A separate vendor development cell was created, which reported directly to the Managing Director. Its role was to develop entrepreneurs from fresh engineering graduates in order to meet component requirement of an increasing production volume. In 1978 PTL received the ASSOCHAM AWARD for ancillary promotion.

12.2 Coping with Product and Manufacturing Problems

To cope up with teething problems on the product, a Product Servicing Group was created. It reported to the Marketing Manager, and worked in close coordination with R & D. Later it was brought under R & D.

The assumptions of 90 percent machine utilization and 90 percent operator efficiency which had been made while planning for facilities did not come out to be correct and balancing machinery had to be purchased. Also third shift working had to be introduced. Third shift working had its attendant problems of poor discipline and low efficiency. Experienced workers could not be recruited as salary bills had to be kept low. Machinery selected were more of the general purpose type which required high operator skill, which could be developed only over a period of time. Special jigs and fixtures had to be designed to de-skill the operations.

13) Developing a Marketing Strategy

By 1974 the tractor industry was in the midst of a major depression. In addition there were 11 manufacturers in the fray, which had resulted in the market's transition from a seller's to a buyer's one. PTL faced a challenging task in marketing Swaraj. When PTL began its effort in the selection of dealers, the factory was still under construction and prospective dealers were doubtful about the company's ultimate success. PTL's management realised that, in a competitive market, product performance, product quality and reliability, and easily accesible servicing facilities were critical dimensions, which would dictate customers' decision-making.

PTL did not begin lining up dealers until the end of 1973 and the beginning of 1974. By mid 1975 it had 19 dealers in a 200 mile radius of Chandigarh. By the end of 1975 it had 60 dealers and at the end of 1976, 80 dealers spread as far as Patna on the east,

Baroda on the west, and Hyderabad and Guntur on the south. Out of the roughly 10,000 tractors sold by mid 1978 over 80 percent had been sold in Punjab, Haryana, Delhi and U.P.

When the tractor market was very tight in 1975-76 and 1976-77, PTL began experimenting with incentives to dealers. If a dealer sold over 100 tractors a year, he would get a seven-day paid vacation in Kashmir. If he sold over 150 tractors he would get a ten-day vacation in Goa. During tight condition PTL began exploring diversified uses and outlets for its tractors - as "road masters" for transport and haulage, without the hydraulic lift - for Rs.2,500/- less. PTL was also exploring the use of the tractor as a hydraulic lift platform for fixing street lamps, electric transmission lines.

PTL provides a one-year guarantee on its tractors. Most other tractors carry only a six month guarantee.

Servicing is ofcourse critical to building up a satisfactory group of customers who in turn are a product's best salesman. PTL has three service centres with personnel and dealer coverage indicated in Table 3 below. PTL's goal was to develop a total service network which will mean that no tractor is out of commission more than 24 hours.

TABLE 3

Swaraj Service Centres

Centre	Dealer Coverage	Staff
Chandigarh	52	24
Lucknow	29	6
Bhopal	19	1

PTL was also trying to establish auxiliary service centres in small towns. PTL's input would be to provide training for the mechanics.

The Director's report for 1976 stated :

To cater to a larger market spectrum the product range was enlarged in November 1975 with the introduction of a new 35 HP tractor, the Swaraj-735. Swaraj-735 has been developed by the company's own R & D and is again 100 percent indigenous.

Some of the key dimensions of PTL's marketing strategy were : i) intensive marketing, (ii) limited introduction of the product and slow extension of distribution to keep control on the product, and dealers and give close attention to the customer; (iii) servicing of customers by PTL's own group to give prompt and effective service; iv) maintenance of uniformity in product performance; (v) creation of a product servicing group under R & D and close association of R & D with all aspects of marketing to enhance R & D's sensitivity to the needs of the farmers; (vi) rapid product diversification (16).

14) Research and Development

R & D received importance in this company from the very beginning as brought out by the following statement made by the R & D manager :

We strongly believe that for our country to develop at a fast rate, Indian R & D is a must and products suitable for Indian conditions and at suitable prices can best be done by R & D in India. The founding of our company has been on the basic principle itself. Our company started with the purpose of using indigenous design for manufacture and consequently R & D was set up at the start of the company.

The tool room was the first block to be commissioned on August 16, 1972 and from October shift working was started for manufacturing jigs and fixtures. The R & D department of the company was started from the very inception of the company. The tool room facilities were shared by the R & D department for development of prototypes.

The activities of the R & D department were determined through meetings between the managing director, the R & D manager, and marketing manager. Many of the new product ideas came from the managing director himself.

The R & D expenditure shown in Table 4 was quite small compared to that of the larger firms in the industry. However its performance was extremely good.

TABLE 4

R&D Expenditure (Rs. millions)

Year	Capital	Recurring
1972-73	-	0.041
1973-74	0.300	0.126
1974-75	0.030	0.365
1975-76	0.052	0.394
1976-77	0.080	0.047
1977-78	0.100	0.510

Of the 7 projects that were finally taken up, five were completed. About 80 - 90 percent of all the new products developed by the R & D department had been commercialised and all the products manufactured and marketed till the time of the study were their own. Manufacturing started towards the end of 1973 with Swaraj 724 the 26.5 h.p. tractor. Inspite of all the tremendous teething problems, non-availability of supplies, quality problems of the ancillary industries etc., PTL came up with a new tractor model, the Swaraj 735 in November 1975, which was also a 100 percent indigenous tractor. By 1978, the economy model, the Swaraj (18 h.p.) model had been test marketed. Regular commercial marketing was commenced on October 2, 1978.

The success of the R & D department could be attributed to the organization's commitment to it and the close integration with other involved departments. Even at the design and development stage, the R & D groups met with the production, industrial engineering and other technical groups to reach an understanding on the basic parameters. Though the R & D department did not have its own facilities, it was able to feed the company with a number of new products in a relatively short period of time. The company was not in a position to spend on capital equipment for R & D because of the paucity of funds but by proper coordination the tool room was utilized both for prototype development as well as manufacturing tools. In situations which were conflicting the managing director himself gave the priorities regarding scheduling of the use of tool room facilities. This policy helped in avoiding considerable capital expenditure.

The major strength of R & D department was its people. It had about 15 engineers, a few with a master's degree in technology and about 20 technical support staff. The department was organized on a project basis. The department recruited people with previous R & D experience or fresh from college but not with any other experience.

Quarterly review meetings were held to evaluate the progress of the projects and once the go-ahead signal was given to the departmen for developing a new product the R & D manager was given full freedom to use all resources to meet the time target.

15) Analysis and Discussion

The process of development of technology in CMERI and its subsequent transfer for commercialization to PTL could be looked at from two vantage points, (i) from the perspective of the management of CMERI and (ii) from the perspective of the public policy maker in Government.

The focus of the case study has been more on the actions taken by the management of CMERI and later PTL. Very little data was collected on the processes of decision making in the various governmental bodies and their interrelationships. What has been revealed about governmental processes has been through the understanding of the impact of management actions taken by CMERI or from the response of the government to them. The case study was almost entirely based on information collected from interviews of PTL's executives and those of other competitors as well as secondary data. Though the author did visit the Directorate General of Technical Development - a government department, the data collected from there was not very significant. Given these limitations, the analysis in this section would be restricted to the managerial processess involved in the innovation process.

15.1 Nature of the innovation process

The innovation process as described in the case study seems to be very complex. The overall process could be described as a process of "muddling through" very similar to that observed in a study of governmental decision making (17).

However, on closer scrutiny it seems inappropriate to give that label. The initiation of the project required great vision on the part of Mr. Suri and an ability to sense the external environment and integrate considerably diverse information to perceive the opportunity and then convince the governmental machinery to allow CMERI to undertake a major project at a time when the organization was still in its formative stage. As we have seen earlier CMERI's credibility was very low. The CSIR was a relatively new organization and there was a pervasive preference for anything that was foreign. Till then CMERI had taken up relatively small projects. In such a situation the tractor project was a very big step and could be described as an "entrepreneurial" (18) decision as the part of CMERI's management.

Once the decision to undertake the project was taken the characteristics of the total process seemed to change. The private company which had promised to support the development of the prototypes backed out because of its own problems. So CMERI searched out another potential client which also backed out after sometime. At this time CMERI was in a very difficult situation. Initially hopes were raised when HMT showed interest but again when NIDC recommended the foreign technology there was great uncertainty regarding the fate of the project till CMERI could convince PSIDCL to finance the project. Till the transfer of technology to PTL took place CMERI exhibited a reactive behaviour. It responded to a number of crisis situations. The reasons could be that CMERI could not possibly gauge the financial condition of MAMC in advance or it could not predict what recommendation NIDC would give. This part of the innovation could be termed as a "muddling through" process.

However, once the technology was transferred to PTL, the same team which had been transferred to the new company exhibited a greater orientation towards systematic planning of their activities with a longer time horizon. Though there were many deviations from the original plan for example, (i) addition of balancing machinery, (ii) changes in building design, etc. to reduce capital investments, (iii) change of product mix, there was a pro-active stance in the management actions. After the technology was transferred, the PTL team designed their functional strategies keeping in view the environmental developments and their resource position. Hence instead of designing a manufacturing plant of the capacity of 10,000 tractors per annum PTL phased its manufacturing programme so that the earnings from the first phase could be used to finance its growth and product diversification. Other instances of the pro-active stance of the PTL team in the post-technology transfer phase were, (i) their convincing the GOI to exempt them from excise duty of

10 percent to off set its higher input prices of domestically bought components from 1975 to 1977 for a period of 2 years, (ii) taking the decision to manufacture all the components within its own premises temporarily to build credibility vis-a-vis potential suppliers; (iii) introducing 2 more tractor models by 1978 based on R & D started at the inception of PTL etc. The latter part of the innovation process showed that the PTL team looked at environmental opportunities keeping in mind their strengths and weaknesses. Though the business strategy of PTL was designed with a fairly long term horizon. They adapted fast to environmental changes, which probably shows that perhaps in their analysis contingencies had been considered which helped them to respond fast. The post-technology transfer to PTL stage in the innovation process could be described as a planned-learning process (19). The adaptation resulted from the learning/new knowledge during the implementation process.

Hence on the basis of the dominant management orientation, the total innovation process could be broken up into, (i) entrepreneurial stage, (ii) reactive, muddling through stage and (iii) planned-adaptive stage.

15.2 Reasons for problems faced by CMERI

The case of the Swaraj tractors project reflects the kinds of problems any research laboratory in a developing country would face. CMERI was in its formative stages at a time when the country was groping in the nation-building process. Mr. Suri had to crusade to secure support from its external constituencies. CMERI's problems were exacerbated by a hostile environment and lack of external credibility. However, the dogged determination, persuasive skills and the network of relationships with key persons which Mr. Suri had cultivated helped him to secure support of Government.

An important factor to be noted is the fact that the opportunity was not presented to Mr. Suri but it was perceived and created by him when he happened to be a member of the delegation sent by the Government to Soviet Russia. He was aware that a certain private sector firm wished to diversify and that a certain public sector undertaking had idle capacity. All these bits of information were nicely fitted into his arguments for designing and producing an indigenous tractor when the country's balance of payment position was not good. During this stage CMERI's relations with external constituencies seemed to be managed quite well. However, troubles began only after this stage was over.

At the time CMERI took up the tractor project, its existing technical, managerial and financial resources and capabilities were not appropriate for the task. The tractor was not a new product in the country. Many thousands had already been sold by dealers of imported tractors and also indigenous manufacturers who produced them according to their technical collaborators' designs. However, for CMERI it was a novel task. It had never tackled such a complex technical task. It required superior engineering skills, which had to be developed on the job. A project of this size and complexity had not been undertaken by any of the CSIR laboratories related to the engineering industry. Nor was there any experience of industry-laboratory collaboration on such a complex task. By undertaking a project, which did not match its resources and capabilities, CMERI externalized its locus of control.

It had to depend on external funding to a significant extent. Though the private company had initially promised support it withdrew when its performance declined. Developments in the external environmental context had an adverse impact on the project. MAMC, which had initially shown interest also withdrew when its performance also declined. When HMT showed interest NIDC recommended foreign technology. This kind of situation resulted in considerable strain on the

organization's members. It was a very frustrating experience. However, the team members did not desert the organization even though industry could offer more lucrative jobs. This was perhaps because of the ability of the top leadership to sustain their zeal and determination through certain sense of pride imbibed in them. /a

The successive loss of support from potential clients because of their poor performance and difficult financial situation probably points to an inadequate appraisal of the potential client's ability to undertake the project. It is possible that a good strategic analysis of the client could have given warning signals to CMERI in advance which could have resulted in a better response than the reactive, muddling through type of action. NIDC's response also could have probably been predicted. NIDC's task was to evaluate the two technologies (i) Swaraj Tractor design and (ii) Motokov's technology. The latter was a proven technology and a large number of imported Motokov tractors had already been sold in the country. The farmers were quite satisfied with these tractors.

On the other hand Swaraj was a prototype model, it had yet to be productionised. The market did not know it. One could a priori argue that there would be some market resistance to it because, (i) it was the first indigenous product of its kind, (ii) it had no brand image, (iii) farmers would prefer a proven and reliable product which could give them good service during the short period between harvesting and the new sowing season, (iv) and it could be expected to have technical problems initially.

HMT had become the pride of the public sector in India, because of its superior overall perfomance. It therefore wanted to diversify into a product line which would help in earning some money to wipe out the losses which they had started making in the machine tool business in 1967. Therefore for NIDC, the choice was very rational.

Hence it said that Swaraj would require a few years to earn profits for HMT whereas the foreign technology would help it to earn profits from the very beginning because initially completely knocked down (CKD) packs could be imported and assembled in India and sold in the market. Gradually the import content could be reduced. For HMT the choice was clearly the second option. Also perhaps in their great zeal the CMERI team became technically overambitious.

This seemed to result in their giving little weightage to marketing considerations. The original tractor design incorporated an air-cooled engine, which was thermodynamically more efficient than an equivalent water cooled one.

But a few years before PTL came into being one of its competitors and now a very well known tractor manufacturer had suffered a bad image because of technical problems with an air-cooled engine driven tractor which they had introduced in the market. PTL was aware of this, but still it had decided to go ahead with an air-cooled engine. However, during negotiations with PSIDCL one of the latter's senior officers told them that as such they had to overcome the market resistance to indigenous technology, hence opening up another front by trying to market an air-cooled engine did not make good strategic sense. This comment at the late stage, probably sometime in 1970, convinced the PTL team that it would be better to attack limited fronts at a time and hence they changed the design. Their lack of sensitivity to marketing information in the initial stage of the innovation process indicated by the fact that though they started operations with the Swaraj 724 (26.5 h.p.) they changed the product-mix completely within 2 years when they realised that the market was willing to pay about Rs.4,000/- more for a 35 h.p. tractor whereas the associated cost increase was about Rs.2,000/-.

It is interesting to note that different organs of the Government behaved in different ways, some supported Swaraj, others went against it. Though the Planning Commission supported the project, the Minister of Industry did not.

Though one would have expected the Planning Commission and the Ministry of Industry to work in unison it did not happen in actual practice. Here comes the role of personalities. It is possible that the Industries Minister believed in developing indigenous technology but perhaps not at the cost of current manufacturing capability which could be built up relatively more rapidly by acquiring foreign technology rather than through indigenous efforts. This explains why both HMT and PTL were given licences to manufacture tractors though both were in the public sector. PTL was even given exemption from excise duty for 2 years which radically changed the financial situation. One may speculate in such a situation that had CMERI been aware of such a possibility perhaps the seemingly sudden loss of governmental support may not have caused too great a frustration. This is important because public undertakings as it is face great difficulties in attracting highly qualified people (20); with such happenings even the few who join such organizations would be difficult to retain. The Swaraj tractor project was in a very uncertain situation from 1965 to early 1972, which was quite a long period. The fact that the whole team was more or less intact only speaks about the very high quality of motivational skills of CMERI's top leadership.

Institutionalised linkages with important decision-making centres in Government could atleast have given advance warning signals about the thinking of influential persons and the impending decisions. In this case though Mr. Suri had cultivated a network of decision makers in Government he did not seem to be aware of the thinking of the Ministry of Industry.

15.3 Factors influencing the innovation process positively

Inspite of a number of problems faced by CMERI the Swaraj tractor project finally turned out to be a successful innovation. What were those factors which helped in the success of the venture ?

CMERI was indeed fortunate to have had a leader like Mr. Suri who championed the cause of indigenous technology and who galvanised a group of not very experienced engineers into a strong technical group. The value orientation this team imbibed towards indigenous technology helped it tide over many difficult situations. In fact Mr. Suri could be described as the "product champion" (21). When he left CMERI there was a leadership vacuum, but the new director-in-charge, Dr. A.K. De also supported the project as he too felt that the Swaraj could become a successful product of indigenous technology. Mr. Chandra Mohan, the leader of the design team also provided the needed leadership after the transfer of the team to PTL.

The transfer of the CMERI design team was an important aspect of the technology transfer process. This group of engineers had worked together during difficult times for a long period which had resulted in a high degree of complementarity between them. During the implementation stage many changes were made in the design of buildings, plant-layout, building technology, manufacturing processes, etc. in a very short time. This was possible because of a very good rapport existing amongst the team members. The rapid decision-making was also enabled by the fact that during the 6 years of development this group had worked alongwith potential suppliers. Changes in design could be effected only because there was an understanding between the team and some of the suppliers of critical items. Much technical knowledge cannot be documented. It exists in the form of experience which was retained in PTL by transferring the team. This strategy provided the organic linkage between the technology development stage and the productionising

stage even though the two sub-processes in the total innovation processes were spatially as well as temporarily separated.

The Swaraj project was being evaluated at different stages. In the initial stage it received a set back when the Industries Minister signed the agreement with M/s. Motokov. However, because of the support it received from potential clients and the determination of the CMERI team the project continued. Then again sometime in 1969-70 towards the end of the technology development period the Government finally supported NIDC's recommendation to HMT to go ahead with foreign technology. However, PSIDCL which was a relatively new organization in Punjab could be convinced by CMERI of the potential benefits of having the project in Punjab. Once this support was available, it become easier to arrange for the funding from the financial institutions. IDBI's new management's policy was to support development and indigenous technology but only after they were convinced of the financial viability of the project (15). CMERI's design team was highly technologically oriented, which might have resulted in a lack of sensitivity to market considerations as we have seen earlier. During the process of evaluation prior to approval of the funding the adhoc committee of experts appointed by IDBI asked a number of strategic questions related to, (i) product technology, (ii) time required for production build-up, (iii) market demand etc. The PTL team as a result of the evaluation changed the d.p.r. a number of times and also made a number of changes, one of the important ones being changing the prime mover from an air-cooled to a water cooled engine. The evaluators, fortunately were supportive of the venture but at the same time were aware of the problems it might face in becoming financially viable. The consultants also played an important role in transforming the predominantly technological orientation of the team to a business orientation which was crucial for the success of the innovation (22).

16) Concluding Remarks

It was discussed that though India has a relatively large technological infrastructure its performance has not been as desired. There have been relatively few cases of major technological innovations in the CSIR laboratories. The Swaraj tractor project is a major achievement of the CSIR. It was for this reason that a study of this case was undertaken to develop an understanding of the managerial processes involved in successful innovations in a typical developing country like India. In the foregoing analysis a number of tentative conclusions were reached, which are summarised below :

1) The innovation process consisted of three major stages differentiated by the dominant orientation of the management of the concerned organization. The creation of the opportunity for CMERI was characterized by an "entrepreneurial" mode, while the technology development and transfer stage was characterized by a reactive muddling through approach. After the technology was transferred to PTL the management's approach could be described as planned -learning one. /a The planned-learning approach seemed to be the more effective one.

2) The "Planned-learning" third stage during which the technology was productionised and manufacturing and marketing operations were commenced was characterized by the management's perceiving environmental opportunities with their strengths and capabilities in mind. This resulted in organizationally feasible strategies and hence greater effectiveness.

3) The motivation of the CMERI design team could be sustained during the long development period because of the charismatic personality of the product champion who was able to galvanize the members into a cohesive team. The commitment of the team could be generated through a value orientation towards indigenous technology, and the sheer excitement of the novel work they were involved in.

4) The success of the Swaraj project was to a very great extent due to the leadership provided by the product champion who developed effective relationships with key persons, crusaded for the cause of indigenous technology and built a cohesive design team. CMERI was fortunate in having a new leader who supported the innovation after the product champion left the organization.

5) The innovation process was characterised by the interaction of a large number of organizations with different goal structures. This was one cause of the long time that elapsed between generations of the idea and its successful commercialisation. Identifying relevant organizations and forging lateral linkages with them was a very important task of the top leadership of both CMERI as well as PTL more so because of the inherent resistance they encountered, as well as to mobilize support when necessary.

6) A critical element of the technology transfer process was the transfer of CMERI's whole tractor design team to PTL. This not only ensured the continued commitment and determination of a highly cohesive team of persons, but it also helped in retaining the indepth knowledge gained by them over a considerable length of time. This was a great strength in the rapid adaptive decisions that had to be made during the implementation stage. Transfer of these key people provided an organic linkage between spatially and temporally separated subprocesses of the total innovation process.

7) The innovation process revealed the interesting transformation of the CMERI design team with a dominantly technological bias with low sensitivity to marketing information into a well-knit group with an enhanced business orientation. The supportive external evaluative process towards the end of the innovation and the association of the consultants on the job for over six months played a major role in this attitudinal transformation.

REFERENCES

1) Ashok Parthasarathi, "India's efforts to Build an Autonomous Capacity in Science and Technology for Development", Development Dialogue, 1979.

2) S.R. Valluri, "Management of R & D Institutions : A Brief Review of the Indian Experience", (a paper prepared for the Hand Book on Management of R & D Institutions in Developing Countries under the auspices of the Foundation for Institutional Training, Canada) July 1983, p.1, 5.

3) Ashok V. Desai, "Research and Development in India", Margin, Vol.7, No.2, January 1975, pp.52-91.

4) _____ "The Origin and Direction of Industrial R & D in India", Research Policy, Vol.9, No.1, 1980. pp.77, 90, 91.

5) C. Cooper, "Science Policy and Technological Change in Under-developed economies," World Development, (March, 1974).

6) D. Crane, "Technological Innovation in Developing Countries : A Review of the Literature", Research Policy, Vol.6, No.4, October 1977, pp.374.

7) G.S. Aurora, and Ward Morehouse, "The Dilemma of Technological Choice in India : The Case of the Small Tractor", Minerva, Vol.XII, No.4, October, 1974.

8) V.V. Bhatt, "Decision Making in the Public Sector : Case Study of Swaraj Tractor", Economic and Political Weekly, 13 (21), May, 1978.

9) Shekhar Chaudhuri, "Acquisition and Assimilation of Technology in the Tractor Industry in India : The Strategic Perspective", Unpublished doctoral dissertation, Indian Institute of Management, Ahmedabad, 1980.

10) Kenneth R. Andrews, The Concept of Corporate Strategy. (Bombay : Taraporevala, 1972).

11) H. Igor Ansofi, Corporate Strategy : An Analytic Approach to Business Policy for Growth and Expansion. (New York : McGraw Hill, 1965).

12) Richard S. Rosenbloom, "Technology, Strategy and Innovation : An Analysis of the State of the Art," (unpublished Working Paper, Harvard Business School, 1974).

13) Council of Scientific and Industrial Research, "First Get Togetner of Research and Industry - Addresses and Key Papers", (New Delhi, December 20-21, 1965).

14) Detailed Project Report prepared by M/s. Motokov for the setting up a plant for the manufacture of tractors in the public sector. This d.p.r. was studied by the author during his visit to the Hindustan Machine Tools Limited, a public sector undertaking.

15) V.V. Bhatt, "Decision Making in the Public Sector : A Case of Swaraj Tractor" (World Bank Domestic Finance Studies No.48, Feb. 1978).

16) Yash Mahajan, "Marketing Horizons for Farm Durables", (Speech given at International Marketing Convention on February 3, 1979, at New Delhi).

17) David Braybroke and Charles E. Laidblom, A Strategy of Decision, (New York : Free Press, 1963).

18) Henry Mintzberg, "Strategy Making in Three Modes", California Management Review, Winter, 1973, Vol. XVI, No.2.

19) H. Igor Ansoff, Roger P. Declerck and Robert L. Hayes (ed), From Strategic Planning to Strategic Management, (New York : John Wiley & Sons, 1979), pp.72.

20) S. Vathsala, and Krishna Kumar, "Top Executive Pay Parity", Lok Udyog, Vol. XIII, No.3, pp.41-46.

21) Donald A. Schon, Technology and Change : The New Heraclitus, Pergamon Press, 1967.

22) Shekhar Chaudhuri and Shyam Sundar, "Technological and Economic Perspectives in Corporate Strategic Decisions, "Lok Udyog, Vol. XVIII, No.1, April 1984, pp.17-24.

* * * * *