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MODIFYING IMPORTED TECHNOLOGY BY LOCAL ENGINEERS: HYPOTHESES AND CASE STUDY OF INDIA

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I. INTRODUCTION

INTRODUCTION of foreign technology, and more importantly its modification, is, in view of the Japanese experience of industrial technology development, definitely a short-cut for late-comers in their efforts at catching up with the technology level of earlier starters.

Y. Hoshino [12] points out that modification can be classified into two distinct types: minor and major. He emphasizes that accumulation of know-how for making minor modifications eventually gives rise to a major modification, and then to innovation.

A United Nations University's project team,[1] in which I took part as an associate coordinator, formulated in its final report a "stage theorem" hypothesis with respect to development of technology from the stage of introduction. According to this theorem, introduced technology goes through the following stages: (a) mastering of operation, (b) mastering of maintenance, (c) mastering of repair, (d) accumulation of modification know-how, (e) creation of new design, and (f) domestic manufacture based on the new design.[2] It is modification of imported technology by local engineers that is emphasized in the UNU project's final report as a key step in the further advancement of the technology concerned.

Japanese firms can be taken up as evidence of this since they seem to be concerned more with improvements on imported and existing technology than with invention, even today, when the level of their technology has by and large caught up with that of the United States and Europe. A recent survey conducted by T. Hirota [9] [10] supports this by showing the fact that the R & D efforts of large Japanese corporations are mainly focussed on such improvement.[3]

[1] The project was concerned with import, transformation, and development of technology as reflected in the Japanese experience in the late nineteenth and early twentieth centuries, and coordinated by T. Hayashi.

[2] See [8, p. 89]. Another stage, "the stage of export of modified technology," should now be added in view of the recent phenomenon of increasing export of technology by once relatively underdeveloped countries like Japan, Korea, Hong Kong, India, Brazil, etc.

[3] T. Hirota reveals from his study of 500 top Japanese companies, based on a questionnaire survey, that in no less than 116 companies R & D efforts were geared toward improvement; toward basic research in 11 companies, and toward applied research in 55 companies (double replies were allowed). Hirota further points out that the average length of an R & D project in the Japanese firms is three years only compared to five to six years in the United States on the basis of a questionnaire survey of the top 500 companies there.

The first part of this paper (Sections II and III) contains a theoretical consideration of the possible courses of development or decay of a transplanted technology after its transfer,[4] and the importance of modification of foreign technology by local engineers themselves during and after the technology transfer.

Modification of imported technology is likely to be attempted under certain conditions. Take the Japanese experience again for instance—severe competitive market situations combined with a certain absorptive capability of the local recipient of foreign technology are considered to be the very conditions explained by K. Iida [13], S. Ishikawa [16] and others. The latter half (Section IV) is devoted to testing this arguement through the case studies conducted by me on improvements made by Indian engineers with respect to the industrial technology transferred from Japanese firms to India.[5] Indian cases were taken up here because India has been a successful developing country in accumulating the capabilities of absorbing, and even modifying, foreign technology.

II. SIGNIFICANCE OF MODIFICATION OF FOREIGN TECHNOLOGY: A KEY FOR CATCH-UP

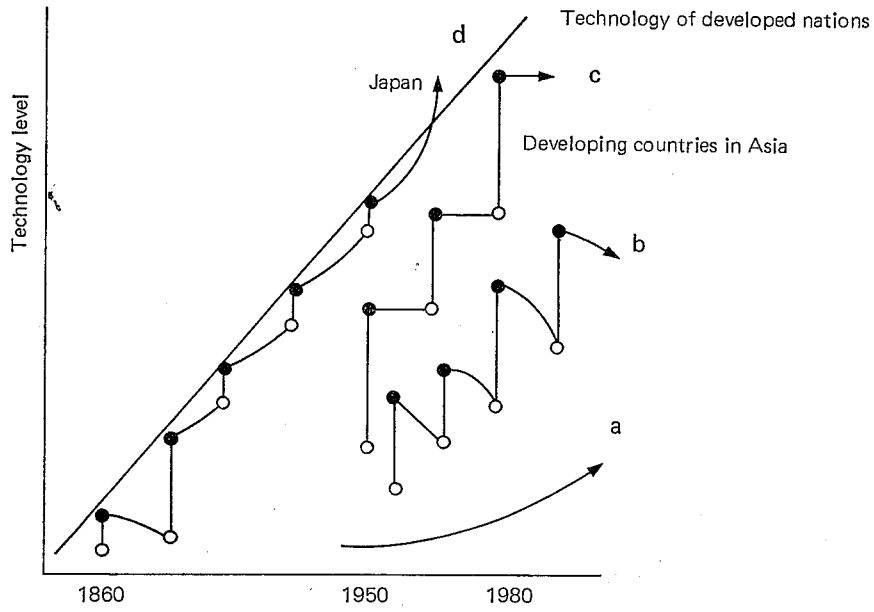
Technology can be transferred abroad through various commercial and non-commercial channels. Even if we confine ourselves to commercial channels, there are a variety of different channels of transfer. *International movement of a commodity* is a primitive channel; it often accompanies technology transfer because the commodity embodies certain technology, and the know-how for its use and maintenance is also transferred, resulting in a general leveling-up of the technology level of the recipient. For instance, the import of foreign cars often leads to the emergence and spread of repair shops. *Plant construction* by a foreign engineering contractor creates a wider and faster flow of technology. But if such channels of technology transfer do not raise the capability of the recipient to produce the commodity or plant itself, the technology gap between the donor and recipient of the technology will never be narrowed. The level of indigenous technology in this case rises quite slowly, as seen in curve a in Figure 1.

As the level of indigenous capability rises, these channels of technology transfer give way to the establishment of *100 per cent foreign owned subsidiary companies*, then to *joint-venture company*, and finally to *pure technology transfer* [6]. The level of the recipient's technology rises as shown by curves b and c. In curve b,

[4] Technology transfer is primarily a flow of technology requiring a certain length of time. Since this paper is concerned with technology transfer under collaboration agreements, transfer is assumed to commence at the conclusion of a technology transfer agreement and end at its termination.

[5] While technical cooperation as part of ODA amounted to 98 billion yen in 1982, the total amount of technology exports (remittances received by private Japanese firms and semi-governmental corporations in return for supplying technology) to all the developing countries was 103 billion yen in the same year. Technology export to India alone was only 1.5 and 3.4 billion yen in 1982 and 1983 respectively. (These figures are based on unpublished source compiled by the Statistics Bureau, the Management and Coordination Agency, Government of Japan. The region-wise gross figures only are published in [18]. Also see Itō [17].)

Fig. 1. Technology Catch-up Patterns Against Developed Nations



Note: ○—Beginning of a technology transfer.
●—End of the technology transfer.

the recipient's technological capability is not high enough to maintain the original level alone and the level of introduced technology is unintentionally downgraded.

We have, in fact, come across quite a few cases of technology transfer in which the production technology could not be maintained at its initial level, and downgraded, often very quickly, after the supplier's experts left the site on termination of the agreement. Unless the recipient becomes sufficiently capable of maintaining and repairing an introduced production system, it will never be able to enhance the capability to modify and improve its technology.

Curve c demonstrates that the recipient has managed to maintain the level of imported technology. But it has not yet accumulated the know-how to modify and improve on the foreign technology: It is probable that such recipient's technology level will never exceed that of the supplier.[6] However, the recipient

[6] One engineer in a leading machine tool manufacturing company in Japan remarked that his company provides its counterparts in some developing Asian countries including India with the latest models of machine tools but that the company is "not at all worried" about its counterpart catching up because they cannot develop, design, or make a newer model and are only learning the provided technology. By the time they have mastered it, the Japanese company will be offering another new model on the world market. We find in this case a paradox in the field of latest technology that a late-comer can easily obtain very new technology but will find it very difficult to catch up with the early-starter as the technology life cycle is particularly short in such fields.

would become sufficiently capable of modifying and improving foreign technology as, in due course, the recipient masters the introduced technology through learning how to maintain and repair.

The rising technology level in Japan up till today through active introduction of foreign technology and subsequent modification is depicted in curve d. In the initial stage the original level of newly introduced technology could not be maintained because the local experts did not have the ability to digest the technology. In the course of time, however, they could accumulate the capability to master the foreign technology and began modifying it to suit prevailing internal economic conditions and technological levels and, in many industries, finally catch up with the level of the early-starters' technology.

III. IMPORTANCE OF MODIFICATION BY LOCAL EXPERTS

When a technology is transferred from one country to another, the technology should be modified either by the supplier or recipient, or both, to suit differing social, cultural, and economic situations so as to improve economic efficiency in the production of goods or services.

The modification is planned, designed, and executed by the supplier alone when local engineers or managers are virtually nonexistant, as is the case in technology transfer to a newly established 100 per cent subsidiary company.[7]

When the technology level of the recipient is high, however, the recipient may take an active part in modification work from the initial stage of a technology transfer.

Active participation by local experts can greatly contribute to the raising of technology levels toward self-reliance. And modification made by local experts should strictly be distinguished from that made by foreign expert alone for the following reasons. First, such participation is a sure sign that they have attained a high level of capability. Second, the more such participation is made, the more intensive and extensive exchange of technical information between the local and foreign experts is likely involved, and it may lead to the accumulation of know-how for minor or even major modifications. Third, modification by foreign experts alone tends to have inherent disadvantages. They may not properly understand local conditions and needs; some local conditions might be beyond their awareness. For instance, a very high quality product could not be manufactured under certain local conditions which may not have been foreseen by

[7] We have observed various types of modification executed by the technology suppliers. Even the basic design is altered, particularly when the scale of production is greatly reduced, even by as much as one-tenth. One phenomenon frequently observed is a breakdown of the work process into its most simplified stages where no stage requires multiple skills. Also the introduction of new devices which make the work process simpler and does not demand multiple skills that take time to acquire. For example, a Japanese subsidiary in Malaysia manufacturing mechanisms for music boxes, introduced an osciloscopic apparatus to adjust the tone of the sound. Skilled Japanese workers, however, do not use such sophisticated apparatus and depend entirely upon their ears for the adjustment work.

the foreign experts. Fourth, the technology supplied from developed countries tends to be excessively capital intensive. It is certainly more capital intensive than that supplied by developing countries as Lecraw's study of Thailand [20] clearly demonstrated.[8]

It should be noted here that intentional modification of foreign technology by resourceful local experts tends to result in a downgrading in technical terms but in an upgrading in terms of economic efficiency.[9] This is because local conditions such as quality of labor, wage levels, and users' demand and needs are more likely to be taken into consideration. Thus the intentional modification of a given technology by capable local experts should usually result in appropriate technology development.

This type of downgradation, however, should be regarded as entirely different from that which results unintentionally from insufficient absorptive capability on the part of the recipient. In the case of the former, recipients would be able to re-upgrade it by themselves toward the initial high technology level as local situations mature, while this could never happen in the case of the latter.

IV. MODIFICATION OF FOREIGN TECHNOLOGY BY INDIAN EXPERTS

A. *A Remarkable Case of Technology Downgrading in India*

Although Indian experts must be commended on their attempts at modification of imported technology given the climate created by the policies of the Indian government (including restrictions on imports of low technology, "unpackaging" of technology, etc.), only a few case studies have so far been carried out in this regard.[10]

[8] Needless to say, a technology supplier makes the decision to hand over a technology taking into account various means of profit-making; not only the income from the sale of technology itself but also the initial sale of plant and machinery, continuing sales of intermediary inputs (parts, components, and raw materials), dividends, etc. According to one survey of ours, Japanese companies have made relatively substantial profit through the sale of machinery and the subsequent supply of materials and parts to Indian partners [14, pp. 27–30]. Capital intensive technology is apparently more profitable for the suppliers, which may cause inappropriate technology transfer. Capable local experts would avoid this.

[9] Japan's history of technology import, transformation, and development is characterized by intentional downgradation of introduced technology. One notable instance is the case of the silk reeling process during the Meiji Era. The demonstration factory, Tomioka Reeling Factory established by the Government, was a blind imitation of a French one equipped with the latest machinery housed in European-style factory buildings. But they were too capital intensive and so every effort was made by local entrepreneurs to modify the machinery and overheads so that they could take advantage of Japan's abundant labor force at that time. The reeling technology was downgraded but economic efficiency upgraded to successfully compete in the international market in terms of cost. See Hayashi [7] and Kiyokawa [19] for silk industry, Iida [13] for iron and steel industry, and Takeuchi [21] for shell button industry as typical examples of technology downgradation.

[10] Works by Baranson [1], Chaudhuri [2], Chaudhuri and Moulik [3], and UNIDO [22] are illustrative of the modification activities of Indian engineers.

Chaudhuri and Moulik [3] have studied the very impressive process of assimilation of imported technology by Indian experts in the Eicher Tractors India Ltd., a joint-venture firm floated in 1959 between the Goodearth Ltd. and Gebr Eicher, a West German company, the latter having minority capital participation.

The Goodearth Ltd., established in 1948, had been a dealer and importer of Ferguson and Gebr Eicher tractors. Over the course of time they decided after careful investigation to manufacture in India Gebr Eicher's tractor under a technical-cum-financial collaboration which was signed in 1959 and expired in April, 1973. They chose this obsolete model of tractor because it was simple, easy to maintain by even poorly trained village mechanics, low priced, and economical in operating costs, so it was most appropriate for India.

The Indian party did not import in toto the manufacturing system of the German company: They attempted at modifying and downgrading the foreign technology in order to survive the prevailing severe competition. What they did was deployment of the very simple locally made machine tools called *addas* in place of the modern German, or Indian machine tools built by established manufacturers like the Hindustan Machine Tools Ltd. In order to assure efficiency and accuracy, they devised a number of new jigs and fixtures and fixed them to the *addas*. Goodearth could thus not only survive the competition but grow fast enough to be eligible for another leap to begin the manufacture of commercial cars in 1985 through collaboration with Mitsubishi Motors Corporation, Japan.

B. *Cases of Modification in India as Viewed by Japanese Experts*

I have conducted three rounds of surveys in 1983, 1984, and 1985 concerning technology transfer between Japanese and Indian firms on a commercial basis.[11] It is notable that most of the Japanese engineers remarked, when interviewed, that Indian engineers were in general knowledgeable and experienced enough to very quickly understand the technology supplied and to put it into practice fairy well in accordance with Japanese engineers' instructions. However, many of the Indian engineers are not as good at reforming and improving the technology provided.

It should be recalled here that most of the manufacturers in India in the fields of newly introduced industries have been enjoying monopolistic or oligopolistic conditions—a seller's market. This is often considered to be one factor which may discourage efforts toward technological progress.[12]

In the 1985 survey, I obtained from fifty-two Japanese companies written replies in response to the question: "What is expected most of the engineers of

[11] The surveys include the following: (a) "Country Report Japan," in Lutz Hoffmann et al. [10], (b) Institute of Developing Economies [15], and (c) The Japan Committee [14]. This is a survey based on the replies to a questionnaire sent to all Japanese companies assumed to be, or to have been, in a collaboratory relationship with an Indian party. The return rate was as high as 40 per cent. The studies (a) and (b) were basically the outcome of interviews with selected Japanese companies. Twenty-one cases and eleven cases of collaborations were taken up for these studies respectively. In the case of study (b), the corresponding Indian partners were also interviewed by us in India.

[12] See Desai [4] [5].

TABLE I

CASES OF MODIFICATION OR IMPROVEMENT REALIZED THROUGH THE INITIATIVE AND EFFORTS OF LOCAL ENGINEERS

Case	Modification
A	Improvements in facilities and production techniques to make them suitable to local environments and technical levels.
B	Improvements based on local conditions.
C	Installation of agitator as an energy-saving measures.
D	Improvements in production facilities.
E	Replacement of pilot valves with smaller-capacity valves.
F	Improvements for evenly drying/heating.
G	Modification of electrical component parts.
H	Introduction of new materials, new methods, and new processes.
I	Several minor modifications to meet market conditions.
J	Several minor modifications to meet market conditions.
K	Local procurement of repair parts.
L	Detail not given.
M	Detail not given.

your partner company?" The replies contained sixty-six opinions in all. They included four opinions that they would like them "to try to solve minor technical problems on their own," and seven opinions along the lines of "efforts should be made to modify Japanese technologies to best suit India," "originality should be developed, instead of just copying our know-how," and "it is necessary to make active efforts to develop new applications based on the provided technologies" [17, pp. 39–41]. In other words, no less than eleven out of the sixty-six opinions were concerned with *continued reliance upon the Japanese side.*

The question, "Have your provided technologies been modified or improved through the initiative and efforts of your partner?", obtained only thirteen positive answers from a total of seventy companies; the rest answered "No."[13]

The thirteen cases are as presented in Table I.

C. *Case Stories*

This section is based on my follow-up survey of March–April, 1986 regarding these cases of modification. The objectives of this study was to find out the general direction in which modifications in India proceed and the common conditions under which they are conducted.

Here I will briefly describe only eight out of the thirteen cases of modification for sufficient information was not obtained with respect to the remaining five cases for various reasons. The salient features of those eight cases are shown in Table II.

[13] The small number of incidences of modification perceived by the Japanese side should not be taken seriously since the respondents to the questionnaire are not in a position to see the situation *after* termination of the technology collaboration agreement.

TABLE II

SALIENT FEATURES OF THE CASES STUDIED

Case[1]	Year[2]	T/F[3]	Product[4]	Direction of Modification[5]	Japanese Commitment[6]	Other Factors		
						Attitude of Management[7]	Experience of Engineer[8]	Market Situation[9]
A	1981	T	Textile machines	CS LC FD PD	Low	TO	Over 10 years	C
B	1978	T	Automobile parts	CS LC PD	Low	TO	Over 10 years	C
C(p)	1977	T	Electric switch gears	FU PD	Low–High	TO	Over 10 years	H
D	1974	F	Ossein	CS PU	High	—	Less than 5 years	L
E	1978	F	Oil pressure appliance	CS FD	High	TO	5–9 years	C
F	1972	T	Pesticide	CS PD	Low	TO	Over 10 years	H
G(p)	1960	T	Time-piece	CS LC FU PU PD	High	TO	Over 10 years	L–C
H	1984	T	Forging	CS	Low	TO	Over 10 years	H

[1] (p) denotes that Indian partner is a public corporation.

[2] Year of conclusion of collaboration agreement. If renewed, the earliest.

[3] F=technical collaboration with minority financial participation, T=purely technical collaboration.

[4] The name of product or process for which technology was provided.

[5] CS=cost saving modification, LC=local content raising, FU=intentional product upgradation, FD=intentional product downgradation, PU=intentional process upgradation, PD=intentional process downgradation.

[6] The Japanese commitment is judged as "High" when the collaboration accompanies financial participation, particularly when the Indian company's name includes that of a Japanese company, and/or when success or otherwise of the technology collaboration affects substantially the business results of the Japanese side.

[7] TO=highly technology oriented management, in which a director with a technical background is responsible for the project.

[8] Length of time in years of main engineers' experience in the concerned field at the time of the modification.

[9] H=highly competitive market situation, C=competitive market situation, L=nearly monopolistic market, L–C=market changed from L to C.

Main hypotheses assumed are (a) direction of modification is toward cost saving, (b) when Japanese commitment is high, modification by the Indian side is encouraged, (c) the attitude of Indian management and the capability of Indian engineers is important for modification, (d) modification is attempted when forced with pressures of competitive market situation.[14]

Case A. Modification for deployment of locally available parts and machinery

Background. The Indian government has long made it a principle to manufacture industrial machinery at home including sophisticated textile machinery. This case is a recent technical collaboration between a Japanese and well-established Indian company with respect to the manufacture of textile machinery and parts.

Modification. The specifications and detailed designs were modified by local engineers on their own initiative for cost-saving reasons. The modifications were of three types. First, the Indian experts utilized parts and components locally available though they were functionally a little inferior. Second, specific, thus costly, Japanese machines for specific processes of manufacturing were replaced by locally-produced machines successfully. Third, a few parts and components from countries other than Japan, which were readily available at lower price, were installed in the Japanese model machines motivated to some extent by brand-orientedness.

Conditions. Textile machinery builders are faced with a highly competitive market in India in certain types of machines. The machines concerned in this case study are in a highly competitive market. The above-mentioned modifications were realized because, in addition to the engineers' high technological capability, they had ample information concerning related parts and components produced all over the world, as well as long experience in this field of production.

Case B. Modification for meeting different markets

Background. An Indian automobile parts manufacturing company, in long standing collaboration with a German manufacturer, approached a Japanese company for a new model of an automobile component. This was in line with the government's policy of import substitution of automobile parts. The Japanese side is rather passive.

Modification. An important part in the component was replaced by an Indian-made part in order to meet the specifications required by customers in India, with due modifications—downgradation—in the manufacturing process.

Conditions. A competitive market situation forced the Indian party to obtain the new model component in order to forestall the competitor. Two additional facts deserve special mention in this case. First, the Indian company knew very well that Japan attained technological progress not merely by learning foreign technology but also by resourceful modifications, and made it a principle to

[14] The capability of engineers was measured by the length of experience of the main engineers. For this and other definitions, refer to the notes in Table II.

learn Japanese know-how with regard to modification from their Japanese counterpart. Second, the Indian company made a detailed working manuals themselves by revising the manuals provided by the Japanese company because they felt the latter were insufficiently documented in comparison with the German manuals. This was done by observing how the Japanese workers were operating and by consulting with the Japanese experts. The Japanese side acknowledges that Indian engineers are very experienced and competent in this regard.

Case C. Modification in response to climatic variations

Background. An Indian public sector manufacturer in the field of engineering goods decided to diversify into electric switch production. They identified, after a careful study, a medium-scale Japanese manufacturer specializing in the field who had unique and sophisticated technology. The case represents a technology collaboration in which both parties have enjoyed an expanding business relationship and a deepening understanding of each other's needs and problems.[15]

Modification. The modifications in design were introduced on the initiative of the Indian side first to make the periodical inspections simpler for users and, second, to reduce the potential problems that may arise from the moisture in the rainy season and the dust in the dry season, which reach much greater levels in India than in Japan. The basic designs were thus consequently rearranged. The Indian engineers played an active part in process modification suitable for scaled-down production.

Conditions. Six conditions can be pointed out: first, both the Japanese and India engineers have understood their counterpart very well through extensive interaction and now place full confidence in each other. Second, the Indian company has a century-long history of its own and the engineers in this company are very much experienced in manufacturing this kind of product though with less automation process. Third, top management in the company is very technology oriented. The company spends as much as 5 per cent of sales for R & D purpose. Fourth, the company itself is a government-owned enterprise, so management is not so worried about the government's licensing and other policies. Fifth, the company makes full use, while attempting modification, of the Indian government's various centers for testing industrial materials and equipment, which are readily available for public use at low cost. Last but not least the products in question have all been facing severe competition.

Case D. Modification for enhancing technical efficiency

Background. Introducing a ban on the export of raw materials in their crude form and inducing export of such materials after some processing, i.e., export substitution, is one of the means of industrialization of a country exporting primary products. Cattle bones used to be exported to Japan as a raw material for high quality gelatine used in color films. The government of India banned

[15] Most Japanese companies in collaboration with Indian companies are not very happy with business results [14, pp. 30–33].

this raw material export and in the early 1970s Japanese importers were required to go into technical collaboration to establish a factory for extracting crude gelatine, or ossein, from the bone. Because this product is indispensable for quality film, the Japanese commitment can be judged to be very high.

Modification. The notable modification was the introduction of a stirring apparatus to the process of drying an intermediate product, which resulted in cost saving. This idea was proposed by the local engineers while the collaboration was still under way.

Conditions. The Japanese technical director encouraged the realization of the idea, giving advice when required. He had from the initial stage an opinion that the local experts should be motivated enough to be able to deal with problems they faced in daily work and to solve them by themselves. It was the technical director's firm policy to foster creative and resourceful thinking amongest all the employees.

For this purpose, the Japanese side, from the first stage of training both in Japan and India, exerted efforts to have main Indian engineers understand key elements of the Japanese style of management. And in the new factory in India several elements were introduced: a large office room where no officers are confined to a separate room, uniform clothing, a common dining hall, etc. In addition, the "top down" decision-making process was avoided as far as possible and weekly group meetings of technicians and workers together were organized so that they could solve any technical or other problems by themselves. The success of the modification efforts is considered to be the outcome of such motivation provided by top management, though their self-help attitude seems to be still insufficient, with technicians on the shopfloor fearing possible failure arising out of their own new efforts, and consequently being fired.

Case E. Intentional downgradation of an oil pressure appliance

Background. The collaboration was initiated by the Indian side in line with the Indian government's policy of import substitution. It is a technical-cum-financial collaboration. The company carries part of the name of the Japanese company unlike all other cases taken up in the present case studies, though the Japanese partner has minority capital participation (24 per cent). Thus the commitment of the Japanese side is considered to be very high.

Modification. The oil pressure appliance is of a type operated through two bulbs—a guide bulb and power bulb—with the latter working according to the guide bulb's movement. The conventional ratio of the guide bulb's capacity is one-fourth that of the power bulbs. The Indian side proposed that cost could be cut down to a minimum if a much smaller guide bulb were used, though it would make the movement of the whole appliance less accurate. At the interview, the Japanese experts confessed that this idea was beyond their imagination since they were used to having to create increasingly accurate appliances in order to forestall competitors in the developed world.

Conditions. In the eyes of Japanese technicians their partner engineers' technical level is very high. Their novel idea was hatched by the Indian side to gain

price competitiveness in order to win in a market that had by then become highly competitive.

Case F. Intentional downgrading of a fine chemical

Background. A Japanese company had invented a new pesticide which was later widely acknowledged as less pollutive though more costly than conventional ones. A famous Indian company began importing the pesticide as sole agent, but the Indian government's move toward import substitution forced the Japanese company to transfer the technology to allow the Indian party to make the pesticide in order to maintain the share it enjoyed in the Indian market, although the pesticide was a new product in the early stage of its product-life-cycle. The Japanese company knew that the Indian company had had years of experience in business and manufacturing in the field of various fine chemicals.

Modification. It was not difficult for the well experienced Indian engineers sent for education and training in Japan to understand the know-what and know-how of the pesticide. Meanwhile they realized that the Japanese factory's highly automated system of production was too capital intensive for them. They proposed, therefore, that many of the automatic appliances and bulbs could be replaced by manually operated ones, which were being used in the Indian factory.

After long negotiations about downgrading the quality in each of the appliances, bulbs, tubes, and materials, the Indian company succeeded in getting consent from the Japanese company to execute a variety of downgrading on condition that the quality of the final product met original specifications and that the responsibility for any possible accidents would be wholly borne by the Indian company.

The quality of the pesticide produced by the Indian company succeeded in meeting the expected standard. Subsequently, as their financial capacity rose, the Indian company could gradually introduce automatic appliances and bulbs.

Conditions. The market for the product is notably very competitive, forcing the Indian company to rationalize the production process. Also the wide range of experience on the part of Indian engineers was, no doubt, the reason why they were able to modify the technology to suit the given conditions. It is further noteworthy that they are able to upgrade the technology again whenever they wish.

Case G. Active efforts for modification

Background. A large Indian public corporation and a Japanese time-piece maker have been in continuous technical collaboration for two and a half decades. Since the products carry with them the Japanese brand name, the Japanese company's commitment is high from the inception.

Modification. The Indian engineers introduced a series of modifications with respect to both the materials and manufacturing process. They initiated the use of wood and black aluminium for some frames. This has never been conceived of in Japan. New methods were tried and introduced into the manufacturing process; acid liquid for gold plating was replaced by alkaline liquid, which resulted

in longer durability and a better tone of color; the conventional method of making the window glass was changed to ensure greater reliability of the product; a new method of setting the patterns on the dial employing metal patterns was devised; instead of steel, glass was sometimes used for the negatives for printing the dial; even the movement in the watch with automatic winding was reformed: they introduced a revised mechanism which can wind the main spring amply with less active movement on the part of the wearer.

Conditions. The company has been managed for a long time by a dynamic managing director who has an engineering background and has been recruiting many excellent engineers.

Another factor was that the Indian experts have had continuous contact with the resourceful Japanese company which has frequently altered and improved the product and manufacturing process; this too has contributed to the fostering of a self-reliant spirit.

Case H. Self efforts for the raising of product quality

Background. This is a case of pure technical collaboration between Japanese and Indian metal forging companies. The Indian side sought advice from a Japanese company for the raising of productivity and technology level of its existing foundry. Its products enjoy a strong demand from many technology-oriented assemblers, both foreign and local. The Japanese company has no other interest than to receive a small technical fee for assistance given. The channel of transfer of technology in this case is simple: periodical visits are paid to the Indian company by Japanese experts, who inspect the shopfloors, hold meetings of managers, and offer them advice which ranges widely from the processing of a tiny pin to the layout of foundry sheds. It should be noted that this channel, though simple, has worked well in contributing to the raising of technology levels.

Modification. The modification in this case, unlike the other seven cases above, does not just concern one particular process or type of technology provided, but rather involves technical advice from Japanese experts. Every one of the suggestions offered by the Japanese is discussed jointly by the Japanese and Indian experts from the standpoint of its feasibility and appropriateness given the Indian situation.

Conditions. In general, the Indian side is sincerely attempting to learn Japanese know-how. The motive behind this effort is to survive increasingly severe competition by supplying quality goods.

V. SUMMARY

We may perhaps draw the following conclusions from the above case stories summarized in Table II.

(1) Direction of modification was in most cases toward cost saving.

(2) Modification can take place even if the technology supplier's commitment is not high.

(3) Technology oriented management provides a favorable climate for modification.

(4) Long experience of engineers seems to be important for modification.

(5) A competitive market situation pushes firms toward modification efforts.

(6) A case of intentional downgrading (Case E) showed that they could also upgrade again as they wished.

(7) All the cases involved modification carried out while the technology collaboration was still ongoing. Technology collaboration, therefore, does not necessarily have to result in an eternal reliance upon foreign technology if the recipient staff are competent.

To sum up, the competency of local engineer, working in a competitive market is a key element in any potential technology development.

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