IDRC-171e

Absorption and diffusion of imported technology

Proceedings of a workshop held in Singapore, 26-30 January 1981

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Absorption and Diffusion of Imported Technology : proceedings of a workshop held in Singapore, 26–30 January 1981. Ottawa, Ont., IDRC, 1983. 112 p. : ill.

/Science policy/, /technology transfer/, /choice of technology/, /technological change/, /South Asia/, /Indonesia/, /Korea R./, /Philippines/ — /small-scale industry/, /textile industry/, /self-reliance/, /employment opportunities/, /foreign investments/, /case studies/, /comparative analysis/, /list of participants/.

UDC: 62.001.1

ISBN: 0-88936-298-X

Microfiche edition available

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Analysis of Systems Behaviour in the Absorption and Diffusion of Imported Technology

Suck-chul Yoon[1]

This paper aims to systematize the major findings from a case study of the absorption and diffusion of imported machinery technology in Korea during the 1970s. A systems approach was used in order to view the whole system macroscopically.

Even though the word "system" has been defined in many ways, all definitions agree that a system is a set of parts coordinated to accomplish a set of goals. Regardless of the definition chosen, one can outline five basic considerations that must be kept in mind when applying a systems approach: (1) the total system objectives and, more specifically, the performance measures of the whole system; (2) the system's environment or fixed constraints; (3) the components of the system, the activities and goals; (4) the resources of the system; and (5) the control of the system. Each of these aspects will be discussed in detail.

System Objectives

An industrial technology is not like an object of art, which can exist by itself. It is merely a "subsystem" of a more comprehensive system, the latter usually a business corporation, which may employ the industrial technology as a means to conduct its business or achieve economic goals. In other words, the objectives of an industrial technology are only viable within the constraints of the more comprehensive system's objectives, which are usually oriented toward economic efficiency.

Thus, it is quite natural to assume that an appropriate industrial technology is determined not only by technological but also by economical dimensions. It is often argued that it is only possible for large-scale, centralized, capital- and energy-intensive technology to exist in a society where a whole host of special conditions are satisfied. Therefore, western technology is inappropriate in underdeveloped countries and western aid should not concentrate on helping underdeveloped countries to acquire the kind of technology developed countries rely upon.

This "appropriateness" issue was considered in the case study under discussion and three hypotheses were set up to investigate its validity:

(1) Western technology is capital intensive, it uses a lot of expensive machinery and little labour.

(2) Western technology depends upon a supply of highly skilled labour of all kinds, from skilled manual workers to managers. This cannot be easily provided by most underdeveloped countries. For this reason, an imported plant is either run inefficiently or else its operation depends upon foreign experts.

(3) Western technology is extremely expensive and its import by an underdeveloped country means a significant drain on foreign reserves. Interestingly, executives and top managers of Daewoo Heavy Industry (DHI) agreed that their diesel-engine technology deserved all of these criticisms.

As for the argument of capital intensiveness, DHI tried to solve the problem by running the plant on a three-shift basis instead of one shift, as originally designed. Because interest rates in Korea were three times higher than in western countries, it was believed that plants erected using borrowed foreign capital should be exploited three times as much.

Regarding the demand for highly skilled labour, this created problems for the company from the outset of its operation, even though manpower employment contracts with the technology supplier alleviated the problem considerably.

Concerning the expensiveness and foreign

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reserve drainage, the company began to face insurmountable financial difficulties and eventually came under the "financial control" of the Korea Development Bank, the company's major creditor. Seeing the situation evolving in this way, the Korean government began to seek a private company that might be competent enough to overcome the managerial and technical predicament into which the company had fallen. Under these circumstances, the Daewoo Industrial Company was chosen and persuaded by the Korean government to take over the ailing company in 1976.

Thus, a conclusion drawn at this stage of the analysis might confirm the hypothesis that large-scale, centralized, capital- and energy-intensive technology is inappropriate for underdeveloped countries and that western aid should not concentrate on helping underdeveloped countries to acquire the kind of technology developed countries rely upon. Further study, however, revealed that some environmental changes, either by chance or by governmental action, can play a decisive role in changing the entire behaviour of a technological system.

Environments and Their Impact

The environment of a system is what lies outside of the system. This is not an easy matter to determine because not only is the environment something that is outside the system's control, but it is also something that determines, in part, how the system performs. In the case of an industrial firm, sales demand lies within the environment of the system because its nature influences system performance.

In 1975, there were three major automobile manufacturers in Korea, each of them reluctant to use domestically produced engines. There were several reasons for their reluctance. Firstly, they had no confidence in the quality of domestic engines. The manufacturers were already having enough problems with the quality of many other automobile parts that were being supplied domestically. Secondly, there were either insufficient or negative price incentives to use domestic engines. This surprising phenomenon came about for the following reasons:

(1) Due to restricted market size, "economy of scale" in production was not achievable.

(2) Most parts and raw materials were imported from abroad at a higher cost because the quantity ordered was not large enough (also due to small market size) to qualify for a cheaper price; also, most buyers were in a captive position.

(3) Due to financial infirmity, production facilities were usually bought through foreign or domestic loans, thereby resulting in heavier interest burdens.

(4) Costs incurred as a result of technical inexperience and lack of management know-how were transferred to the price of the products. For these reasons, domestic machinery products were more expensive than imported goods.

In an environment with this kind of confidence gap and negative price incentives, the engines produced by the Hanki Corporation in 1975 could not find their way onto the market and the diesel-engine project fell into financial difficulties. Hence, personnel who were employed in the diesel-engine project were transferred to other projects, either voluntarily or involuntarily. The company could not afford to keep highly paid technical personnel working on a project when the project was losing money due to a lack of market demand for the products produced. Without the continuity of demand for the products, it was not possible to retain those employees engaged in the technical activities of production. This, in turn, rendered the continual absorption and accumulation of technical knowledge in the area torpid or even backward.

This case study proposes, therefore, that the rate of absorption of an imported technology is heavily affected by an environmental factor — the nature of demand for the products the technology produces.

Encouraged by the Korean government, Daewoo Industrial Company bought the controlling portion of Hanki Corporation's equity. The first major step Daewoo Industrial Company took was to ask the Korean government to impose a ban on the importation of diesel engines from foreign countries. The Korean government accepted the appeal on the condition that the price of the diesel engines produced by Daewoo Industrial Company would come under the control of the government.

During the latter half of the 1970s, the Korean economy, on the whole, grew at more than 10% annually, and real industrial growth averaged about 30% per annum. Accordingly, transportation requirements rose rapidly during the same period and shortages of trucks and buses began to emerge.

If it can be assumed that the steady approach of the rate of output to the designed capacity and the decreasing rate of defective items are quantifiable indicators of the rate of absorption of an imported technology, Table 1 can be used to corroborate the hypothesis that manufacturing know-how and related technical activities are steadily absorbed and accumulated in a company

Table 1. Diesel-engine output, 1975–1978.

	1975	1976	1977	1978
Design capacity	24000	24000	24000	24000
Actual production[a]	1120	2578	9385	15206
Sales	285	3119	9313	15041
Defective (%)	30.78	27.15	20.45	15.42

[a]Actual production figures = gross production – defective items.

as the market demand for the products produced using the imported technology becomes stable and steady. However, for the technological breakthrough to be achieved in this case, environmental or market changes were not solely responsible; there were many other interrelated problems to be cleared up, problems resulting from the fact that a technological system is comprised of a multitude of subsystems that are interrelated with each other.

Interrelationships among Subsystems

A major technical problem encountered from outside the system boundary was to mount the MAN (Machienenfabrik in Augusburg und Nürnberg) engines in buses and trucks that were being manufactured by the three major automakers. Engines are not final products by themselves, i.e., an engine is a subsystem of a larger system. There always exists a certain degree of interrelationship between a subsystem and its global system. Hence, for an engine to be mounted in a vehicle, some technical problems to integrate the two into a total functioning system must be worked out unless the two were initially designed as a system. However, because Korean automobile manufacturers were already producing trucks and buses with imported engines up to 1975, technically, it was not immediately possible for the MAN engines to be mounted in the vehicles that were being produced. Considering that the licencing agreement did not contain or mention anything about this kind of adaptation problem, it was, apparently, a mistake on the company's part not to have considered that this kind of problem might occur.

After taking over the company, Daewoo Industrial Company launched a project to solve the mounting difficulty. Firstly, Daewoo Industrial Company's project team worked in close contact with the Korea Institute of Science and Technology (KIST), a research institute established by the Korean government to help business industries solve technology-related problems. In addition, Daewoo Industrial Company asked MAN for assistance. In the beginning, MAN was reluctant to provide extra assistance that was not included in the licencing agreement. However, at Daewoo Industrial Company's repeated and earnest request and after having learned about the seriousness of the barrier to the market due to this mounting difficulty, MAN began to help by providing technical information and assistance to solve the adaptation problem. After almost a year's struggle, the problem was solved satisfactorily.

The quality level of a technological system is determined by the lowest quality level that a subsystem of the system attains. This system relatedness, between the global system and its subsystems, is responsible for the diffusion of technology to other firms supplying parts. In recognition of this, Daewoo Industrial Company launched a program, in line with governmental directives, to assist small parts-manufacturing firms by providing technical know-how combined with financial support, a quasi-forced diffusion! This program started noticeably in 1976 and achieved considerable success not only in localizing materials and parts but also in enhancing their quality level.

Resources of Industrial Technology

Resources are the general reservoir out of which the specific actions of the system can be shaped. The specific actions a business corporation can take regarding its industrial technology are to import foreign technologies, adapt them to their specific needs, diffuse them voluntarily or involuntarily, or develop their own technology. During the course of this case study, it was found that even though the localization and quality enhancement program discussed earlier succeeded insofar as to contribute significantly to production-cost reduction and foreign currency savings, foreign dependence was still significant, particularly in the area of engineering design. "Engineering design," remarked a chief engineer who had been engaged in the diesel-engine project at DHI, "requires, as it were, 'know-why,' if manufacturing products as already designed in the blueprints provided by the licencing agreement could be said to require what they call 'know-how'."

According to this explanation, manufacturing know-how could be incorporated in manuals, blueprints, or other forms of documents with relative ease, whereas know-why can only come from the general reservoir of basic sciences in which developing countries are normally weak,

i.e., the general knowledge of basic sciences, which is needed to understand the basis upon which numerical data, mathematical dimensions, and geometrical configurations are calculated, selected, and decided upon, cannot be concentrated in a neat container, to be transferred from an advanced country to a developing country. This kind of know-why barrier was felt so seriously when DHI tried to add a couple of new models to their production line that they had to make another licencing agreement with a Japanese diesel-engine maker in 1977 as a result. On the other hand, it cannot be assumed that firm-specific technology, which can give a firm a real competitive edge in international markets, is normally not accessible to developing countries. Foreign technologies, which developing countries can buy from advanced countries, however, are likely to be restricted to a narrow spectrum of system-specific technologies.

Thus, the following hypothesis can be drawn concerning resources for developing countries to rely upon for their technological development: Even though the know-how portion of system-specific technologies may constitute resources for developing countries to utilize, the know-why level and internationally competitive firm-specific technologies are generally not transferable from advanced countries to developing countries.

Management or Control of the System

The management of a system deals with the generation of plans for the system, i.e., consideration of the overall goals, environment, utilization of resources, and components. Not only does the management of a system generate the plans of the system, but it must also make sure that the plans are being carried out in accordance with its original ideas. If they are not, management must determine why they are not. This activity is often called control of the system.

Goals of the System

From the standpoint of a developing country, one of the most important goals of its industrial technology systems is to import foreign technologies and absorb and diffuse them within the nation to build up technological capabilities. In addition, a developing country normally has another goal to pursue — to manufacture products utilizing imported technologies and to sell them in the international markets in order to earn foreign currency.

These goals, however, can easily conflict with each other. If a developing country wishes to pursue the goal of learning, absorbing, and diffusing imported technologies, it should start with simple technologies because simple technologies are believed to be easier to learn. On the other hand, when developing countries hope to produce products that will be competitive in international markets, the requirements of product quality (of which precision, standardization, and consistency of manufacturing process are primary determinants) demand importation of techniques that are usually sophisticated with specialized automation and numerical control mechanisms. These sophisticated technologies are believed to be much harder to learn than simpler technologies.

Hence, the importation of sophisticated technologies in order to be competitive in international markets could frustrate the process of learning, absorbing, and diffusing imported technologies. To the extent that this reasoning is valid, the following conclusion can be drawn: A developing country should strategically choose between two extreme policy alternatives: one is to emphasize being competitive in international markets in the short run and the other to build up technological capabilities as a long-term goal.

The Environment

In most developing countries, firms cannot support highly-paid technical manpower in money-losing projects. Therefore, if the demand for the merchandise produced using imported technologies is not secure, it is not possible to retain those people engaged in the technical activities of production. Furthermore, this results in the breakdown of absorption and accumulation of technological knowledge. Hence, in order for a developing country to secure continuous and sound absorption of imported foreign technologies, governmental control over the degree of competition among firms using similar technologies is needed. This could be accomplished by restricting the number of approvals to import foreign technologies of a similar kind so that competition might not be too excessive for the market size.

Excessive competition among firms using similar techniques also affects the diffusion of technology. The case study revealed that the diffusion of technologies took place through engineers who moved to other competing firms to obtain promotions and higher salaries. This kind of manpower robbery may contribute to the diffusion of technologies in the short run, but it

proved to be detrimental to the sound accumulation of technologies at the firm level. In a developing country, sound absorption and accumulation of technologies should be the first priority, after which healthy diffusion may be possible.

In recognition of the need for environmental control policies, the Korean government resolved to force major firms competing excessively in the field of automobiles, power-generating facilities, heavy electrical equipment, etc. to merge in 1980.

Resources

Superficially, the fact that underdeveloped countries tend to get all, or nearly all, of their needed technologies from foreign sources may look like the rather obvious result of a particular aspect of the comparative advantage theory of world economics. However, if an economy that is short of particular skills or technologies continuously relies upon external sources of technical knowledge, the opportunities to nurture domestic resources, such as scientists, engineers, technical managers, and technicians, are very likely to be narrowed. This will be particularly true when the transfer process is packaged. Hence, efforts by a developing country to "unpackage" the transfer process will doubtlessly be conducive to raising domestic technological resources through the learning-by-doing opportunities offered during the unpackaging process.

There are, however, some problems with the unpackaging transfer process. The first is a financial problem. Unpackaging the transfer process involves risks. If the size of the financial risks involved seems too great for the technology-importing firm to bear, the unpackaging decision will be difficult. Normally, business firms in developing countries are not financially strong enough to undertake unpackaging the transfer process.

The second problem is of a technical nature. Unpackaging itself takes a certain degree of know-how. When the firm importing technology from an advanced country is ignorant of the technology, the firm will likely be ignorant about methods to unpackage the process. Unpackaging is, therefore, not possible for technology-importing firms until they reach at least a minimum level of technological capability to unpackage the transfer process.

These problems constitute barriers to the desire to unpackage the process of technology transfer from the standpoint of developing countries. In particular, they created difficulties for engineering firms in Korea during the 1970s.

Interrelationships among Subsystems

The gains from learning-by-doing are normally external economies as far as individual enterprises in the developing country are concerned, i.e., the enterprise itself, which makes the decision to purchase domestic skills, may not benefit from the skills and experiences developed and accumulated in the country due to this decision. Thus, the individual private enterprise left to itself in the world technology market will attach little importance to building up local technological capabilities, i.e., private companies are apt to pursue suboptimization as long as the state government does not interfere in the market to produce nationally optimal results.