Findings from Systems Analysis on Absorption and Diffusion of Imported Foreign Technology

Suck-Chul Yoon

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Preface

This paper aims to systematize major findings from a case study on absorption and diffusion of imported machine technology into Korea during the 1970's. The author resorted to a systems approach in order to view the whole system macroscopically.

Even though the word 'system' has been defined in many ways, all definitions incorporate a set of parts coordinated to accomplish a set of goals. Regardless of the choice of definitions, one can outline five basic considerations which must be kept in mind when applying a systems approach:

1. total system objectives and more specifically, performance measures of the whole system
2. the system's environment or fixed constraints
3. components of the system, their activities and goals
4. resources of the system
5. control of the system

This paper will concentrate on what the objectives of industrial technology

筆者：서울大學校 經營大學 經營硏究所 硏究員, 서울大學校 經營大學 副敎授

are, what environment the technological system is in, how the total system is supported by the activities of its subsystems, characteristics of the resources of the system, and finally, how the system should be controlled or managed.

System Objectives

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

Hence it is quite natural to assume that an appropriate industrial technology is determined not only by technological dimensions but also by economic ones. 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 can be inappropriate for underdeveloped countries, and western aid should not necessarily concentrate on helping underdeveloped countries acquire the kind of technology developed countries rely on.

This 'appropriateness' issue was taken up from the standpoint of both technology and economics in case study. Three hypotheses were proposed to investigate their validity with respect to our case:

1) Western technology is capital intensive, requiring much expensive machinery and little labor.

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

3) Western technology is extremely expensive and its import by an under-

developed country means a significant drain on foreign reserves.

Interestingly, executives and top managers of the case study subject, Daewoo Heavy Industries (DHI), agreed that their diesel engine technology deserved all the above criticisms.

As for the first 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. Since interest rates in Korea are about three times higher than in the West, they believed plants erected on borrowed foreign capital should be exploited about three times more than in western countries.

As for the second argument of demand for highly skilled labor, this was indeed a problem for the company even though a manpower employment contract with the technology supplier alleviated the problem considerably.

Concerning the third point of expense and foreign reserve drainage, the company actually began to face insurmountable financial troubles and eventually fell into the state of what was called 'financial control' by the Korea Development Bank, who was the company's major creditor. Observing these developments, the Korean government decided to seek a private company which might be competent enough to overcome the managerial and technical predicament into which the company had fallen. It was under these circumstances that the Daewoo Industrial Company was chosen and persuaded by the Korean government to take over the ailing Hanki Company in 1976.

Thus a conclusion drawn at this stage of our analysis might confirm the hypothesis that large scale, centralized, capital and energy intensive technology is inappropriate to underdeveloped countries and that western aid should not concentrate on helping underdeveloped countries acquire the kind of technology developed countries rely on. However, further study revealed that some environmental changes either by chance or by governmental action, could play a decisive role in changing the behavior a technological system. What constitutes the 'environments' of a technological system and how they affect the performance of the system will be discussed in the following section.

The Impact of Environment

The next aspect of the system we are talking about is its environment. The environment of a system is what lies outside of the system. This boundary is not always easy to distinguish since the environment is not only something outside the system's control, but also something that determines in part how the system performs. In the case of an industrial firm, sales demand is a part of the environment of the system because it is a given, and because its nature influences system performance.

In 1975 there were three major automobile manufacturers in Korea, all three of whom were reluctant to use domestically produced engines. There were several reasons for their reluctance. First, they had no confidence in the quality of domestic engines — there were enough problems already with the quality of many other automobile parts which were domestically supplied. Second, there were either insufficient of even negative price incentives to use domestic engines. This surprising phenomenon was caused by the following reasons:

(i) Restricted market size, limiting the economy of scale because large scale production could not be attained.

(ii) Most of the raw materials and precision components had to be imported at relatively high cost — partly because the buyers were dependent on a sole source, and partly because the quantities were not large enough to enable the buyers to negotiate a more favorable price.

(iii) Due to financial weakness, production facilities were ordinarily bought on foreign or domestic loans resulting in heavy interest burdens.

(iv) Costs incurred from technical inexperience and lack of management know-how translated into higher prices for their products.

For these reasons domestic machinery products were by and large more expensive than imported ones.

In an environment with this kind of confidence gap and negative price incentive, the engines produced by Hanki Corporation in 1975 could not find their way into the market and their diesel engine project fell into financial trouble. Personnel employed in the diesel engine project began to transfer to other projects either voluntarily or involuntarily because the company could not afford to keep highly paid technical personnel in a project where they were losing money due to lack of market demand for the products the project produced. And with no demand for their products the continuity of men engaged in technical production was not possible. This in turn stifled absorption and accumulation of technical knowledge of production techniques, and contributed yet further to the project's declines.

Therefore this case study proposes another hypothesis, "The rate of absorption of imported technology is heavily affected by the environmental factor—the nature of demand for the products which the technology produces." This hypothesis is supported by further analyses of the case as follows.

Encouraged by the Korean government, Daewoo bought a controlling portion of Hanki's equity. The first major step Daewoo took was to ask the Korean government to impose a ban on the import of diesel engines from foreign countries. The Korean government accepted this appeal, but on the condition that the price of diesel engines produced by Daewoo would come under the control of the government. Meanwhile during the latter half of the 1970's, the Korean economy as a whole grew more than 10 percent annually, while real industrial growth averaged about 30 percent per annum. Accordingly, total transportation requirements rose rapidly during the same period and shortages in trucks and buses began to emerge.

If we presume a steady increase in the output rate up to design capacity, and that a decreasing rate of defective items are quantifiable indicators for the rate of absorption of imported technology, then Table 1 will corroborate our hypothesis that manufacturing know-how and related technical activities are steadily absorbed and accumulated in the company at the same time while

Table 1. A steady increase in the output rate and decline in the defective rate are quantitative indications of the rate of absorption of imported technology.

	1975	1976	1977	1978	1979	1980	1981
Production Capacity	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Actual Production	1,120	2,578	9,385	15,206	16,200	15,300	15,010
Sales	285	3,119	9,313	15,041	16,144	14,219	13,111
Defective (%)	30.78	27.15	20.45	15.42	12.50	11.35	10.50

market demand develops.

Environmental and market changes were far from being solely responsible for technological assimilation, there were other interrelated considerations as well.

These considerations ensued from the fact that a technological system is comprised of a multitude of interrelated subsystems, and that this kind of system nature shows up persistently both upwards and downwards. This characteristic of our technological system will be discussed in the following section.

Interrelations Among Subsystems

A major technical problem encountered from outside the system boundary was to mount West German MAN engines on bus and truck chassis manufactured by the three major auto makers. Engines are not final products in themselves, rather they are components of a bigger system, and of course there always exists a direct relationship between sub and global systems. For an engine to be mounted on a vehicle, some technical integration difficulties are to be expected unless the two were designed initially as a single system. Although Korean automobile manufacturers were already producing trucks and buses with imported Japanese engines before 1975, it was not feasible to mount the West German engines directly onto the existing chassis without extensive modifications. Since the licensing agreement did not mention anything about adaptation problems, it was a serious shortsight for the company to

have failed to anticipate this kind of problem.

After taking over the company, Daewoo launched a project to resolve the engine installation problem. First, Daewoo's project team worked in close contact with KIST or the Korea Institute of Science and Technology—a research institute established by the Korean government to help industry solve technology-related problems. Further, in crucially important technical areas which called for in-depth engineering resources, Daewoo asked MAN for assistance. MAN was initially reluctant to give assistance not provided for in the licensing agreement, but after realizing the seriousness of the engine installation problem, MAN began to help by opening some of their engineering resources to Daewoo and providing technical information. And after almost a year's struggle, the problem was resolved satisfactorily.

The downward system nature of machine systems leads us to conclude that the overall quality of a mechanical system is likely to be determined by the lowest quality level to which a component of the system falls. The relation between a technological system and its subsystems is responsible for the diffusion of technology to other firms supplying parts.

A machine is composed of a large number of functional parts or components. A sewing machine for example, comprises about 200 to 500 parts depending on its degree of sophistication. Hence it is often technically or economically unfeasible for one manufacturer to produce all parts in-house. It may be for this reason that the macrostructure of machine industry in industrially advanced countries such as Japan or West Germany, is based on coordination and cooperation among firms.

On the other hand, a machine is a fabricated system of parts or components functioning in conformity with each other to perform a specified job. Since the performance of the machine as a whole is ultimately determined by the performance of each functional part—one malfunctioning part could destroy the whole machine. Due to this high degree of system interdependence, high quality machine production entails that the performance of parts suppliers who

do not perform to specification must be enhanced if alternate suppliers are not available. In recognition of this need, Daewoo launched a program in line with governmental directives to assist parts-manufacturing firms by providing technical assistance combined with financial support. (A quasiforced diffusion!) This program, begun in 1976, achieved considerable success not only in localizing parts and materials but in enhancing their quality as well.

Resources of Industrial Technology

Resources are the general reservoir out of which the specific outputs of the system can be shaped. The specific actions a business corporation can take regarding its industrial technology are: to import foreign technologies, to adapt them to specific requirements, to diffuse them voluntarily or involuntarily, or to develop their own technology. In the course of this case analysis it was found that although the localization and quality enhancement program discussed in the previous section succeeded in reducing production costs and saving foreign currency, foreign dependence was still heavy—especially in areas 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'" as opposed to the 'know-how' required for the manufacture of already-designed products in blue prints provided by the licensing agreement.

According to his explanation, manufacturing know-how could be incorporated in manuals, blue prints, and other documents with relative ease, whereas know-why can only come from the general reservoir of people educated in the basic sciences—an area in which developing countries are not normally strong. The fundamental grounding in the basic sciences which is needed to understand the basis on which numerical data, physical dimensions, and geometrical configurations were calculated, selected, and decided, cannot be concentrated into a neat container to be transferred from an advanced country to a developing one. This kind of know-why barrier was felt so seriously that

when DHI tried to add some new models to their production line, they could not help but make another licensing agreement with a Japanese diesel engine maker in 1977.

It is reasonable to assume that firm-specific technology which can give a company a real competitive edge in international markets is not normally available to developing countries. Foreign technologies which developing countries could buy from advanced countries are likely to be restricted to a narrow spectrum of older state-of-the-art technologies. Therefore the following hypothesis can be drawn regarding resources developing countries need for technological development: even though the know-how portion of specific technologies can constitute resources for developing countries to utilize, design capability and internationally competitive firm-specific technologies are generally not transferable from advanced countries to developing ones.

Management and Control of the System

We now consider the last aspect of the system, its management. The management of a system has to deal with the generation of plans for the system, *i.e.*, consideration of the overall goals, the environment, the utilization of resources, and the components. Not only does the management of a system generate plans for the system, it must also make sure that those plans are being carried out in accordance with the original intent. If they are not, management must determine the reasons. This activity is often called control of the system.

(i) Goals of the System

From the standpoint of a developing country, one of the most important national goals is to import foreign technologies and diffuse them in order to build technological capabilities. On the other hand, a developing country has another goal to pursue—manufacture of products utilizing imported technologies for export in order to to earn foreign currency and alleviate their currency

shortage problem. However, these two goals can easily conflict with one another. If they wish to pursue the first goal of absorbing, learning, and diffusing imported technology, it would be best to start with simpler technologies since simpler technologies are believed to be easier to learn.

On the other hand when developing countries want their products to be competitive in international markets, the requirements of product quality of which precision, standardization, and consistency of manufacturing process are primary determinants, require importation of techniques which are usually sophisticated with specialized automation and numerical control mechanisms. These sophisticated technologies are believed to be much harder to learn than simpler technologies. Therefore the importation of sophisticated technologies in order to be competitive in international markets could frustrate the process of absorption, learning, and diffusion. To the extent that this reasoning is valid, the following conclusion can be drawn: a developing country should choose between two strategic policy alternatives—emphasis on competitiveness in international markets in the short run versus expansion of technological capabilities as long term optimization.

(ii) The Environment

In developing countries, few corporations are financially sound enough to support highly paid technical personnel in money losing projects. Therefore, if demand for the products manufactured using imported technology is not strong, the continuity of men engaged in technical production activities utilizing the technology is not secure, and when this skilled manpower continuity is broken the continual absorption and accumulation of technical knowledge is disrupted. So in order for a developing country to continuously absorb imported foreign technology, governmental regulation of the degree of competition among firms using similar technology may be beneficial. This could be done by means of restricting the number of approvals to import foreign technology of similar kind so that competition will not be excessive for the domestic market size.

Excessive competition among firms using similar techniques also has some-

thing to do with diffusion of the technology. The case analysis revealed that the diffusion of technology took place through the engineers who were lured to other competing firms with the prospect of promotions and higher salaries. This kind of manpower robbery may contribute to the diffusion of technology in the short run, but it proved to be detrimental to the sound accumulation of expertise in the parent corporation. In a developing country sound absorption and accumulation of technology should be secured first, since only after successful absorption of the technology will healthy diffusion be possible.

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

(iii) Resources

Superficially, the fact that underdeveloped countries tend to get all or nearly all of their technology from foreign resources may look like the result of a particular aspect of the comparative advantage theory of world economics. But if an economy which is short of particular skills or technology continuously relies on external sources of technical knowledge, the opportunities to nurture domestic resources such as scientists, engineers, technical managers and technicians are likely to be narrowed. This will be especially true when the transfer process is packaged. Hence attempts by a developing country to 'unpackage' the transfer process will doubtlessly be conducive to improving domestic technological resources through learning-by-doing opportunities offered during the unpackaged transfer process.

There are two fundamental difficulties in the unpackaging transfer process, however. The first difficulty is that unpackaging involves financial risks. If the size of financial risk involved seems too big for the technology-importing firm to bear, the 'unpackaging' decision may be deferred.

Most business firms in developing countries are not financially strong enough to dare to unpackage the transfer process. The second is a technical problem

in itself because deciding what to unpackage takes a certain degree of know-how. When the firm importing technology from an advanced country is in complete ignorance over the technology, the firm will probably also be ignorant about methods to unpackage the process. Unpackaging is, therefore, not possible for technology-importing firms until they reach a minimum level of technological capability. From the standpoint of developing countries, these two problems constitute the main barriers to their desire to unpackage the technology transfer process.

(iv) Interrelationships Among Subsystems

The gains from learning-by-doing is normally an external economy as far as the individual enterprise in a developing countries is concerned. The enterprise which makes the decision to employ domestic skills may not benefit from the experience and skills developed in his country due to his decision. So the individual private enterprise left to itself in the world technology market will attach little importance to building up local technical capabilities. In fact private companies are apt to pursue suboptimization unless the state government interferes in the market so as to achieve nationally optimal results.