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Absorption and diffusion of imported technology

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26-30 January 1981

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Absorption and Diffusion of Imported Technology: A Case Study in the Republic of Korea

Woo Hee Park¹

Methodology

Scope and Definition

The objective of this inquiry was to learn as much as possible about the absorption and diffusion of the industrial technologies that have been imported into the Republic of Korea from more advanced economies. Attempts were made to answer several questions: What techniques were available, which one was chosen, and why? Through what agency was the technology transferred? Which individuals, of which nationalities, and with which skills were involved? With what organization were these individuals affiliated? How rapidly and efficiently was the technology absorbed? What changes were made in the process and why? What improvements were subsequently made: by whom and with what consequences?

Common to each of the four case studies to be discussed was the set of questions to be answered and the definition of the terms "technology," "absorption," and "diffusion." Technology was taken to mean the entire body of knowledge necessary to fulfill a specific task, usually the production of a commodity. This would include the knowledge required to conceive the manufacturing technique; design and construct the plant and equipment incorporating the technique; bring the plant into operation; maintain efficient production; train all personnel involved; and secure improvements in existing operations and advance to superior techniques. Thus, the concept of technology includes knowledge of the manufacturing process or technique as well as knowledge of all the additional activities of applying, altering, and improving the technique.

Absorption refers to the process by which the imported technology is learned by one or more residents, usually working together, in the developing country, such that they can carry out all of the activities covered by the technology independent of the transferring agent from the developed country.

Diffusion refers to the further spread of technology, from its initial application, throughout the developing country. In principle, diffusion would be complete when everyone, producer or potential producer, has acquired the technology. In practice, however, diffusion will only be partial because, at best, knowledge is costly and time consuming to acquire and, at worst, it may be impossible to acquire due to secrecy or legal prohibition.

Measuring Absorption and Diffusion

Measures of absorption can be based upon labour's contribution, capital's contribution, and the contribution of all inputs taken together. "Labour absorption" is the proportion of individuals needed to carry out each phase of the process of absorption of technology, represented by nationals of the developing country, in this case the Republic of Korea. If Korean citizens are absent during a phase, the measure of absorption is zero; if they are omnipresent, the measure is unity. These two values, zero and unity, set the bounds, and the actual values will lie within their span.

"Capital absorption" covers only one phase in the process, the operating phase. If one imagines that the equipment incorporating the technique attains a particular rate of output when being operated at its full potential, this figure can be compared with the actual rate of output. To the extent that the actual rate of output approaches, or even surpasses, the design rate, the technique

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can be said to have been absorbed. Again, there will be a lower bound, of zero, to the absorption of capital; but there will, in principle, be no upper bound.

Both of these measures are appropriate only if all other complementary inputs, e.g., labour in the case of the measure of capital absorption, are present in sufficient amounts. If, however, there is not enough skilled labour, or raw material, to operate the equipment fully, then the actual rate of output as a fraction of design output is meaningless as a measure of capacity absorption. The third measure of absorption, unit or average cost as a fraction of some standard cost, does not suffer from this limitation because it allows for the contribution of all inputs together. Its limitation is that "standard cost" is not unambiguous: the "standard" could be the cost per unit at the full capacity rate of output, either as estimated when the equipment was designed or as encountered when the equipment was first operated at full capacity, or it could be the cost per unit incurred when the equipment began commercial operation, which accords well with the theory of cost reduction via learning.

With regard to measuring diffusion, the sequential pattern, through time, of adoptions by firms in the industry is not appropriate for the case studies discussed here except, possibly, that of the textile industry. The other industries are all monopolized, so the first adoption is the only one. To find measures of diffusion one must look to the suppliers of inputs for the firm absorbing the technology or to the customers. The most significant suppliers of inputs for developing countries are the capital-goods manufacturers: the higher (in value terms) the fraction of the plant and equipment supplied by local capital-goods manufacturers, the further technology has diffused. The same sort of measure can also be applied to suppliers of other inputs, e.g., materials or energy. If the basis for the measure of diffusion is the total cost of all inputs, then a more complete measure of diffusion to suppliers would be the fraction of the total cost of inputs supplied by domestic firms.

Similar quantitative measures do not exist for diffusion to customers; only general observations on the flow of technical knowledge to users of the product, e.g., universities, technical schools, and government.

Summary of Case Studies

Petrochemical Industry

Role of the Korean Government

The Korean government has affected the

outcome initially by specifying output targets in successive Five-Year Economic Development Plans, which determine the reallocation of scarce resources. The scale of individual projects has been influenced by the government's penchant for large plants; swayed by the argument that substantial economies of scale exist in modern petrochemical plants, the Korean government has usually granted monopolies in the production of the targeted output when production is being undertaken in Korea for the first time, or in the increase in targeted output when expansion of existing production is being undertaken. Therefore, the entire initial capacity is installed by one firm, and any increase in capacity between one plan and the next is also installed by one, occasionally the same, firm. In this way, the government has had its first effect on the rates of absorption and diffusion: absorption generally takes place at a slower pace in the larger plants than in smaller plants, and diffusion occurs at a slower pace in monopolistic industries than in competitive industries.

The Korean government's next concern was the degree of foreign ownership of petrochemical plants — none, part, or complete. Torn between conflicting desires of economizing on scarce foreign capital and retaining possession of productive assets for Korean citizens, the government chose fifty-fifty joint ventures, the only exceptions being the wholly domestically owned Hankook Caprolactam Corporation's plant at Ulsan and Dow's wholly owned chlorine-alkali plant at Yecheon. This precludes any choice of technique because the foreign partners always employ, in Korea, the same technology that they have employed successfully at home.

Picking a foreign participant, therefore, inevitably means picking a technique, with its subsequent effect on the rates of absorption and diffusion. Picking foreign participants in the petrochemical industry has meant picking capital-intensive processes of great technical sophistication, whose absorption and diffusion would be expected to be slow. Rather than denying the country the benefits of employing modern capital-intensive techniques, however, the Korean government has tried to compensate for the greater difficulties with respect to absorption by imposing conditions upon the foreign participants. For example, in the case of Korea Pacific Chemical Corporation (KPCC) the major conditions were fivefold: (1) the foreign partner, Dow Chemical, would reveal all of its designs and know-how to its Korean employees; (2) Korean engineers would be trained by Dow in the application of all the aspects of Dow's current technology — basic process design, detailed

equipment design and procurement, construction, testing, start-up, operation, and maintenance — and in the techniques employed in securing improvements to petrochemical technology; (3) Korean engineers would participate in each of these activities as quickly as possible and in sufficient numbers to replace Dow's expatriate engineers; (4) with some qualifications, Dow would automatically inform KPCC of improvements in the imported technology made by Dow or any of its licensees; and (5) KPCC could object, to the Korean government, if it ("it" being the president and executive vice-president of the firm, both Korean citizens) felt that Dow was not proceeding rapidly enough with the technology transfer process.

Conditions such as these are common to joint ventures in the Korean petrochemical industry and have even been imposed upon joint petrochemical ventures in other developing countries; but their enactment from country to country has been quite varied. In Korea, for example, they have been implemented both speedily and effectively. Another role the Korean government has played in the creation of the petrochemical industry is that of leader. The government has never withdrawn its interest in the industry, nor have ministers, planners, or other civil servants slackened in their enthusiasm and determination to secure maximum output and efficiency. In addition to government support, another factor urging the KPCC and other petrochemical firms on is the fear that the Korean government will accept nothing less than proficiency from them.

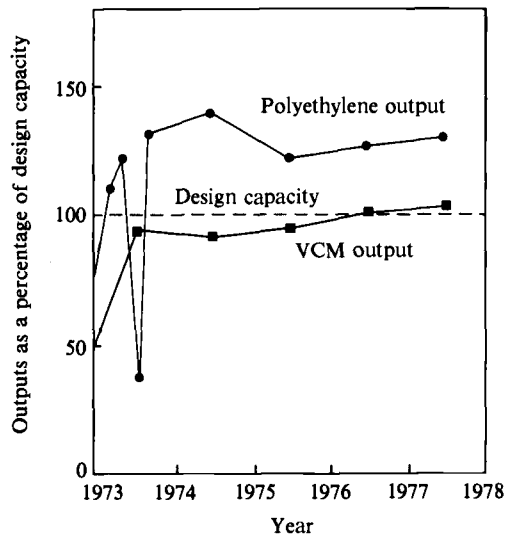


Fig. 1. Output of polyethylene and vinyl chloride monomer at the Ulsan plant as a percentage of design capacity, 1973-1977.

Evidence indicates that the degree of commitment of government to a country's economic development is closely related to the country's overall performance; the Korean government's attitudes and behaviour and the petrochemical industry's achievements conform to this pattern.

Finally, the Korean government has tried to make available the resources necessary for Korean petrochemical firms to operate efficiently. Inputs, particularly the raw materials from petroleum, have been continuously provided in sufficient quantity to maintain production rates at full capacity. More importantly for the absorption of technology, however, is the fact that engineers have been educated at universities and given their initial experience in public firms (particularly the fertilizer producer, Korea General Chemical Company) and operators have been trained at technical schools in sufficient numbers to completely staff petrochemical firms with Koreans. Education in technical subjects is given high priority by a government dedicated to the industrialization of its economy.

Absorption of Imported Technology

Throughout the establishment of the Korean petrochemical industry, it was essentially the government's decisions that determined what type of technology would be imported and what means would be available to absorb it. The result was rapid and successful absorption of petrochemical technology.

Figure 1 illustrates the yearly rates of polyethylene and vinyl chloride monomer (VCM) production at KPCC's Ulsan plant through the years from its process design, commencing in 1970, to its start-up in January 1973, until the end of 1977. The graph of polyethylene production shows that full design capacity output was surpassed after 6 months and, except for a brief period in 1973, has never since fallen below that level. The graph of VCM production shows a quick start-up and steadily rising production, but failure to reach design capacity until 1976, 3 years after start-up. If the standard for full absorption of technology is the rapid attainment of high and sustained rates of output, KPCC can be said to have achieved it almost immediately; if, on the other hand, the standard is the attainment of rates of output equal to or exceeding the capacity for which the plant was designed, KPCC can be said to have achieved it after approximately 2 years, the average for the two products.

There is a distinction to be made between absorption by a firm and absorption by a nation. The latter is a more stringent concept, because a company can absorb a technology completely without using any engineers native to the country

in which it is operating. To the extent that KPCC absorbed the low density polyethylene (LDPE) and VCM operating technology with Dow Chemical's engineers, the absorption cannot be said to be complete from Korea's point of view. Only when the Ulsan plant was operating steadily, or at full capacity, with Korean engineers in full command would absorption be complete in national terms. Figure 2 illustrates this point.

In Fig. 2 the upper horizontal axis, relating to the experience of the plant at Ulsan, extends from 1970-1977. The lower horizontal axis extends over an equally long period, October 1978 - October 1983, appropriate for the Yecheon plant. Thus a point at the top of the graph (equal to 100%) indicates wholly foreign participation in the technology and a point coinciding with the horizontal axis (equal to 0%) indicates wholly Korean participation.

The two plots in Fig. 2 refer to the course of participation in the first of KPCC's petrochemical plants at Ulsan and the second at Yecheon. As would be expected, the second plant, occurring about 6 years after the first and

exploiting what had already been learned, utilizes Korean engineers to a greater extent. The dramatic shift downward occurred in the design and procurement stages of the technology; Korean engineers demonstrated that they had at least partially absorbed these difficult technical tasks. Nevertheless, if one is strict in one's definition of absorption, only 100% participation by Korean engineers in all stages would indicate complete absorption of the technology.

Used in conjunction, Figs. 1 and 2 indicate how quickly Korean engineers were capable of sustaining, on their own, either a high rate of output or full capacity operation.

Thus, when reasons are sought for the rapid rate of absorption of petrochemical technology in Korea the answers become largely subjective. The necessary human resources have been available, as a result of government's foresight in stressing engineering education and training; there have been carefully designed and rigorously implemented plans for the transfer of technological knowledge and experience from Dow Chemical's American engineers to KPCC's Korean engineers; and there has been a large

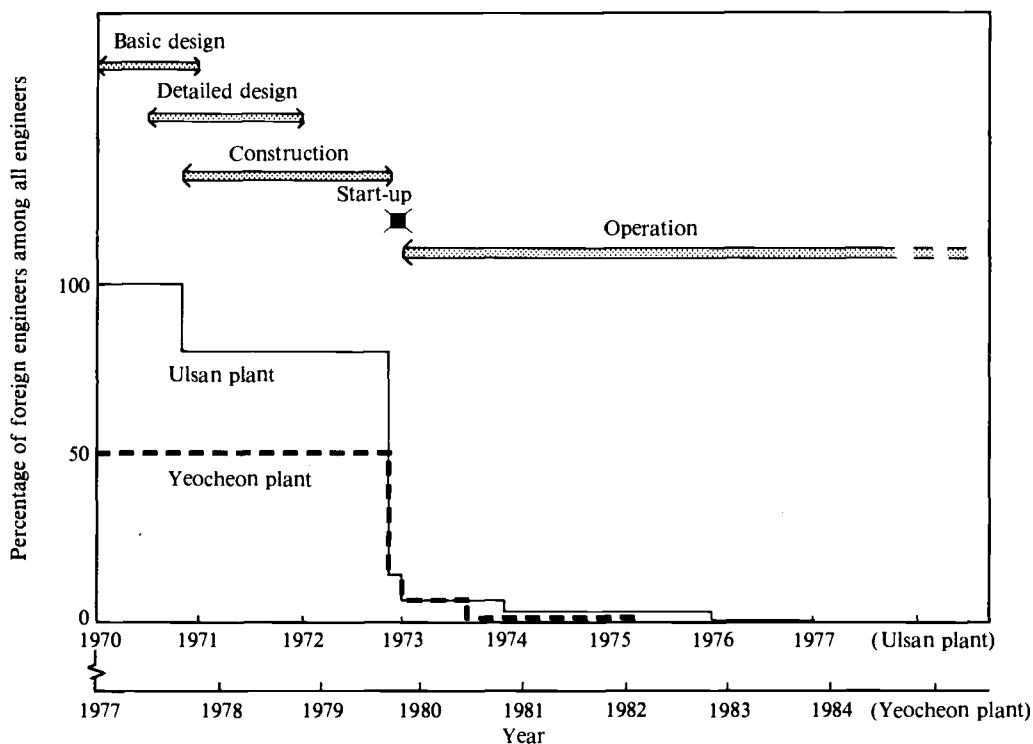


Fig. 2. Participation of foreign engineers at various stages in the absorption of imported technology at the Ulsan (1970-1977) and Yecheon (1975-1982) plants.

market in Korea eagerly demanding all the petrochemicals that can be produced. Nevertheless, the Korean government's impetus and Dow Chemical's cooperation were not, even together, sufficient to explain the rapid absorption. In addition, therefore, it is suggested that the rapid absorption may also be due, in part, to the desire of Korean engineers to acquire modern technical knowledge.

Diffusion of Imported Technology

Diffusion of imported technology in the Korean petrochemical industry has been slow. Diffusion to other firms manufacturing the same products has seldom occurred, for the simple reason that there has not been, and will not be before the completion of a third petrochemical complex, much competition. Where competition has existed, as in the manufacture of caprolactam, engineers have moved in some numbers from the first firm in production to its two successors. Where competition has not been created, as in the case of KPCC's products LDPE and VCM, there has been almost no turnover of personnel at all.

At the same time, however, it is chiefly through the movement of engineers from one petrochemical firm to another, or chemical firms in general, that diffusion can take place in Korea. Engineering principles are freely communicated, but all the technological knowledge that is collected under the term "know-how," without which plants and equipment cannot be designed, constructed, and operated, is not. Know-how accompanies licencing agreements, but in their absence moves only as a result of engineers who change employment. If Korean engineers working in the petrochemical industry do not change employment, their know-how will not be deployed.

That know-how should be kept secret within a firm is not a Korean institution but one acquired, along with the technology, from the petrochemical industry of the developed world. When Korea imported petrochemical technology, it necessarily imported the manner of handling the technology; it would not have received the technology unless it had agreed to honour its privacy. Perhaps the Korean nation could get along without the secrecy surrounding the know-how, but it could not have got along without the know-how itself, and it had to accept the former to obtain the latter. In this manner, the international scheme of confidentiality has been imposed upon the Korean petrochemical industry, and has reduced the diffusion of the imported technology within it.

Diffusion outside the petrochemical industry

has occurred to some extent, mainly through dissemination of knowledge related to equipment design and construction to capital-goods manufacturers. Although there has been a steady increase in the fraction of locally produced capital equipment incorporated in Korean petrochemical plants, it is difficult to state how much further localization of equipment can and should proceed.

Thus, the rate of absorption of imported technology in the petrochemical industry has been rapid, and substantial improvements have been made in that part of the technology relating to ancillary processes. The rapid absorption has stemmed from the Korean government's policies and actions, the foreign participants' planning and experience, and, above all, the attitudes of Korean engineers. The rate of diffusion of the imported technology, however, appears to have been much less rapid, as expected in a young industry, most of whose firms have been granted producing monopolies. The secrecy endemic to petrochemical and chemical industries helped to retard diffusion, whereas the government's program of equipment localization has helped to accelerate it. Finally, the Korean government, in its many roles, has exerted a strong influence on the choice of the technology that is to be imported and an equally strong influence on the speed with which the technology is absorbed.

Iron and Steel

Pohang Iron and Steel Co. Ltd. (POSCO) was the nation's first integrated iron and steel mill with a modern and large-scale continuous production system of iron and steel making and rolling. Most of the technology necessary for the construction and operation of the mill was imported. Because the capital requirements were met through the introduction of a credit line with Japan, a considerable part of the technology and facilities was imported from Japan. Under technical project contracts, the Japan Group (JG) advised and guided the construction and operation of POSCO. Little by little, POSCO has accumulated technology and is going to expand its fourth-stage facilities with its own accumulated technology.

Pohang Iron and Steel Co. Ltd. has seen remarkable progress in the absorption of technology related to planning and construction engineering, whereas core technology, such as the design and supply of facilities, is still primitive. The rapid absorption of field engineering technology can be largely attributed to the training of POSCO engineers in developed countries and the use of highly skilled and educated foremen.

Development of steel products has centred on plain carbon steel, used for general structural purposes, equipment, and in core technology. Thus, the development of the machinery industry is urged along with the steel industry. Because POSCO has only a 10-year history of technology accumulation, its expenditures on research and development are negligible.

Machinery

Role of the Korean Government

During the First and Second Five-Year Economic Development Plans (1962-1971), with capital accumulation and the scale of industries at a relatively low level, business enterprises in Korea could finance most of their equipment through foreign loans rather than public issues of stocks and debentures. Under these circumstances, the Korean government, being aware of the far-reaching impact of foreign investment on the national economy, established guidelines for foreign capital inducement.

(1) In order to ensure sound financial structure, entrepreneurs undertaking heavy and chemical projects were requested to secure their own capital for more than 30% of the total investment. Foreign capital was to be limited, in principle, to not more than 60% of the total investment. Foreign loans and investments were to be utilized, when required, for the acquisition of capital goods and advanced technology that were not available locally.

(2) Although priority was given to loans with favourable terms, direct foreign investments were also to be authorized. Such investments were to be encouraged, particularly when they would help secure dependable sources of raw materials, expand markets for products, or induce the input of advanced technology.

(3) In order to effectively support the development of the heavy and chemical industries, tax privileges under the Foreign Capital Inducement Act and other tax laws were prepared and presented by the government. Income and corporation taxes on foreign-invested enterprises were exempted or reduced in proportion to the percentage of stocks or shares that foreign investors held in the enterprise. Other taxes were also subject to reductions or exemptions.

(4) Industrial sites were selected and constructed under governmental initiative. In order to support construction of the selected industrial sites, the Industrial Site Development Promotion Law was enacted in 1973, and the Korean Water Resource Development Corporation, established in 1967, was reformed into the Indus-

trial Site Corporation.

Because the less-advanced industrial structure and resulting heavy import of capital goods, as well as industrial raw materials, have not only caused serious balance of payment problems but also made the economy more dependent upon foreign savings, basic governmental policy focused on the enhancement of industrial independence through increased domestic production of industrial raw materials and capital goods. With a view toward enhancing self-sufficiency in industrial raw materials, the steel, petrochemical, and nonferrous metal industries have been selected for intensive development. On the other hand, in order to promote self-sufficiency through localization of capital goods, equipment, and parts, the government also selected the machinery and electronics industries as industries destined for emphasized support.

Absorption of Imported Technology

During the course of the case study, a conclusion was drawn that the absorption of imported technology is highly dependent upon the continuity of demand for the products produced by the technology. For example, during the early stages of diesel engine production in Korea, there was not enough demand in the market for the engines. Hence, personnel employed in the diesel engine project were transferred to other projects. The company could not afford to keep personnel working on the project when it was losing money due to a lack of market demand for the product. Thus, when the continuity of personnel engaged in the technical activities of production is broken, the continual accumulation of technical knowledge in the related area will also be seriously hampered.

Because the technology involved in the production of diesel engines is sophisticated, it is not to be expected that Korean engineers would accomplish major technical changes in a short period of time. However, during the 4 years of successful operation of the plant, there have been numerous cases of technological improvement, which were motivated through the movements of raw material savings and loss prevention. These movements were integrated as part of the Saemaeul Movement, which was a government-sponsored nationwide activity encouraging the whole nation to be more productive and constructive through maintaining new attitudes and spirits. The movements resulted in the production of ductile cast iron, the invention of new methods by which raw materials and expendable supplies could be saved, and the reduction of defective products. All of these technological improvements were conducive to lowering costs.

Diffusion of Technology

As in the petrochemical industry, diffusion of the imported technology to other competing firms took place through engineers who moved to other competing firms to obtain promotions and higher salaries. Furthermore, when they moved from one company to another, the movement involved not just one individual but a group — a group that worked together as a team in the previous company. This kind of manpower movement, which was prevalent between 1975 and 1978, was sometimes detrimental to the accumulation of technological capability within the firm that lost the precious technical manpower.

Diffusion of technology to input suppliers has been slowly taking place. Diffusion to suppliers in the machinery sector came, interestingly, from a need that is intrinsic to the sector. Because a machine is an assemblage of a large number of parts of components functioning together systematically to perform a specified function, the quality level of a machine will be determined by those parts with the lowest quality level.

A machine manufacturer should, therefore, recognize the need for cooperation and coordination among firms engaged in machinery manufacturing. Daewoo Heavy Industry Ltd. (DHI), fortunately, was aware of this need and established, in line with government directives, a program for the localization of materials, equipment, and parts by providing smaller parts manufacturers with technical know-how and, sometimes, financial support. The successful accomplishment of the program made significant contributions to cost reductions and foreign currency savings.

Basically, engineers at DHI have absorbed those portions of the imported technology relating to the start-up, operation, and maintenance of diesel engine manufacturing processes. However, basic design and research and development, particularly when the technology involved is highly sophisticated, are still far from having been absorbed or diffused. In order to determine the impact of the degree of sophistication of the technology on its absorption and diffusion an analysis of a simpler technology was made for comparative purposes. The analysis suggested that when a developing nation needs to learn, absorb, and diffuse imported technology, it should start with a simple technology because simpler technologies are absorbed and understood with much more ease than sophisticated technologies. However, when developing countries want their products to be competitive in international markets, the quality requirements of the products call for the importation of foreign

techniques that are usually sophisticated. Thus, a developing nation faces a conflicting situation between a long-term optimization of technology development and a short-term optimization of international trade.

Textiles

The absorption and adaptation processes of nylon technology at Kolon Co. Ltd. seem to be very successful. The company achieved smooth absorption of technology in the areas of start-up, operation, maintenance, and design. The technology was fully and rapidly accumulated in both human and capital resources. Because engineering skills are somewhat different from the skills of the above fields, the company relied upon Chemtex Engineering many times during its expansion and new construction phases.

Intimate technical and capital cooperation with Chemtex and Toray Co. also played a crucial role in Kolon's development. Favourable economic factors such as the planning and implementation function of a strong government, increased and adequate demand for nylon products, price stability, etc. were also very important.

As well, the company has adopted a positive technology policy. In addition to regular on-the-job training, the company systemized general refinement and training for newly hired personnel. It also oversees all training, quality control activities, and research and development activities; has established an improvement proposal system and a patent section; and continues efforts to drive costs down. All of these policies have helped the technology absorption and diffusion processes.

Based on the experiences of Kolon Co. Ltd., several implications regarding technology absorption and development can be made: (1) Particularly during the early stages of technology absorption, it may be better for the importing firm to maintain as intimate a relationship as possible with cooperating firms. (2) As the accumulation of imported technology reaches a certain level, government, as well as related industries or firms, must be very careful to choose an appropriate time to switch from heavy technology dependence to direct research and development promotion. (3) In some cases, joint venture arrangements could help the smooth transfer of foreign technology. (4) The accumulation of minor technological changes at Kolon Co. Ltd. contributed significantly to upgrading its technology. Therefore, various devices that encourage minor in-plant technological improvement should be pursued. (5) Plant expansion and

diversification of products were also sources of technology improvement at Kolon Co. Ltd. Thus, expansion and diversification policies should also be encouraged. (6) As the accumulated technology of a firm matures to a certain internationally acceptable level, the government might consider encouraging the firm to establish a subsidiary engineering firm. This, of course, would not be suitable for every field of various industries, but the possibility should be taken into consideration because an engineering firm backed by a large-scale and technically advanced mother company can break new ground for technology diffusion abroad. (7) Long-term loans are frequently necessary for plant export or diffusion of know-how. Therefore, either government or industry should be ready to arrange such loans for exporting firms. (8) It is very important that the government take measures to protect industrial ownership and subsidize firms to help minimize the technical risks they must encounter as pioneering and leading firms. (9) Government and business would be wise to convene relevant social or industrial conventions to prevent pirating activities among competing firms.

Conclusions and Policy Suggestions

The primary hypothesis of this paper has been that exports and economic growth are facilitated by proper and rapid absorption and diffusion of imported and indigenous technology, i.e., absorption and diffusion of technology affect the level and direction of trade. Comparative advantage shifts from one country to another when the technology needed to produce new goods is acquired by countries with less factor costs. Importing nations may turn out to be exporters and exporting nations importers. Within a country, absorption and diffusion at the producer level tend to reduce imports and increase exports, whereas at the consumer level they have the opposite influences. Absorption and diffusion of demand and production may also proceed at an equal pace depending upon whether or not there is trade. With trade, absorption and diffusion among producers are constrained by domestic supply factors but are freed from domestic demand factors because exports are possible. Without trade, unfavourable conditions in supply and demand factors inhibit absorption and diffusion.

Furthermore, the problem of technological development should be considered simultaneously with the specific and interdependent aspects of importation, absorption and diffusion, and innovation. These aspects are closely intertwined

in relation to technological development and it is not possible to separate them from each other. The speed and extent with which imported technology is absorbed and diffused should be considered together with the importation and innovation of new technology when necessary.

The above are all important policy concerns for which, as yet, there are no definite answers in Korea and, for that matter, in any other developing countries.

From this work, some important findings concerning various factors that influence the degree and speed of absorption and diffusion can be derived. The factors exist in the following forms: government policies and actions, foreign participant's planning and experience, and the attitudes and application of Korean engineers in the case of the petrochemical industry; training of engineers, highly skilled and educated foremen, stable demand, monopolistic market share, and expenditure on research and development in the case of the iron and steel industry; government role, secured market, degree of technological sophistication, and supply of parts in the case of the machinery industry; and intimate relationships with cooperating firms, research and development promotion, joint venture, improvement of minor technologies, plant expansion, product diversification, establishment of subsidiary engineering firms, long-term loans, protection of industrial ownership, subsidies to pioneering firms, and prevention of pirating activities in the case of the textile industry. These factors suggest crucial policy implications on how to manage imported technology for the sake of rapid absorption and diffusion in each industry. How, then, can the findings on absorption and diffusion in the context of economic growth be interpreted?

No doubt, Korea's economic growth over the last two decades has been remarkable in terms of exports and national production. In the sense that investment of material capital and labour was increasingly put into the export sector, it may be argued that a simple Cobb-Douglas production function could be applicable in explaining such a high economic growth.

Entering the new development stage, i.e., heavy and chemical industrialization, where resources such as labour, land, and water are scarce, however, economic efficiency at both the firm and national levels becomes crucial, thus requiring ever-higher levels of technology in all aspects.

Nevertheless, Korean technology, imported and indigenous, is not at a sufficient level to simulate the Schumpeterian attributes that Japanese growth possessed. The pattern of

Japan's postwar economic development fits nicely into Schumpeter's model.² Although Schumpeter's model is deficient in dealing with many of the detailed and intricate operations of modern Japanese economy, it does come to grips with the essential dynamic undercurrents of Japan's industrial experience.

After all, technological change and capital formation were the major catalytic agents that transformed the postwar Japanese economy with such decisiveness and swiftness. Even the capital formation in Japan originated from the technological progress following the working of what Schumpeter called "creative destruction." Productive activity shifted continually from old to newly installed and more efficient manufacturing facilities in pursuit of high productivity. This creative destruction could only be realized when supported by high technological achievements.

In contrast, the Korean experience diverges from the Japanese experience, particularly after the emergence of heavy and chemical industries in the mid-1970s. The art and techniques in western decoration, furniture, gardening, and construction could be swiftly absorbed and even exported in the form of hard- and software. In heavy and chemical industries, however, the situation was quite different. The degree and speed of technological progress in this field was less satisfactory compared with targets set in the long-run economic development plan.

Summarizing what has been learned about the four manufacturing sectors discussed in the case studies, it can be said that the rate of absorption of imported technology has been quite rapid in comparison with other developing countries. Substantial improvements have also been made in relation to ancillary processes. The rate of diffusion, however, appears to have been slow, as expected, except in the textile industry, where even the export of technology has been accomplished. The rate of assimilation has varied according to the sophistication of the technology concerned, but, except in the iron and steel industry, it has not been slow.

It should be stressed here, however, that the rates of absorption and diffusion are rapid only in minor or "peripheral" technology in connection with construction (civil, housing, underground piping, warehouses, foundations, roads, offices, structures, erection, commissioning), start-up, operation, maintenance, training, procurement, foreign-loan application, detailed design, etc., but in major or "core" technology such

as basic design, supply of fundamental facilities, research and development, etc., particularly when the technology involved is highly sophisticated, absorption and diffusion have been trivial.

Based on the findings of the case studies, some policy suggestions related to absorption and diffusion, as well as economic growth, are offered:

(1) The first task confronting Korea is to make a distinction between imported (exogenously available) and indigenous (endogenously created) technologies, and to give priority to the former during the 6th plan period of 1988-1992, even though they are not substitutable but complementary. At present, the import of appropriate technology and its rapid absorption and diffusion are required more, in Korea, than creating domestic innovations. Gradual development of technology, stage by stage, is desirable.

(2) Because the absorption of major core technology was not as rapid as in the case of minor unsophisticated technology, economic targets should be adjusted to levels that the current rate and status of absorption and diffusion will permit. Otherwise, technological dependence will increase and the danger of neo-imperialism might prevail in Korea.

(3) In order to increase the rate and capacity to absorb and diffuse, nonappropriate technology, e.g., so-called "standardized product stage" technology already having entered "the mature or declining stage of commodity life cycle," should not be imported. Instead, technology in "the development or growth stage of commodity life cycle" is desirable. Secondly, an increase in the speed of absorption and diffusion depends mostly on the absorptive and pulling capacity of the economy, in addition to the various factors described earlier. The absorptive and pulling capacity can only be enhanced by the domestic science and engineering activities and negotiating power in importing foreign technology. Domestic activities suggested for Korea are: increase the human capital embodying high technology via proper and efficient education and training, eliminate or diminish administrative red tape, introduce various restrictive clauses and behaviour to technology-supplying firms, and promote technological nationalism to protect or maintain the already widening technology gap.

(4) By improving negotiating power, imported technology has to be unpackaged. For example, Japan has unpackaged petrochemical technology into two components: core and peripheral. The latter was not imported but substituted by domestic engineering firms, whereas core technology was carefully selected and imported. Only the core technology, which is indispensable and

²Terutomo, Ozawa. 1974. *Japan's technological challenge to the West, 1950-1974: motivation and accomplishment*. Cambridge, England, MIT Press.

could not be developed easily, was imported. In Korea, this necessity is much more serious.

(5) In Korea, technology imports have been confined, for the most part, to large firms. The scope and diversification of imported technology, however, must be enlarged to enable small- and medium-sized firms to induce the technology that is appropriate for their industrial uses. The simple techniques adopted by small- and medium-sized firms can be absorbed and diffused much more easily and widely than the sophisticated techniques utilized by large firms. Large firms should diffuse their absorbed technology to small- and medium-sized firms.

(6) Technological change has been far more

extensive than the comparatively simple change in the quality of industrial artifacts. It is a sociotechnological phenomenon in which Korean society is totally immersed. Korea's inferior capability to adopt technological change easily and rapidly stems from its culture, the psychology of the people, and the historical momentum of society. In order to achieve recurrent development of major technological changes initiated by innovators and later followed by others in what Schumpeter called "swarmlike appearance," science and engineering mentality should sweep all over the country and people. Social value should change, therefore, toward favouring science and technology.

Comments: V. Kanesalingam

The Korean paper covers four case studies dealing with the (1) petrochemical industry, (2) iron and steel industry, (3) machinery industry, and (4) textile industry.

As the author states in the synthesis report, the objective of the case studies has been to learn as much as possible about the absorption and diffusion of imported technologies from advanced economies. Through a set of common questions and the adoption of a common definition of the terms technology, absorption, and diffusion, the author has attempted to strike a common basis of comparability in the behaviour of imported technology, in relation to the capacity of the Korean industrial system and the environment in which it operates, and indicated by the capacity of this system to absorb and diffuse technology.

The case studies seem to have been inhibited by one major limitation, the fact that it was not a single firm but a number of firms that were concerned with the activities forming part of the technology studied. For instance, the technology required for the design, construction, operation, maintenance, and improvement of a polyethylene manufacturing plant was the concern of more than one firm, which meant that the enquiry into the absorption of the technology had to be carried out in not one but in several firms, i.e., not only the firm producing polyethylene but also the firms producing and installing machinery for its production.

Another problem facing the study was that economic theory did not provide much guidance regarding the study of absorption and diffusion of modern technologies. The enquiry, therefore, had to be guided by "learning-by-doing." The absence of economic theory to guide the enquiry was further complicated by the post-transfer

adaptation of technology in the importing country. True absorption of imported technology ought to include any adaptation in the importing country, but the author found that existing economic theory provides little guidance to analyze and evaluate this phenomenon.

The author laments that in studying the diffusion of imported technology, the use of economic theory was limited by the fact that the number of firms within the industry receiving the technology was too few — in many cases it was one large firm — and the absence of a greater number of similar firms meant that a major precondition for diffusion was absent.

In spite of these limitations, measures of both absorption and diffusion are present. Three devices required to measure absorption are cited: (1) the measure of labour absorption reflected by the extent of participation of nationals in the successive phases of absorption; (2) the measure of capital absorption, which is confined to the operating phase only; and (3) unit or average cost as a percentage of some measure of standard cost. The author states that these measures were easy to apply to the studies and were revealing. Although measures could be devised to evaluate the extent and quality of absorption, to measure diffusion one had to look backward to the suppliers of inputs or forward to the customers of the products of the firm. Backward diffusion can be measured, for example, by the extent of substitution with local supplies of plant and equipment forming part of the capital goods of the firm. A similar quantitative measurement of forward diffusion does not exist. What are available are general observations on the flow of technical knowledge to users of the product, students, and the general public.

Petrochemical Sector — The author studied one firm in depth and a few others superficially, the subject of the in-depth study being the Korea

Pacific Chemical Corporation. At the time of the study the Korea Pacific Chemical Corporation was 50% owned by a U.S. firm and 50% owned by Korean citizens. Although there was no Korean government ownership of the single firm studied, the study reveals that the role of the Korean government has been crucial in promoting or enhancing the rate of absorption of imported technology in the petrochemical industry. In fact, the findings of the study show that absorption has been very rapid. The rate of diffusion, on the other hand, has been rather slow. The reasons for this are explained in the study.

In contrast to the Sri Lankan situation, this study is quite revealing. Two aspects that differ from the Sri Lankan situation are (1) the industry being a joint venture, facilitated by the "learning-by-doing" process and the rapid absorption of technology and (2) the policy of the Korean government facilitating this process. One also notes from the study that a major factor contributing to the low rate of diffusion of technology in this industry is the low turnover of technical personnel from this firm to other industries or even abroad.

Adaptation of technology is well explained in the study by analyzing and evaluating the measures adopted by the firm regarding raw materials savings and energy conservation.

The presentation of data is quite lucid and another good point in this study is the account provided in it of the policy measures adopted by both the Korean government and the firm to retain the technical personnel developed in the firm, and in this way retain and protect the "know-how" acquired by the firm; and finally to diffuse technology through research projects and consultancy.

On the whole, the case study of the petrochemical sector is balanced, its analysis quite revealing, and findings clearly indicated. The only limitation, a major one, is that the findings are based on the study of one firm, from which the author seems to have no escape.

Iron and Steel Industry — This study reveals a situation different from that related to the petrochemical industry. Pohang Iron and Steel Co. Ltd. (POSCO) is the first integrated steel mill in Korea. Its technology was part of the package relating to supply of capital. The study does not

adequately discuss government policy. It is not clear how government policy has facilitated the absorption of imported technology. The lack of information on this aspect is glaring because in the case of the petrochemical industry this has been elaborated on in the analysis.

Another weakness of the study is in its coverage. The author admits that an analysis of the absorption of technology in more than one steel mill is necessary to evaluate more meaningfully the pattern and velocity of absorption and diffusion of the imported technology. This has not been attempted, however. Admittedly, the findings are based on the analysis of a narrow base.

The study refers to the fast absorption and assimilation of imported techniques and attributes it to POSCO's attention, early in its evolution, to the training of its personnel, but it is questionable whether the absorption as depicted in the discussion could be referred to as remarkable. Even on the question of diffusion of technology it seems that the analysis is not adequate enough to allow any meaningful conclusions to be reached.

Machinery Sector — This study presents a situation different from that of either the petrochemical or iron and steel industry. The Daewoo Industrial Co. had changed its corporate form several times between 1937 and its tie with the German firm MAN in 1970. The study concentrates on the period after 1970. An interesting finding of this study is that the absorption of imported technology is highly dependent upon the continuity of the demand for the products of the technology.

The study also highlights the impact of the Saemaeul Movement on the attitude and motivation for import substitution of machinery parts and devising measures to economize on energy and save on raw materials.

The study ends by posing a question that merits further research: Should developing countries opt for simpler technologies that are easier to learn, absorb, and diffuse or for sophisticated technologies that will enhance their competitive capacity in international markets by ensuring a higher quality product? Taken as a whole, this study is a bold attempt to delve into the technological evolution of an industry that has had a chequered history.