Abstract

This paper analyzed the case of a Korean company that imported industrial technology to produce diesel engines. The main objective of this paper was to develop a theoretical model to describe the systemic nature of industrial technology transfer, using a case methodology. The model has identified four systemic factors affecting the commercial feasibility of technology.

Objectives and Approaches

The primary purpose of this study is to examine the systemic nature of industrial technology to identify key factors that affect the commercial feasibility of technology. This study takes the systems approach to the analysis of Korean company that imported both product and process technology from Germany. The company manufactured diesel engines to sell them to other companies manufacturing trucks and buses. Most business activities described in this case study took place back in the 1970s when the Korean economy was growing rapidly. Thus, it should be noted that most data in the case do not represent the economic and technological circumstances of present-day Korea. This case study seeks to perform a postmortem analysis of a classical failure case in the Korean business history, rather than to describe the current situations of Korean companies.

This study attempts to develop a theoretical model, based on the generalizable findings of the case analysis, to describe the interrelationship among the four factors: business firm, the firm’s technology, the subsystems of the technology, and its market environment. The conceptual model in this paper identifies four systemic factors that engineers and technology managers often fail to consider when they evaluate the commercial feasibility of certain industrial technology.

The Systems Approach

The ‘systems approach’ is a method of analysis which researchers often use when they deal with complicated problems. Although many definitions of ‘system’ have been suggested, most scholars and practitioners agree that a system is made up of sets of subsystems (or components) that work together in a given environment for the overall objective of the whole (Churchman, 1968, pp.29-35). It should be noted that industrial technology, while it plays a critical role in a firm, is not an end itself but a means to the overall end of the firm. The overall end of a business firm is to produce goods and services and sell them in the market for profit. In the process of achieving their objectives business firms need to adopt some kind of industrial technology. In the parlance of the systems approach, industrial technology is a subsystem serving its higher (or super-ordinate) system.

The environment can be anything external to the system that puts constraints on the system, while affecting the system’s performance. For example, if a system operates under a fixed budget, the budgetary constraints are a part of the system’s environment. Because business firms use certain industrial technologies to produce goods and services for the market, competitions in the market, governmental regulations, and the availability of other competing technologies make up the environment of the technology. Industrial technologies are invisible because they are embedded in products. For example, a truck is a product in which a large amount of industrial technologies are embedded. A truck can be viewed as a system made up of many technical subsystems, one of which is the diesel engine. The diesel engine, on the other hand, can be viewed as a
system comprising its own subsystems (such as an oil pump, a water pump, etc). Let’s take an example of a transport company that uses trucks for its business. In this case, trucks are subsystems working for the company. Likewise, an industrial technology can be viewed as a subsystem residing in the middle of a hierarchical chain of systems.

**The Background of the Case**

The Korean economy in the early 1970s was struggling with problems inherited from the chronic poverty of the past. The economy grew successfully during the first and second five-year economic development plans (1962-1971). However, insufficient domestic savings, heavy dependency on foreign capital for development financing, chronic inflation, a backward industrial structure, and a lack of industrial technologies were problems that had yet to be resolved. In order to resolve these problems, the Korean government adopted aggressive and strong policy measures. The first important measure was the promotion of New Community (‘Saemaeul’ in Korean) Movement to rear rural development by stimulating the spirit of diligence, self-help, and cooperation among farmers and fishermen. The second important measure was the Presidential Decree of August 3, 1972, whose purpose was to alleviate the financial burdens of business enterprises by coercing all curb market financing terms into bank rate loans. The third one was the Presidential Declaration of Heavy and Chemical Industrialization Policy of January 12, 1973. Of these three policy measures, the third one had the most significant impact on the technological advancement of the Korean machine industry. Heavy imports of capital goods, as well as industrial raw materials, caused serious balance of payment problems, and made the economy more dependent on foreign capitals. Thus, the Korean government wanted to enhance industrial independence through increased domestic production of both industrial raw materials and capital goods. The steel, petrochemical, and non-ferrous metal industries were selected for intensive development as suppliers of raw materials. On the other hand, the government focused on the machinery and electronics industries for development of capital goods suppliers. Most business enterprises, however, could not afford to finance their necessary investment even with the help of the government. The capital that could be raised through the issuance of public stocks or debentures was simply insufficient. Thus, the Korean government established some guidelines to facilitate foreign loans. The government approved and guaranteed foreign loans only for the acquisition of capital goods and advanced technologies, which were not available locally. Foreign direct investment was also encouraged within 60 percent of total equity. Under this environment, Hankook Machine Industrial Co. in Inchon began to explore the possibility of manufacturing diesel engines by importing foreign technology with loans.

**The Company**

Hankook Machine Industrial Company (to be abbreviated as Hankook hereafter) was founded in 1937 when Korea was under Japanese occupation. After Japan’s retreat in 1945, the Korean government nationalized the company and restructured it as a public corporation. In 1968 the company was privatized. Despite its leading role in Korean machinery industry, the company was running under a chronic deficit mainly because of both insufficient domestic demands for their products and unstable management. Encouraged by the guidance and supporting measures of the Korean government in the early 1970s, Hankook began to search for a breakthrough to overcome their difficulties. Hankook expected the transport volume of industrial goods to increase, creating a new demand for diesel engines for trucks and buses, as the Korean economy would grow. In such expectations, Hankook began to investigate the possibility of manufacturing diesel engines. The investigation showed that the engine types produced by M.A.N. of Germany were the most suitable for their purpose. Following rapid negotiations, Hankook and M.A.N. of Germany signed a licensing agreement with financial loans arranged by M.A.N. on August 31, 1970. The license authorized Hankook to manufacture several types of diesel engines in the power range of 130 to 160 HP, and to market the products throughout Asia with the exception of India and Turkey. On October 28, 1970, a supplementary contract was drawn that provided both training of Korean engineers and employment of Korean skilled workers at M.A.N's manufacturing plants in Germany. According to this contract, thirty Korean engineers were sent to Germany during the first five years (1970 through 1975). During the following 10 years (1976 through 1985), additional 32 engineers and 361 skilled workers were employed at M.A.N’s engine and truck manufacturing plants. While there was nothing unusual about M.A.N’s training Korean engineers, the number of Koreans involved was far larger than usual for a normal training program and their stay in Germany was much longer than was customary. Moreover, while they were working for M.A.N the Korean workers were treated as if they had been
MAN’s employees. Considering that there was a shortage of skilled workers in Germany in the early 1970s, it must have been MAN’s substantial advantage to be able to draw upon a pool of industrious and technically educated workers from Korea. To the individual Koreans, the advantage was presumably the higher income they could make there. Nearly 31 per cent of the Korean workers did not return to Korea; they either remained in Germany through marriage to Germans, or moved to other Western countries.

In spite of the high attrition rate, Hankook felt that the employment program was beneficial. The Korean engineers and skilled workers at MAN absorbed the technical knowledge relating to the start-up, operation and maintenance of a diesel engine manufacturing plant. In fact, the transfer of German technology to Korea proceeded smoothly until the first problem stemming from the systemic nature of the technology appeared.

Systemic Factor No. 1
The first systemic problem occurred because people failed to realize that a diesel engine was a subsystem of its higher system, that is, trucks and buses produced in Korea. By 1975 Korean vehicle manufacturers were already producing trucks and buses using imported engines. An engine has to be compatible with the vehicle to be mounted on. But the Korean vehicles and MAN engines were not designed initially as compatible systems. Thus, the MAN engines could not be mounted on the Korean vehicles. German engineers who initially performed the feasibility study for the technology transfer must have overlooked this compatibility problem, an unfortunate omission. This extra financial burden caused by this problem crippled Hankook. During the 1970s, the interest rates were above 20% in Korea, about three times higher than those in advanced countries. Hankook’s major creditor was the Korea Development Bank, a government-owned financial institution. The Korean government, therefore, looked for a financially strong company to take over Hankook.

Daewoo, then a large general trading company, was rated highly for its managerial ability. The Korean government offered Daewoo to buy a controlling share of Hankook’s equity. In 1976 Daewoo took over Hankook, and renamed the company Daewoo Heavy Industrial Company (to be abbreviated DHI hereafter). DHI immediately initiated a project in technical collaboration with KIST (Korea Institute of Science and Technology) to fix the mounting problem. KIST was a research institute established by the Korean government in 1966 to help business firms solve technical problems. DHI also asked MAN for technical assistance to solve the problem. MAN was reluctant to give extra assistance because it was not included in the original licensing agreement. However, after DHI’s repeated requests, MAN began to help by providing DHI with technical information. After a year’s hard work, the problem was finally resolved, and the Korean vehicle manufacturers were able to mount the MAN engines on their buses and trucks.

Systemic Factor No. 2
The second systemic problem occurred when people fail to realize that the commercial performance of industrial technology was strongly affected by the market (i.e., the environment) condition of the product in which the technology was embedded. Although the mounting problem was eliminated, sales of the diesel engine did not grow as had been forecast in the initial feasibility study.

There were four reasons for this problem. First, the price of DHI engines was initially set to recover costs, which were high because of the small size of domestic market. Second, imported raw materials and components were purchased at a relatively high price since quantity discounts could not be negotiated for small lots. Third, the domestic interest rate was three times higher than the rate in advanced countries. This made the financial costs associated with domestic production higher than those for imported products from advanced countries. Finally, the Korean consumers were reluctant to buy the engines because they could not trust the quality of products made by inexperienced managers and engineers. In a nutshell, because of the lack of scale economy and consumers' low confidence in domestic engineers and managers, domestic diesel engines could not compete with those imported from advanced countries. DHI asked Korean government to impose a ban on the import of diesel engines. In 1977, Korean government acquiesced to this request in exchange for its right to control the price of diesel engines. The price was consequently set at approximately the price of imported diesel engines and the domestic market for medium-sized engines began to be supplied entirely by DHI.

Systemic Factor No. 3
The third systemic problem occurred because of the failure to recognize that a product such as a diesel engine comprised a large number of subsystems (or parts) functioning together. The quality of the product depends on the quality of each functioning part. On the other hand, it is not feasible either technically or
economically to manufacture all the parts within a company. Thus, most of the parts should be purchased from outside the company. However, the final assembler of the product assumes full responsibility for the quality of the parts from suppliers. In the present case, Daewoo had to initiate a program to assist parts suppliers with the manufacturing know-how they had obtained from Germany. This effort by DHI happened to be in line with Korean government’s guidelines to encourage business firms to use as much as possible domestic components, parts, and materials. These guidelines were to help small and medium-sized suppliers build up their technical capabilities while alleviating foreign exchange problems of the nation.

**Systematic Factor No. 4**

The fourth systemic problem resulted from the failure to understand that industrial technology was not an end itself but a means to attaining the objective (or the profitability) of the business firm employing the technology. When Daewoo built the first diesel engine plant, there were no competitors in Korea. However, several other companies quickly made licensing agreements with foreign firms, preparing to enter the diesel engine market only a year after Daewoo started its operation. The increase in the number of competing firms resulted in an oversupply of diesel engines.

At the outset of the diesel engine project, the German consulting firm Aktiengesellschaft fur Entwicklungsplanung of Essen carried out a feasibility study. Based on the sales forecast of the feasibility study, the capacity of the plant was set at 24,000 diesel engines per year with one shift per day, or 72,000 engines per year with three shifts per day. Korean companies wanted to run their facilities with three shifts per day to make up the disadvantage of high interest rates. However, because of the increase in competition and manufacturing capacity coupled with insufficient demand, none of the competing firms could operate at optimum speed for even one shift. Under such circumstances, DHI could not afford to keep high-paid technical personnel who were originally trained for the project. They were transferred to other projects. As a result, DHI could not utilize their valuable skills effectively. Furthermore, some engineers, being lured by promotion and higher salaries, left DHI for its competitors. When they moved from one company to another, they usually did so not individually but as a group in which they worked together. Such turnover among engineers, which was prevalent during the boom of the 1970, was probably detrimental to DHI’s accumulation of technical capabilities. During this period there were disputes between competing firms over what they called ‘technical manpower robbery,’ sometimes accompanied by the theft of blueprints. From the standpoint of DHI, the ‘robbery’ was a ‘forced diffusion’ of their technical capability to its competitors.

**Conclusion**

In the science of physics what is known as Ohm’s Law states that where there is a flow of electricity there is resistance. An analogy may exist in the world of technology; where there is a transfer (or flow) of technology from a source to recipient, there emerges systemic resistance. By systemic resistance I mean the resistance arising from the systematic nature of technology.

This paper has identified four different types of the systemic resistance. This study has also shown that each type of the systemic resistance negatively affects the commercial feasibility of the technology or the products produced through the technology. This paper calls these four types of systemic resistance ‘systemic factors.’ A schematic diagram can be created to show the sources of the systemic factors in relation to the systemic elements of the technology. The diagram is presented in Figure 1.
To the extent that the systemic nature is generic to most industrial technology, those four types of the systemic factors identified in this study can be generalized to many other cases of technology transfer. The conceptual model presented in this paper may help technical managers predict possible systemic problems in their planned technology transfer and evaluate the commercial feasibility of the technology. Business firms should be able to resolve the systematic problems negatively affecting the commercial feasibility of the technology. Unfortunately, however, business firms in most developing countries do not have the adequate financial resources and technical capabilities to resolve the problems on their own. In developing countries, therefore, governmental interventions are often called for to secure the technical capabilities needed for their economic development.

The first systemic problem (i.e., compatibility between a system and its subsystem) could be avoided by rigorous technical feasibility studies. In the current case of diesel engine technology, the feasibility study team made a mistake that was very unfortunate to the recipient firm. In developing countries, both financially and technologically weak companies are often helpless in the face of such systemic problems. In this case, assistance from the government would be required. In our current case the Korean government went so far as to change the company’s ownership and management. As for the second problem (i.e., increasing competitions in the market) the Korean government’s policy was to impose a ban on the import of diesel engines. Regarding the third problem (i.e., problems with parts suppliers), the company’s interest in resolving the problem was in line with that of the government. However, the individual firm’s optimum solution is sometimes in conflict with the government’s optimum solution. As for the fourth problem, the diffusion of the imported technology from a firm to its domestic competitors may be good from the standpoint of the state because the diffusion generates an effect of ‘external economy’ to the other firms. However, if this kind of diffusion takes place prematurely by the turnover of technical personnel, it may impair the proper accumulation of technical capabilities within the original importer of the technology. Thus the government should be careful to make sure that that the timing is appropriate, when allowing new firms to compete in market with the same technology. Only when there are enough demands for the products, the personnel trained in the technology can be continuously employed in the same activity so that they can accumulate experience.

REFERENCES