the field of research in which classification is imposed.

The government has not put forward any compelling reasons for instituting a system of classification that is so at odds with previous systems. The government's own reports, including reports issued by the Department of Defense, seriously question the cost, effectiveness, and need for more classification. They draw particular attention to the dangers of overclassification.

Executive Order 12356 requires drastic revision in order to be tolerable to a community of scholars committed to free inquiry. The application of the order to nonclassified information, which is already subject to potential restraints under existing laws and regulations, is at best superfluous. The heavy emphasis on classification is misplaced: the provision for reclassification should be removed and the standards for classification rewritten so that they do not sweep unnecessarily broadly and thereby significantly threaten academic freedom.

If the government's executive order or its successor continues to deny due recognition to the need of the independent research scholar for academic freedom, the cost will be borne not only by the researchers who are affected but by the nation as a whole.

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Japanese Industrial Development and Policies for Science and Technology

Toshio Shishido

Summary. Two important factors that contributed to Japan's economic success were government investment in industrial development and the early recognition that a good educational system is a prerequisite to technological progress. Government policies promoted the importation of technologies from Europe and North America and encouraged the education of students abroad. This facilitated the rapid development of Japanese industry and the adaptation of foreign technologies to local conditions. Many of the methods used to develop industry in Japan could be used to advantage in developing countries today.

In this article I describe Japan's industrial development and Japanese policies for science and technology. In the process of industrialization and modernization, Japan imported many new technologies in a wide variety of fields and at the same time made great efforts to improve these technologies and adapt them to local conditions. The success of these efforts depended on many factors, the most important of which were the education of the general population and government initiative and support.

The development of industry in Japan over the last 100 years can be divided into four stages. During the first stage, which lasted from the mid-1800's until the end of the 19th century, the metal, chemical, and machine industries became increasingly dependent on imports (Fig. 1). The technological development of these industries, and of the light industries that produced such important export items as textiles, was therefore limited until the beginning of the second stage in about 1900. The third stage of development began after World War II, when Japan had to undergo a rapid development process to catch up with the advanced technology of the West. By the early 1970's the level of technology in Japan had surpassed that in Europe and reached about the same level as in the United States. Now, in the fourth stage of development, Japan's attention is turning from imitative to creative technology.

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Stage 1. Policies for Promoting Industries

The Meiji government (1868 to 1912) recognized that increased production and the promotion of industries were essential for establishing a solid economic foundation for the construction of a modern state. The immediate target of its policies was the curtailment of imports and the promotion of exports, with greater emphasis on the former. With the opening of the country to foreign trade, foreign products poured into the domestic market, putting pressure on the domestic cotton-yarn industry as well as other industries, and causing a chronic deficit in the international balance of payments.

To counter this trend, the introduction of modern industry was urgently called for. However, there was little private capital available, so that nothing short of direct investment by the government could accomplish the desired objectives. Since the government aimed at encouraging the private sector to follow its example, it made direct investments covering the operations of its own factories, the construction of railways, the exploitation of mines, and the management of experimental stations.

The Ministry of Engineering, created in 1870, was charged with the responsibility for encouraging the development of many industries and running the mines, railways, and communications. During the ensuing 15 years it operated the government-owned factories and mines, many of them expropriated from the former Tokugawa Shogunate and the feudal lords. Tomioka Spinning, for instance, was established in 1872 by the government; it was equipped with French-made spinning machines and was operated by French techniques.

In this manner, the Meiji government

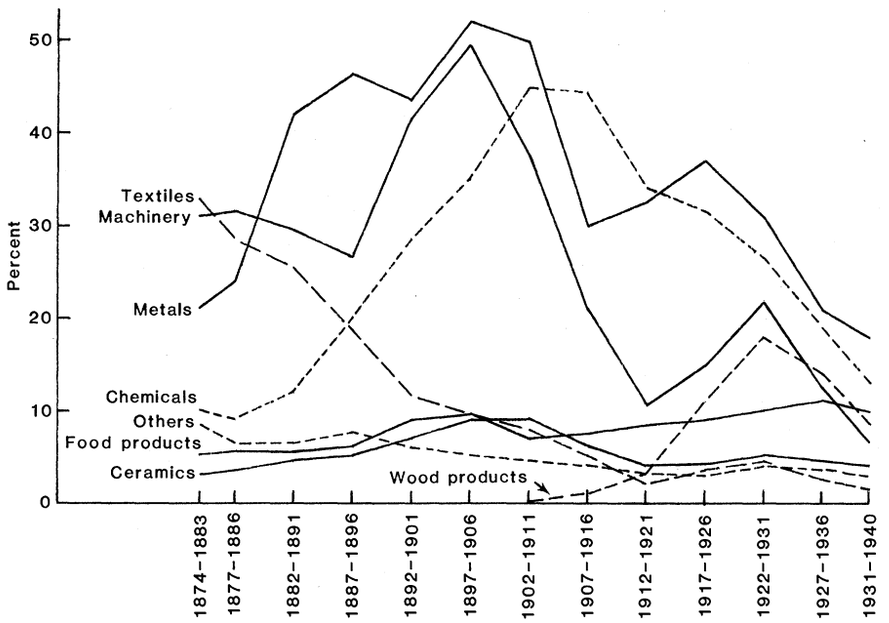

Fig. 1. Import share by industry. Numbers on the ordinate are percentages of the current price. [Data from (*17*)]

succeeded in introducing foreign industries and technology through the examples of its own direct activities. Although its accomplishments may have fallen short of its desired objectives, the Meiji government undoubtedly played an important role in the modernization of private industries and technology (*1*).

The industrial technology of the early Meiji era, having been almost wholly dependent on technology imported from Europe and North America, had little affinity with contemporary indigenous production techniques. This technological dependence took the form not only of employing foreign engineers and craftsmen and importing plants, machinery, and industrial raw materials, but also of importing such elementary techniques as the making of bricks. This was found necessary on account of the lack of a technological tradition on which to draw for the development of modern industries. Having been transplanted to state-run factories with total disregard of its economic justifiability, such technology found little direct application in the private sector of industry.

There was nevertheless a substantial gain, since local employees working in these state-run factories acquired skills in operating various machines and transferred these skills to the private factories that were subsequently built. Thus the privately owned spinning mills built in the 1880's imported their machinery from England and other Western European countries but were operated by Japanese workers who had been trained under the direction of foreign technicians, in some cases to such a high level that they in turn were qualified to become instructors. In a similar fashion, large shipyards became training centers for shipbuilding engineers, and other technologies of foreign origin also were introduced and diffused into local industries in the later 1880's (*2*).

Transfer to private ownership. Because of fluctuations in business and bureaucratic inefficiency, the government's business undertakings were unable to avoid running into deficit. They were therefore gradually transferred to private ownership. Nevertheless, the government recognized the need of these enterprises for protection and maintained a vigilant surveillance over them. As they gained in self-reliance, the government gradually reduced intervention in their management and, after 1897, switched to a less direct and more modern type of protectionism. By early 1890, the spinning industry and several others had established themselves entirely with private capital.

Industry in Japan made great strides after the Sino-Japanese War (1894 to 1895), and during the ensuing years until the Russo-Japanese War (1904 to 1905) the slogan "increase of production and promotion of industries" was replaced by that of "postwar management," which embraced all spheres of national policy. Implicit in this slogan were stepped-up armaments, the development of education, and a well-defined industrial policy, one of whose manifestations was the series of war factories that emerged after the Sino-Japanese War. The expanding requirements for armaments led to large demands for strategic material of all kinds, including rolling-stock and ships. However, deciding that the creation of heavy industries adequate to meet such large demands could not, and should not, be left to private capital, the government again invested in the heavy industries by way of direct ownership and management. The Yawata Iron Works, decreed in 1896 and established in 1901 by the government, was typical of such industries.

Early administrative structure for scientific and technological research. Scientific and technological research agencies were at first systematically organized in the respective administrative agencies of the state, with the creation of private organizations for scientific and technological research coming about rather later. From 1868 to about 1885, Japan depended entirely on foreigners for scientific and academic guidance. Thus nearly all the teachers in the higher scientific and technological educational institutions were foreigners invited and employed by Japanese authorities. But as time went on, they were gradually replaced by Japanese scholars who had studied abroad or had received scientific training under foreign teachers, and who then initiated their own original courses of study. An early example of this new regime is represented by the Earthquake Prevention Research Council, established in 1892, all of whose personnel were Japanese.

Stage 2. Rationalization

Policy for Industry

Drastic changes in the industrial structure of Japan were effected by the policies of the Meiji government. A landmark was reached in 1919, when the output of industry for the first time outstripped that of agriculture. The structural changes accelerated the attainment of self-sufficiency in technology, therefore consolidating the foundations of the modern industries. During World War I, when the introduction of foreign technology was abruptly suspended, the government made a determined effort to establish and realign state-run research laboratories serving manufacturing industries, and at the same time gave friendly consideration to the views and proposals of private scientists and engineers relative to the opening up of engineering institutes.

In an effort to devise an effective industrial policy, the government enlisted academicians and businessmen to form research councils in various fields. The councils or boards appointed by the Ministry of Agriculture and Commerce (and then by the Ministry of Commerce and Industry) included the Supreme Council of Agriculture, Commerce and Industry (1896), the Production Research Council (1910), the Economic Research Council (1916), the Temporary National Economic Research Council (1918), the Council of Commerce and Industry (1927), and Temporary Industrial Council. The first of these—the Council of Agriculture, Commerce and Industry—was associated with the deliberations leading to the Factory Act, and the Production Research Council was instrumental in recommending to the government in 1912 various measures designed to develop industries.

The activities of these councils helped to make the government's industrial policies truly effective; they dealt with such questions as reduction of the price of industrial salt; development of hydroelectric power; promotion of technical education; additions to the curriculum of engineering high schools of courses related to special industries; expansion and reinforcement of state-run industrial experiment stations; and encouragement of the manufacture of machinery. Similarly, the Research Council of the Chemical Industry recommended measures for fostering the soda industry and subsidies for the tar-refining industry and for the development of research in the electrochemical industry. It also advocated priority for the physical sciences along with the establishment of a chemical research laboratory. Moved by their recommendations, the government established a chemical and physical research laboratory in 1917.

Realizing the importance of orienting more research toward technological development to compensate for the cutting off of technology imports during the war, the Ministry of Agriculture and Commerce, rather than simply expanding the Industrial Laboratory, set up a number of new industrial research institutes. These included the (temporary) Nitrogen Laboratory (1918), Osaka Industrial Laboratory (1918), Textile Industry Laboratory (1918), Porcelain Laboratory (1919), and the Monopoly Bureau's Central Laboratory (1920). During the same period, the Ministry of Communications established the Ship Equipment Inspection Station in 1916, and transformed its Electro-Technical Bureau into an independent agency as the Electro-Technical Laboratory.

The Physico-Chemical Research Institute was established in 1917 with a government subsidy and contributions from industrial circles, but its financial foundation was not really stable. Nevertheless a liberal atmosphere, rarely encountered in universities, prevailed in the institute's organization and operation. Active interchange between the different research branches was encouraged, and the institute was managed under a basic policy calling for a careful selection of priority research projects to receive financial support and for an extension of joint research activities. As a consequence, many of the studies accomplished earned high international esteem. On the technological side alone, the successful results included Masatoshi Ohkochi's piston ring, Umetaro Suzuki's synthetic sake (Japanese rice wine), Yosei Suzuki's Ultramin (textile finishing agent), and Kotaro Honda's magnetic steel. Two Japanese Nobel Prize winners, moreover, were formerly members of the staff of this institute.

Besides these research agencies, institutes dealing with aviation and metals were set up in the Tokyo Imperial University and Tohoku Imperial University, respectively, around 1920. Thus a tradition was built up of attaching importance to basic studies. Since then, the practice of establishing research institutes in universities has been continued, and by 1968 there were about 200 institutes attached to national universities.

Table 1. Trends in the trade of technology. Patent fees are paid by the receiver annually, in proportion to production, for 20 years until expiration of the patent right. Japanese payment for imported technology has increased because of the increased production based on imported licenses. Numbers in parentheses show payments on the first year of patents newly contracted in 1979. [Data from (*16*)]

Year	Imports (billions of yen)	Exports (billions of yen)	$E/I \times 100$ (%)
1955	11.9	0.1	0.8
1960	34.2	0.8	2.4
1965	60.1	6.1	7.8
1970	155.9	21.2	13.6
1974	159.8	57.1	35.7
1979	240.9 (26.8)	133.2 (52.1)	55.3 (194.0)

Stage 3. Catching up with Advanced Technology

After recovering from the ruinous conditions of the postwar years, Japanese industry in about 1955 was able to exceed the prewar level of production. This recovery was achieved through expansion of the basic industries that had completely modernized their production facilities during the early 1950's; it was further consolidated by the development of new industries such as synthetic chemicals, petrochemicals, and electronics.

Underlying these achievements were government policies promoting domestic industry. At the same time, the importation of foreign technology was highly encouraged, and entered into every branch of industry. Table 1 shows that the cost of imported technology during 1970 amounted to 13 times the cost in 1956. Thus Japan's technological recovery owed much to imported technology. The assimilation of this technology depended on a certain mature technological base that was, in turn, instrumental in reducing imports. The total sales of products derived directly from imported technology in early 1970 accounted for more than 30 percent of the total sales of the entire industry of Japan, and about 20 percent of the new products and technology developed during the years 1957 to 1961 were based on imported technology (*3*). Since 1965, moreover, imported technology has contributed increasingly to the production of plants, installations, and consumer goods for export (*4*).

Whereas in 1955 more than 50 percent of the technology imported had been developed before or during World War II, in the 1960's the greater part dated from after the war (*5*). Thus the industrial processes used in Japan were catching up with those of advanced Western countries. The importation of perfected foreign technology in the past obviated the risks and uncertainties inherent in the development of original technology, and provided a rapid and effective method of enhancing the technological level of Japanese industries.

Policies for the introduction of foreign technologies. The door permitting the entry of foreign technologies, which had been closed since the war years, was

reopened in 1950, when the government enacted two laws dealing, respectively, with the introduction of foreign capital and with foreign exchange and trade control. These laws were designed to assist the postwar rehabilitation of the Japanese economy. Safeguards were included in the form of stipulations that such foreign technology should contribute to the improvement of the international balance of payments, and the corresponding policy on foreign exchange involved control of the influx of foreign capital. Paradoxically, this restrictive aspect actually helped to attract foreign holders of technology, and resulted in the selective importation of foreign technologies of such high quality as to warrant their cost in external payments. From 1965 onward, moreover, substantial payments were received for technology exported from Japan.

Of the technology imported, some 80 percent was related to the machinery and chemical industries (*6*). As a result, production in those industries increased markedly in the latter half of the 1950's. In 1960 the value of production derived from imported technology and allocated to domestic consumption equaled the total imports as calculated on the basis of the customs clearance (*7*). However, the export of goods produced by imported technology still remained at a comparatively low level in 1960. Japan caught up with American standards in many spheres of technology in 1970, and was able to start selling Japanese commodities, turned out by modern industrial complexes, at relatively low prices in other countries.

Stage 4. From Imitative to Creative Technology

According to estimations made by the Japan Productivity Center, the labor productivity (added value base) of Japanese steel industries exceeded that of the United States in about 1973. Labor productivity in the electric appliance industries became superior in the mid-1970's, and in the automobile industries labor productivity is likely to exceed that of the United States in the 1980's. This means that technology in Japan is already on the same level as that in the United States and has surpassed that in the European nations. The total balance of payment for technology is still unfavorable to Japan. However, when the transactions are limited to patents and know-how contracted in a single year (Table 1), since 1977 Japanese technology exports have exceeded the technology imports. The receipt (export) from newly contracted patents in 1979 was almost double the payment for imported technology newly contracted in the same year. Thus Japan is now an exporter of technology (*8*).

Higher productivity as well as good-quality products were the secrets of Japan's economic performance after the oil crisis of 1972. Manufacturers in the United States are now eager to "learn the Japanese way," and fear that selling technology to the Japanese may boomerang, particularly in the fields of electronics and genetic engineering.

Japanese economic expansion, which relied heavily on imported technology, may soon be affected by a technology embargo. There is a national consensus that Japan should change her policies for science and technology from emphasizing imitation to promoting invention. Investment for research and development in Japan increased at an average annual rate of 16 percent in the 1970's, and its ratio to gross national product increased from 1.4 to 1.8 percent. The government intends to increase this rate to 2.5 percent in the mid-1980's.

Higher productivity in Japan than the United States has been reached by the use of applied technologies, with special attention being paid to the areas of automation and robots, as well as quality control. Developing originality is a new experience for Japan. Investment in R & D is not the only factor that will determine the country's new technological developments. Japan will also have to put more effort into developing new educational systems that will increase the human resources adaptable to creativeness.

The government is now declaring that Japan will become a technology-oriented state rather than a trade-oriented state. National and social demands for new technologies will include:

1) Substituting other sources of energy for oil, which will include development of solar cells, high-efficiency gas turbines, and biomass.

2) Developing computer technology with the use of a combination of electronics and mechanics, as in industrial robots.

3) Investigating potentially useful materials such as new ceramics and carbon fibers.

4) Promoting research in the life sciences, especially genetic engineering.

Two-thirds of Japan's R & D is now done by the private sector on commercial projects. The government will now have to take more responsibility for R & D of basic technology.

Japan's Advantages in Technological Development

To appreciate Japan's ability for technological development it is necessary to consider not only the country's policies but also her historical and cultural background.

Centralized political system and sense of unity. When challenged from outside, the Japanese have a strong sense of unity, reflecting their long history as one race and one culture. Even at the beginning of the Edo era about 370 years ago, the Japanese political system was highly centralized, being governed by a shogunate. With such a homogeneous society and centralized decision-making system, it has always been easy to get a national consensus on goals (*9*).

Utilization of the home market. The mere existence of a large home market, represented by a population of 30 million at the beginning of the industrial revolution, has encouraged the development of new products and manufacturing processes.

Accumulated capital. Capital accumulation is an essential prerequisite if technology is to be utilized in such a way as to generate effective production facilities and raise productivity. The particular nature of capital accumulation in the Japanese economy has been characterized by: (i) the high rate of accumulation; (ii) the great contribution made by personal savings; (iii) the direct use of accumulated capital in fields where it can help to increase productivity; and (iv) certain aspects of the banking system.

Coexistence of modern and traditional industries. Leaders of some of the developing countries are under the misapprehension that traditional customs inhibit the development of modernized industry and the introduction of new techniques. The Japanese, in contrast, have utilized their dual economy to their advantage. Some of the industrial sectors were quick to adopt Western ways, but others took much more time. Transportation, such as railways and ships, as well as modern industries such as iron and steel, cotton-spinning, beer brewing, and cement production, were quickly transformed by labor-saving and capital-intensive technology. In the consumer and distribution sectors of Japan, however, westernization was greatly delayed. Although cotton-spinning was modernized, the textile industry remained largely as a side business of farmers. In the case of raw silk, which was Japan's leading export until the 1920's, and the match industry, which had a considerable export volume, Western technologies were

adapted to Japanese traditions. In this manner, capital costs were kept low and the industries could make use of cheap labor. Thus the transformation of modern industries into traditional ones was an important factor in our growing process (*10*).

The larger modernized enterprises absorbed a large part of the government's investments but also introduced labor-saving techniques. Thus the increasing rate at which labor was employed by these industries was moderate compared to the rapid growth of production. The increases in employment between 1890 and 1935 reveal that whereas modern industry absorbed 3.7 million workers, the traditional sector absorbed 7 million (*11*).

High standards of education. The transfer of technology on which Japan's industrialization has depended has been facilitated by the country's traditionally high educational standards. Even at the beginning of the Industrial Revolution in Japan, the level of education was considerably higher than that in many of the developing countries today (*12*).

That good education is a prerequisite to a country's technological progress was recognized early in our history, and government policy has always been designed to encourage the accumulation of technological education. According to a white paper published by Japan's Ministry of Education, the level of technological knowledge in 1960 was about 23 times the level in 1905.

Selection of appropriate technology. As a latecomer to industrialization, Japan had the particular advantage of being able to choose well-established technologies from already developed countries and thus save the costs of trial and error. However, in order to select the most suitable technologies for importation, Japan had to make full use of its development planning abilities and educational resources. As a result of government initiatives, Japan made great efforts to send students and technical missions abroad, and to invite foreign specialists for consultation. It was thus possible to select the most appropriate technologies on the basis of opinions of well-informed advisers (*2*).

Problems Faced by Developing Countries Today

Technology transfer and small markets. Recent problems in developing countries are strongly related to the technological characteristics of modern production facilities. As modern technology has increased in sophistication, production facilities have also become more complicated. Automatic control devices have therefore been developed to simplify the operation of such facilities, so that a developing country can easily start production with an imported facility provided it has trained the necessary operators. The trouble begins when the imported facility suddenly breaks down. Since a plant is physically depreciating and wearing out, maintenance and repairs are always necessary, and can be dealt with locally. However, the replacement of any one part requires a whole modern industry base that can only be provided by developed countries. Thus a country that fails to supply a domestic engineering capability increases its dependency on both foreign technology and foreign exchange (*13*).

Many developing countries do not have enough capital on foreign exchange to purchase modern industrial plants, nor do they have a large enough market to utilize a plant of even the smallest efficient size. There is a dynamic interrelation between the growth of a market and the expansion of plant scale. Whereas a high initial price may result in low capacity utilization and high costs, a low initial sales price may increase demand and lead to a larger scale of production with a low cost in the next stage. This cycle is very important in the initial stages of technology transfer. Some developing countries try to establish a new industry based on the domestic market under protective tariffs, but the small size of the market does not allow them to introduce an efficient plant, so that the cost of production is not competitive with the world price. As a result, there is a chronic underutilization of the facility.

It is therefore important to create an international market. If the size of the domestic market is somewhat smaller than the efficient capacity of the plant, it is desirable to build an efficient plant and make full use of the external market. The formation of a common market, or regional cooperation, can be effective in creating a market of sufficient size.

Large production facilities use much energy and raw materials, and an efficient transportation network must be developed to supply these materials and to distribute the products. Since capital, labor, and raw materials are concentrated in the production activity, the income generated by the production is also concentrated. In this respect, developing an efficient redistribution system for income is crucially important for the sound development of a society. If the income is concentrated in a limited number of people, this group may influence the political power structure and work against the integration of a society.

Confronting multinational corporations. The role of multinational corporations in international development is increasing. Many of these companies prefer to transfer capital as well as management as a single package. However, this packaged transfer of technology often neglects the potentiality of some local factors that could otherwise be utilized to the advantage of the recipient country. For example, if a licensing agreement is made between a multinational company and a locally owned company, most of the raw materials should be supplied by the local market. This is particularly important from the standpoint of increasing local employment.

Most multinational companies directly apply the technology developed by and in their country of origin without bothering to adapt it to local conditions. It is therefore important for the science and technology policies of recipient countries to orient the research efforts of multinational companies toward development of indigenous technology. Policy measures are necessary that give priority to certain types of imported technology, incentives for competition in R & D, and facilities for technological education and training. The coordination of such measures for the efficient development of technology can be a difficult problem in a country with a weak governmental infrastructure. Another problem is the tendency of multinational companies to monopolize local markets. This enables them to influence the economy and the politics of the developing country, and to generate conflicts with the national authority.

The economic policies of developing countries today have to depend on multinational companies not only for technology, but also for financing of capital. It would be more helpful in the future if these companies would put more emphasis on the dynamic effects of development, acting as centers for technology transfer and helping to strengthen the abilities of the host country.

Nationalism and rationalism. The recent trend toward economic nationalism is well expressed by the nationalization of foreign-owned companies and by regulations requiring the use of domestic parts in certain proportions in assembled products. Nationalization of foreign-owned companies, which was not part of the Japanese experience, often starts because of complaints that the companies do not fully contribute to the local econ-

omy. These complaints usually stem from the differences between individual goals and social goals. Individual goals are usually centered on profit maximization, whereas social goals are of a long-term nature requiring emphasis on the utilization of domestic factors in production and on the acquisition of technology. For instance, if the domestic market is protected by high import tariffs, the best way for a company to maximize profits is to limit the level of production. But from the social point of view, it may be more desirable to increase production and earn foreign exchange through exports.

If a transferred technology is linked effectively with local activities, the natural diffusion of the technology through production will increase the ability of the society to form technological forward and backward linkages. But if the transferred technology forms a kind of technological enclave, as in such processing industries as petroleum refining and petrochemicals, where there are no direct technological linkages to stimulate domestic technology, the individual goals of profit maximization are separated from the social goals.

Nationalism puts great emphasis on social goals, and a society's will to focus on these goals and develop by itself is very important for its progress. Although a company's emphasis on social goals will increase its contribution to the society, the extent of the contribution will more often be determined by the choice of a technology that has linkages to domestic industries. Thus, rationalism in the choice of technology, which has been an important part of the Japanese policy for technology transfer, has a crucial role in the development of a society.

A developing country using an imported technology to produce industrial goods must also build up its own technologically related industries. However, care must be taken not to weaken the purchasing power of other sectors, such as agriculture, because this could lead to a poor market structure and result in an overproduction of industrial goods. In building up its own industries, the developing country must first master the operation and maintenance of the imported machinery, and then must copy it as accurately as possible. At this stage many problems are likely to arise concerning the materials and mechanical processing, and these can only be solved by having a stock of production facilities and technologically trained personnel. Attention can then be turned to designing machinery that meets the requirements of a special market. At this stage the developing country may be said to have its own technology with which it can build technology appropriate to its social conditions. Thus, developing countries have to use technology that is ready made in developed countries until they can reach the final step of mastering the technology required to design and produce their own machinery (*14*).

The transfer of technology does not mean the mere importation of capital goods. It means increasing the ability of a society to reproduce and extend the technology as a result of the transfer. So the will of a country to improve by itself plays a very important role in the digestion and adoption of transferred technology. In this respect, the experience of Japan could be utilized by many developing countries today (*15*).

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