FOLLOWERS' STRATEGY FOR TECHNOLOGICAL DEVELOPMENT

ASIM SEN

I. INTRODUCTION

TECHNOLOGY is one of the major factors of determining a nation's economic development and military power. While developed countries try to increase their economic well-being and military power through developing new technologies, many developing countries have been transferring standardized technologies. From among these countries only Japan, which used to be considered a less developed country that hardly had any modern technologies a hundred years ago, was able to transfer technologies successfully and acquire advanced technologies and become an advanced country.

This paper deals with Japanese technological development and its implications for presently developing countries. Most of the developing countries are still struggling to obtain many of the standardized technologies that Japan had acquired in a relatively short time many decades ago. We focus on the following questions: how did Japan obtain these technologies, and what are the key factors of this rapid technological development? Consequently we seek to determine whether there are any implications in the technological development of Japan which might serve as examples of patterns which other countries trying to achieve technological development might find useful.

Technological development is a continuous historical process; thus our analysis of this process has been in a historical perspective through utilization of the technological life cycle hypothesis which is verified from the empirical data.

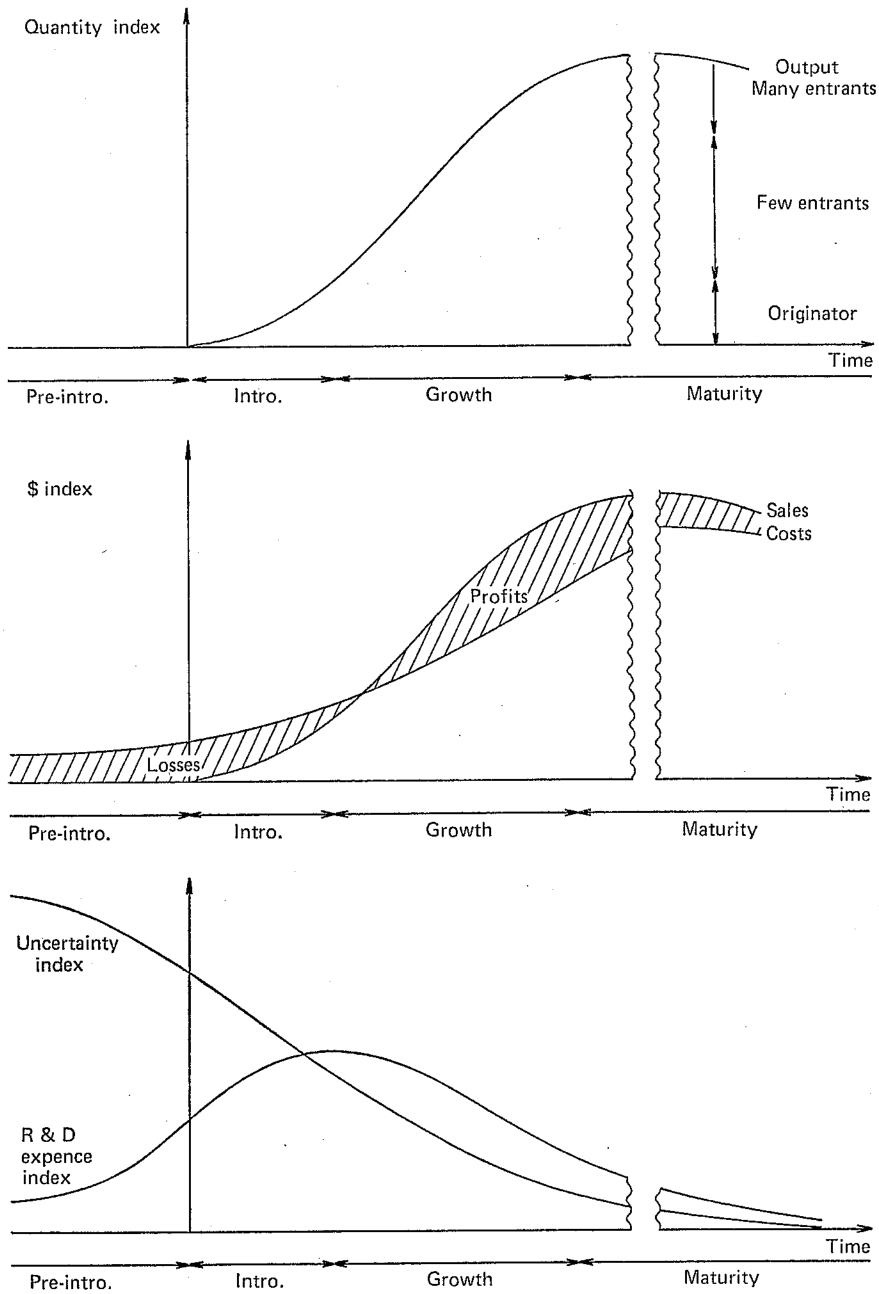
II. THE PROCESS OF TECHNOLOGICAL DEVELOPMENT

Technology may be defined as knowledge, methods, and equipment which are applied to produce goods and services for a society's needs. Technological development is the advance of technology; such advance often takes the form of new methods of producing existing products, new designs which enable the production of products with important new characteristics, and new techniques of organization and management.

Technologies which involve inanimate power, scientific operations and methods, and skilled manpower can be considered modern technologies. The origin of these technologies was probably the textile technology, which had been established in the early period of the history of modern technological development; since then, many different modern technologies have been developed.

The development of each of these technologies is a continuous and accumu-

Fig. 1. Hypothetical Stages of Product Life Cycle



lative historical process which can be explained by the technological life cycle (TLC) hypothesis which has been tested empirically for many technologies.[1] The results provide sound understanding for the process of technological development.

According to the TLC hypothesis, development of a technology passes through four stages; pre-introduction, introduction, growth, and standardization. Each of these stages can be identified by its important production and market characteristics as shown in Figure 1.

In the pre-introduction stage, development of a technology includes inventions and basic research and development activities. Highly qualified scientists, engineers, and research institutions in many industrial organizations, universities, and government departments are required for these activities. The future result of these activities are usually uncertain since many activities result in failure or are discontinued. Most of these activities take place in advanced countries, especially in the United States [31, p. 124] [32] [48, pp. 1–48].

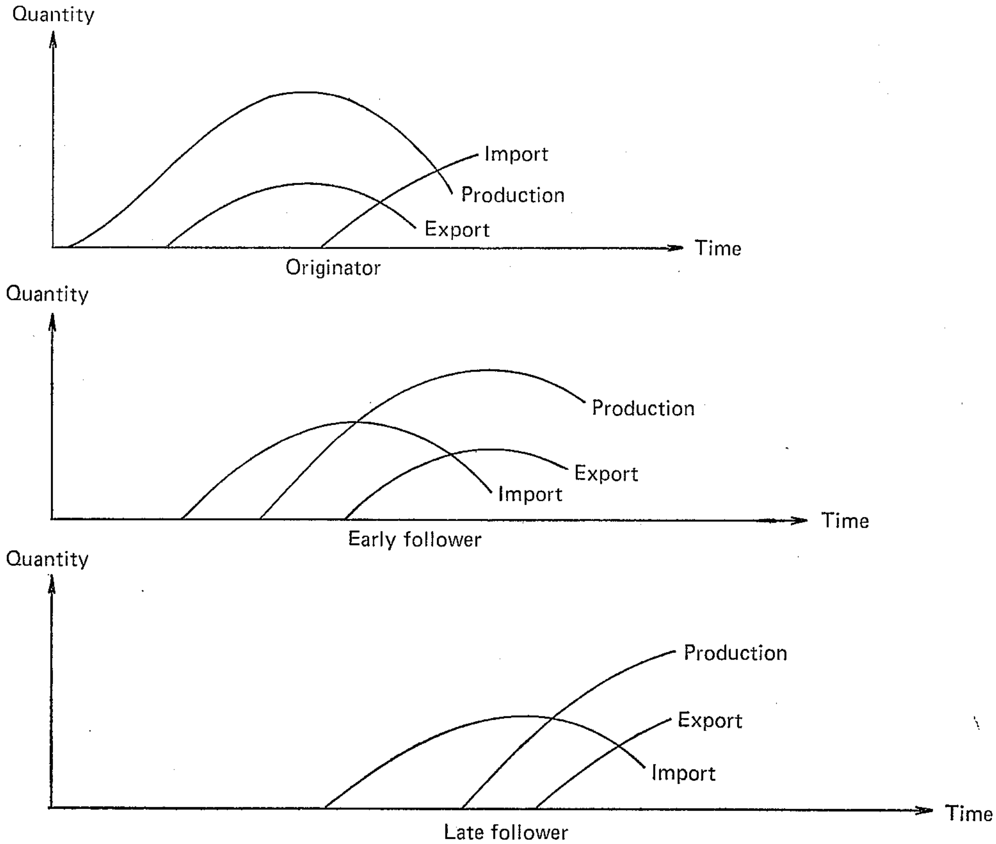
The introduction stage includes the application of an invention and the result of basic research and development activities for production which can be called innovation [26, p. 12] [27]. Innovation leads to the introduction of a new significantly improved product into an economy or the implementation of a new or significantly improved production process. Thus innovation is the key stage in the process leading to the full evaluation and utilization of an invention and pre-introductory development activities for the development of a technology. This stage of a technological development costs more than any other stage, since it requires large amounts of scientific input including scientists, engineers, technicians, and new plants and machinery, before the innovation is successful. Sometimes despite attempts at redesign and improvement, the innovation never is successful. It has been argued that in the United States the average division of innovation costs contain 70 to 85 per cent of the total development costs [31, p. 76]. Therefore, at this stage the returns are minimal or nonexistent. Thus there are usually only a few firms or nations that engage in new technology development at this stage.

During the growth stage various technical as well as market problems are solved by a series of related improvements. The economies of scale start increasing through mass production and standardization of operations and facilities. Thus production cost begins to decline and sales start ballooning due to considerable acceptance of the product in the domestic market as well as other markets through trade.

Finally, all the improvements in technique, knowledge and operations are usually exhausted. Increases in labor and material input per output reach a stable point and all elements of the production process become relatively standardized. The products become widely known and sales reach peak volume.

[1] The product cycle was identified first by S. Kuznets [25] and studied by R. Vernon [49] and M. V. Posner [39], and empirically tested by K. Brockhoff [11]; W. Gruber, W. D. Mehta, and R. Vernon [18]; G. G. Hufbauer [22]; L. T. Wells, Jr. [52] [53]; J. E. Tilton [43]; A. Harman [20]; and H. Tsurumi [44].

Fig. 2. Trade and Technological Development



When technology is standardized the relative importance of scientific and engineering input requirements becomes less important and the cost of unskilled labor begins to be more important. Thus those nations that manage to acquire standardized technology and have both a relatively low income and low wage labor costs, can provide a comparative advantage which enables them to capture a large portion of the existent market. Meanwhile, the nation that standardized this technology, which generally has a relatively high income level and high labor costs, loses its competitive position and consequently loses the large portion of the existent market as shown in Figure 2.

III. STRATEGY OF A NATION'S TECHNOLOGICAL DEVELOPMENT

One can postulate two possible strategies in which a nation can have a modern technology available to it. It may originate modern technology by proceeding through all the stages of the technological life cycle described earlier. The countries which follow this strategy are called originators.

An alternative possibility is for a country to import standardized technologies and adopt, modify, and change them for its own purposes. The countries which follow this strategy are called followers.

A. *Originators' Strategy*

Originators support all activities of basic knowledge across the broadest front to produce most of the technologies by going through all the stages of technological development. In other words, the originator strategy integrates the elements of technologies forward from invention to standardization. A nation following this strategy aims to maintain a position in all advanced fields of military, economic, and political importance. The United States, the Soviet Union, Great Britain, Germany, and France are major originators. The Organisation for Economic Co-operation and Development (OECD) found that of 110 significant innovations developed since 1945 which occurred in the advanced industrialized countries, 74 were in the United States, 18 in the United Kingdom, 14 in Germany, and 4 in Japan [32].

However, none of these countries originated all of the technologies that they have used. When a new technology is standardized by one or a few of these countries, it is often transferred to others through diffusion, patent and license agreements, or imitation.

Successful technology transformation is possible among the advanced countries because the necessary supply and demand conditions for the transformation of these technologies exist in these countries. The supply conditions are mainly technical, managerial, economic, and institutional in nature. The basic knowledge involved in these technologies has been accumulated in these countries. They already have established high-level scientific institutions, universities, scientific libraries, and information services, basic and applied research and development centers, and laboratories. They produce a considerable amount of skilled manpower: scientists, engineers, managers, and technicians [32]. This high-quality manpower is already engaged in scientific and technical education; training and popularization of basic knowledge through the mass media; application of basic knowledge in industrial and agricultural production; and services of all kinds including routine design, engineering, production control, medical services, and administration. These countries have already been actively producing similar technologies and have accumulated enough technical knowledge and experience to undertake the development of new technologies by themselves.

These countries also enjoy similar domestic demand conditions that stimulate a wide range of innovations or transformations of new technologies; high wage rates promote labor-saving new technologies; high personal incomes generate a strong demand for new products; and large military programs support many new technologies. However, these conditions will not be enough either for innovation or transformation of new standardized technologies unless they are accompanied by favorable economic and social conditions, including education, communications, business enterprise, acceptability of new ideas, organizational effectiveness, and political leadership.

Because these conditions are highly developed in advanced countries, and there are no major technological or other relevant gaps between these countries, the process of absorbing new standardized technologies through diffusion, license and patent agreements, or imitation occurs in a relatively short time, notably two to four years in most cases. We call these countries early followers or originators because of this short imitation time and because they are also innovators for other technologies. Their technical capabilities and resources permit early identification of significant foreign developments and facilitate the actual transfer of technology by adopting it in their own technological development.

Yet when these conditions are not close to each other and a considerable gap exists between originators and followers, transferring of standardized technologies from originator countries to followers takes a different route and generates different results for different countries.

B. *Followers' Strategy*

It is well known that there is a great gap between advanced and developing countries concerning technical, managerial, economic, as well as other conditions [38] [50] [16] relevant to technological development. Most of the developing countries possess supply and demand conditions to produce relatively low income products which require intermediate technologies. These technologies like textiles, food processing, construction, building materials, agricultural implements, light machinery, and light metallurgy, are relatively high labor and low capital intensive and scientifically unsophisticated. Intermediate technologies are, mostly, organizationally simple, mechanically easy to operate, and require low labor and managerial skills. They use relatively low energy and other raw materials that are scarce globally. These technologies absorb large quantities of labor which are available in most of the developing countries and reduce unemployment. The products of intermediate technologies, like textile products, have been historically the most important consumer goods next to agricultural products, notably food and drink. Finally accumulated technical knowledge, experience, and many other relevant elements from the handicraft and agricultural technologies which exist in most of the developing countries can be used and adjusted for intermediate technologies with simple modification and short preparation.

On the other hand, heavy technologies are comparatively low labor and high capital intensive. Their development and operation require high scientific and managerial skills, trained labor, and complex organization. They need a large capital investment and a large amount of high quality research and development activity. They use much energy and other input materials which are costly and scarce globally and generate an excess of pollution and other environmental hazards that cause considerable crisis and great concern for most of the presently industrialized countries.

Thus it is economical and technically the most feasible for developing countries to develop intermediate technologies in the early period of their industrialization and heavy technologies in the later period of their industrialization. Historically, most advanced countries have developed intermediate technologies before developing advanced and frontier technologies simply because of the techniques and economic characteristics stated above which make it quicker, cheaper, and easier to develop less sophisticated technologies earlier and more sophisticated technologies later. For the same reasons, presently developing countries should proceed in the same order.

However, developing countries should acquire these technologies through importation after they have standardized rather than going through all stages of a technological life cycle. This may provide further advantages for developing countries: the quick availability of standardized technologies will hasten the technological development; choosing the best (often the newest) technologies among the existent standardized technologies will provide competitive advantages; finally the opportunity to avoid large basic research and development costs for invention and innovation will provide further advantages for developing countries. Thus it is quicker and cheaper for developing countries to acquire standardized technologies through technology importation.

However, the costs and benefits of the technology importation mainly depend on the success of the developing country's absorption of imported technologies. Successful technology absorption requires certain technical, economic, social, and political conditions and policies to improve these conditions to accompany the technology importation. If these conditions are not favorable and proper policies are not taken to improve them, technology importation may be substituted for local scientific research and development activities, which creates self-perpetuating technological dependence and eventually leads to slowing down the domestic technological development.

Among the many developing countries, Japan, which has been using the followers' strategy, has succeeded in developing advanced technologies and has moved fully into the category of a developed and innovator advanced nation [41]. The Japanese success in technological development through the followers' strategy was possible under favorable technical, economic, social, and political conditions and proper policies. In the following sections, we will discuss these conditions and policies which may indicate the successful use of the followers' strategy.

IV. JAPANESE TECHNOLOGICAL DEVELOPMENT: A SUCCESSFUL USE OF FOLLOWERS' STRATEGY

Japanese modern technological development started changing significantly during the Meiji period (1868–1912). At the beginning of this period, there was a considerable technology gap between Japan and the Western countries. In order to obtain modern technologies and close the gap quickly and economically, Meiji leaders adopted the followers' strategy through which Japan imported standardized technologies from the Western countries and acquired intermediate as well as heavy technologies before World War II.

During World War II, some of the Japanese technologies had been destroyed and after the war the remaining technologies were old and of low quality compared to Western technologies. At the same time, access to contemporary technology was opened to Japanese technologists by the West, especially by the United States. Thus Japan, again, used the followers' strategy through patent and license agreements and acquired advanced technologies successfully and even became a technology innovator and exporter.

In order to understand how the Japanese used followers' strategy so successfully and what the key factors of this process were, it is convenient to analyze textile technologies.

A. *Development of Modern Textile Technologies: The Case of Silk Reeling and Cotton*

Modern textile technologies notably in silk and cotton constitute one of the most important intermediate technologies for human life. Textiles are technologically simple, labor intensive, and highly demanded for every nation. England was the first nation to utilize modern technology in textile production during the Industrial Revolution. At the beginning of the eighteenth century, the spinning wheel was the only machine which was transforming raw cotton or wool into yarn. Many inventions and innovations were introduced during the eighteenth century. Subsequently, textile technology was standardized and started diffusing into other countries [6] [15].

Germany was the first follower of England by importing mules and new machines, thereby establishing a factory system in 1872. France, Switzerland, Canada, and the United States were other early followers in the West adopting British cotton technologies through importation of textile machines, these countries started their own technological development by utilizing and further improving British textile machines. These activities led to further innovations in textile technologies and by 1814 the United States of America had already started producing power looms [7] [12].

In Japan, the development of textile technologies started in the second half of the nineteenth century, 50–100 years later than the West. However, in less than 50 years, Japan had developed the world's most advanced cotton technologies and became the world's foremost exporter of cotton goods.

When Japan was forcibly opened to free trade with other nations, raw silk was the only important national resource that Japan could export [8]. However, hand reeled Japanese silk could not compete with the machine reeled products of France and Italy. In order to survive under these competitive conditions, Japanese silk reelers and sericulturists had to modernize their technologies.

At the same time, high quality cotton products started flowing into the Japanese market from abroad following a free trade agreement. Imported high-quality cotton products partially destroyed the indigenous handicraft industry and strained Japanese currency, creating a serious balance of payments problem for the Japanese economy [30, p. 144]. Thus development of modern technology in this field was essential for the survival of the Japanese economy.

The Meiji leaders concentrated on activities modernizing the existent silk technologies first, since the large capital required for cotton technologies could only be generated through silk exports. The only other alternative was borrowing necessary capital from other countries, an act which was rejected by the Meiji leaders who strongly believed that Japan should not depend on other countries economically, technologically, or militarily. In summary, they concentrated their resources on the development of silk technologies first to increase exports, and later with the accumulated capital and technological experience, they started the development of cotton technologies to substitute for the imported cotton products. This process is generally known as export promotion and import substitution [4].

In 1872, the government imported reeling machinery from the French Lilienthal and Company, and built the largest mill in Japan at Tomioka. The main purpose of the mill was to encourage the adoption of mechanical reeling by private producers and to train workers in the new modern methods. Many European engineers, and technicians including women reelers, carpenters, and silk experts were employed for these purposes. The Tomioka mill employed four hundred women operators, who had been selected for their skill as handicraft reelers. As they learned to operate the new reeling machinery, they were transferred as instructors to the new private mills that were being established following the Tomioka mill example.

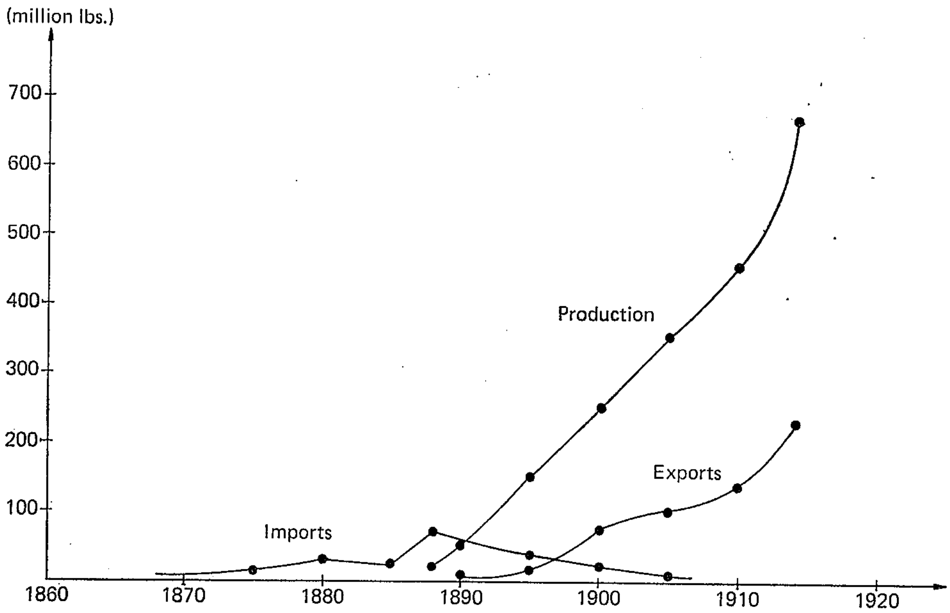
The training process was so successful that in 1875 the mill was placed under Japanese managerial and technical control entirely and the contracts of the foreign employees were cancelled. The Tomioka mill continued as a government training school for twenty years and helped to spread new reeling techniques throughout Japan [33, pp. 100–104] [42, pp. 54–66].

Based on the Tomioka silk mill model, the government built many other mills and stimulated the adoption of machine reeling by private producers. Consequently, the mechanical reeling was rapid and about 20 per cent of Japanese silk was being reeled by machine in 1878 and 31 per cent by 1880. This figure reached 75 per cent in 1910 and during 1930–37, 78 per cent of the world production of silk was produced by Japan [42].

While silk reeling underwent rapid mechanization, the cotton spinning technology did not start to change until the late 1870s because the mechanization of cotton spinning was far more difficult technically and more expensive than the reeling of raw silk. Thus Japanese cotton production fell off sharply and even almost disappeared while the imports of cotton products kept increasing rapidly. Cotton yarn and cloth combined made up from 24 per cent to 42 per cent of the total imports throughout the first decade after 1868.

In an effort to promote the mechanization of the cotton industry, cotton machinery and technicians were brought from England, and a cotton mill began operation, with steam power, in 1870. The government used it for much of the same purposes as the Tomioka model mill, i.e., to train workers and show prospective private investors what equipment was required for machine spinning and how the production was organized. At the same time, many efforts were made to adapt foreign technology to Japanese conditions [33, pp. 367–71]. As a result more efficient machines were imported and 90 per cent of the total cotton yarn output in Japan was made on imported spinning machines in 1889;

Fig. 3. Imports, Production, and Exports of Cotton Yarn



Source: [40, pp. 304–5].

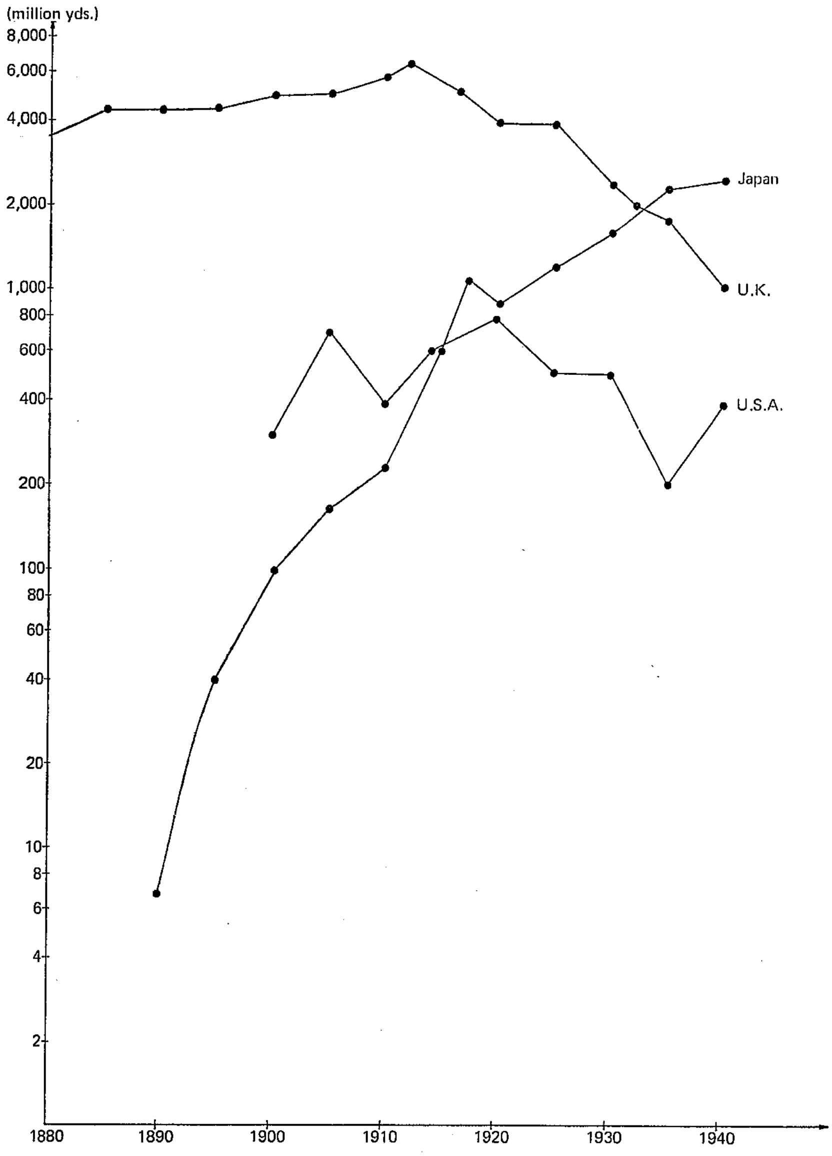
this figure was over 96 per cent in 1892 [45, p. 12] [46, p. 2].

Although the modern spinning industry of Japan owed much of its development to imported Western technology, the Japanese made considerable technical contributions to the industry by developing the Toyoda automatic loom through invention and innovation [37]. This automatic loom was superior to the Lancashire machines and was imported by many Western countries.

As a result of improving textile technologies and production processes, Japan began to export textile goods. By 1897, exports of cotton yarn exceeded imports and by 1910, imports had totally disappeared as shown in Figure 3. Other intermediate technologies such as light machinery, tools, electric machines, and bicycles followed a similar development pattern [3].

During World War I, machinery imports were cut off, forcing Japan to rely on its own domestic output. Consequently, the cotton and silk spinning industry had turned to Japanese power loom manufacturers and machinery makers for spinning equipment. In a short time, Toyoda automatic looms were built and utilized throughout the country on a large scale. Many other looms were built and utilized throughout the country on a large scale. Many other looms and intermediate technologies including light machinery, tools, electric machinery, and bicycles were acquired through domestic facilities and human resources. Thus Japan had achieved the technological capacity to imitate, standardize, and even innovate intermediate technologies after World War I. As a result, Japan acquired self-sufficiency and independency in these technologies. Subsequently,

Fig. 4. Changes in Exports of Cotton Fabrics



Source: [40, p. 32].

Japan's plentiful low wage labor became a major factor for providing comparative advantages in these technologies against Britain and America, the originators of these technologies. Japanese exports of cotton fabrics increased remarkably and exceeded those of England and the United States, and Japan became the largest exporter of cotton fabrics in the world as shown in Figure 4. These results are in agreement with the technological life cycle hypothesis.

B. *Development of Heavy Industry Technologies*

The development of textile technologies increased the demand for machine and transportation equipment. This in turn, increased the demand for chemicals, iron and steel, ship building, heavy machinery, and engine technologies. Thus due to chain effects and the war needs in late 1930s Japanese technological development shifted to heavy industries [14] [5] [47] [45]. Consequently, textile production and exports declined. This was partly due to the fact that other developing countries had acquired textile technologies and realized the same low wage labor advantages which Japan had realized earlier.

The pattern of development of most heavy industry technologies was similar to the patterns of textile technologies [14] [5] [47] [45]. Japan imported these technologies from Western countries, and based on machinery and equipment models, they built similar or modified Japanese versions. Japan reached such a high level of technical and managerial capability before World War II, that they could build products using a standardized technology from blue prints or other resources that provided basic design information. However, Japan's technological and its pure science and basic research capabilities were still behind those of the Western countries. Furthermore, wartime isolation with extensive destruction of production capacity and research facilities resulted in a greater technological gap after World War II. In addition, the bulk of Japan's heavy and chemical industries before and during the war had been dependent upon the production of war goods.

Thus the leading firms using up-to-date technology found themselves, after the war, in great need of discovering and developing new markets for their output and meeting the rising competition within the domestic market as well as in international markets. Many firms considered the importation of Western technology to be the quickest, the least costly, and most rational alternative to undertake. Thus Japan, again, eagerly followed the followers' strategy, through mostly patent and license agreements and acquired advanced technologies throughout the postwar era [34].

During the period of 1950–70, Japan concluded two thousand license agreements with Western nations; 60 per cent of these agreements were with U.S. firms, and 35 per cent with enterprises in OECD countries other than the United States and Canada [34]. These agreements provided detailed drawings, operating instruction, manuals, and exchange of technical and managerial persons between Japanese and U.S. firms. Technical assistance included in patent agreements gradually decreased while Japanese technological development increased; but still in 1972 only 17.2 per cent of the technical agreements provided patent rights alone, and the remainder included know-how and other forms of technical assistance [23]. Thus in the 1970s, the technological gap and dependence on foreign know-how still existed in Japan.

However, despite some technological dependence, Japan acquired many advanced technologies and became a technology standardizer, innovator, and exporter. For example, in the steel and iron industry, Japan adopted rather quickly the Basic Oxygen Furnace (BOF) technology which had been first invented in Austria around 1954. The Japanese rate of adoption of the BOF has been faster than that of any other major steel producing country [44]. If major technological innovations during 1953–73 are considered, Japan's share of innovations reached about 10 per cent; however, it achieved the largest growth rate [23]. The mean time interval between invention and innovation is the shortest in Japan with 3.6 years followed by West Germany with 5.6 years, the United States with 6.4 years, France with 7.3 years, and the United Kingdom with 7.5 years [48, pp. 2–27]. This partly indicates the Japanese high level of technological development and high speed of absorption.

Japan also became a technology exporter. The receipts from technology exports increased to $34 million in 1968 from $0.3 million in 1956. Most of the exported technologies were imported from the Western countries and then improved, modified, and adopted to conditions of developing countries. Japanese technology is also exported to advanced countries which consists largely of patented, high level technology involving chemicals and electronic products [35].

Mainly as a result of this rapid technological development, Japan became highly competitive in the international market and achieved a high rate of economic growth. By 1953, the Japanese economy had recovered its prewar level. By 1967, Japan's international ranking was first in shipbuilding; second in car production, in TV set production, in chemical fiber production, and in number of telephones in use; and third in steel production and in electronic computers in use. Its economic growth rate was 9 per cent in the 1960s, and 13.5 per cent in the early 1970s. It is argued that, if its present trend continues, Japan will be equal or surpass the United States in standard of living and industrial productivity in this century and will be the first in the twenty-first century [2].

The process of Japanese technological development demonstrates that Japan acquired an advanced level of technological development in a relatively short time, and subsequently realized major economic benefits at a cost of relatively small technological dependence by following the followers' strategy. However, the Japanese success, was possible only under certain relevant conditions or factors and policies that were important for Japanese technological development. In the following section, we will discuss these conditions or factors and policies and subsequently their implications for presently developing countries.

V. KEY FACTORS AND IMPLICATIONS OF JAPANESE TECHNOLOGICAL DEVELOPMENT

The success of Japanese technological development through followers' strategy was mainly due to the high quality of Japanese human resources, equipped with a high level of education, technical and managerial knowledge. In addition, favorable social, economic, and political conditions hastened the Japanese technological development. Japan continuously prepared, organized, and utilized these resources for technological development. The policies of preparation and utilization of these resources might provide useful guidance for presently developing countries using followers' strategy for their technological development.

We realize that there are many different supply and demand conditions in developing countries that require varied plans and procedures for their technological development. However, the problems that they face for their technological development through the followers' strategy are generally similar. Japan also faced these problems as a developing country and was able to deal with them successfully. It is doubtful that any other country can or will do the exact same things, but the Japanese experience provides a tested alternative and guide for developing countries' technological development. In fact, Japan herself has demonstrated that lessons from other countries can be very helpful if they are chosen and utilized properly. The Japanese experience can even provide better lessons for developing countries than other advanced countries, since Japan has been in the position as a developing country comparatively recently.

Many difficulties in achieving modern technological development are faced in countries at the start of development. If some of these problems are not solved at the beginning stage, they become a dragging force in later periods by delaying and slowing down development. Thus in what follows we mainly concentrate on the initial period although important implications from later periods which may be relevant to developing countries will be covered briefly.

A. *Preparation and Utilization of Indigenous Human Resources*

The modern technologies demand high-quality human resources, notably scientists, engineers, technicians, and managers. Their activities for technological development which involve scientific thinking, learning, and doing require education at all levels. Education provides the seed of new understanding, new capabilities to adopt, improve, and change, along with desire for new technologies.

Educated human resources demand new technologies; and the rising technological development demands better quality as well as greater quantity of human resources at every level. Thus balanced growth in quantity and quality of human resources is necessary for technological development. Not only primary education for all human resources is involved in technological development but secondary education for skilled workers and technicians, and higher education for engineers, scientists, and managers developed interdependently by supplying and demanding each other simultaneously and continuously. Recognizing this, Japanese leaders educated, trained, and prepared its human resources for technological development continuously.

Japan did not have enough high-quality human resources when it started its modern technological development. However, it started advantages of a largely literated population [36] [17] [24] and very early took proper measures to develop facilities for the education of more highly trained personnel rather than employing foreign human resources with transferred technology on a long-term basis, or allowing foreign corporations to establish the needed technologies with their own personnel. In order to speed up the preparations, Japan began by directly employing foreign experts on relatively short-term contracts at every level (scientists, engineers, teachers, and technicians), and sent Japanese students abroad to study relevant science and technology [55] [51] [28]. In less than a decade, Japan was able to prepare its own human resources and replace the foreign human resources [55] [51] [28].

Parallel to educational establishments in Japan, research and development activities (mostly applied type) started at universities, and in public and private institutions for technological development. At the same time, new universities and other institutions for high level education as well as laboratories and applied research and development centers were set up. Research and development activities and institutions provided the essential factor of modern technological development for its transformation, adaptation, assimilation, and improvement. Thus the high level of education, research and development activities and related institutions, and modern technologies developed interdependently; and Japanese government has taken the necessary actions to promote these activities continuously.

Most of the developing countries lack high-quality human resources and employ them from advanced countries along with imported technologies. Developing countries' indigenous technical capabilities would improve only slowly with this process. In addition, it may cost more and generate foreign dependence for high-quality human resources. Developing countries have to prepare their own human resources for the transfer and absorption process which are essential to successful technological development.

The preparation of high-quality human resources for technology transfer takes considerable time depending on the developing country's conditions. However, the preparation time can be shortened by employing experts on short-time contracts and by sending students, engineers, and managers abroad to study relevant science and technology as Japan did. At the same time, universities and other institutions for high-level education as well as applied research and development centers should be set up.

Many presently developing countries are already starting to prepare their high-quality human resources. However, they are faced with mass illiteracy, and thus must carry out much more extensive educational programs. The Japanese example also shows the advantages of having universities and other institutions engage in research and development activities related to the immediate needs of applied research rather than mere theoretical work. It likewise demonstrates the value of such institutions remaining in close contact with the industrial organizations which can use the results of their research.

Utilization of high-quality technical human resources is also as important as their preparation. In fact, many developing countries fail to utilize their high-quality human resources and consequently suffer from "brain drain" considerably. Japan avoided this by coordinating the training of scientists and technicians with the domestic demand for their services.

Technologies developed in advanced countries are based on their own conditions, the transferee countries have to adapt these technologies to their own conditions: size, input and output qualities, and labor characteristics. Imported new technology will also change people's ways of life through changing their clothes, houses, apartments, and their communities. These changes have to be coördinated with their own social conditions through adjustments, improvements, and modifications to prevent anti-foreign feelings for technological development and instead promote domestication and modernization.

Japan successfully solved these problems by adapting every new technical change through modification, improvement, or just by using new shapes, sizes, and colors to make it appear more Japanese rather than foreign to its customers. These changes not only erased the negative feelings against products of foreign technology, but generated new enthusiasm and new talent and experience that gave Japanese even more economic and technical advantages from improving foreign made technologies.

In order to hasten the process of diffusion, technical links were established among various industrial organizations, and technical cooperation and communication were maintained. The Japanese government took measures to make sure that most productive techniques and processes discovered in one organization would be provided to the others without any secrecy or delay.

The governments of developing countries should take proper measures to protect their technological and economic development especially during the infant stage until it reach maturity and close the technological gap. Japan protected its technological and economic development for a long time. Similar measures and policies may work well for developing countries.

B. *Generation and Accumulation of Domestic Capital*

Japan financed imported technologies through utilizing its domestic resources. It neither borrowed substantial capital from abroad nor let foreign direct investment in Japan. In fact, Japan enacted laws to prevent such operations. However, in order to finance imported technologies, Japan first concentrated on its own agriculture to increase exports and later replaced these agricultural products with the products of intermediate technologies, notably textile products. Japan realized considerable comparative advantages mainly due to low wage labor when it closed the technology gap in the textile technology. Thus lowering the price of textile products increased the exports which Japan used to finance with imported technologies.

Textile technologies also provided the main source of capital for internal investment. With the establishment of the modern textile industry in Japan, new employment opportunities were created, which in turn, raised the general income and savings level. This new income caused a corresponding increase in spending which created further demand for textiles and further employment through new investments in such things as housing, transportation, and urban public services. The investment, employment, and income in the textile industry were increased with the change of consumer market behavior; including new locations, occupations, and consumption patterns of the people [21]. This process spread throughout the country and expanded through integration of the less developed areas into the general economy. Thus with this process, Japan made modern technological products not only available to limited amounts of consumers, but also to those who lived in the village. Consequently, the demand for modern technologies increased and helped further technological development. Thus generating new investments, employment, and income and savings, Japanese economy entered into self-generating dynamic growth pattern.

Developing countries should also integrate the less developed parts into the general economy which will increase employment, income, savings, and demand for modern technologies. Today a large portion of the population in developing countries live in villages far away from cities and engage in farming. Most of them do not have enough land or employment to generate enough income to save or to buy the products of modern technologies. Their limited income is barely enough for their basic needs. Thus they are virtually outside the market of manufactured products. The villagers also are deprived of education. Many villages do not even have elementary schools. The secondary schools are usually available only to children in towns and cities far away from the villages, and universities are located in cities in which villagers cannot afford to pay rent and other expenses to educate their children.

Without education and economic power, the villagers have also been excluded from politics. Usually the landlords, their children and relatives are the principal participants in both local and national politics. Although the government may change at the hands of these minorities (mostly the rich families), the main policies do not change to alter the situation.

When a developing country starts industrialization with these social, economic, and political conditions, the possibilities of technological development will be limited by the fact that much of the rural population will remain outside the market for a considerable period. The demand for manufactured goods is largely confined to the urban population. Although new industries using more or less modern technology can be established to make domestically goods which were previously imported, this process will usually come to an end before much of the rural population has been brought into the market. At that point, social reforms will be needed before further economic and technological development can proceed.

More specifically, the large land holdings will need to be redistributed to create productive agriculture by providing farmers their own land to work. This will increase their incentives for the use of more modern technology, which will increase output. Increasing output leads to more monetary income; this will give villagers a chance to buy manufactured products. Economic independence will generate political power, which in turn, draws attention to other needs of the villagers for schooling, transportation, communication, and other services. Thus villages will be linked to the cities and integrated into the general economy. Without these activities, the rural employment and demand cannot be generated; and without their employment and demand, technological development cannot spread beyond the city limits.

Thus, the expansion and diversification of industrialization can be increased through linking cities to villages; in other words, a link between the manufacturing and agricultural sectors is necessary for further technological development and economic growth. This link increases the demand for both sectors. Through this link between agriculture and industry, general income level and demand for both manufactured and agricultural products increase. Consequently, new locations and occupations generate new demand for new technology; thus the technology will diversify and the economy will hopefully enter a self-generating dynamic growth pattern by generating further necessary technical, managerial, and financial factors.

The separation of city and village also existed in Japan when it started its modern technological development at the beginning of the Meiji period (1868–1912). A large portion of the population lived in villages and engaged in farming. Landlords and daimyos dominated village economic, social, and political life. The Meiji leaders took measures first to change this situation; land and tax reforms, and the demolition of the old class structure were at the heart of these measures [41, Chap. 4]. Japan's example shows that such reforms are a key to successful technological development.

C. *Full Participation of Government*

The preparation of human resources, providing large capital requirements, maintaining proper trade conditions, and providing general education and social reforms for technological development, all require full participation and strong leadership by the government in developing countries. The Japanese case provides an example of the advantages of such a government, and of relative social and political stability insofar as economic and technological development is concerned.

Poor technical, managerial, and capital conditions do not promise enough incentives for private entrepreneurs without full government participation. In the Japanese case, a strong government, dedicated to economic and technological development, first took the lead to prepare technical and managerial resources and provide the necessary capital. Although the government later decreased its active participation, it worked closely with public and private institutions that are engaged in technological development.

Technological and economic development require long-term planning without political or ideological disruptions because of the need for continuity for their successful achievement. Most of the presently developing nations have central planning bodies, but these often change when the government changes, or new governments rely on their own plans and programs rather than the ones prepared and recommended under earlier regimes. It is often customary in developing countries that the parties or groups in power often consider short-term political advantages rather than long-term technological and economic advantages, thus making development a political and ideological issue. The plans and projects for technological development are quite often cancelled, seriously altered, or stopped for a certain amount of time for political reasons. Japan demonstrates the advantage of technological and economic development being a national goal and not being made a political or ideological issue due to personal or party politics and ambitions.

The success of national planning (goal attainment) such as economic and technological development partly depends on the commonness of the goal and coordination among the people, including the general public, business organization, managers, and workers. The government should lead and unify all these groups for such goal attainment. Japan's experience has demonstrated that the social unity among its general population, managers, and workers played a strongly positive role for its economic and technological development [29] [9] [1] [54] [19]. The Japanese social system and values provided the bases of this social unity among its human resources. Its centralized government, with loyalty to the emperor, was efficient and respected. Its people had a highly sophisticated cultural background and a strong sense of national unity. Conflicts among groups caused by differences in race, religion, tribal heritage, and the like do not exist in Japan as they do in many of the developing nations today. Although developing countries do not have some of these conditions, they should take measures to utilize their own social values and adjust them for economic and technological development. Following Japan's example, developing nations should give more attention to providing the kind of leadership which will stimulate their people to be diligent, industrious, and dedicated to the task of working together.

Japan's experience shows the value of government spending being concentrated mostly on capital equipment, at least at the beginning stage where sufficient private investment was lacking for rapid technological development. The Japanese government helped capital savings through taxes and allowing private industries' monopolistic and joint market operations which generated great capital accumulation. There was a trade off between rapid technological development and social welfare for a long time; Japan surpressed the social welfare earlier and took steps to foster it later, after reaching a stage of advanced technological development [13] [10]. It is certainly more difficult for countries developing in the last part of the twentieth century to do this than for Japan to do so a century earlier, because the "revolution of rising expectations" leads workers and middle class elements in presently developing countries to expect social security and other benefits at a relatively early stage.

VI. CONCLUSION

Developing countries may find it beneficial to follow the Japanese model by acquiring and adapting foreign technology as embodied in machines and producing relatively low-quality products as Japan did during the first stage of its industrialization. Developing countries possess supply and demand conditions to produce relatively low-quality products which require relatively labor-intensive technologies. Japanese experience has demonstrated that developing countries acquire major comparative advantages in these technologies. Developing countries can acquire similar comparative advantages by concentrating on these technologies first rather than acquiring capital-intensive technologies. However, these comparative advantages may not be sufficient to overcome the technological advantages of the developed countries in the early stages of acquiring these technologies. Thus developing countries will find it beneficial to protect their industries until the technological gap between them and the developed countries is closed in these particular technologies. It is only after closing this technological gap that the comparative advantages of developing countries due mainly to low-cost labor become effective in international competition in that industry.

Developing countries will continually be faced with the necessity to change their production structure to keep up with the dynamic comparative advantage because the markets for the products in which particular developing countries once had an advantage will disappear, and the developing countries will either have to adapt their product characteristics and processes in line with such developments, or switch their specialization. Generally, these switches will lead to increasing capital intensity of production. Thus labor-intensive products will be displaced by more capital-intensive products and production of the developing countries will have to adapt accordingly as Japan did.

Developing countries with a large market and considerable economic size, such as India, Pakistan, Iran, Turkey, and Brazil may well follow the Japanese experience and move into capital-intensive products for which they have a considerable market, by acquiring the results of foreign research and development (transistors, new steel production technologies, etc.) and developing them by themselves as Japan has been doing since World War II. On the other hand, the countries with small-size markets and economies may find it advantageous to specialize in only some of these technologies.

Developing countries may follow the Japanese model for handling some of the major problems relevant to industrialization; such as providing social reforms, high level of education, and high literacy; preparing engineers, scientists, and managers; establishing research and development institutions and linking their activities with the industrial need; most important, establishing coordination and unity between government leaders and a variety of business and public groups. In this manner, the Japanese experience of handling these problems will be a valuable guide for presently developing countries.

REFERENCES

1. ABEGGLEN, J. C. *Management and Worker: The Japanese Solution* (Tokyo: Sophia University, 1973).
2. ————. "The Economic Growth of Japan," *Scientific American,* Vol. 222, No. 3 (March 1970).
3. AKAMATSU, K. "A Historical Pattern of Economic Growth in Developing Countries," *Developing Economies,* Preliminary issue No. 1 (March–August 1962).
4. ALEXANDER, R. J. "The Import-Substitution Strategy of Economic Development," *Journal of Economic Issues,* Vol. 1, No. 4 (December 1967).
5. ANDŌ, Y. "The Formation of Heavy Industry—One of the Process of Industrialization in the Meiji Period," *Developing Economies,* Vol. 3, No. 4 (December 1965).
6. BAINES, E. *History of the Cotton Manufacture in Great Britain* (London: H. Fisher, R. Fisher and P. Jackson, 1835).
7. BARDER, L. *World Development in the Cotton Industry* (New York: New York University Press, 1925).
8. BEASLEY, W. G. *Selected Documents on Japanese Foreign Policy, 1853–1868* (London: Oxford University Press, 1955).
9. BENNETT, J. W., and ISHINO, I. *Paternalism in the Japanese Economy* (Minneapolis: University of Minnesota Press, 1963).
10. BENNETT, J. W., and LEVINCE, S. B. "Industrialization and Social Deprivation: Welfare, Environment, and the Postindustrial Societies in Japan," in *Japanese Industrialization and Its Social Consequences,* ed. H. Patrick (Berkeley: University of California Press, 1976).
11. BROCKHOFF, K. "A Test for the Product Life Cycle," *Econometrica,* Vol. 35, No. 3–4 (July–October 1967).
12. CHAPMAN, S. J. *The Cotton Industry and Trade* (London: Methuen and Co., 1905).
13. CHUBACHI, M., and TAIRA, K. "Poverty in Modern Japan: Perceptions and Realities," in *Japanese Industrialization and Its Social Consequences,* ed. H. Patrick (Berkeley: University of California Press, 1976).
14. COHEN, J. B. *Japan's War Economy in War and Reconstruction* (Minneapolis: University of Minnesota Press, 1949).
15. DANIELS, G. W. *The Early English Cotton Industry* (Manchester: University Press, 1920).
16. DEDIGER, S. "Underdeveloped Science in Underdeveloped Countries," *Minerva,* Vol. 2, No. 1 (Autumn 1963).
17. DORE, R. P. *Education in Tokugawa Japan* (Los Angeles: University of California Press, 1965).
18. GRUBER, W.; MEHTA, W. D.; and VERNON, R. "The R&D Factor in International Trade and International Investment of United States Industries," *Journal of Political Economy,* Vol. 75, No. 1 (February 1967).
19. HAGEN, E. *On the Theory of Social Change: How Economic Growth Begins* (Homewood, Ill.: Dorsey Press, 1962).
20. HARMAN, A. *The International Computer Industry: Innovation and Comparative Advantages* (Cambridge, Mass.: Harvard University Press, 1971).
21. HAZAMA, H. "Historical Changes in the Life Style of Industrial Worker," in *Japanese Industrialization and Its Social Consequences,* ed. H. Patrick (Berkeley: University of California Press, 1976).
22. HUFBAUER, G. G. *Synthetic Material and the Theory of International Trade* (Cambridge, Mass.: Harvard University Press, 1966).
23. Japan, Prime Minister's Office, Science and Technology Agency. *Annual Report of the Import of Foreign Technology* (1972).

24. KAIGO, T. *Japanese Education: Its Past and Present* (Tokyo: Kokusai Bunka Shinkōkai, 1968).
25. KUZNETS, S. *Economic Change* (New York: W.W. Norton and Co., 1953).
26. MANSFIELD, E. *The Economics of Technological Change* (New York: W.W. Norton and Co., 1968).
27. ————. *Industrial Research and Technological Innovation: An Econometric Analysis* (New York: W.W. Norton and Co., 1968).
28. NAKAMURA, T. "The Contribution of Foreigners in Society, Science and Technology in Japan," *Journal of World History,* Vol. 9, No. 2 (1965).
29. NAKANE, C. *Japanese Society* (Berkeley: University of California Press, 1970).
30. NORMAN, H.E. *Japan's Emergence as a Modern State: Political and Economic Problems of Meiji Period* (New York: Institute of Pacific Relations, 1940).
31. NORRIS, K., and VAIZEY, J. *The Economics of Research and Technology* (London: George Allen and Unwin, 1973).
32. Organisation of Economic Co-operation and Development. *Gaps in Technology, Comparisons between Countries* (Paris: OECD Press, 1970).
33. ORCHARD, J.E. *Japan's Economic Position: The Progress of Industrialization* (New York: McGraw-Hill Book Co., 1930).
34. OZAWA, T. *Japan's Technological Challenge to the West: 1950–1974* (Cambridge, Mass.: MIT Press, 1974).
35. ————. *Transfer of Technology From Japan to Developing Countries* (New York: United Nations Institute for Training and Research, 1971).
36. PASSIN, H. *Society and Education in Japan* (New York: Columbia University, Teachers College, 1965).
37. PEARSE, A.S. *The Cotton Industry of Japan and China* (Manchester: David Smith, Garnett and Co., 1929).
38. PEARSON, L.B. *Partners in Development, Report of the Commission on International Development* (New York: Praeger Publishers, 1969).
39. POSNER, M.V. "International Trade and Technical Change," *Oxford Economic Papers,* Vol. 13, No. 3 (October 1961).
40. SEKI, K. *The Cotton Industry of Japan* (Tokyo: Japan Society for the Promotion of Science, 1956).
41. SEN, A. "The Role of Technological Change in Economic Development: The Lessons of Japan for Presently Developing Countries" (Ph.D. diss., Rutgers University, 1978).
42. SMITH, T.C. *Political Change and Industrial Development in Japan: Government Enterprise, 1868–1880* (Stanford, Calif.: Stanford University Press, 1955).
43. TILTON, J.E. *International Diffusion of Technology: The Case of Semiconductors* (Washington, D.C.: Brookings Institution, 1971).
44. TSURUMI, H. "A Bayesian Test of the Product Cycle Hypothesis Applied to Japanese Crude Steel Production," *Journal of Econometrics,* Vol. 4, No. 4 (November 1976).
45. TSURUMI, Y. "Japanese Efforts to Master Manufacturing Technologies" (Ph.D. diss., Queens University, 1970).
46. ————. "Technology Transfer and Foreign Trade: The Case of Japan, 1950–1966" (Ph.D. diss., Harvard University, 1968).
47. United Nations Educational, Scientific, and Cultural Organization. *Technological Development in Japan* (Paris, 1971).
48. U.S., National Science Foundation, National Science Board. *Science Indicators, 1974: Report of the National Science Board* (Washington, D.C.: U.S. Government Printing Office, 1975).
49. VERNON, R. "International Investment and International Trade in the Product Cycle," *Quarterly Journal of Economics,* Vol. 80, No. 2 (May 1966).
50. WARD, B., ed. *The Widening Gap: Development in the 1970's* (New York: Columbia University Press, 1971).
51. WATANABE, M. "Science across the Pacific: American-Japanese Scientific and Cultural

Contacts in the Late Nineteenth Century," *Japanese Studies in the History of Science,* No. 9 (1970).

52. WELLS, L. T., Jr. "Tests of a Product Cycle Model of International Trade: U.S. Exports of Consumer Durables," *Quarterly Journal of Economics,* Vol. 83, No. 1 (February 1969).
53. WELLS, L. T., Jr., ed. *The Product Life Cycle and International Trade* (Boston: Harvard University, Graduate School of Business Administration, Division of Research, 1972).
54. YOSHINO, M. Y. *Japan's Managerial System: Tradition and Innovation* (Cambridge, Mass.: MIT Press, 1968).
55. YUASA, M. "The Growth of Scientific Communities in Japan," *Japanese Studies in the History of Science,* No. 9 (1970).