PART I

FDI AND TECHNOLOGY TRANSFER
IN
ASIA

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New Strategies for Asian Technological Development: Problems Facing Technology Transfer and Backward Linkage

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1. INTRODUCTION

It is generally said that multinational corporations (MNCs) are reluctant to transfer their technology to developing countries and to purchase domestic parts and components. This paper examines some of the reasons and possible solutions related to these issues. In both the above cases, the determining circumstances usually depend on the level of technological and educational development in the host country, as the level of the MNCs' technology is normally high in relation to the work forces' ability to absorb it.

Technology has its own development stages or levels, and generally, these stages cannot be jumped by two or three steps from the current level, particularly, in the case of basic technology. In the manufacturing sector, basic technology is related to processing procedures. For example, in the case of metal working – turnery, welding, cutting, casting, forging, extruding, pressing, shaving, metal molding and plating – are basic processes which require micron-unit precision. It has been argued that these processes can be done by numerically controlled machines nowadays. However, this is wrong.

The skill or hand-working techniques that are required to complete such procedures are embodied in workers not machines. The final check or final touch on high-quality products depend on the skill of the worker, and this know-how can only be obtained by thorough and on-going training. This sort of skill accumulation or human-resource factor in "monozukuri" (making goods) is considered very crucial by the manufacturing sector in Japan.

For the same reason, MNCs in developing countries are reluctant to buy locally produced parts and components because the product quality is insufficient to satisfy the required levels from the technological point of view.

Furthermore, the issue of intellectual property rights has became a major political issue in recent years, and restrictions on copying new technology and "reverse engineering" a priority of the World Trade Organization (WTO). As a consequence, developing countries are more eager than ever to upgrade their available level of technology through R&D (research and development), vocational training and general education. As well as through the purchasing and licensing of new technology on a commercial basis. As technological developments have an everyday spillover effect, which filters down to society in general, dissemination of such knowledge can be exploited by developing countries.

The global strategies of the MNCs are also changing. The location of factories worldwide requires products to attain a certain high-quality standard wherever they are produced. Therefore, there is a growing trend among MNCs to introduce technology and train workers in host countries by themselves.

Another recent development, owing to the nature of the borderless information age, is that information-related industries can be set up in developing countries while skipping the normal stages of technology development. This leapfrogging effect can be observed in service industries, especially, in the computer-related software sector. For example, in India and Taiwan it has been realized by directly connecting local offices to Silicon Valley via satellite. However, such innovations remain limited to a very narrow sector of industry, and in general, the manufacturing sector follows the continuous technological development path.

The remainder of the paper focuses on the various areas relating to development as follows:

Section 2 – the acquisition routes of technology from advanced foreign countries.

Section 3 – why MNCs do not want to transfer their technology.

Section 4 – why MNCs are reluctant to purchase locally manufactured goods in the host country.

Section 5 – Japan's experience of technology acquisition and technological policies.

Section 6 – suggested effective technological development policies for developing countries.

2. MODES OF TECHNOLOGY ACQUISITION

In order to obtain new technology or knowledge, there are five main routes for developing countries (Mani [1997], Yamashita [1991]): (i) technology transfer by MNCs through foreign direct investment (FDI); (ii) purchasing new technologies by paying royalties or licensing fees (disembodied technology); (iii) purchasing (importing) new tools and machines which contain new technology (embodied technology); (iv) efforts at domestic creation (or catch-up) of new technology through R&D and education; and (v) technological cooperation through official development assistance (ODA).

2.1. FDI Route

A typical case of technology transfer (TT) by FDI is as follows: a MNC establishes a firm in a host country to produce consumer durable goods, say TV sets, by assembling parts and components. At first, almost everything – factory layout, assembly lines, machines and equipment, product design, parts and components, and production techniques – are brought in by the MNC. The MNC supervises and trains local workers to assemble the product through on-the-job training (OJT). If technical hitches are experienced in the production process, foreign technicians are on-hand to solve them.

Gradually, local industries may be able to supply standardized parts and components such as resisters and condensers, and the work force become accustomed to production methods. Under certain circumstances, the MNC will train local producers to manufacture specific parts for the factory. However, the key components, such as color tubes and mother boards, continue to be imported from the MNC's parent company, and this technology remains beyond the reach of the host country.

Openness of technology information also depends on the form of capital undertaken. If the firm is owned 100 percent by the MNC, the MNC is quite reluctant to transfer technology to the host country. In the case of a joint venture, where the local partner is eager to learn the new technology, the MNC will usually cooperate. Eventually, considering costs (transportation, transaction, wages of the MNC's country, etc.), demand for the assembled product, and the level of technology of the host country, there comes the point when the MNC decides to transfer all production know-how, particularly, in the case of standardized products. Some MNCs establish their own training centers in the host country (Toyota Motor Co., for example, established a training center in Thailand in 1997). Local staff may be sent to the MNC's parent factory for training. Through such processes, new technology is transplanted by FDI to the host country.

In recent years, within the framework of a borderless world, MNCs' world strategies have also been changing. Strategic alliances between MNCs and large companies in developing countries are common, while MNCs themselves deploy affiliates worldwide. Products have to meet the same high-quality control standard wherever they are produced. Therefore, there is an increasing tendency for MNCs to train their work force in developing countries to upgrade the quality of their products to an internationally recognized standard. The above mentioned trend of establishing training centers in developing countries follows the same line of thought.

2.2. Disembodied Technology Route

Technology is not free. It costs a lot to invent a new technology, particularly, at the initial R&D stage. Inventors want to exploit monopolistic rents for their new innovations. New technologies are usually registered and protected in the form of patents. Therefore, easy but costly ways to obtain such new technologies exist; the purchase of blueprints of prototypes, patents (payment of royalties) and licensed production (payment of licensing fees). Firms set up as joint ventures with MNCs sometimes use this disembodied technology route for technology acquisition.

Another problem which often arises, is that developing countries copy or imitate advanced countries' products without paying any fees. These piratical activities have long been criticized by developed countries and have led to political fallout. The developed countries argue that, as intellectual property rights are marketable, and if technology is paid for on a commercial basis, no problem arises. The WTO strongly recommends this route.

2.3. Embodied Technology Route

New products contain new designs and ideas. Tools and machines for producing such new products also contain new devices and innovative technologies. Importation of new products or machines is yet another way of transplanting new technology. Furthermore, it is sometimes the case that technologically less-developed countries disassemble new products for examination and produce exact copies of the original (what we call "reverse engineering").

In the case of machines, modifications or the addition of appropriate devices, are sometimes made to facilitate local conditions. This process usually violates intellectual property rights. Here again, these activities have been the focus of severe criticism in recent years by developed countries. Nonetheless, it should be pointed out that the current controversy surrounding intellectual property rights has its roots in the 1950s and 1960s, when general awareness of the issue was low and Western countries were generous in transferring new technologies to developing countries – mostly prompted by market share considerations. However, the fact that the technology gap was so great, and that it was generally believed to be inconceivable that the situation would change, also played a decisive role in Western strategies.

Another factor which has to be taken into account when considering the question of copying or imitating new products, is that a certain level of skill and product knowledge has to be available within the developing country. In the case of Japan, when a French spinning machine was introduced during the late-nineteenth century, Japanese workers quickly made a copy and even modified the model to better suit local conditions. This ability to adapt and modify state-of-the-art technology, was due to the high level of skill available within the work force, owing to the country's long tradition of blacksmithery related to sword and matchlock making, and the manufacturing of mechanical puppets.

2.4. Domestic R&D Route

Domestic R&D efforts have two distinct formats for deployment: private sector initiatives and government support. Domestic companies use R&D expenditures for innovation and quality control. Generally, new products are the result of a combination of factors – developments in design, materials, production techniques, machine tools, new concepts, and management know-how.

At the initial stage, domestic firms in a developing country are busy collecting information on advanced technologies. This learning process is realized through a combination of FDI, and the disembodied and embodied technology routes, which we discussed earlier. Gradually, however, efforts are focused on trying to better match the requirements of the domestic environment. And, as local technological levels advance, such innovations become more frequent, until ultimately, the given conditions lend themselves to the invention of completely new products.

The role of government in R&D is quite important. Government can utilize R&D expenditures for the development and dissemination of technology through national institutions, but it can also help the private sector through policy measures such as tax incentives, direct subsidies, financial support, distribution of information and patent controls.

2.5. Technology Cooperation through ODA

International and/or bilateral cooperation is another route for technology transfer. International as well as bilateral governmental assistance in technology development comes in various forms, one of the most important being direct aid – the construction of training centers, dispatching consultants and experts, accepting trainees from developing countries, financial assistance, and information services related to technology.

An understanding of skill formation, as it appertains to youth, can be gained by examining the unique role of the International Vocational Training Competition (the so-called Youth Skill Olympics). It provides a marvelous opportunity to improve basic skills and techniques. Skill levels are judged in 34 categories, covering a broad section of trades – plastering, welding, fitting, sheet metal work, automobile technology, mechatronics and even cookery. Presently, 32 countries/areas participate in the competition which is held every two years. Young professionals under twenty-two years of age compete to achieve excellence. In the 1960s and early-70s, when Japan was largely still on the receiving end of advanced technology transfer, the country produced many champions in various categories (the most successful year being 1970, when Japan won no fewer than 17 gold medals). However, in the 1980s and 90s, South Korea and other NIEs have produced the majority of gold medalists (at the 1995 competition in Lyon, South Korea topped the gold medal count with 10, followed by Taiwan: see Table 1.1).

Although Japanese entrants have not been as successful in recent years as they were a few decades ago, the value of the international competition is still held in high esteem by the country's industrial community. Indeed, the 35th National Skill Competition (organized by the Japan

Table 1.1: Results of the 33rd International Vocational Trainning Competition, 1995 (Lyon, France)

Country	Number of Participants	Gold medal	Silver medal	Bronze medal	Total
Korea	32	10	5	3	18
Taiwan	34	6	6	5	17
Austria	17	3	2	5	10
Japan	28	4	3	1	8
France	34	1	3	4	8
Germany	27	4	2	1	7
Switzerland	20	4	1	1	6
UK	24	3	1	2	6
Ireland	18	2	2	0	4
Brazil	11	2	0	2	4
The Netherlands	21	1	1	2	4
Australia	32	0	1	2	3
Liechtenstein	6	2	0	0	2
Finland	18	1	1	0	2
Singapore	8	1	0	1	2
USA	12	0	2	0	2
Thailand	10	0	1	1	2
Norway	9	0	0	2	2
New Zealand	22	0	1	0	1
Luxembourg	9	0	0	1	1
South Africa	19	0	0	0	0
Malaysia	18	0	0	0	0
Canada	15	0	0	0	0
Portugal	9	0	0	0	0
Sweden	9	0	0	0	0
The Isle of Man	5	0	0	0	0
Macao	5	0	0	0	0
Gibraltar	2	0	0	0	0

Source: Japan Vocational Ability Development Association (JAVADA).

Vocational Ability Development Association) was held in Tokyo in November 1997, and a fresh batch of hopefuls were selected to represent Japan at the next International Vocational Skill Competition in 1999.

3. WHY DO MNCs NOT TRANSFER TECHNOLOGY?

3.1. Technology has its Own Development Stages

When examining the development of technology, it has to be understood that it progresses in stages. For example, when television was first introduced it had a very small screen and the picture was monochrome. Subsequently, after thirty years of R&D, color television was introduced. That development was followed by the invention of the videotape recording system, and, that in turn, led to the development of large liquid-crystal screens, high-definition television and plasma display panels (super thin screens). In the case of the automobile, engine development followed a similar pattern – reciprocating gasoline engine, diesel engine, rotary engine, anti-pollution cars, and hybrid cars (gasoline and electric).

Technology by its very nature is a compound concept. When we view a final product we have to bear in mind that a host of factors aggregate to produce that product, such as parts and components, their materials, processing technologies, in-factory production techniques, tools and machines, measuring machines, quality control, and most important of all, the quality or level of human resource (managers and workers). Furthermore, each of the aforementioned component parts has its own stages of development, sometimes directly related to the final product and in other cases realized in a different field of technology. Therefore, it is important to understand that new technological achievements can only take place when a certain required level of development has been realized in the various interconnected fields. Only when such conditions are met do we find the necessary base for such a giant leap forward. Cost considerations are also an important factor when looking at the overall picture, especially in the case of commercial manufacturing.

A developing country's ability to catch up on new technology is sometimes called "absorptive capacity." Reverse engineering and the making of exact copies are typical initial approaches for developing countries to acquire such new technology, but this process faces many difficulties, from both the technical and quality point of view – finding suitable materials, appropriate machine tools and parts, etc. However, the most crucial and difficult area of all is that of human resource, i.e., the technological knowledge/skill-level of people (engineers, parts makers, and factory workers).

It has been noted that developing countries sometimes criticize MNCs for transferring what they refer to as second-hand technologies. However, such criticism is misplaced if the level of technology embodied in the transferred machinery improves the available level of technology and contributes to the host country's overall developmental progress. For instance, it is often observed that MNCs transfer obsolete textile machines (usually shuttle-type loom) to developing countries for apparel manufacturing. Such machines may be old when viewed from the latest model point of view (water-jet or air-gun-type weaving machines), but may be quite suitable for the level of technology and labor/skill preparedness of the developing country. Such transfers of older technologies also serve a purpose from the pedagogical position, as it allows workers to become accustomed to a superior technology and improve their textile-related knowledge and skills.

There is a time lag in technology development. However, it shortens during the catch-up period (what we call the "compressed process" of development by latecomers). Both Taiwan and South Korea are good examples of this process. The first numerically controlled lathe was produced in Taiwan in 1974, only seven years after initial fabrication in Japan. In 1986, South Korea's semiconductor industry began mass-production of one-mega DRAMs. By 1990, only one year after Japan, it could produce 16-mega DRAMs.

3.2. Educational Problems in Developing Countries

Needless to say, a basic educational framework is necessary for understanding and producing new products. It has been a common saying in Japan since the *samurai* period that reading, writing and calculating are three important elements in the life of people. Thus, the primary and secondary school education system has been universally accepted as the backbone of developed society. Nonetheless, this fact is often ignored in developing countries. Indeed, some, especially in Latin America, tend to put too much emphasis on higher education at the expense of the school system.

Vocational training is another very important area of education. Unfortunately, here again, one too often ignored by developing countries. It is generally acknowledged that the learning of skills is a continuous processes. Skill formation can only be achieved through on-going training and practice. Therefore, proper institutional frameworks for apprenticeship and craftsmanship training are necessary (for example, the German meister system and Japan's vocational training schools). Science and engineering are very important fields of education and this point cannot be emphasized enough. It is a well known fact that the US government had a major rethink about the importance of science education after the Soviet Union successfully launched "sputnik" (thereby taking the lead in the space race), at a time when ideological considerations were predominant.

On-the-job training is yet another way in which to learn new technology. Joint ventures generally have technology agreements which state that the MNC will train the local work force. At the factory level, the MNC will usually teach workers using a manual. Therefore, it is very important to find leaders or foremen from among the work force who can train other people and successfully convey what they have learned. In the case of Japanese MNCs operating overseas, quality control circles (small study groups of 6 to 8 workers) are formed to achieve new skills, improve working conditions, decrease defect ratios, and increase productivity.

Human resource, or technical knowledge held by veteran workers, is heavily emphasized by Japanese MNCs. Rather than relying on manuals, these veterans can directly hand down their skills to young workers through on-the-job training. This unwritten or "tacit" transfer of technology is the person-to-person transmission which is at the heart of the Japanese-style production system.

MNCs are sometimes reluctant to train workers because "job hopping" is common in developing countries. There being little incentive for the MNC to train a worker if he/she is likely to quit soon. Therefore, MNCs tend to set training programs to a minimum, relying as little as possible on production techniques, while at the same time dividing the production processes as much as possible (simple work and simple job description). This pattern contrasts radically with the traditional approach of Japanese MNCs at home, where the seniority system and life-time employment guarantee, provides the necessary motive for training workers on a thorough and on-going basis.

3.3. The Fear of Boomerang Effects

It seems that the main reason why MNCs do not want to transfer their technology to developing countries is the fear of "boomerang effects." If a MNC transfers the know-how to manufacture a certain new product, within a relatively short period of time the host country will be able to manufacture an exact copy and have the potential to export its locally manufactured product back to the MNC's mother country. Thereby, posing a threat to the source industry.

Such boomerang effects are widely recognized by MNCs, and that is why they are reluctant to transfer new technologies. If developing countries reach a certain level of development, they can steal and imitate new technologies, and soon enter into direct competition with the MNC. Thus, MNCs are quite nervous about technology transfer. Furthermore, the rapid pace of technological development in the information and computer sectors, allied with a more open political situation worldwide following the demise of the former Soviet Union and its cohorts, has greatly increased, both in possibility and actuality, the specter of industrial espionage. Consequently, from both an industrial and security perspective, this issue is one viewed with great concern by advanced countries.

Because technological development has a spillover effect, and the dissemination of such knowledge stimulates interest in society in general, a defined pattern of development frequently takes place. The Akamatsu hypothesis (Akamatsu [1956]), of the pattern of wild geese flying in formation, provides one such analogy. It states that the development of a given modern industry in a latecomer country follows a fixed pattern: (i) the formation of a domestic market through imports; (ii) import substitution in the industry; (iii) exporting of its product; and (iv) the decline of the industry and the re-importation of the original product. This sequence of events does not necessarily follow, as the industry in question will generally attempt to keep ahead of the pack by concentrating on the development of more sophisticated technologically-intensive products. Nonetheless, in certain given circumstances, such a pattern can be discerned – the US steel industry and the British automobile industry may be considered as examples.

3.4. Technology is Not Free

To prevent copying and protect intellectual property rights, developing countries have to stamp out piracy. There is no such thing as a free lunch, and that is especially true in the case of technology development. The investment in both time and money required of a MNC in order to compete by applying the latest technology is enormous. Therefore, inventors and innovators are granted monopoly rents and their rights are protected in the form of patents. Through this internationally recognized system we pay for new technology.

Usually (disembodied) technology enters into developing countries as follows:

(i) – skill accumulation through the production of OEM (original equipment manufacturer) agreements or FDI with technology agreements;
(ii) – purchases of blueprints;
(iii) – payment of royalties for patents and trademarks;
(iv) – payment of licensing fees through joint-ventures.

In recent years, under the watchful eye of the WTO, the question of intellectual property rights has assumed a far greater significance, and has become a major priority for advanced countries. In the past, there were several lawsuits between Japanese and US firms, such as Hitachi and IBM, regarding patent infringements.

4. WHY DO MNCs NOT PURCHASE DOMESTIC PARTS?

4.1. Underdevelopment of Supporting Industries

It is said that there are no reliable parts makers in developing countries. However, the development of a successful and robust parts and components industry is crucial for assembly line manufacturers. In Japan, these industries are sometimes cited as supporting industries because they supply parts and components to assemblers. At the end of the 1970s, Toyota Motor Co. managed more than 35,000 small and medium firms through its subcontracting system. Such factors as quality, supply lot, and delivery time, being viewed as a matter of life or death by the assembly line manufacturer.

There are usually accumulated skills available in developing countries owing to the growth of light industries (food processing, textiles, wood products, metal works, etc.). Indeed, some developing countries even have heavy industries such as iron and steel, chemicals, and machine manufacturing. Repair shops for automobile and electric products also add to the available pool of developed skills. However, generally speaking, the standard of expertise or human resource made available by development at this level does not satisfy MNCs' expectations for modern parts and equipment. If MNCs cannot depend on the local parts industry, it follows that they will import the parts from their home country, which is a negative situation for the host country. Therefore, the MNCs' overriding questions become: (a) How to create or foster quality parts and components makers? (b) How to encourage small and medium firms to supply parts and components which satisfy demand?

There are several ways to do this:

(i) – the host country requests that the MNC brings its affiliates or subcontracting firms with it, as part of the initial investment (what I call "a package deal").

(ii) – split-off the parts departments of large existing domestic companies into independent parts makers.

(iii) – foster domestic small and medium enterprises (SMEs) through industrial policies (government support).

(iv) – autonomous development of domestic SMEs.

In developing countries, (i) is usually under way and (ii) is often realized, especially, when the developing country reaches middle-income status and its industrialization process is partially matured, i.e., South Korea and Brazil. In the case of (iii), it tends to be the most controversial approach, owing to the restrictions placed on governmental intervention by the WTO.

However, during the catch-up stage of development, some restrictions must be placed on MNCs, otherwise domestic industries cannot grow. Generally, local content rules and support measures for SMEs are provided through tax and other financial incentives. With regard to the (iv) approach, it is highly desirable but difficult to realize.

4.2. Low Quality of Domestic Products

The main complaint of any MNC with regard to local parts and component supplies, is the poor quality of the products. Local SMEs cannot achieve the required standard for a variety of reasons – low quality of materials; obsolete machines and tools; imperfect processing technologies; and most importantly, the low-level of human resource (the training and educational level of the work force).

Therefore, domestic SMEs require the assistance of MNCs, government policies and self-help to upgrade the quality of their product. The human resource factor is fundamental to the success of the SME. Skill formation levels in manufacturing – turnery, welding, cutting, casting, forging, extruding, pressing, shaving, molding, and plating – are critical to the success of the domestic SME. Quality-control methods must be introduced, covering every area of production, through various channels of training.

4.3. Inability to Respond to Large Orders

Domestic SMEs are generally incapable of responding to large orders placed by a MNC. This is particularly true in the export sector, where the economies of scale work for consumer electronics and automobiles. Large volume assembly production requires large volume parts and component supplies. As domestic SMEs' production capacity is usually small, they cannot respond if the MNC places a large order.

At the initial stages of production the MNC will usually import required parts and components from its mother country, or from a regional supply center (Singapore in the case of ASEAN countries). However, as domestic SMEs grow, and some become medium-sized suppliers, it becomes possible for the MNC to integrate the SMEs into the supply chain. Here again, fostering SMEs in the formation of supply networks is important.

In advanced countries product differentiation is common due to consumer demand/taste. Therefore, it is usual to find a few products with many models on a modern assembly line. However, in developing countries, where consumer demand/taste is not so highly developed and the demand not so diversified, the number of models are limited. Under these circumstances, it can be said that the economies of scale are still working.

4.4. Uncertainty over Delivery Schedules

Usually local SMEs are not punctual when it comes to delivering their products to a MNC. Modern factories are well-scheduled (a typical case is just-in-time production). The synchronization of production schedules between the parts suppliers and the assembler is vital, if a constant flow of production is to be realized.

Proximity of assembler and suppliers is also an important consideration. In this respect, locating in industrial estates or parks, can help shorten delivery time and reduce transportation costs. However, the key to success is to change people's attitude toward business practices such as delivery schedules.

In this context, efficient infrastructure – roads, railways, ports, airports, and telecommunications facilities – are critical. The lack of such infrastructure often results in a bottleneck problem in developing countries. This is principally a government responsibility.

In sum, it is important for local SMEs to form supply networks and for quality, response-time for large orders and delivery time to be improved.

5. ACQUISITION OF TECHNOLOGY: JAPAN'S EXPERIENCE

5.1. A Brief History

Japan's modernization began with the Meiji Government (1868-1911). The government's national policy was "*Fukoku kyouhei*" (strengthen national wealth and military power). Japan hired foreign engineers, experts and professors to promote Western knowledge – 2,299 foreign experts were employed between 1867 and 1889 (Hayashi [1995]), and new machines and equipment were imported. Agriculture, mining, railways, shipbuilding, steel production, textile machinery and telecommunications equipment, as well as modern weaponry, were examples of the absorption of foreign technology carried out by Japan at that time.

Related laws were promulgated, such as the Patent Law (1885) and the Measurement Law or 'Meter Law' (1921), to support technological modernization (Uchida [1986]).

A typical pattern of technology transfer is as follows: (i) existence of traditional technology; (ii) introduction of Western technology; (iii) modification or improvement of the Western technology; (iv) production of hybrid machines; (v) domestic production of new machines. For example, in the case of looms, Japan had traditional hand-looms before Western-type looms were imported in the 1870s. Sakichi Toyoda (carpenter), invented a wooden power-loom in 1896, this was followed by a wood and iron power-loom, and finally, a steel-made power-loom in 1908 (Toyoda was the founder of the Toyoda Loom Co., which later became Toyota Motor Corp.) (Ishii [1986]).

In the case of manufacturing industries, the Meiji government established state enterprises, such as Nagasaki Shipbuilding (1871) and Tomioka Yarn (1872), which were later privatized – Nagasaki Shipbuilding in 1887 and Tomioka Yarn in 1893. Indeed, it was to these factories that the first Western technology imports were delivered. In the beginning, the machines were operated and maintained by foreign technicians, gradually, however, the Japanese work force developed their skills and before long they innovated, modified and improved the machines to better suit domestic conditions.

This pattern was repeated after World War II. For example, in the case of machine tools, conventional machine tools were introduced from Europe and the US. Japanese companies had technology agreements which facilitated the purchase of blueprints and patents and the importation of machines and their reverse engineering. The first NC machine tools were invented by the Massachusetts Institute of Technology in 1952. Six years later, Japan produced its own NC milling machine (Makino Milling in 1958). As the computer industry developed, NC machine tools were combined with computers and computerized numerically-controlled (CNC) machine tools were produced. In 1972, for the first time, Japan's machine tool exports exceeded imports (Tsuji et al. [1996]).

Generally speaking, Japan's methods of approach and expertise has developed within the manufacturing sector, particularly, in-house production techniques – quality control circles, continuous improvements, job rotation, team working, just-in-time methods, etc. Moreover, there has been an accumulation of non-mass-production skills – metal molding, welding, cutting, forging, pressing, boring, etc, – which are related to parts making techniques developed by domestic SMEs. Individual craftsmanship, which is the backbone of the person-to-person teaching method (without manuals), has also been pivotal in Japan's transfer of technology.

Institutional framework differences also deserve scrutiny. In Japan's manufacturing sector, outsourcing and horizontal integration, in terms of parts and components, are commonly practiced, rather than vertical integration within the same company. The subcontracting system grew out of Japan's wartime experience during the 1940s. In order for small-scale industries to participate efficiently and quickly in weapons production, the government introduced a "designated factory" system in 1940. Under this system, the prime firm placed a long-term order with the designated subcontractors; technical assistance was provided as well. The designated subcontractors, on the other hand, were prohibited from trade with other firms. The system did not work well because of its rigidity but some associations formed and *keiretsu* – the formation of industry groups – fermented. Several examples such as Matsushita Electric Co. and Osaka Metalwork can be traced through an old "*Kinkichiku Hacchu-kojo oyobi Kyoryoku-kojo Meibo* (Osaka Directory of Designated Factories)" (Ueda [1992]).

A pyramid-shaped subcontracting system is observed in mass-production industries – automobile, consumer electronics, and machine tools. The primary manufacturer utilizes a supply chain which consist of SMEs, sometimes, reaching down to fifth-layer subcontracting firms. In such circumstances, upper echelon firms offer technical assistance – tools, designs, experts and even financial support to subcontractors. The main purpose of this technology transfer by primary manufacturers to SMEs, is to assure synchronization of production, zero-defect products, and just-in-time inventory control; thus reducing transaction costs while benefiting from increased inter-relational rents (Kagami [1995]).

Japan's technology transfer to Asian countries has mainly followed three routes (Takabayashi [1997]): (i) exports of plant; (ii) FDI; and (iii) ODA. After the reconstruction of Japan's economy, accelerated by the special demands created by the Korean War, Japan began to export products, especially, plant. Between 1973 and 1982, plant exports to Asia increased rapidly, and operational and managerial know-how were transferred. Plant exports included electric power equipment, telecommunications equipment, iron and steel, nonferrous metals, and petrochemicals. Japan's FDI increased after the 1985 Plaza Accords, this time, with the emphasis being placed on mass-production assembly-type factories. Here, know-how related to quality-control and production process technologies were transferred. In the case of ODA, (technical assistance –

receiving trainees, dispatching experts, feasibility studies, loans, etc.) this stage of technology transfer took off in the 1990s.

5.2. On-the-job Training

Japan's skill building techniques are basically derived from on-the-job training. Workers are trained to understand several stages of the production process in order that they can better understand the overall production process. Thereby, increased awareness by participation in several stages of production is realized, and this is very important, especially, when trouble occurs on the production line.

Furthermore, cross-trained workers are able to cover for absent employees, can assist with the training of newcomers, and more importantly, are able to perform different functions in various product mixes and model changes.

Quality-control circles are a form of self-enlightenment. Workers form small groups, which include skilled and unskilled members of the work force, and engineers from various divisions. The groups hold regular weekly meetings, during or outside working hours, to study how best to increase quality levels or to discuss successful innovations achieved in other factories. Groups also discuss their own production process and recommend ideas to increase productivity and quality control. These continuous efforts result in improvements in production efficiency as well as working conditions (continuous improvement or *kaizen*).

There is a widely-held consensus among workers, engineers and managers regarding the "putting the shop-floor first" principle – which states that the general work area, or shop-floor in any factory is the mother of invention. That is why Japanese managers and engineers are willing to put on their overalls and directly participate in shop-floor activities, in order to better understand the everyday running of the factory and learn or find new devices and ideas.

5.3. Technological Development Policy

Government policies related to technology since World War II are divided into two: direct and indirect. Direct policies are as follows:

(i) control on technology imports and contracts,
(ii) fiscal and financial incentives for private R&D,
(iii) public R&D expenditure,
(iv) patent control.

And indirect ones include:

(i) education and vocational training,
(ii) policies regarding Japan's FDI and ODA,
(iii) policies relating to external as well as internal changes (shocks).

5.3.1. Direct Policies

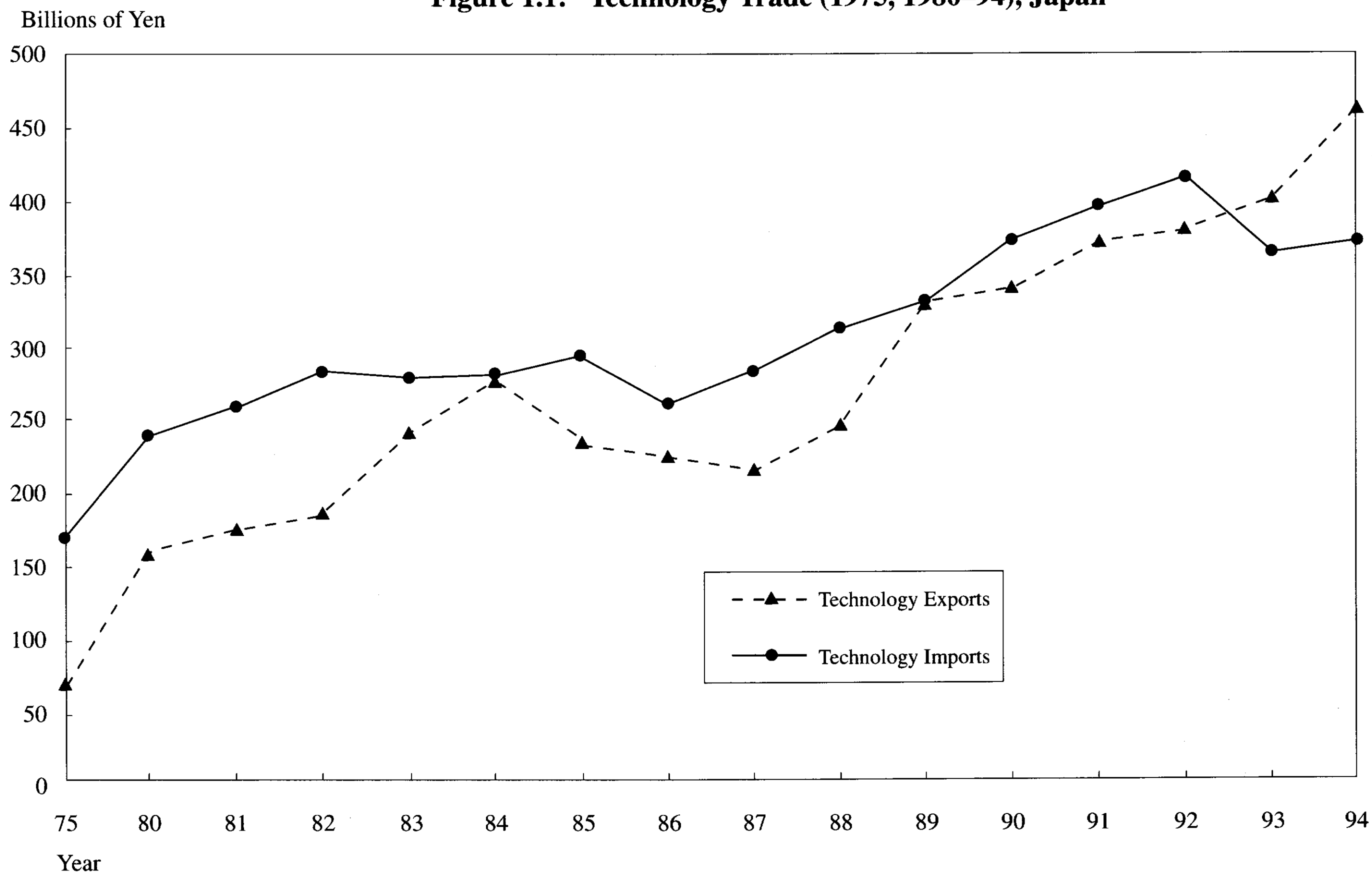
Technology imports and contracts: After the War, control on technology imports was regulated through laws such as the Foreign Exchange and Foreign Trade Control Law (1949) and Foreign Capital Law (1950). Foreign currency was scarce and imports of technology was also controlled by the Foreign Capital Council. These limitation were gradually relaxed – 1961, 1968 and 1972 – in accordance with the liberalization of trade and investment. In 1980, the above laws were integrated into a new Foreign Exchange Law, whereby, all new imports of technology were liberalized, except 12 assigned technologies. However, the assigned technologies lose their unique status when their value falls below 100 million yen (Goto [1993]).

Recent statistics show that Japan's imports of technology reached its peak of 414 billion yen in 1992, while technology exports gradually increased and exceeded imports for the first time in the postwar period in 1993 (exports: 400 billion yen v.s. imports 363 billion yen) (see Figure 1.1).

Technology-related contracts or agreements between foreign and Japanese entities must be reported to the Ministry of Finance (MOF). Contracts involving specially regulated or designated technologies must be approved by MOF and any other ministries that have jurisdiction over the area involved. Licensing agreements are also screened by the Japan Fair Trade Commission (JFTC), which can require alterations in agreements or declare them void, if it considers that the terms represent a restraint of trade or unfair business practice.

Fiscal and financial measures: The government of Japan provides tax and financial incentives for technology development. Exemptions from import tax were provided to promote technology imports during the 1960s. Fiscal and financial incentives are also given to private R&D. Fiscal measures include direct subsidies, tax incentives, such as exemptions from income tax, tax-rate reductions, special allowances, and special considerations for depreciation. Financial incentives include special credit lines, preferential interest rates and extended periods of repayment. SMEs can obtain these incentives through state-owned financial institutions (there are four such banks: the Japan Finance Corporation for Small Business; the People's Finance Corporation; the Shoko Chukin Bank;

Figure 1.1: Technology Trade (1975, 1980–94), Japan



Source: Statistics Bureau, *Japan Statistical Yearbook 1997.*

and the Environmental Sanitation Business Finance Corporation). SMEs' R&D activities are also backed by the 1985 Law on Extraordinary Measures for Promotion of Technological Development by Small and Medium Enterprises.

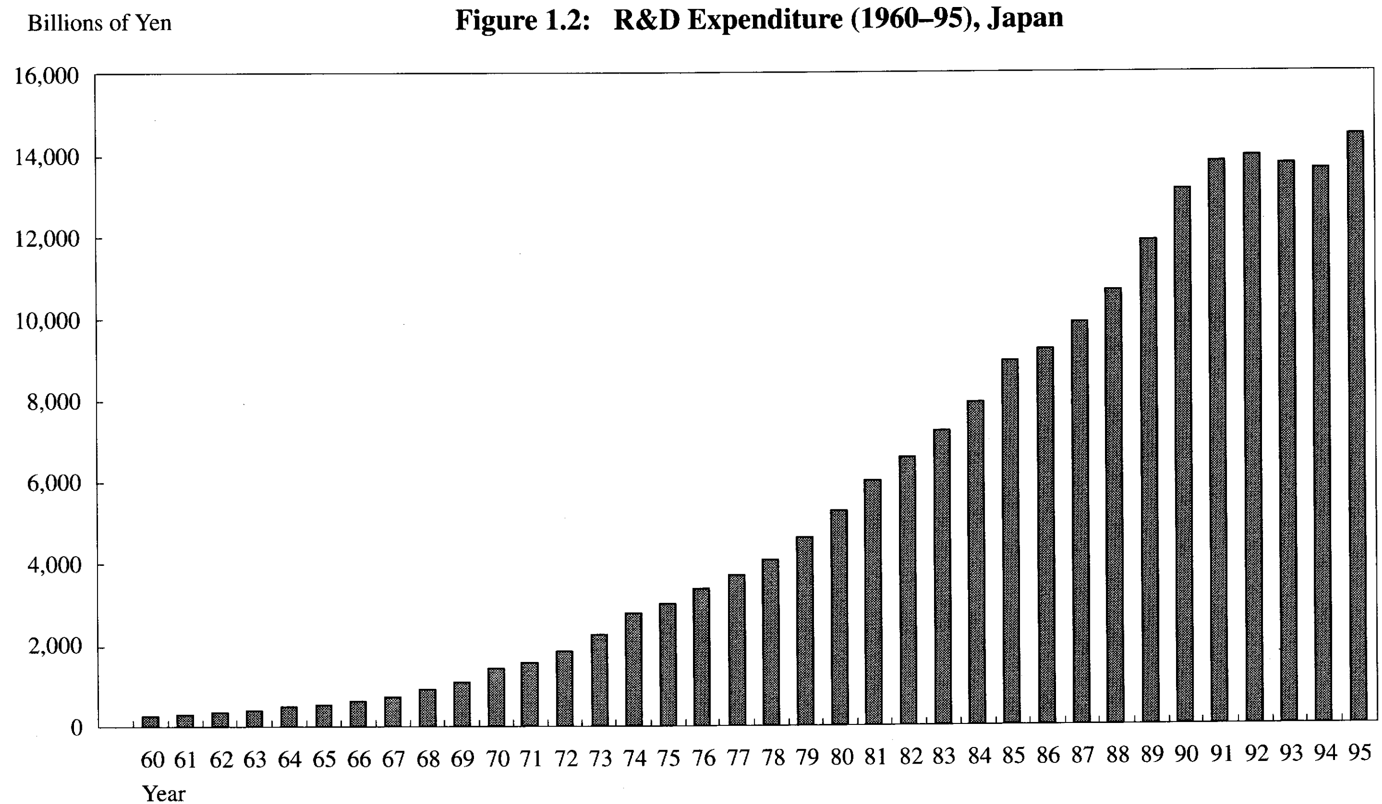
Government R&D: The government directly runs research institutes and observatories for basic research and the dissemination of technology. Local governments also run research centers (*kosetsushi*, public research centers), which will be discussed later. Typical examples of government-led policies on technology are as follows: (i) construction of technology and science parks; (ii) the promotion of new technology through research cooperatives. The Tsukuba Research and Campus City program is an example of the former case. Tsukuba City is located 70 kilometers east of Tokyo, and forty-eight national research institutes (including the Meteorological Institute, the High Energy Physics Research Institute and the National Pollution Institute), and one national university, Tsukuba University, were relocated there at the beginning of the 1970s. Networking and agglomeration of information among these institutions, together with private research institutes that also relocated, facilitates collective efficiency and information externality.

An example of the latter case, is the formation of research consortiums by private companies with government guidance (the Ministry of International Trade and Industry, MITI). The first consortium to be regulated by law was the Mining and Industry Technology Consortium in 1961. The most successful example, however, was the Computer Technology and Research Consortium, established in 1962, to develop large-scale computer systems. Computer manufacturers such as Fujitsu, NEC and Oki Electrics joined the project. This in turn was followed by the Super LSI Technology and Research Consortium, established in 1976, to develop super LSI for use in the development of fourth generation computer systems. This consortium however did not produce the expected results.

Between 1961 and 1990, ninety-six research cooperatives or consortiums were formed. The introduction of R&D consortiums in response to the formidable presence of large foreign monopolies has three merits: (i) to avoid duplication of investments by each member company; (ii) to share results of R&D among members and their spillover effects to non-member companies; and (iii) to make product markets competitive. Nonetheless, in the case of the super LSI project, even the government sometimes finds it convenient not to mention it.

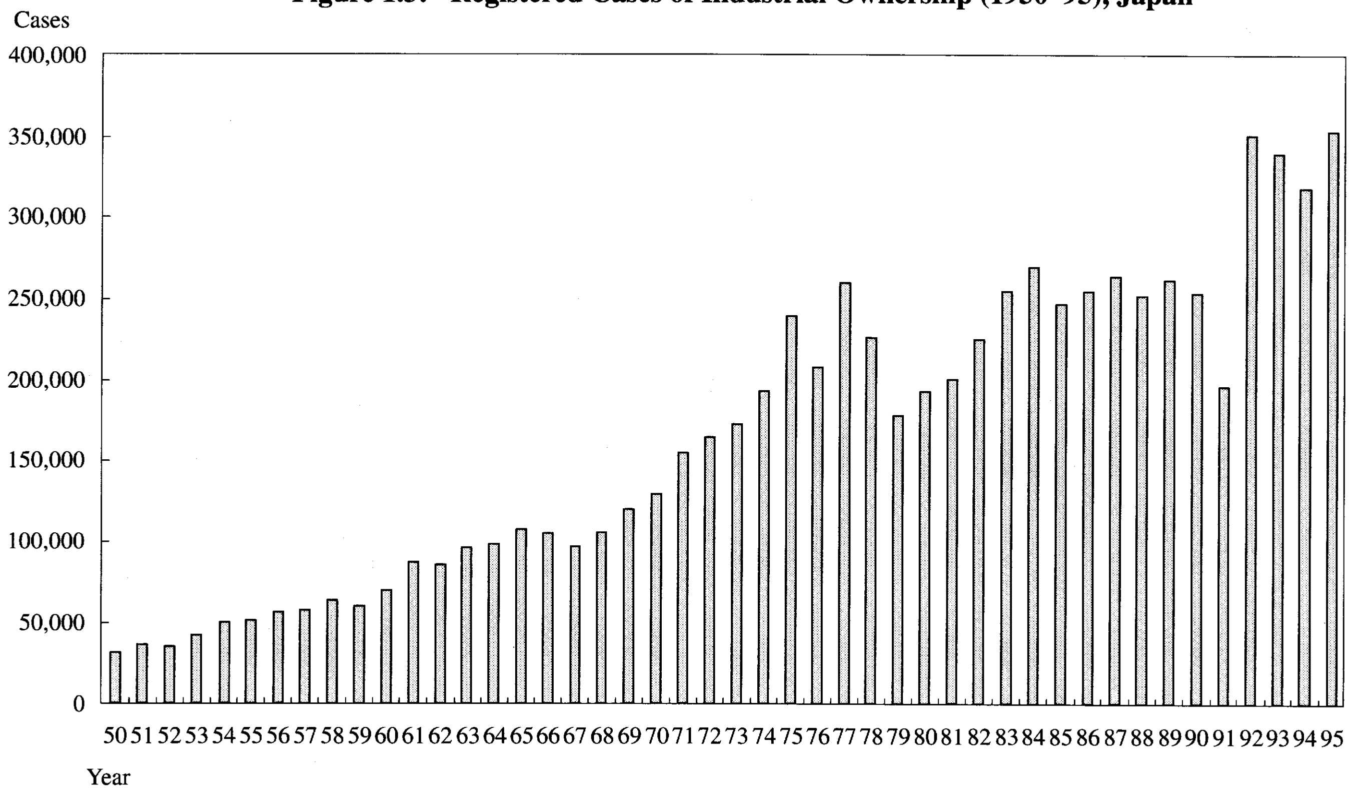
During the period under discussion, R&D expenditure constantly increased. From 211 billion yen in 1960, to a peak of 13,910 billion yen

Figure 1.2: R&D Expenditure (1960–95), Japan



Source: Management and Coordination Agency, *Report on the Survey of Research and Development,* various issues.

Figure 1.3: Registered Cases of Industrial Ownership (1950–95), Japan



Source: Japan Statistical Association, *Historical Statistics of Japan*, vol.5, 1987, etc.

in 1992. Thereafter, it decreased to 13,709 billion yen in 1993 and 13,596 billion yen in 1994. In 1995 it rebounded once again, climbing to 14,408 billion yen (see Figure 1.2).

Patents: Protection of intellectual property and trademark rights is governed by the Patent Law (1962), Trademark Law (1960), and Copyright Law (1971). New inventions have to be registered at the Patent Office for examination and approval. Patent rights are acquired on a "first in time, first in right" basis, i.e., whoever first applies to register a patent owns it. The duration of a patent right is 15 years, from the date of publication of the application, but cannot exceed 20 years as of the date of application.

Utility model rights are related to patents but are governed by a separate statute, the Utility Models Law (1962). A new invention, which is not required to be as "high grade" as one subject to the patent law, but has a practical utility in regard to form, composition or assembly of goods, can be registered, and the owner afforded protection similar to that of a patent holder. Designs are also afforded legal protection (the Design Law 1962), through a process of registration similar to that of patent and utility models.

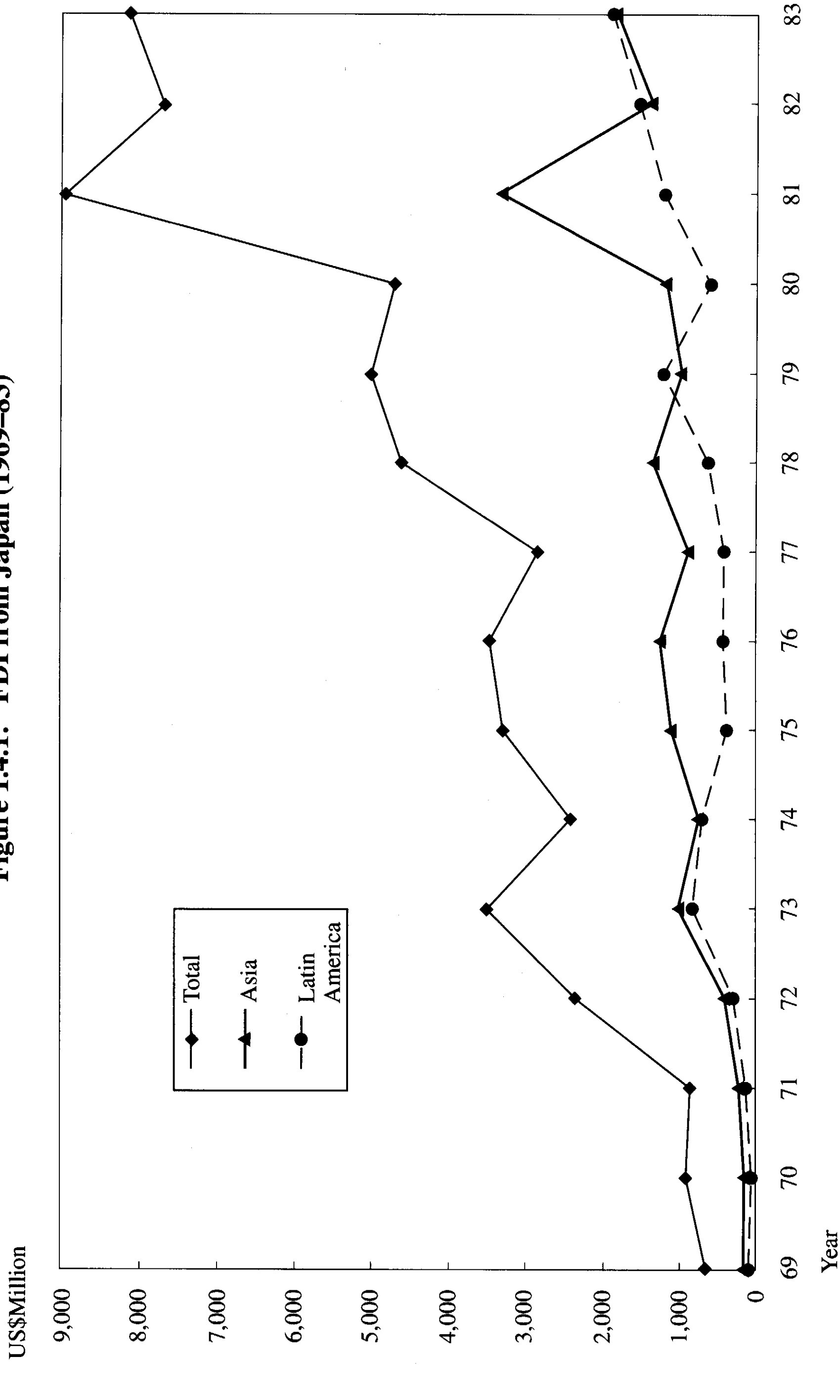
Industrial ownership (registered cases of patent, utility model rights, designs, and trademarks) increased from 32,434 successful applications in 1950 to 352,864 successful applications in 1995 (see Figure 1.3).

5.3.2. Indirect Policies

Human resource development: Apart from general education, Japan has polytechnic high schools and vocational training schools (the latter is governed by the Ministry of Labor and local governments or *ken*). In 1961, the School Education Law was amended to include 5-year technical colleges, where mid-level industrial engineering is mainly taught. Later schools for electric wave and commercial shipping were established, and a total of 62 such schools existed as of 1995. In addition, there were 3,476 special training schools, conducting various skill-learning programs as of 1995.

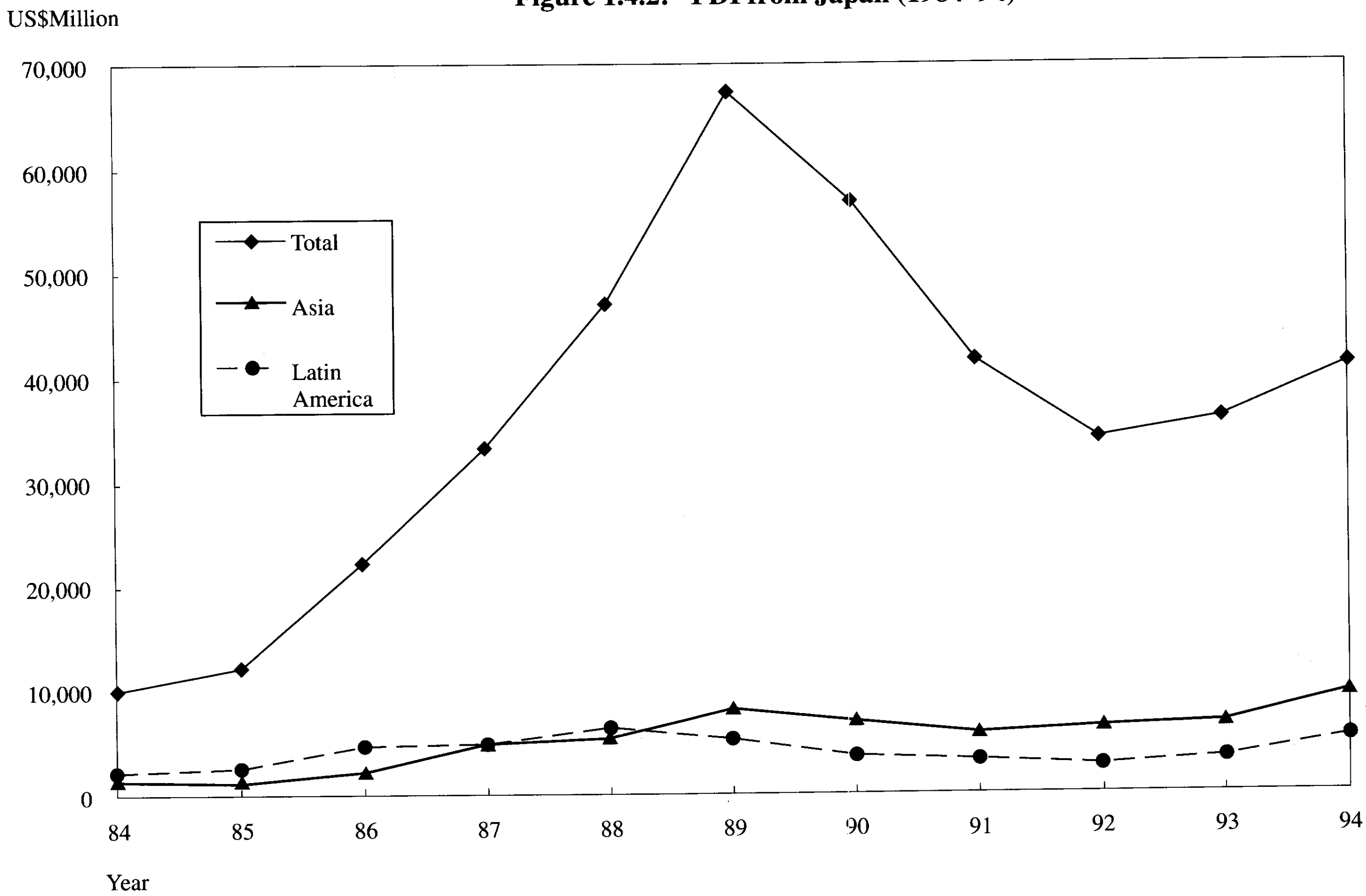
Vocational training schools (or ability development centers) are run by prefectural (regional) governments, the Agency for Employment Promotion (AEP), and private companies. There are 343 public training schools (91 of which are run by the AEP), as of 1997. In the case of private training schools owned by private companies, prefectural governors authorize them. As of 1997, there were around 1,400 such facilities throughout Japan. Recently these schools, especially technical colleges,

Figure 1.4.1: FDI from Japan (1969–83)



Source: Ministry of Finance, *Monthly Statistics on Finance and Money*, various issues.

Figure 1.4.2: FDI from Japan (1984–94)



Source: Same as Figure 1.4.1.

have attracted much attention because of their repeated success in winning the National Robot Competition.

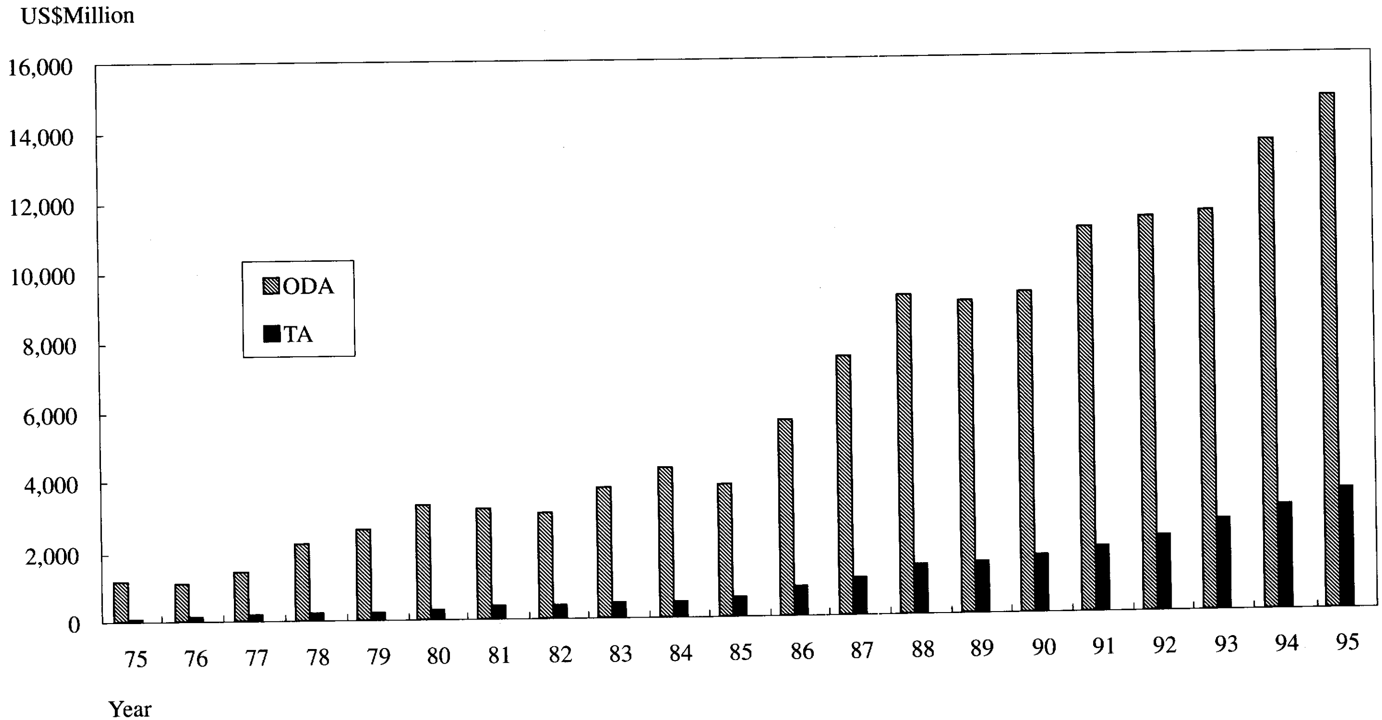
Japanese FDI: Technology transfer from Japan to Asia was accelerated through FDI. There were two peaks of Japanese FDI to Asian countries. The first FDI boom came at the beginning of the 1970s. It dramatically increased in 1972-73 because of the appreciation of the yen, after the collapse of the Smithsonian monetary system. The government fully liberalized direct overseas investment in July 1972, so that total FDI jumped from US$858 million in 1971 to US$2,338 million in 1972 and reached a record level of US$3,494 million in 1973. Japan invested US$998 million in Asian countries in that year, which accounted for 29 percent of total FDI expenditure. In 1981 there was a further surge, however, that was mainly due to large investments in a LNG project in Indonesia (see Figure 1.4.1).

The second boom followed the rapid appreciation of the yen caused by the Plaza Accords (1985). During this second boom period, the two most investment intensive regions were Asia and the US (Japan sought to decrease enormous trade imbalances with the US). In Asia, the increases in FDI reflected an ambition to exploit the low cost of labor and raw materials. Total FDI jumped from US$12.2 billion in 1985 to US$ 22.3 billion in 1986 and peaked at US$67.5 billion in 1989. FDI to Asia also increased, in this case from US$1.4 billion in 1985 to US$2.3 billion in 1986 and peaked at US$8.2 billion in 1989 (see Figure 1.4.2).

Through this FDI, Japanese technologies were transplanted in Asian countries to form a new type of horizontal division of labor. It is usually said that FDI accelerates the decline of the Japanese industry, or what we call "hollowing out." This is not true. Firms' planning and design divisions do stay in Japan along with the more technology-intensive units. Therefore, what we see is that Japan changes its industrial structure toward more technology- and knowledge-intensive sectors, while exporting standardized technology-intensive units to Asian countries. Among Asian countries, industrial demarcation and product differentiation are developing according to the given level of technology and dynamic comparative advantage.

Official Development Assistance (ODA): ODA does not only assist developing countries in regard to self-help, but also is beneficial for Japan's trade and FDI. By the same token, in the case of technical assistance (TA), public technology transfer is used to upgrade skills and the level of technology in developing countries, but, at the same time, it indirectly stimulates Japan to change her industrial structure toward a more high-tech, knowledge-intensive one. Therefore, TA fulfills a function as

Figure 1.5: Technical Assistance (TA) and ODA (1975–95), Japan



Source: Ministry of International Trade and Industry, *Present Situation and Problems in Economic Assistance*, various issues.

one of the measures to transform Asian industries including those of Japan, to form an interactive and version-up industrial structure.

ODA-based technical assistance soared from US$87 million in 1975 to US$3.5 billion in 1995. Its share to total ODA increased from 7.6 percent to 23.5 percent, which highlights the growing importance of this type of assistance (see Figure 1.5).

Outside changes and shocks: Unexpected environmental destruction and oil shocks affect government policies and, thereby, indirectly influence technology development. Rapid industrialization during the 1960s led to increased levels of pollution and environmental destruction. By the late 1960s, problems such as smog and water pollution forced the government to acknowledge and address these external diseconomies. The government promulgated the "Basic Law for the Prevention of Public Nuisances" in 1967, to combat pollution and other negative effects of industrialization. With respect to smog devices, the US "Clean Air Act, Amendment of 1970" (Muskie Act), stimulated Japan to formulate an equivalent standard. As a consequence of these endeavors, by 1978 Japanese automobile companies had achieved the strictest carbon dioxide and nitrogen emission standards in the world.

The two oil shocks (1973 and 1979) also affected Japan due to her enormous dependence on imported petroleum. Under government policy guidance, the private sector made efforts to save energy and find substitutes. Thus, anti-pollution technologies and energy-saving technologies became two areas where Japan gained a greater technological comparative advantage.

5.4. *Kosetsushi* (Public Research Centers)

Japan has a unique system of research networks. It is called *kosetsushi* or public technology (or research) center systems that belong to local (prefectural and municipal) governments which promote technical assistance for local enterprises, mainly for SMEs. Each local government or *ken* has one or more such technology centers. Its main objectives are: (i) counseling and consulting: – dispatching technical experts or advisers, etc. (ii) inspection and examination: – open or free laboratory access, inspection of products and issuing guaranty, etc. (iii) R&D. (iv) education and training: – offering courses, vocational training, etc. (v) information: – offering new technology information, patents, issuing newsletters, etc.

As of 1992, there were 171 centers throughout Japan (JICA [1992]). These centers have a long history. After the Russo-Japanese War (1904–5), the first such center was established in Hyogo prefecture for the textile industry. Modernization of the textile industry was urgently needed at that time. Soon Kagawa and Fukui prefectures also opened centers. Local centers were closely related to local products. Food processing, fermenting, wood processing and textiles were main fields of the centers' activities. By the late-1920s, centers for metal works, machinery, and chemical products had been gradually established. This paralleled with development of a national defense industry. In the post-1945 era, technical demand was high because there was a lack of engineers, due to the War and special demands created by the Korean War. Even large enterprises asked for technical assistance from *kosetsushi*. During the 1960s, SMEs were involved in the formation of supply chains or subcontracting systems, and public research centers contributed to assist SMEs. At the same time, pollution related problems came to the fore and the centers' role in developing anti-pollution measures and their guidance was in demand. During the 1980s, restructuring of the centers became inevitable owing to changing demand, especially high-tech development.

Collaborating with national research centers and universities, *kosetsushi* played a vital role during the catch-up period in disseminating new technology and assisting SMEs to overcome technical problems. Particularly, when local products faced fierce competition from abroad (for example, the invasion of low-cost Korean products), they had to transform their products into either product differentiation or search for new products. In such cases, centers assisted SMEs to achieve a smooth transformation by providing suitable technical consultation.

6. POLICY SUGGESTIONS FOR DEVELOPING COUNTRIES

6.1. Fostering Supporting Industries

Industrialization which takes place without the development of successful parts and components industries or supporting industries is a shallow one, and, this in turn, leads to too much dependency on MNCs. It results in trade and current account deficits and little in the way of technology transfer. It cannot produce domestic forward as well as backward linkages. Current account deficits are not improved because MNCs in developing countries import lots of parts and components as well as capital goods from their home countries. In addition, royalty and licensing fees have to be paid. Furthermore, the level of skill and production knowledge cannot accumulate without the solid foundation of supporting industries. Therefore, it is necessary to strengthen and foster SMEs in order to create successful supporting industries.

Some lessons can be drawn from Japan's experience in assisting SMEs through government programs as follows:

(i) fiscal and financial support is necessary for starting up new SME businesses, particularly innovative ones.

(ii) public assistance can be effective in basic technology development and its diffusion. Public testing facilities are also quite beneficial for SMEs.

(iii) subcontracting or supply chains can be mainly established through private initiatives or through such bodies as industrial associations or chambers of commerce and industry. Horizontal networking among different SMEs can also be formed through private initiatives. Governments may help these movements by providing science parks and information infrastructure.

(iv) skill formation is mainly the responsibility of the private sector and human embodied technologies should be handed down to the next generation continuously. However, government initiatives advocating the importance of upgrading skills are useful (such as sponsoring the Youth Skill Olympics and related competitions).

(v) needless to say, education is the key to strengthening the absorptive capacity of the nation. Especially, basic education (reading, writing, and calculating), as it is the fundamental requirement for the modern shop-floor worker.

6.2. Institution Building

The human body is in trouble if it has a strong heart but a weak brain. This means we need good organs as well as a sound nervous system. In society, institutions are important and such organizational aspects play a vital role in running the society as a whole. In technology development, well-organized education and R&D systems are urgently needed.

For example, in Japan the collaboration of national research institutions and universities, and local government public research centers (*kosetsushi*) greatly helped R&D activities, especially for SMEs. Such institution building and the establishment of research networks is urgently required in developing countries.

By the same token, systematic financial support is needed for SMEs and thereby supporting industries. Building state-owned financial systems for channeling funds for SMEs is one such way, as was the case with Japan. However, the fostering of financial markets (and "angels") by private initiatives with tax incentives to pool risk capital for innovative SME entrepreneurs is another way.

The pyramid-shaped subcontracting system in Japan is another example of the institutional framework approach to supplying parts and components for major firms. However, a simple grafting of this system onto developing countries does not work. Some modifications to represent the conditions of the host country are needed, but essential points, such as smooth technology transmission from the prime firm to the subcontracting firms and an efficient supply chain system should be taken into account.

Finally, Japan should play a leading role in the transfer of technology, both privately and publicly. Among Asian countries, a dynamic horizontal division of labor is forming: Japan aims at the most technology-intensive fields; Asian NIEs at middle technology-intensive ones; the ASEAN countries at standardized technology fields; and China and Vietnam at labor-intensive categories. Gradually, we will have to upgrade these layers in order to form a more multi-layered industrial structure among Asian countries. In order to do so, Japan should transfer its technology to these countries. Therefore, here again, we need to rethink the role of such institutions and private transfer of technology as well as government ODA.

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