# International Trade and Technology[1]
# 国際貿易と科学技術

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## 1. Technology

The word "technology" has a different nuance in East Asia as compared with the Western interpretation. In English, currently, "art" means skill and occupation closely related to handicraft, and "engineering" means architecture or management related to construction and mechanization or production, whereas "technology" means industrial arts related to the most modern science. Of course, each expression has a historical background and "art" etymologically covered not only handicraft, weaving, ceramic art, carpentry, or blacksmith skills but also astronomy, navigation, mathematics, music, etc. During medieval times, "engineering" first and foremost meant civil engineering for roads, canals, bridges, mines and military affairs, but the definition extended to far-ranging areas after the first Industrial Revolution around 1800 AD. In modern times, advanced countries are characterized in terms of technology.

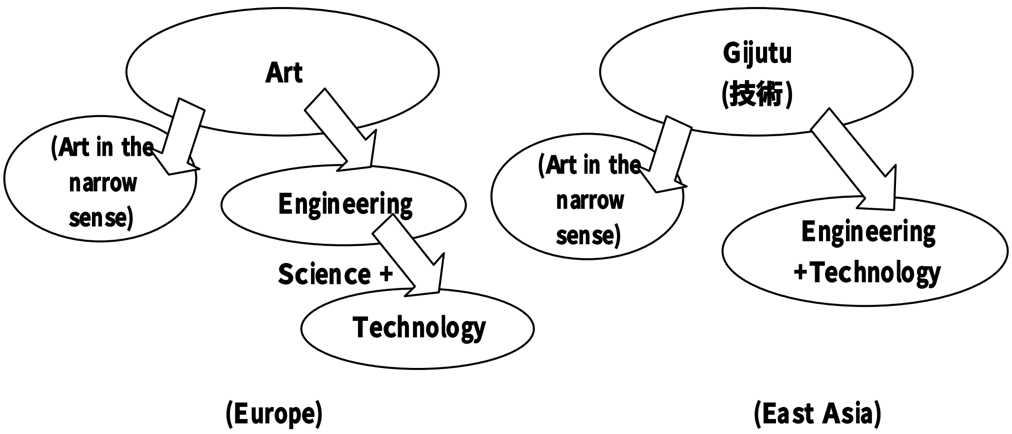
In East Asia, "art" in the narrow sense existed from ancient times but the term "*gijutu*" (技術), which is equivalent to "engineering" and "technology" in modern usage, appeared in China during the 1st century BC. Like "art" in Europe, "*gijutu*" covered skills in many areas --- from medicine, weaving, and architecture to music, military arts, and so on, and even to magic arts. In Japan, only after the open-door policy in the 1850s did the engineering and technology aspect of "*gijutu*" become emphasized and separate from "*geijutu*" (工芸 or 芸術), which is equivalent to "art" in the narrow sense. Even now, however, "*gijutu*" (or in some uses "*kougaku*" [工学]) covers both "engineering" and "technology."

Thus, the western notions of the three major elements of art, engineering and technology do not directly correspond to the terminology in East Asia, at least not in Japan. This means that East Asian people may have interpreted technology as being part of engineering, or it may imply that because modern engineering and technology were almost simultaneously introduced to East Asia in the late 19th and early 20th centuries, the differentiation between the two might have been difficult to sense and conceptualize.

The differentiation may not have been so crucial soon after the first Industrial Revolution, which is characterized by a paradigm shift in the use of energy and machinery, nor after the second Industrial Revolution, characterized by a paradigm shift in the applied use of electricity, internal combustion engines, and atomic power. Now, however, digitization, together with information technology (IT), is being rooted in both academic and business communities, minimizing the costs and burdens for transportation, reproduction, miniaturization, differentiation, and magnification. Although many people have nostalgia for the term "engineering" and some people argue that the technological changes in the first and second industrial revolutions exceeded, in scope and intensity, all that has happened since the start of the IT revolution, the combination of industrial arts and most modern science has been so strongly stressed that there may be an increasing need to differentiate "technology" from "engineering."

Nevertheless, the difference in the usage of "technology" between east and west can be illustrated as follows:

**Figure 1: Art, Engineering and Technology**

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The impact of modern engineering and technology, which were fostered in West Europe between the 17th and 19th centuries, was so great that the meaning of "industry" differs clearly between the Western and Eastern worlds. In Europe, "industry" covers agriculture, manufacturing and service and financial business; the most important factor in this usage is "diligence", that is, being industrious in economic activities. In Asian peoples' eyes, in contrast, the typical western industries were represented by machine-based manufacturing businesses. Nowadays, however, even in Europe, the emphasis on the term "industry" has sifted toward the mechanical side and the adjective "industrial" has been much more frequently used than "industrious" in everyday life. In Japan, this is more straightforward and people tend to think that "industry" just means "mechanical". At any rate, up until the 1980s, "engineering" and "technology" were almost always thought of as being synonymous by most Japanese; conversely, "*gijutu*" was ambiguous to them.

In recent times, however, the use of "technology" has gained increasing momentum in Japan. This seems to be mainly due to the impact of digitization, which has revolutionized modern society both scientifically and economically in the form of IT and prompted new diversified ideas, approaches and theories in more far-flung areas. Engineering itself comes etymologically from the combination of "engine" and "stuff", and engine originates from "*ingenium*" in Latin (natural disposition or talent), which is believed to have evolved during the medieval period to mean "wonderful invention" or "wonderful weapon". "Engine" did not have any meaning of "motor" or "power-producing machine" at the beginning but the wonderful machine invented by James Watt in 1774 was named "steam engine" and it has since had the connotation of "motor machine".

Now, in Japan, "new technology" appears to have deprived "engineering" of the attractive part of its definition and is beginning to carry a connotation of wonderful IT-related invention and innovation for economic breakthrough. It remains to be seen whether this usage will gain wide acceptance or not, but for me it implies that the majority of Japanese are anxious for technological innovation which will break the impasse we have faced since the beginning of the 1990s and enable us to revive our economy in the new century.

## 2. Technology and International Trade

Historically, technological innovation appears to have been prompted by accumulation of scientific knowledge and discovery. There is no denying, however, that technology has been derived also from such factors as the nature of subsistence commodities (textiles, grains, cattle, timber, or soil), and labor skills, from the need for increased agricultural production or the military purposes, or in modern times from government industrial policies and R & D subsidy --- in addition to being born of intellectual curiosity. International trade appears to be advanced through technology and innovation and motivated by economic concerns.

Originally, international trade was only in the form of exchange of primary products, such as foodstuffs, textiles, precious stones, metals, and some handicraft --- all with a clear relationship to natural resource endowment. The purpose of international trade today is the same as it was in ancient times ---satisfying needs arising from economic activities. The only aspects that appear to have changed are scale (from local and regional to global) and efficiency (from time-consuming to time-saving).

International trade, however, has been diversified and evolved. A variety of primary products (spice, silk, tea and cotton, and at one time, even horses and slaves) were in the public's interest as crucial tradable commodities and dramatically promoted international trade. Now, international trade has been increasingly dominated by manufactured products, production plants and equipments, and other capital goods. And even electricity and digital information have become crucial trading commodities. Almost all changes, however, appear to have been just the result of some sort of technology or innovation.

While developments in science are certain to give impacts to international trade, some historical evidence suggests that the causal relationship can work in reverse --- that is, that international trade begets technological innovation.

For one, international trade was often motivated by curiosity about new and strange products. The curiosity helped human beings more precisely compare, understand and utilize difference in the subject matter and was closely related to scientific knowledge. Oriental silk fascinated Western people even in the periods before Christ and inspired them to study the origin, seek good information on the route to the East, and sophisticate their trade art. The increased need for spice trade in the15th century promoted the innovation of navigation technology and enriched geographical information.

During the Middle Ages, Muslim traders kept a stronghold on the Moluccas, the 0ld Spice Islands, where clove, nutmeg and mace throve. The islands were a magnet that drew traders from many parts of the Old World, because these spices were thought for centuries to be able to preserve meat, flavor roast, and cure any disease from the Black Plague to a lover's anguish and were literally worth their weight in gold. In addition, soon after Constantinople fell to the Turks in 1453, the trade spice route from the East to Europe was blocked detrimentally. This, however, strongly stimulated the Portuguese to explore possibilities to sail directly to the East through a voyage down the coast of Africa. After experiencing a series of epic voyages to India and Malacca, the key entrepôt of spice trade, they finally captured the Spice Islands in 1512. On the one hand, this triggered off colonialism in Asia as well as economic dynamism in the world; on the other, it also gave rise to energetic scientific exploration, research, and discovery in geography, biology, geoscience, etc., as well as technological innovation in navigation, measurement/surveying, and above all human beings' worldview.

Another example occurred toward the end of the 17th century: cotton products (calico), introduced to England by the East India Company, ignited enormous desire for new textile with soft touch, dyeability, hygroscopicity, etc. Calico's popularity immediately posed a serious threat to England's manufacturers of woolen and silk products. The British Government adopted strong import controls against calico, which protected the traditional woolen industry as well as a cotton spinning and weaving industry in England. Meanwhile the East India Company expanded its calico business to other European countries for sale and to North America and Africa for cotton cultivation. America's Civil War between 1861 and 1865 shifted the emphasis of cotton production from North America to Egypt, which was under the control of Britain (1882~1952), and Central Asia, which was subject to Russia (1860s~1990).

Under the strong industrial protection, the newly emerging cotton industry in England made every effort to catch up with the technical level of Indian calico, creating mechanical spinning, weaving, bleaching and dyeing technology --- competition in international trade always required quality improvement, mechanical solution, and economic efficiency --- and it was not long before the English cotton products outperformed the Indian calico and dominated the international cotton market: Indian "Calicut cloth" was almost completely replaced by "Manchester goods".

The increased need for transportation of cotton products, combined with the invention of the engine, led to the railway business as well, and the combination of progressive science and mechanical engineering widened the scope of technological innovation considerably. The outcome became known as the first Industrial Revolution around 1800, characterized by an economy that was highly machine tool-based and mass production-oriented. The 19$^{th}$ century succeeded in institutionalizing the technology, centering on railway, gas, electricity, telephones and telegrams, and the 20$^{th}$ century succeeded in deepening and widening the accelerated technological innovation, ranging from automobiles, electric appliances, and chemical products to sophisticated capital equipments and goods as well as nuclear and space apparatus. In addition to products, international trade also transferred technology. In the 1960s, Raymond Vernon presented a product cycle theory, which suggested that, once tradable commodities are standardized, LDCs soon acquire the technology needed to capture a mass world market.

Japan's thorough renovation soon after the open door policy in the 1850s was strongly spurred on by international trade with the US, Europe and neighboring Asian countries. In particular, the rapid increase in raw silk export enabled Japan to secure export proceeds and accumulate financial resources for the subsequent industrialization of its economy. In addition, some traders of raw silk converted themselves into modern entrepreneurs in electricity, gas, railway, and manufacturing industries. Meanwhile, efforts in import substitution for cotton products led to the rapid fostering of the spinning and weaving industry. Although much trial and error was required in the process of export promotion and import substitution, the silk and cotton textile industries formed the mainstream of Japan's economy later on.

Fortunately, the efforts were successfully combined with traditional manufacturing, modern science and education. Later on many Japanese corporations diversified: for example, *Toyota* evolved from textile business to car production business. *Suwa* region to the west of Tokyo shows another example in which filature art was sophisticated by a combination of French, Italian and Japanese traditional experiences, which in turn has transformed *Suwa* business to precision machinery including quartz-driven timing devices, and further to the most modern electronic business.

With the benefit of technological resources (described later), many other corporations evolved their technology and diversified their businesses: from dairy products business to pharmaceuticals, from records to VHS videos and further to DVD players, from film to digital cameras, from ordinary vessels to Super-PanaMax containers and techno super liners (TSL), from alcohol to biochemicals, from mechanically driven quartz-driven timing devices, from natural fiber to manufactured inorganic fiber and further to polyacrylonitrile (PAN) carbon fiber and optical telecommunication cables, from traditional textiles to supply-chain-management (SCM) based digitized textiles, etc.

And the competition generated by international trade is yet another area in which we see trade inducing technological innovation. Competition also serves to lift the general level of industrial skills, which then propagates even further innovation. Both external and internal competition tend to identify each region or country's comparative advantage, the characteristic most crucial to each region or country's economy.

As discussed previously, the increased competition in international trade has facilitated transfer of technology from advanced countries to LDCs. Product cycles suggest that more and more LDCs have been catching up with advanced countries by producing such trading goods as sophisticated textile products and TVs and other electric appliances and exporting them. Many Asian countries have industrialized themselves, and some have renovated their industrial structure --- from labor-intensive to capital-intensive. A few of them have increased their interests in R & D activities. In brief, both international trade competition and technical innovation have been institutionalized, at least in East Asia.

## 3. International Trade and Technology

Lack of competition in international trade tends to stagnate technological innovation. One typical case was a traditional clock peculiar to Japan. In the 1630s European clocks were introduced to Japan but the subsequent closed-door policy severely hindered technological improvement in clock production. When Japan reopened its door in the 1850s, the existing Japanese clocks were so expensive and obsolete that they had to be treated practically as antiques. In contrast, harsh competition in international trade tends to help technology grow, leaving obsolete processes in its wake. Japan's automobile industry is an oft-cited example but the occurrence is also apparent in modern machine tool industry, chemical industry, computer industry (closely tied with semiconductor industry), software industry and telecommunications industry.

Although many American and European corporations continue to be leaders in many industries, not a few Japanese corporations have preserved comparative advantages in their many respective areas. Their comparative advantages in international trade have been sustained through intensified improvement in managerial resources, government policies for deregulation and competition, and, in particular, technological clusters formed jointly by corporations that otherwise compete aggressively with each other.

The most representative case of the clusters is Silicon Valley in California, where corporations compete in terms of products, technology and service but simultaneously cooperate in terms of training qualified researchers and specialized labor, raising educational levels, and establishing standards through geographical concentrations. Such regions (and in some cases countries) succeed in sustaining their technological innovation through strong comparative advantages in international trade and competitiveness. In terms of economics, they have succeeded in creating the benefits of competition and the networks that enable people to share essential information, and enjoy brokerage functions of inputs such as labor skills and supportive services. As compared with traditional economies dominated by resource endowments and labor skills, the recent technological innovation is proceeding in a highly dynamic process.

The above can be summarized as follows:

First, when two communities are very heterogeneous, as the spice trade suggested, international trade can create a paradigm shift in perception and motivation, resulting in a leap of technology. Second, as the calico trade illustrated, international trade competition can ignite technological revolution. Third, as the silk and cotton trade indicated, international trade can create continuous technological innovation and evolve business patterns. And fourth, as the recent comparative advantages have shown, technological innovation tends to be a dynamic process. While international trade has created such negative effects as environmental problems, economic and financial instability, deprivation and sterilization of traditional cultures, and income and digital divides, it is a fact that it has effectively stimulated and enhanced technology.

As a matter of course, the contribution of the factors behind international trade and technology is difficult to generalize, because they are most likely to differ from country to country, from industry to industry, and from corporation to corporation. Information technology (IT) provides one example. Although many factors have contributed to the rapid development of IT, one crucial factor, the Internet, arose from the original communications network for defense consideration and research. Without vast investment by the US Defense Department in this area, this rapidity could not have been achieved.

With these points in mind, the above arguments and historical interpretations could be simplified and schematically illustrated as follows:

## 4. Anecdotal Interpretation

Silk fabrics used to be one of the most important commodities in international trade. They were well known in the West for centuries, even before Christ. Some

**Figure 2: Interaction between International Trade and Technology**

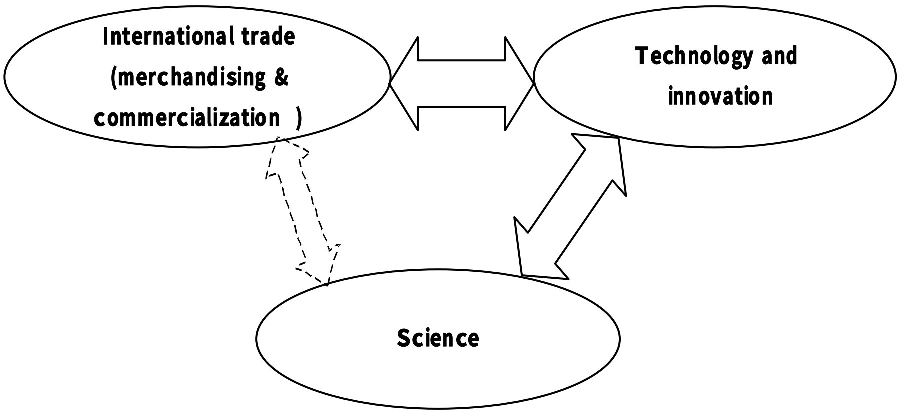
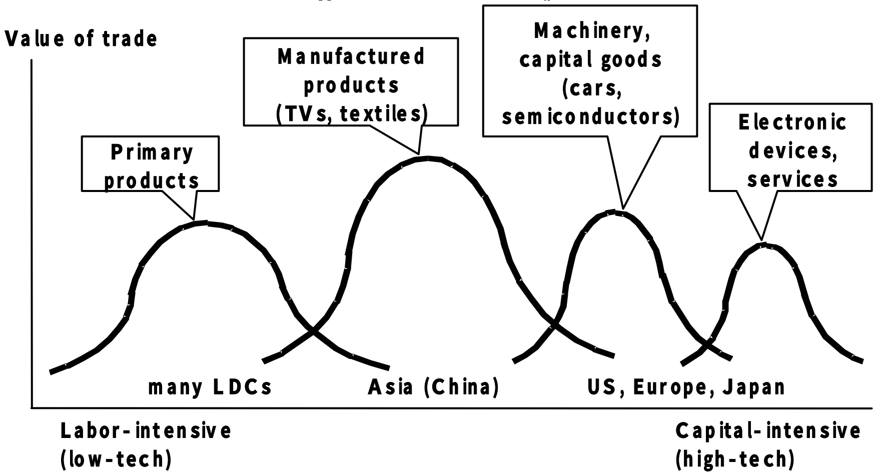



**Figure 3: Product Cycle**



historians argue that Alexander the Great was the first to come across silk, thus linking the West with the East. Peoples to the west of the Taklimakan Desert and the Tianshan mountain range were fascinated by the exotic, fine, soft and smooth textile, and it dominated other textiles such as flax, wool, cotton, and artificial rayon even in early 1900s. Up until the 1940s before nylon appeared, silk was the most valuable textile and everybody longed for it.

Sericulture has been practiced in many parts of Asia and Europe, but before the 2nd or 3rd century AD it had not been allowed out of China, where, legend says, an ancient queen happened to pick up a thread from a cocoon dropped into hot water and discovered raw silk. Chinese legend also says that before the 5th century a Chinese princess had cocoons and mulberry with her when she was married off to a king west of China. European legend says that two Nestorian monks carried cocoons and mulberry secretly out of China to Constantinople at the time of Justinian I. There was no argument for property rights at that time. Whereas silk culture remained a secret to the West, Persia was a center of silk trade, and silk dyeing and weaving developed in Syria, Egypt, Greece, and Rome, but the silk yarn was obtained by unraveling the silk fabrics from the East.

From Byzantium, silk culture spread through Europe: after 8th century AD, sericulture and silk industry flourished in Italian city-states, and later in France. The silk industry expanded gradually to more European countries. Around 1854, however, a devastating silkworm plague occurred in Europe, so raw silk was sought in East Asia. With its open-door policy occurring concurrently by chance, Japan began to export raw silk and rapidly assumed leadership. Raw silk continued to be Japan's major export commodity until the 1930s. After World War II, however, manufactured fibers such as nylon reduced the silk industry. Nowadays China has regained leadership of sericulture, accounting for 65 percent of world production. (See Table 1 and 2.)

Silk trade has had some implications for technology.

First, silk trade gradually introduced Western peoples to sericulture, spinning, weaving, and dyeing technology. In the process, technological aspects attracted more attention than the silk fabrics themselves.

Second, the high price and limited supply of silk fabrics induced the textile industry to seek substitutes for silk, ultimately leading to the manufacture of inorganic fiber in the 20th century. So whether directly or indirectly,

**Table 1: Raw silk production in the World (In bales of 60 Kg)**

| | Production | Share (%) |
|---|---|---|
| Japan | 18,500 | 1.8 |
| China | 673,600 | 65.5 |
| India | 237,700 | 23.1 |
| Brazil | 30,300 | 2.9 |
| Uzbekistan | 18,700 | 1.8 |
| Thailand | 17,900 | 1.7 |
| Vietnam | 14,400 | 1.4 |
| North Korea | 2,500 | 0.2 |
| Turkey | 500 | 0.0 |
| Korea | 100 | 0.0 |
| Others | 14,900 | 1.4 |
| Total | 1,029,100 | 100.0 |

(Source: Estimates by Agriculture and Livestock Industries Corporation)

**Table 2: Raw silk situation in Japan (In bales of 60Kg)**

| | Production | Export | Import | Memo |
|---|---|---|---|---|
| 1880 | 33 | 14 | -- | Raw silk export started in 1850s |
| 1890 | 68 | 21 | -- | |
| 1900 | 118 | 46 | -- | |
| 1910 | 198 | 148 | -- | "Rayon" (artificial silk) was invented in 1910s |
| 1920 | 365 | 175 | -- | |
| 1930 | 710 | 477 | -- | Raw silk export peaked around 1930 |
| 1940 | 713 | 294 | -- | "Nylon" was announced by Du Pont in 1938 |
| 1950 | 177 | 95 | -- | |
| 1960 | 301 | 86 | -- | Raw silk import started in 1960s |
| 1970 | 342 | 1 | 66 | Raw silk export disappeared in 1970s |
| 1980 | 269 | -- | 50 | |
| 1990 | 95 | -- | 35 | |
| 2000 | 9 | -- | 38 | |

(Source: Ministry of Agriculture, Forestry and Fisheries, Statistics on Sericulture (March 2002)) silk trade continued to stimulate textile production technology.

Third, silk trade was accompanied by goods such as china, japan, medicine, and music instruments. The expanded trade facilitated exchange and promotion of technology as well as religion, science and culture in general.

Fourth, the silk industry has been a source for a variety of so-called high-tech products, which in turn have affected the pattern of international trade. Intricate analysis of various aspects of silk culture has enabled scientists and industrialists to use a biochemical approach to make new textile stuffs: for instance, inborn colored cocoons and delicately processed and synthesized fibers. Also the chlorophyll naturally exhausted by silkworms has been used for toothpaste, and the inherent delicacy of silk industry has indirectly led to micro- and nano-technology.

Fifth, the heavenly blessed silk has always presented a model that could not be surpassed artificially. Careful comparisons of technological outputs with the natural products have often given good insight for further technological innovation. What is naturally contained in silk is perhaps beyond our current scientific understanding, and throughout its history silk trade has fostered a widening and deepening of varied views and information; perhaps, technology is only part of the whole outcome.

Finally, silk fiber provides a natural analogy for optical telecommunications cable, the most crucial part of IT, which is as follows:

(1) The silk fiber that silkworms produce to build their cocoons comprises twin filaments (fibroin) held in place by a gummy substance (sericin). As for optical cable, the silica-based fiber's core (like fibroin) is held in place by a structure called cladding (similar to the function of sericin).

(2) Although the process of the spinning of cocoon fiber is different from the initial-stage silica-based preform (**母材**), the process of reeling the thread from the boiled cocoon (the so-called spinning in the textile industry) is again very similar to the process of tapering and reeling the second-stage silica-based fiber of the optical cable.

(3) Further, the process of intertwining several fibers into a thread is very similar to that for optical cable. However, the technique for optical cables is different from (or still far behind) the technique developed in twisting silk threads (**撚り**) and the technique employed in weaving silk fabrics: the interlacing of the weft (**緯糸**) with warp (**経糸**).

(4) Of course, end purposes of silk fiber and optical cable are completely different --- warmth and body protection as well as decoration vs. telecommunications; however, technological scale of both is at the micron level, and their ultimate purpose is for better comprehension and harmonization of nature and life.

While many natural products remain difficult to surpass, exploration has been pursued across technological boundaries. Again more trial and error, enthusiasm and disillusion will follow in the process. Already highly efficient information processing and multi-layered accumulation of scientific information have been facilitating a multidisciplinary strategy, which will be reinforced by exploring new possibilities in info-technology, nano-technology and beyond.