Technology Transfer: Experience from Japan and South Korea

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1. Introduction

- Technology transfer is a process in which science or knowledge or capabilities are transferred from one entity (person, group, organization) to other for the purpose of further development and commercialization (Swamidass &Vulasa, 2009; Lane, 1999).
- The process includes the identification of technologies, its protection by patent or copyrights and the development of commercialization strategies.
- Technology transfer fosters productivity growth and creates new innovation
- For a successful technology transfer, effective technology strategies are required.
- supportive and dynamic government policies and institutions.

2. Channels of Technology Transfer

- ***Foreign Direct Investment (FDI):*** FDI has a spillover effects in transferring technology for the local firms
  - Demonstration effects: local firms adopt the technologies by reverse engineering or imitation.
  - Labor turnover: switching of trained or experienced workers from multinational to the local firms.
  - Vertical linkages: supplier or buyer relation between the multinationals and receiver firms.
- **Joint Venture:** initiated by a supplier as part of a management strategy that promotes multinational business.
- **Licensing:** involves the purchase of production or distribution rights and the underlying technical information and know-how.

Channels of ……..

- ***Trade:*** Technology is mostly embedded in the goods. Example: capital goods contain learning process.
- ***Human Capital Transfer/ Movement of people:*** International movement of people associated with nationals studying or working abroad for a limited period and applying their new knowledge when they return, or the inward movement of foreign nationals into the country
- ***Reverse Engineering:*** Reverse engineering is a systematic approach for analyzing the design of existing devices or systems.

3. Japan's Technology Transfer: Meiji Period

- Japan's opening of its ports in 1859 brought with it the beginnings of trade with Europe and the US, and, at the same time, opened a way for it to import technologies from the West.
- Since then Japan has achieved industrial modernisation through the deliberate and selective introduction of technologies from the West.
- One of the primary reasons for the unprecedented Japan's economic growth was technological progress derived through the introduction of foreign technologies.

Technology Transfer in Meiji……..

- Imported technologies played vital role to economic growth by enabling Japanese producers to acquire new and advanced knowledge.
- Japanese private companies picked up the new technologies brought from abroad, and improve them into goods of superior quality making them competitive and penetrate into the world market.
- Japan has become the first non-Western nation to successfully receive, modify and internalize Western technology as early as in the late 19th century.

Technology transfer in Meiji……

- The transfer of technology that took place from the West to Japan throughout the Meiji period could belong to any of the types listed below:

A. Overseas factories founded through direct investment by suppliers

B. Businesses established by migrants from the supplier country

C. Joint ventures

D. Management contracts with suppliers

E. Turnkey contracts, where suppliers guarantee the transfer of technology when they construct a factory

F. Employment of engineers and skilled workers provided by the suppliers or by businesses owned by the receivers

G. Purchase contracts for machinery and know-how

H. Technology transfer as an integral part of the machinery imported by the recipient

I. Patent licence agreements

J. Production of imitations

K. In-house development of a technology

Technology transfer in Meiji……

1. Early attempts in the late Edo period

- In 1854, the Bakufu made its first effort to import foreign technology when it adopted Western-style armaments for coastal defence against possible foreign invasion.
- To smelt and process metals for casting cannons, many furnaces were built by scholars of Dutch studies and traditional craftsmen.
- Source of technology used to design and build the furnaces was just by reading imported Dutch books.

Technology transfer in Meiji……

- But, realizing the limitations of imitating technology from books, the Bakafu changed its strategies and reverted to directly importing firearms manufactured abroad as soon as Japan opened its ports.
- First successful on-site technology transfer: construction of a Western-style wooden sailing ship at Heda port in Izu Peninsula in 1854.
  - Japanese carpenters participated on designs by Russian naval officers and under instructions of Russian shipwrights.
  - The Japanese carpenters absorbed the technology so well they later became the first skilled workers at Japanese naval arsenals or privately-owned shipyards.

Technology transfer in Meiji……

- Second attempt was establishment of Nagasaki Naval training Centre:
  - Dutch naval personnel trained the crew of Japan's first Western-style battleship.
  - The Japanese crew received both on-the-job and off-the-job training focusing on operational technologies.
  - Graduates of the training centre played a great role in replicating the technology they acquired.
  - The form of technology transfer that Japan exercised here possesses the characteristics of a type C transfer (a joint venture).

Technology Transfer in Meiji……

2. **Foreign experts and turnkey projects**

- The Meiji government hired foreign advisors to on a project contract basis, at considerable fiscal cost and established Western-style, state-owned enterprises in the areas of railways, telegraphy and silk reeling.
- In terms of employment of foreign professionals, government-run businesses employed large number of foreigners including engineers.

Technology transfer in Meiji……

- These businesses transferred an exact replica of the supplier's factory organisation as well as importing its hardware.
- A foreign director was assigned in charge of supervising the activities
- This form of technology transfer can be classified as type D (Management contracts with suppliers).

Technology transfer in Meiji……

- Another type of businesses, employed a handful of foreign workers
- The Japanese took over the management works.
- The role of the foreigners here was to fill specific technological needs of the project under Japanese ownership
- They provided special advising services.
- This form of technology transfer can be classified under type F where the Japanese enjoyed higher degree of independence in technology transfer.

Technology transfer in Meiji……

- Regarding technology transfer under the turnkey projects, the Japanese government established a state-owned mint, telegraphic service, railways and shipyards with the intention of introducing modern industrial infrastructure comparable to Western models.
- These projects were put in place on turnkey contract basis where the technology supplier guaranteed the transfer of technology when they construct a factory.
- All the operations under the turnkey project were managed by foreign directors and advisors with hired Japanese employees performing only unskilled or auxiliary works.

Technology transfer in Meiji……

- The foreigners who run these businesses managed them in the same manner as the businesses they had managed at home.
- From around 1875 government-run businesses began shifting away from hiring foreigners, and by 1880 foreign engineers and skilled workers were replaced by Japanese workers.
- Many businesses managed to continue operations without hiring replacement foreign workers

Technology transfer in Meiji……

3. Engineering Education

- After the departure of foreign engineers, Japanese engineers took the responsibility of internalising and diffusing Western technologies in Japan.
- The process of acquiring engineering technology in Japan, in terms of the technical education system, can be classified into three categories:
  - early Meiji-era engineers
  - university graduates
  - and technical high school graduates.

Technology transfer in Meiji……

Early Meiji-era engineers:

1. Scholars of Dutch studies who had taught themselves from technical journals.
2. Graduates from five schools; namely, Nagasaki Naval Training Centre, the Yokosuka Shipyard School, the Telegraphic Service Technical Training College, and the Imperial Japanese Naval Academy's Institute for Maritime Studies and the Railway Engineer Training Centre.
   - At these schools, foreign engineers taught Japanese trainees the engineering knowledge required for the functions they performed.
3. Engineers consists of people who studied engineering skill abroad.

Technology transfer in Meiji……

- Japan has sent a large number of students to study their engineering education in well-equipped Western technical schools.
- Up on return to Japan, they were welcome to work as experts in both the public and private sectors.

Technology transfer in Meiji……

By field of study

shipbuilding	21
mechanical engineering	17
civil engineering	13
mining and metallurgy	10
manufacture	6
Chemistry	4
Total	50

By the destination country

Britain	28
US	20
France	14
Germany	9
Netherlands	8
Total	79

Number of Engineers by type of education

Employer	Category of Engineer	Year				
		1880	1890	1900	1910	1920
Government departments and agencies	Early Meiji-era engineers	61	72	-	-	-
	University graduates	25	183	474	1,075	1,795
	Technical college graduates	-	45	263	1,160	1,999
	SUBTOTAL:	86	300	737	2,235	3,794
Private organizations	Early Meiji-era engineers	-	17	54	34	-
	University graduates	-	131	385	846	3,230
	Technical college graduates	-	34	389	1,963	7,138
	SUBTOTAL:	-	182	828	2,843	10,368
TOTAL	Early Meiji-era engineers	61	89	54	34	-
	University graduates	25	314	859	1,921	5,025
	Technical college graduates	-	79	652	3,123	9,137
	GRAND TOTAL:	86	482	1,565	5,078	14,162

Technology transfer in Meiji……

4. Import of machinery and foreign partnership

- One method was technology embodied within the machineries and equipment imported. This method of transfer involves types G (the technology embodied in goods) and H (purchase contracts for goods and services).
- The second method employed by Japan was by entering into technical collaboration agreements with Western enterprises to introduce technology to specific industries. Returning to our classification of technology transfer, the second type can be classified as type A, C or E

4. Technology transfer in South Korea

Introduction

- Korea transformed itself from an agrarian society to one of the world's most highly industrialized nations by pursuing a successful transfer of technology
- The Korean economy has grown through strong government support and engaged people (i.e., high quality of human capital)
- Koreans regarded the export of its industries as the only means to lift itself from poverty in the early 1960s.
- Government and business leaders together developed a strategy of targeting export-oriented industries for development in the early 1960s.
- The strategy involved plans for the successful transfer of technology that generates new innovations

Choi, 2009

Introduction

- In Korea, modern technology development and/or technology transfer began only in the early 1960s.
- Old industrial equipment and facilities from developed countries were imported on a turnkey basis through foreign aid or loan programmes.
- At that time, Korea's production technology was characterized by simple manufacturing with unskilled or semi-skilled labour.
- Most training was dependent on foreign experts.
- To achieve the goal of technology transfer, science and technology policy has been adjusted to confirm to national development goals and strategies.
- Korea made concrete plans that included multiple steps for the transfer of technology due to strong government support.
- Today, Korea became a donor of technology in high-tech fields, such as electronic, information technology, and communication.
- How did Korea achieve such growth in technological capability in only four decades?

DYNAMICS OF TECHNOLOGICAL LEARNING

Three Stages of technological learning

1. Duplicative Imitation Stage
2. Creative Imitation Stage
3. Innovation Stage

Duplicative Imitation Stage

- Imitating technology by acquiring, assimilating, and improving generally available mature foreign technology through various mechanisms.
- Duplicative imitation began in such light industries as textiles, toys, plywood, and consumer electronics in the 1960s and in such heavy industries as automobiles, steel, shipbuilding, and machinery in the 1970s.
- Four most important knowledge-building mechanisms for Korea in the duplicative imitation stage
  - Education
  - Foreign technology transfer,
  - Deliberate creation of *chaebols* (large family-owned conglomerates)
  - Mobility of experienced technical people.

Duplicative Imitation

1. Education

- Education to develop human resources was one of Korea's most conspicuous efforts in industrialization.
- Unlike other developing countries, Korea was unique in achieving well-balanced expansion at all levels of education early enough to support its economic development.
- Expansion of education outpaced economic progress in the early years, creating a severe unemployment problem for the educated.
- However, the formation of educated human resources laid an important tacit knowledge base for the subsequent development of the economy, which soon absorbed the surplus.

Duplicative Imitation

2. Foreign technology transfer

- Korean firms relied heavily on foreign sources for both explicit and tacit knowledge at the outset.
- Most tacit and explicit knowledge were obtained via informal mechanisms as literature, reverse engineering, and technical assistance.
  - This mode of technology transfer was seen in small firms.
  - Large Korean firms resorted to such formal mechanisms as turnkey plant transfer or technical licensing agreements with foreign suppliers.
- However, informal technology transfer has been most significant in further broadening the capabilities of both large and small firms.

Duplicative Imitation

3. Deliberate creation of *chaebols*

- Government deliberately created and nurtured Chaebols as engines for rapid economic development.
- The Chaebols became the major source of Korean industrialization.
  - They recruited the best-qualified entrants to the workforce,
  - They had technical and financial resources to purchase foreign technologies,
  - They achieved rapid diffusion of technological capabilities across subsidiaries by applying experiences gained in one field of business to another
  - They were at the forefront of the expansion, deepening, and globalisation of industrial R&D in Korea.

Duplicative Imitation

4. Mobility of experienced technical people

- Most effective way for late entrants to acquire the necessary knowledge base.
- For instance, majority of consumer electronics producers in the 1970s entered the industry by poaching experienced managerial and technical people from existing firms.
- Large state-owned chemical and machinery companies in the 1950s and 1960s relied completely on turnkey transplant and foreign engineers for the initial knowledge base, but engineers who accumulated modern production experience in those firms eventually joined private enterprises to provide the crucial knowledge base there

Duplicative Imitation

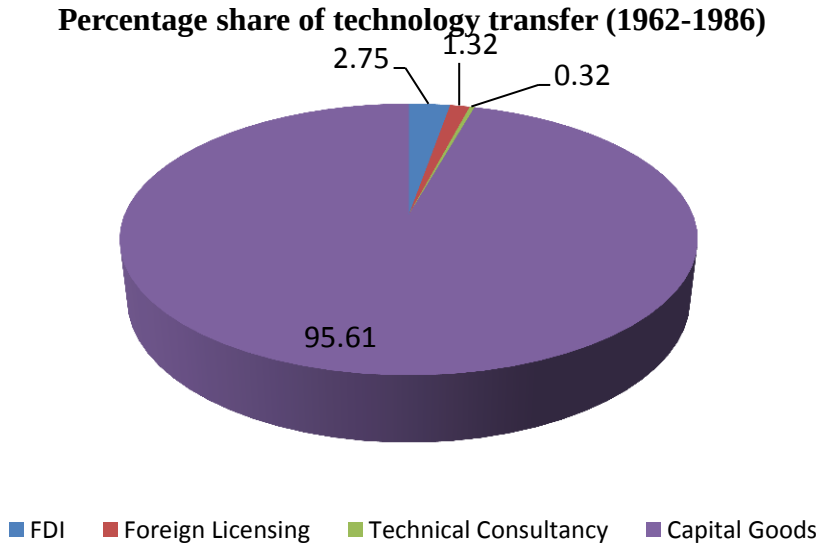
Role of Korean government and corporate top management to raise the intensity of effort in technology transfer

- Export promotion: Given the small domestic market, the government used export promotion as a major instrument for achieving economic growth goals.
- Hasty creation of heavy and chemical industries (HCIs): The most significant result of the hasty HCI promotion was speedy technological learning.
- Technology transfer strategy: In the 1960s, the Korean government restricted foreign direct investment (FDI) but promoted instead technology transfer through other means such as capital goods imports.
- Crisis construction: Korean firms set ambitious goals as a means to expedite technological learning.

Duplicative Imitation

Foreign Technology Transfer to Korea (millions of US dollars)

Channel technology transfer	1962-66	1967-71	1972-76	1977-81	1982-86	Total
Foreign direct investment	47.4	218.6	879.4	720.6	1766.5	3632.5
Foreign Licensing	0.8	16.3	16.5	451.4	1184.9	1749.9
Technical Consultancy		16.8	18.5	54.7	332.3	422.3
Capital Goods	316	2541	8841	27978	86718	126394



Source: Kim, 1990

Creative Imitation Stage

- Korean firms shift their learning orientation from duplicative imitation to creative imitation in the 1980s .
- Firms needed higher level of existing knowledge base than that in the preceding stage to bring about creative imitation.

Role of government and corporate top management to raise existing knowledge base

Five major sources of knowledge in the creative imitation stage:

1. Formal technology transfer

- Foreign technology transfer still continued to be a major means of building the existing knowledge base in Korean firms.
- Foreign patent holders became serious about controlling imitation by developing countries which pushed Korean firms to formal technology transfer such as FDI and foreign licensing.
- FDI increased from $218 million in 1967-1971 to $1.76 billion in 1982-1986, while royalties associated with FL increased from $16.3 million to $1.18 billion during the same period

Creative Imitation

2. Reverse brain drain

- As of 1967, 96.7 percent of Korean scientists and 87.7 percent of engineers educated abroad remained there.
- In the 1970s, the Korean government made systematic reverse brain-drain.
- Those individuals played a pivotal role in both emerging government research institutes and corporate R&D centers

3. **Corporate research and development**

- Assimilation of imported technologies, and generation of new knowledge through knowledge conversion and by research.
- Corporate R&D laboratories increased from 1 in 1970 to 966 by 1990.
- Total R&D investment increased from US$28.6 million to US$4.68 billion.
- The growth rate of R&D was the highest in the world. The private sector accounted for only 2 % of the nation's total R&D expenditure in 1963 but 81 % by 1990

Creative Imitation

4. Universities

- Universities played an important role to produce well-trained scientists and engineers and to have more sophisticated basic capabilities.
- Government also founded the Korea Advanced Institute of Science and Technology, a research oriented graduate institution specializing in science and engineering.

5. Government research institutes

- Government took the initiative in establishing several government research institutes by recruiting overseas-trained Korean scientists and engineers.
- research institutes were industry-oriented, focusing on such sectors as chemicals, machinery, electronics, ocean science, standardization, nuclear energy, biotechnology, system engineering.
- experienced researchers produced by the government research institutes joined corporate R&D centres

Innovation stage

- Having mastered intermediate technologies for creative imitation, some Korean chaebols began to challenge emerging technologies for innovation.
- For instance, in semiconductors, Samsung developed the 256 mega and 1 giga dynamic random access memory (DRAM) chips ahead of Japan (Kim 1997b).
- Korea was the first country to succeed in commercialising code division multiple access (CDMA) mobile telephone technology.

How did Korea reach the innovation stage in terms of the existing knowledge base?

1. Basic research in universities
2. Mission-oriented applied research at GRIs,
3. Intense corporate R&D activities,
4. Globalisation of R&D
5. Recruitment of high-calibre personnel from abroad

Changing trends in technology transfer in Korea

Decade	Major Industry	Core workforce	Scope of Technology	Technology Transfer Mechanism
1950	Agriculture	Simple labor	Pre-modern	-
1960	Handicrafts	Skilled labor	Declining	Turnkey and project
1970	Light industries	Skilled technicians	Declining and maturing	Licensing (partly)
1980	Heavy industries	Engineers	Maturing	Licensing
1990	High-tech industries	Engineers and Scientists	Growing	Licensing and Joint venture

Source: Bennett, 2002

5. Policy implication for today's developing countries

Japan's and Korea's in building technological capability has many implications for today's developing countries.

- Export promotion is an effective public policy instrument that creates competitive stimulus for firms to expedite technological learning.
- Expanding and improving the quality of education at all levels are among the most fundamental and effective measures governments can take to help firms build an adequate existing knowledge base.
- Liberal policy on brain drain in the early stage of industrialization can benefit developing countries over the long run.
- Technology transfer strategy should evolve over time, as industrialization progresses.

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