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Technology Management and Export Competitiveness: Lessons From South Korea and Taiwan for Developing Countries, Particularly, the Philippines

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Abstract: **This paper explains the elements of technology management and discusses technology management lessons that developing countries like the Philippines can learn from South Korea and Taiwan if they want to attain export competitiveness. The particular case of the failed industrialization efforts and technological laggardness of the Philippines is analyzed in the context of the successful industrialization of South Korea and Taiwan.**

Keywords: **Technology Management, Export Competitiveness, South Korea, Taiwan, Philippine Industrialization, Newly Industrializing Countries (NICs).**

1. INTRODUCTION

The key ingredient in the success of South Korea and Taiwan, but is missing in the industrialization efforts of the Philippines is the conscious, competent, and concerted practice of technology management by the national government and domestic firms. Most Philippine firms have remained mere importers and users of foreign technologies. As a result, they have been trapped in a vicious circle of technological laggardness and dependence that has stunted the competitiveness and productivity of Philippine industries. The most important roles of the government are to secure a stable and conducive macroeconomic environment for long-term investments and to provide adequate educational, technological and infrastructural support to industrial development.

During the past decade there has been a tremendous global expansion of interest in technology management among business executives, government leaders, and business schools as shown by the recent mushrooming of graduate programs, books, and journals in this new interdisciplinary field.

In the Philippines, the institutionalization of technology management was pioneered by the University of the Philippines at Diliman when it established the Technology Management Center in 1995 and started offering the Diploma and Master's Programs in Technology Management in 1996, becoming only the second academic institution in Asia to do so.

This recent explosive growth of interest in technology management is but a manifestation of the increasing awareness among corporate and government leaders that competence in technology management - that is, adeptness and agility in selecting, acquiring or generating, exploiting, and mastering technology - is the key strategic factor in creating and sustaining competitive advantages for a firm or nation.

Although the formal recognition of technology management as a distinct field of management is a recent development, the practice of technology management at the firm and national levels has long been pursued as far back as the Industrial Revolution.

In Asia, the Japanese used technology management competently and effectively in their successful drive towards industrialization and technological catch-up.

Following this Japanese model of technology management, the South Koreans and Taiwanese succeeded in industrializing their economies, becoming export tigers, and narrowing their technological lags at a much faster pace (within 25 years) than the Japanese. In contrast, although the Philippines started its own industrialization efforts in the 1950s ahead of South Korea and Taiwan by at least a decade, it has not yet attained the status of a newly industrialized country (NIC), much less that of an export tiger.

What is worse is that whereas 50 years ago the Philippines was ahead of South Korea and Taiwan in all aspects of national development, it is now behind these two NICs by at least 25 years in technological development. So what was the ingredient or factor that was key to the success of South Korea and Taiwan but is missing in the Philippine industrialization effort?

This ingredient, of course, is the conscious, competent, and concerted practice of technology management by the national government and the domestic firms.

Therefore, if the Philippine government and industries are really serious in attaining NIC status and global export competitiveness, it is imperative that they study how the South Koreans and Taiwanese used technology successfully to become NICs and export tigers and derive lessons from their experiences that they could adapt to the Philippines own situation.

It is for the purpose of learning the technology management lessons from the successful industrialization of South Korea and Taiwan that this paper is written.

There are some people, however, who believe that it is worthless studying the South Korean, Taiwanese, or Japanese models of industrialization and technology management because of the recent Asian economic crisis that has plunged these countries into recession. Yet, what these people neglect to point out is that these economic tigers' current temporary economic problems have been caused not by the failures of their technology management but rather by weaknesses in financial management at the corporate and national levels, particularly the corruption and collusion among government and corporate officials that masked serious corporate financial problems.

Hence, this paper takes the position that the South Korean and Taiwanese experiences in technology management can offer developing countries like the Philippines valuable lessons that can be useful in the national drive towards industrialization and export competitiveness. In the next section, we explain what technology management is all about, and then describe in Section 3 the main features of the export-led technological learning and catch-up strategies that the South Koreans and Taiwanese pursued to develop their technological capabilities and export marketing skills simultaneously. Section 4 discuss the particular lessons in technology management that can be drawn from South Korea and Taiwan.

Section 5, finally presents a list of technology management recommendations that developing countries like the Philippines can adopt to attain export competitiveness.

2. METHODOLOGY IN EXPORT COMPETITIVENESS: LESSON FROM SOUTH KOREA AND TAIWAN

Critical Review and Analysis of the Relevant Literature on the Topic.

The Elements of Technology Management:

Technology can be narrowly defined as "the engineering knowledge needed to create and produce a new product or process." In a broader sense, technology management is "the means of accomplishing a specific task". In Michael Porter's value-chain model, a firm's technology is the way it performs its value-chain activities, as depicted in **Figure 1** and **Figure 2.**

It is clear, therefore, that technology, broadly defined, pervades all activities of a firm. Hence, a firm can create competitive advantages for itself - whether in terms of lower costs, through the use of better process technologies, or of distinct and better products through the use of better product technologies, by making appropriate technological decisions for each value- chain activity as to the selection, sourcing, acquisition, generation, exploitation, assimilation, improvement, or abandonment of technology. The integrated and consolidated set of technological decisions for all of the firm's value-chain activities will constitute the firm's technology strategy.

We can now define technology management as the strategic formulation and operational implementation of a technology strategy that informs, and conforms with, the firm's competitive strategy. In other words, technology management at the firm level involves the strategic and operational management of the firm's various technology-related functions and activities such as technology audit, scanning, forecasting, selection, sourcing, acquisition or generation, commercialization or licensing, absorption and adaptation, mastery, transfer, and abandonment.

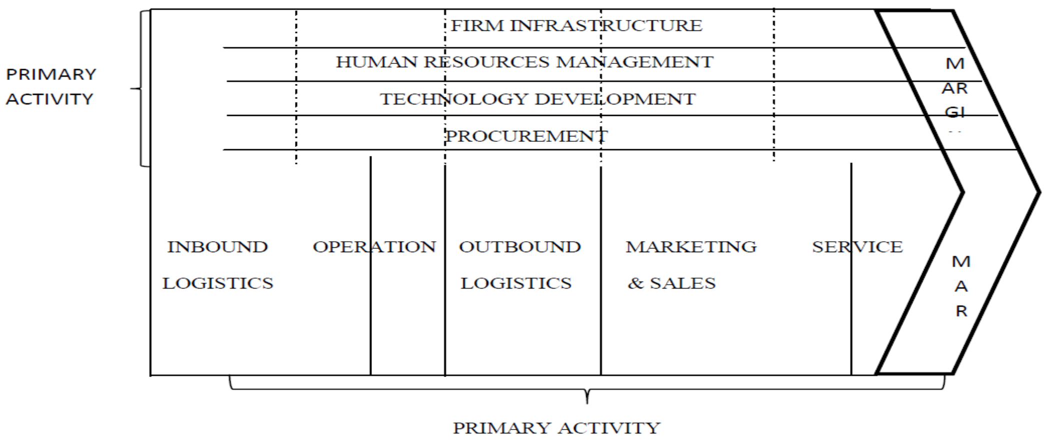

Figure 1: Michael Porter's Value-Chain Model of a Firm

Firm Infrastructure, Human Resources Management, Technology Development, Procurement:

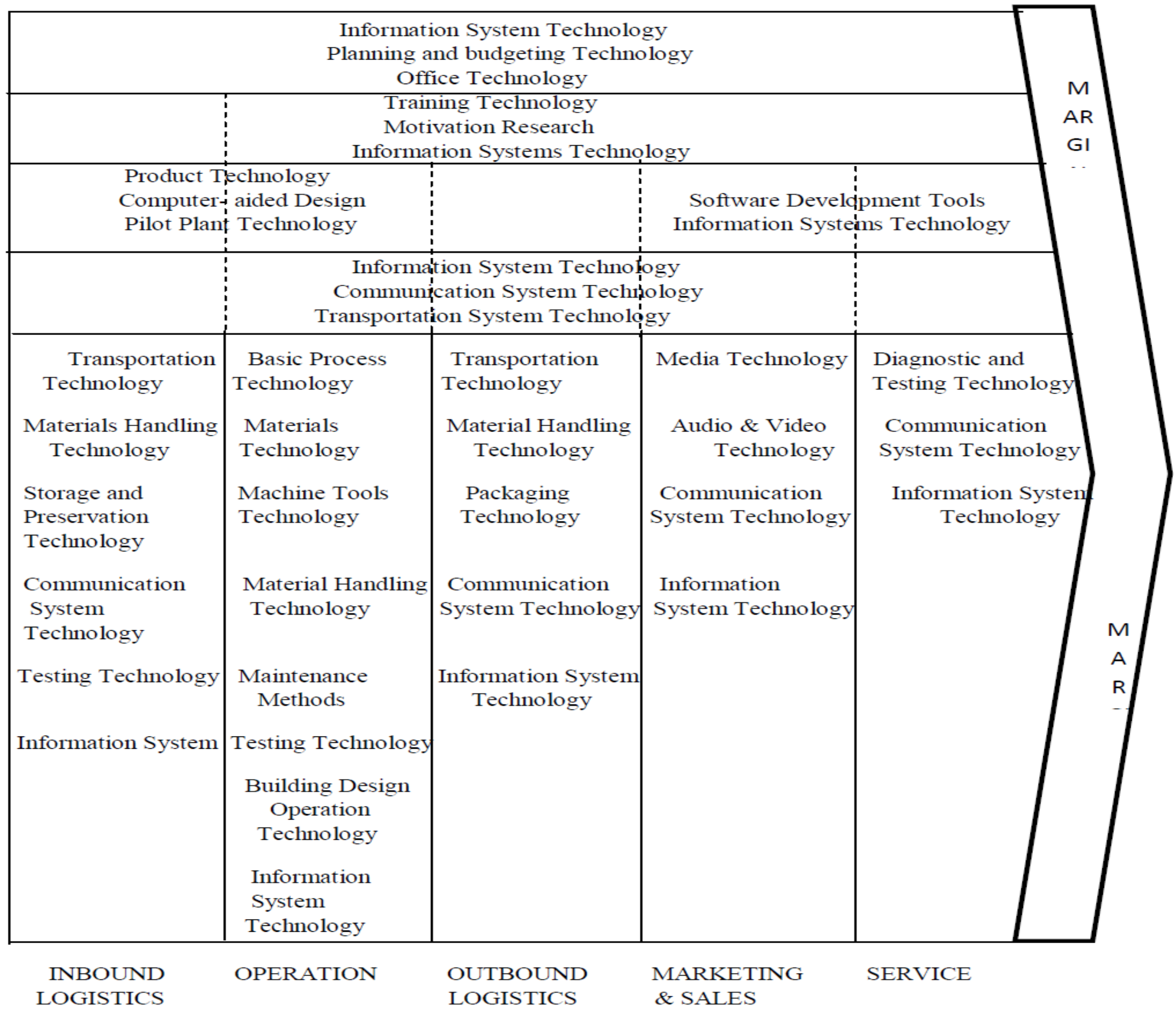

Figure 2: Representative Technologies In A Firm's Value Chain

Products or services over competing alternatives on a sustainable basis, then it is obvious that technology management is strategically important to competitiveness for it can improve the firm's product technology (i.e., the design of novel or better products), or its process technology (i.e., the efficient production of products).

The first step in technology management is the technology audit of a firm or a nation, which is essentially the assessment of the firm's or nation's technological status for each technology in terms of two measures: (1) its level of technological sophistication (i.e., the measure of its proximity to the technological frontier or state-of-the-art); and (2) its level of technological capability (i.e., the extent of its technological mastery of that technology).

A firm's level of technological capability is indicated by its position or rung in the following technological ladder of capabilities.

1. Operative Capability - the ability to use or operationalize an externally acquired technology efficiently and to carry out routine maintenance and minor repairs on the technology.

2. Adaptive Capability - the ability to adapt an externally acquired technology to local conditions through a modification and/or localization of the technology's scale, inputs, and peripheral components.

3. Integrative Capability - the ability to select, procure, and integrate parts of a technology system in order to reconstruct, without external assistance, a production or service facility on the model of a previous externally acquired facility.

4. Replicative Capability - the ability to reproduce through reverse-engineering a local replica or imitation of an externally acquired product, equipment, or process.

5. Innovative Capability - the ability to design and commercialize a significant but incremental improvement or "upgrade" of an externally acquired product or process.

6. Creative Capability - the ability to create a radically new technology from endogenous research and development (R&D) and to commercialize it into a novel product, process, or service.

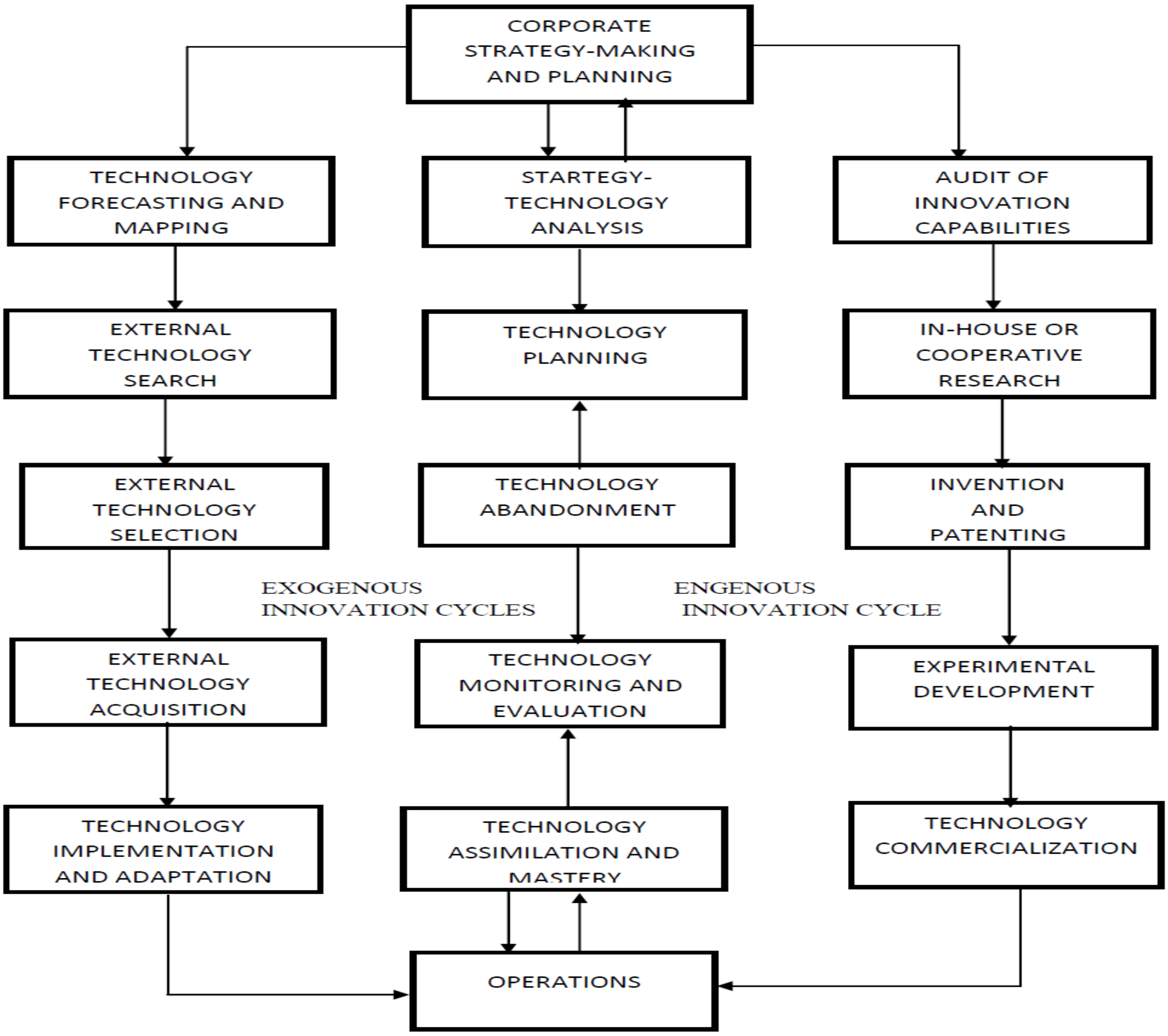

Figure 3: Technology Management Framework in tyerms of an Endogenous Innovation Cycle or an Exogenous Innovation Cycle (Copyright Roger Posadas, 1997)

A firm at the lowest or operative rung of the technological ladder is a mere technology user, while one at the highest or creative rung is a technology creator or producer. The technological sophistication of a firm's technology can be gauged in terms of its location along the curve of the technology's life cycle, as shown in Figure 4. Thus, a technology can be: (a) state-of-the-art if it is at the introductory stage of the technology life cycle; (b) a dominant design if it is at the growth stage or upward slope of the curve; (c) standardized or mature if it is at the plateau of the curve; (d) declining or aged if it is at the downward slope of the curve, and (e) obsolete if it is at the terminal segment of the curve.

The Technology Life Cycle:

Using these measures of a firm's technological status, we can make a rough depiction of the overall technological profile of Philippine domestic firms. Large firms, especially those linked with foreign firms, use foreign technologies that range in sophistication from "standardized or mature" to "dominant design" but their technological capabilities are generally limited to the operative and adaptive levels. On the other hand, most domestic firms (comprised of small and medium enterprises or SMEs) use technologies ranging in sophistication from "obsolete" to "standardized or mature" even though their technological capabilities may have gone beyond adaptive levels.

In general, Philippine domestic firms do not make any effort to reverse-engineer or improve an imported technology; they simply buy another set of foreign equipment or license another foreign process when they decide to replace their technology. Thus, most Philippine firms have remained mere importers and users of foreign technologies. As a result, they have been trapped in a vicious circle of technological laggardness and dependence (shown in Figure 5) that has stunted the competitiveness and productivity of Philippine industries.

At the same time, successive Philippine governments have failed to formulate and implement a coherent and effective system of national technology management as shown by the fact that over the past 50 years, the country did not have a coherent national industrialization strategy nor a clear national technology strategy.

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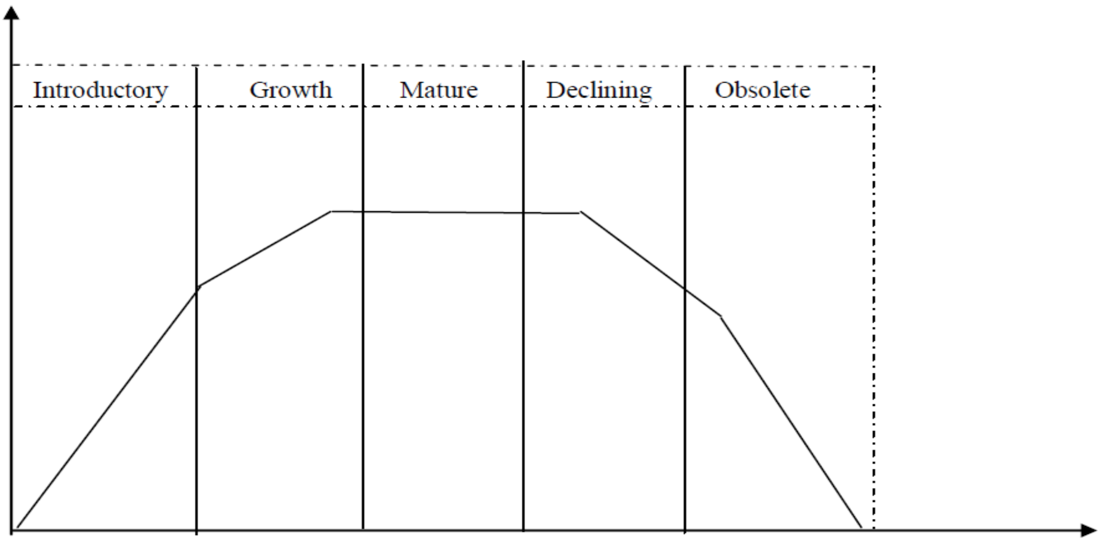

Figure 4: The Technology Life Cycle

As I have explained in an earlier paper, our government's S&T policies and programs have been largely nothing more than R&D policies and programs that tried addressing the demand side and linkage part of national S&T development. Therefore, I maintain that the continuing failure of the Philippines to achieve NIC status and export competitiveness is due mainly to its continuing weaknesses in technology management at the firm level and national level, which have perpetuated the technological laggardness and dependence of Philippine industries. A Japanese economist has aptly described our country's half-century of industrialization efforts as "technology-less industrialization".

Since the essence of industrialization is the relentless mastery of manufacturing technologies and continuous accumulation of manufacturing skills, it is obvious that any industrialization effort that neglects technology management is doomed to fail.

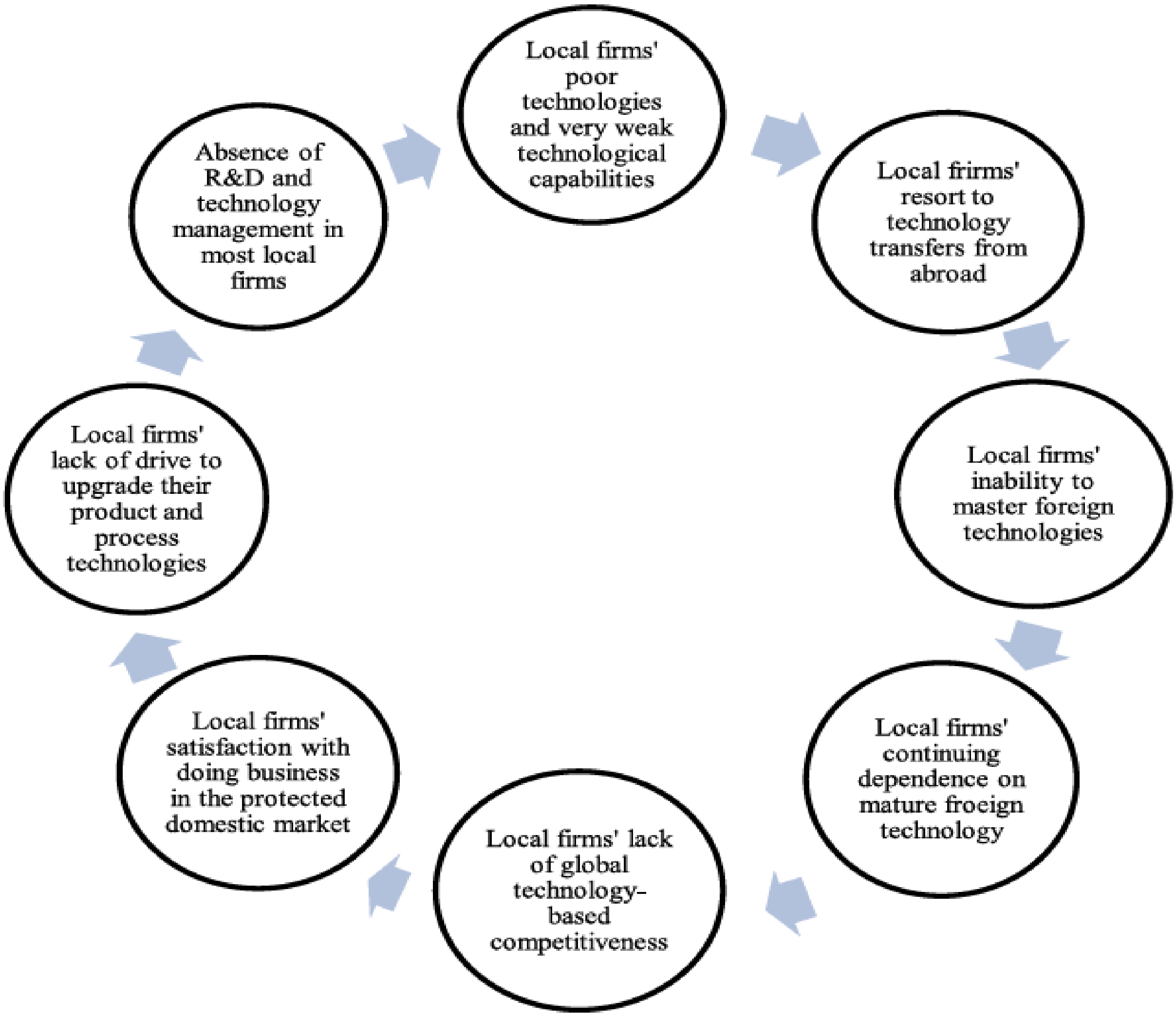

Figure 5. The Vicious Circle of Technological Backwardness and Dependence Observable in Most Philippines Firms

3. LINKING TECHNOLOGY MANAGEMENT AND EXPORT MARKETING IN SOUTH KOREA AND TAIWAN

This section will discuss how South Korea and Taiwan were able to achieve NIC status and export competitiveness by linking technology management with export marketing. In the 1960s, when both South Korean and Taiwanese governments decided to pursue export-led industrialization, they both adopted national technology management policies that were supportive of their export oriented policies, although they differed in their growth strategies, with Korea concentrating on large, diversified conglomerates called *chaebols*, as its engines of growth, and with Taiwan relying on a multitude of small and medium enterprises (SMEs).

Both South Korean and Taiwanese firms that wished to enter export markets in the 1960s had to overcome two sets of competitive disadvantages: (a) serious technological disadvantages because of their huge technological lag behind the world's technology leaders; and (b) serious market disadvantages in terms of their isolation from export markets and their lack of experience in export marketing. Their basic problem then was how to overcome international market and technology barriers to entry.

The South Korean and Taiwanese firms were able to overcome the initial barriers to entry by using international technology transfer mechanisms to acquire technology and to enter export markets.

The international technology transfer channels used by the Korean and Taiwanese firms were the following:

1. Foreign Direct Investments (FDIs)
2. Joint Ventures
3. Technology Licensing
4. Subcontracting
5. Original Equipment Manufacture (OEM)
6. Own-Design and Manufacture (ODM)
7. Technical Assistance by Foreign Buyers
8. Reverse-Engineering of Foreign Products
9. Informal Means (Overseas Training, Hiring of Foreign Engineers, Recruitment of Locals Trained in TNCs
10. Overseas Acquisition of, or Equity Investments in, Foreign High-Tech Firms
11. Strategic Alliances

Most of these channels provided South Korean and Taiwanese firms with access to both technologies and export markets.

Exploiting these channels, South Korean and Taiwanese exporting firms succeeded in accumulating export marketing skills that enabled them to graduate from the supply of labor intensive assembly services to the export of sophisticated products, and simultaneously climbing up the technology ladder from operative capabilities to innovative and creative capabilities that enabled them to graduate from technological imitators and apprentices to technological innovators.

The linked stages of export marketing and technological capabilities that South Korean and Taiwanese firms went through are given in **Table 1** Below.

Export Marketing	**Technological capabilities**
1. Passive importer-pull; Cheap-labor assembly; Dependence on buyers for distribution	1. Assembly skills basics production capabilities with respect to mature products
2. Active sales of capacity; Quality and cost-based; Dependence in foreign buyers	2. Incremental process changes for quality and speed; Reverse-engineering of foreign products
3. Advanced production sales; Establishment of marketing department; Start of overseas marketing; Marketing of own designs	3. Full production skills; Process innovations; Product design capability
4. Product marketing push; Direct sale to overseas distributors and retailers; Build-up of product range; Start of sale of own-brand	4. Initiation of R&D for products and process; Product innovation capabilities
5. Push of own brand; Direct marketing to customers; Use of independent distribution channels and direct advertising	5. Competitive R&D capabilities; Linking of R&D to market needs; Advanced product/process innovation

To South Korean and Taiwanese exporting firms, export markets provided the demand that pulled their technological learning up the technology ladder from imitation to innovation. At the same time, the intense competition from other domestic firms and pressure from the government pushed the exporting firms to continuously improve their technologies and upgrade their technological capabilities. In turn, the technological development of South Korean and Taiwanese firms raised their productivity and product quality, enabling them to sustain their competitive advantages and expand their exports.

However, the buildup of technological and marketing capabilities in South Korean and Taiwanese firms could have been hampered or undermined if they had not been supported by a government which provided them with: (a) a stable and favorable macroeconomic environment of low inflation and low interest rates that was conducive to long-term planning and investment; (b) adequate educational and infrastructure support; (c) a competitive market that pushed competing firms to upgrade continuously; and (d) a national technology management system which supported technological learning and innovation.

4. TECHNOLOGY MANAGEMENT: LESSONS FROM KOREA

The phenomenal rapid industrialization and accelerated technological progress achieved by South Korea within a few decades can offer many lessons in technology management to developing countries like the Philippines which has been trying unsuccessfully to industrialize for the past 50 years. These lessons can be divided into those pertaining to national technology management and those pertaining to firm-level technology management.

4.1 Lessons from Korea's National Technology Management:

4.1.1 Role of Government:

In the 1960s and 1970s, a strong, developmental, interventionist government played a key and effective role in driving and steering the South Korean economy into its successful export-oriented industrialization by targeting certain preferred industries, using carrots and sticks to push Korean firms into achieving ambitious export goals, and protecting the domestic market from imports and FDIs. In the 1980s and 1990s, however, the effectiveness of the Korean government's interventions was reduced because of rapid changes in the world's economic environment and because political corruption led to a collusion between the government and the big conglomerates or *chaebols*.

Lesson 4.1.1: State intervention in the economy can be effective for only as long as the government's leaders and technocrats are competent and incorruptible.

4.1.2 Industrial Policy:

Industrial policy, specifically "targeting" or the selection of particular industries for government support and development, was pursued by the South Korean government with mixed results: it was successful in electronics, steel, and shipbuilding but unsuccessful in chemical and machinery industries.

Lesson 4.1.2: Targeting can be a risky government policy. The government should instead promote and develop industrial clusters that can integrate and link related and complementary industries as well as large, medium, and small firms.

LESSON 4.1.3: Export-Oriented Policy The South Korean government in the 1960s and 1970s vigorously pushed South Korean firms to upgrade their technologies and achieve ambitious export goals while supporting them with financial, technological, and international marketing assistance. In 1962 the South Korean government created the South Korea Trade Promotion Corporation (KOTRA) which by the 1980s operated about 100 international trade centers throughout the world and, with the help of 30 or so South Korean trade associations, tracked export markets and supplied information to foreign buyers and Korean exporters.

LESSON 4.1.3: To achieve export competitiveness, the government must vigorously push exporting firms to continuously improve their product and process technologies to world-class standards while providing them with financial and technological assistance and global network of marketing support services similar to Korea's KOTRA and Japan's JETRO.

4.1.4 Technology Transfer Policy:

In the 1960s, the South Korean government adopted a restrictive policy against FDIs and foreign technology licensing and allowed mainly technology transfers through imports of foreign machinery. This policy allowed Korean firms to avoid management control by TNCs and to pursue an independent approach in sourcing and acquisition of foreign technologies. In addition, the policy forced them to undertake reverse-engineering of foreign products. In the 1970s, however, the government relaxed its restrictions on FDIs and licensing as Korean firms gained capabilities in assimilating more complex technologies.

LESSON 4.1.4: To attain an independent, self-reliant technological capability, the industrialization strategy should not depend primarily on FDIs but should instead build up domestic industries and firms as the engines of industrial growth. Too much reliance on FDIs sustains technological dependence and laggardness.

4.1.5 Industrial Structure Policy:

The Korean government adopted in the 1960s an industrialization strategy that relied heavily on large, widely diversified, vertically integrated, family-owned, rigidly hierarchical and bureaucratic conglomerates known as chaebols for the scale-intensive mass production of standardized products for mature export markets. This strategy, however, neglected the development of SMEs. It was only in the 1980s when the importance of SMEs was belatedly recognized that an institutional framework for supporting and upgrading SMEs was established. Nevertheless, unlike the Japanese keiretsu, the chaebols failed to develop a supply chain of specialized SMEs, leaving them dependent on foreign (mainly Japanese) competitors for key components, parts, and materials.

LESSON 4.1.5: SMEs should be given as much importance as large firms in a nation's industrialization because SMEs can serve as suppliers and support service providers to large firms. They can be niche exporters like Taiwan's SMEs. The continuous technological upgrading of SMEs and their linkage with large firms through industrial clusters should be a priority program of government.

4.1.6 Education and Training Policy:

The South Korean government in the 1960s invested heavily in education to produce a well-trained, hardworking workforce for industrialization. In 1974 the government passed a law that required all industrial firms with 300 or more workers to provide in-plant training. A year earlier, the government enacted a law which decreed that technicians/craftsmen had the same status as scientists and engineers. Since the 1970s, however, investments in education declined, particularly in higher education, resulting in shortages of high-level engineers and scientists and the development of only a few research-oriented universities.

LESSON 4.1.6: The upgrading of educational institutions and programs at all levels should be an essential priority of government. Private firms should also be urged to institutionalize a regular training program for their employees. Technical and vocational education and training should be made as attractive and prestigious as college education.

4.1.7 Government Research and Development Institutes:

In the 1960s the South Korean government established the Ministry of Science and Technology to manage the country's S&T development programs. It started the organization of a network of government-owned R&D institutes (GORDIs), beginning with the Korea Institute of Science and Technology (KIST) in 1965. The GORDIs played important roles in assisting in the 1960s and in 1970s in sourcing, acquiring, reverse-engineering foreign technologies and by serving as the key implementers of the country's national mission-oriented R&D programs during the 1980s and 1990s. Their effectiveness, however, has been weakened in recent years because of their stifling bureaucracies and the loss of researchers to universities and corporate R&D centers.

LESSON 4.1.7: The role of GORDIs in a country's R&D system should be reviewed as university and corporate R&D centers develop. GORDIs could still find a niche in the development of nonmarket-oriented technologies and in the diffusion

4.1.8 R&D Promotion and Financing:

The Korean government promoted domestic R&D activities by means of direct and indirect R&D incentive packages. Direct R & D incentives are for developing R&D infrastructure and financing R&D in universities and GORDIs; Indirect R & D incentives, which included preferential R&D loans and R&D tax concessions, are for at stimulating private sector R&D. By the 1980s the government's preferential R&D loans became the most important means of financing private sector R&D-- accounting for about 64% of total R&D expenditures in manufacturing in 1987. National expenditures on R&D, as a percentage of GNP, rose rapidly from 0.32% in 1971 to 2.61% in 1994. The bulk of R&D expenditures also shifted to the private sector which accounted for only 2% in 1963, but accounted for as much as 84% by 1994.

LESSON 4.1.8: Various R&D incentive packages coupled with intense domestic competition and high export goals can be effective in promoting R&D in private firms.

4.1.9 National Mission-Oriented R&D Programs:

In the 1980s and 1990s the South Korean government formulated and sponsored several advanced, mission-oriented R&D projects that were undertaken jointly by the GORDIs, university laboratories, and the private sector and designed to solve South Korea's current and future technological problems. These projects were: (a) Industrial Generic Technology Development Project (IGTDP), (b) National R&D Project (NRP), and (c) Highly Advanced National R&D Project (HAN).

LESSON 4.1.9: Huge national mission-oriented R&D projects involving government-academia-industry are hard to manage and are not too fruitful. Cooperative R&D projects undertaken through independent institutes affiliated with industrial clusters may be more effective than national mission-oriented cooperative R&D projects.

4.1.10 Technology Entrepreneurship and Commercialization:

In the 1980s the South Korean government enacted laws establishing more than 30 venture capital firms all jointly funded by the government and the private sector - as a means of promoting new technology venture firms. In 1992, the government introduced the Spin-off Support Program which sought to encourage GORDI researchers to spin off their research outputs and establish new technology-based small firms by offering them financial, managerial, and technical assistance. Then in 1993 the government initiated the New Technology Commercialization Program in which preferential financing could be obtained from the government for activities related to R&D and technology commercialization.

LESSON 4.1.10: The establishment of a venture-capital industry and a spin-off support program should be implemented in the Philippines.

4.1.11 Science and Technology Parks:

The South Korean government created two S&T Parks: the Seoul Science Park in 1966, and the Taedok Science Town in 1978. The latter had 14 GORDIs, 3 tertiary-level educational institutions, and more than a dozen corporate R&D laboratories by 1998. However, after 20 years of existence, Taedok Science Town had not yet become a dynamic breeding ground for technology-based startups like the USA's Silicon Valley or Taiwan's Hsinchu Science-Based Industrial Park.

LESSON 4.1.11: Science Parks, Technology Parks, Research Parks, Science Towns, or Technopolises have been created not only in South Korea but also in many other countries, but only a few have been able to approximate the bustling dynamism and technology-business synergy of Silicon Valley. Industrial clusters, linked to academia and government agencies, have greater promise of promoting technology entrepreneurship.

4.1.12 Technology Diffusion and Extension:

As a belated realization of the importance of SMEs, the South Korean government in the 1980s established an extensive network of government, public, and private (non-profit) technical support systems to provide technology diffusion and extension services to SMEs. This network is coordinated by a government agency, the Industrial Advancement Administration, and composed of a national network of technical extension services, a separate network for technology diffusion, and an online network of S&T information dissemination.

LESSON 4.1.12 Korea's extensive networks of technology diffusion, extension services, and online S&T information dissemination should be adapted to Philippine conditions in order to support the development and upgrading of SMEs.

4.2 Lessons from Korea's Corporate Technology Management:

Most South Korean firms, especially the chaebols, were fiercely committed to a technology strategy of moving up the technology ladder rapidly through a technological learning process that consisted of four phases: (1) preparation, (2) acquisition, (3) assimilation, and (4) improvement. They also had certain remarkable characteristics such as: (a) heavy investment in in-house R&D, (b) strong commitment to training of personnel, (c) orientation towards low-cost, high-volume production, (d) early efforts to develop their own products and to market these abroad under their own brand names, (e) drive for growth and willingness to take risks, (f) strong discipline and fierce competitive can-do spirit. The following are the major lessons that can be learned from Korea's corporate technology management.

4.2.1 Preparations for Technology Acquisition

South Korean firms diligently monitored technological developments in advanced countries through technical assistance agreements with foreign firms, the setting up of technological outposts in Silicon Valley, establishing R&D and marketing subsidiaries in California, short-term observation of foreign plants and exhibitions, short- and long-term training and education abroad, direct ties with local S&T information centers, direct links with foreign research institutes, and subscriptions to foreign journals. In preparation for the acquisition of a particular technology, they would conduct extensive reviews of the technical literature, pirate experts in the technology, conduct an observation of the technology in actual operation abroad, or undertake a joint research with a local R&D institute in that technology. These preparatory activities enabled the Korean firms to select appropriate technologies, identify suppliers of the technology, and strengthen their bargaining positions in the acquisition of the technology.

LESSON 4.2.1: These preparatory activities are worthy of emulation by Philippine firms because these would help them in selecting and acquiring appropriate foreign technologies.

4.2.2 Technology Acquisition Strategies:

The strategy used by South Korean firms in acquiring technology depends on the supplier's willingness to transfer technology, extent of patent protection, and nature and maturity of the technology. If the technology is simple and mature, South Korean firms would reverse-engineer the foreign product to create clones or knock-offs. If the technology is complex but mature (as in the case of cars) and reverse-engineering is not feasible, but suppliers of technology are willing to transfer, then South Korean firms enter into licensing agreements. When the technology is in the growth stage of its life-cycle and has unexpired patents and if the foreign firms were unwilling to transfer it, then South Korean firms would collaborate with a local R&D institute smaller foreign firms in cracking technology through advanced reverse-engineering, as in the case of optical fibers, industrial robots, microwave ovens, electronic switching systems, and personal computers. When the technology is new and its foreign owners are unwilling to transfer it, some South Korean firms would establish R&D laboratories and listening posts in foreign country, buy the technology from distressed small high-tech companies, or take over foreign high-tech companies. Finally, when the technology is still embryonic or emerging, South Korean firms invest heavily in their own in-house R&D and enter into strategic alliances with TNC high-tech leaders like IBM, ATT, Toshiba, Microsoft, etc.

LESSON 4.2.2: South Korean firms' aggressiveness and adeptness in acquiring foreign technologies should be emulated by Philippine firms.

4.2.3 Technology Assimilation and Improvement:

Upon the acquisition of a foreign technology, South Korean firms immediately exerted efforts to assimilate and improve the technology by moving the technology ladder from the operative rung, to the adaptive, integrative, replicative, and innovative rungs. To help in their assimilation efforts, South Korean firms hired retired or moonlighting foreign (usually Japanese) engineers as tutors or consultants.

LESSON 4.2.3: The South Korean practice of assimilating and improving an imported technology should be emulated by Philippine firms so they can avoid costly dependence on foreign technology suppliers while being able to improve their competitiveness through incremental innovations in product and process technologies.

4.2.4 Corporate R&D:

South Korean firms invested heavily in in-house R&D as they moved towards the technology frontier in their product and process technologies. The leading *chaebols* also established in the 1980s several R&D centers in the USA, particularly in California, to tap the R&D expertise of experienced South Korean-American and other American scientists and engineers. From 1981-1991 Korea recorded the highest growth rate of private sector R&D per GDP at 31.6% as compared to Singapore's 23.8%, Taiwan's 16.5%, and Japan's 8.8%.

LESSON 4.2. 5: Philippine manufacturing firms should start investing in in-house R&D not only as a means of improving their product and process technologies but also as a leverage for acquiring foreign technologies.

4.2.5 Technological Training:

The *chaebols* were strongly committed to the training and development of their personnel in order to facilitate technology learning and assimilation. They established their own training institutes, formulated their own training programs, and sent their engineers and top technicians abroad for advanced training.

LESSON 4.2.5: Corporate education and training has become imperative for the development of a world-class workforce that can cope with the demands of globalization and rapid technological change.

4.2.6 from OEM to ODM to OBM:

Starting from OEM (i.e., original equipment manufacturer where a domestic firm produces a domestic firm produces a finished product to the precise specification of a foreign TNC, which then markets the product under its own brand name through its own distribution channels), South Korean firms quickly tried to graduate to ODM (i.e., own-design and manufacture, where the local firm undertakes some or all of the product design and production processes needed to make the product according to a general design layout supplied by a foreign TNC) and then to OBM (own-brand manufacture). So from the outset, the *chaebols* were committed to developing their own products and marketing them abroad under their own brand names such as Samsung, Hyundai, and Daewoo.

LESSON 4.2.6: This is a path that could also be followed by Philippine manufacturing firms, but it entails full commitment to technological learning and continuous technological innovation

5. TECHNOLOGY MANAGEMENT LESSONS FROM TAIWAN

Taiwan presents a stark contrast to South Korea because while the latter relied mainly on large, diversified, hierarchical, vertically integrated *chaebols* as its engines of industrial progress, the former depended on a multitude of SMEs. On the other hand, Taiwan also has similarities with South Korea because its firms were also successful in climbing up the technology ladder and transforming themselves from technological imitators to technological innovators. Hence, the Taiwanese model of technology management and export competitiveness bases on SMEs offers an alternative to the South Korean model based on *chaebols*. Again the lessons from Taiwan will be divided into those pertaining to national technology management and those pertaining to corporate technology management.

5.1 Lessons from Taiwan's National Technology Management:

5.1.1 The Role of the Government:

The Taiwanese government played a less interventionist role in the economy than did the South Korean government but it was also protectionist until only recently. Although the government promoted the development of heavy and intermediate-goods industries (such as steel, petrochemicals, and shipbuilding) through direct intervention and financial support, it encouraged private enterprise in light industries such as electronics, textiles, and plastics while providing a stable macroeconomic environment of low inflation and low interest rates and protecting, until recently, the local market through import restrictions.

The government has played a very active role in the technological upgrading of the economy. The long-term development of science and technology was placed under the responsibility of the National Science Council, while the planning and coordination of industrial development was the responsibility of the Ministry of Economic Affairs.

LESSON 5.1.1: In industrializing countries, the most important roles of the government are to secure a stable and conducive macroeconomic environment for long-term investments and to provide adequate educational, technological, and infrastructural support to industrial development.

5.1.2 Export-Oriented Policy:

Like Korea, Taiwan shifted from an import-substitution policy to an export-oriented policy in the 1960s which led to the proliferation of SMEs concentrating on labor-intensive industries. Publicly owned enterprises were set up as reliable upstream suppliers of low-cost raw materials to the downstream private SMEs, thereby playing an important supportive role in industrial development.

LESSON 5.1.2: The export-led SME-based industrial development model of Taiwan offers a viable alternative to the Korean export-led *chaebol*-based industrialization model of South Korea. The Taiwanese model is also more conducive to industrial clustering.

5.1.3 Technology Transfer Policy:

In the 1960s, government policy towards FDIs was termed "encouragement with caution" in which the government adopted a "positive list" of areas where FDIs would be allowed. In 1988 the "positive list" was changed to a "negative list" which stipulated that FDIs would be automatically approved provided these were not in prohibited sectors. Unlike the case in South Korea, FDIs played a central part in electronics, metal products, chemical products, and machineries up to the 1990s. The government encouraged FDIs, joint ventures, and OEM agreements although it often negotiated the terms of entry of TNCs. TNCs attracted the formation of local SMEs which swarmed and clustered around the TNCs, offering their goods and services and entering into OEM arrangements with the TNCs.

LESSON 5.1.3: FDIs should be attracted to seed or develop industrial clusters because they can serve as sophisticated buyers and spur the formation of local SMEs as suppliers or supporting industries.

5.1.4 Education and Training Policy:

The Taiwanese government invested heavily in the expansion and development of the educational system. Public expenditure on education as a percentage of GNP went up from less than 2% in the 1950s to more than 4% in the 1980s. Technical colleges were also established in the 1970s to enable vocational students to earn a bachelor's degree and to raise the status and prestige of technicians.

LESSON 5.1.4: The development of education at all levels is essential to industrialization and technological development because the lack of engineers, scientists, and technicians could hamper technological learning and development.

5.1.5 R&D Promotion and Financing:

Taiwan's gross R&D expenditure as a percentage of GNP was 0.84% in 1979 and increased to 1.04% in 1986. The government's share of total R&D expenditure in 1986 was 60% while that of the private sector was 40%. This was divided into 11% for basic research, 38% for applied research, and 51% for technology development. To encourage the private sector to shoulder a bigger share of the country's R&D expenditures, the government offered incentives like tax credits and preferential financing similar to the incentives offered by the Korean government.

However, based on a survey of 1,406 firms in 1987, these incentives were not considered effective. What the firms considered to be the most effective government measures for promoting technological development were: (a) educating more R&D personnel, (b) government coordination of joint research among firms, (c) government assistance in introducing new technologies from abroad, and (d) commercializing and diffusing technologies from GORDIs.

LESSON 5.1.5: Tax credits and preferential loans are not always the most effective ways of inducing the technological upgrading of firms.

5.1.6 Government owned R&D Institutes:

Since the SMEs had limited amount of resources for R&D, they had to rely heavily on the government to develop technologies and transfer these to them. In the electronics and information industries, the Taiwanese government established two government owned R&D institutes or GORDIs: the Industrial Technology Research Institute (ITRI) in 1973 and the Institute for the Information Industry (III) in 1979. ITRI was tasked with developing hardware-related technologies, while III was tasked to develop software technologies and provide computer-related services.

What was remarkable about these two GORDIs was that they were vested with corporate powers that enabled them to establish a new spin-off venture company jointly with the private sector or form joint ventures with TNCs. Thus, since 1982, six IC fabrication companies have been spun off from ITRI while successful joint ventures were formed between III and IBM.

LESSON 5.1.6: To encourage Philippine GORDIs to be market-oriented and to venture into technology commercialization, it is imperative that they be vested with corporate powers similar to those enjoyed by ITRI and III.

5.1.7 Science and Technology Parks:

In 1980 the government established the Hsinchu Science-Based Industrial Park under the administration of the National Science Council as a means of attracting investments in high-tech industries by returning Taiwanese students or overseas Chinese. What makes the park attractive is that it offers world-class facilities, utilities, housing, schools, and other amenities and allows an investor to move in and immediately start a business. By December 1988, there were already 96 high-tech firms in the park with total employees numbering 16,500.

LESSON 5.1.7: The Hsinchu Science-Based Industrial Park could serve as a model for prospective S&T parks in the Philippines.

5.2 Lessons from Taiwan's Corporate Technology Management:

5.2.1 Technology Strategies:

In contrast to South Korea's *chaebols* which relied on the scale-intensive mass production of mature products, Taiwan's SMEs focused on niche production, relying on speed, adeptness, and agility for their survival and success.

Taiwan's manufacturing firms usually began with OEM arrangements with TNCs, gradually accumulated product design skills to move up to the ODM (own-design and manufacture) stage and then finally acquired product innovation capabilities and established marketing channels to graduate to the OBM (own-brand manufacture) stage.

LESSON 5.2.1: Most Philippine firms do not try to graduate from the OEM stage to the ODM stage. They must emulate the technological development trajectories of Taiwanese firms if they want to be globally competitive.

5.2.2 SME Clustering around TNCs:

Taiwanese SMEs exploited the business opportunities offered by TNCs and foreign buyers by supplying them with parts, components, or assembly services. The availability of low-cost and reliable Taiwanese suppliers would attract more foreign investors, which in turn would stimulate more local SMEs to enter, leading to the improvement of the supply infrastructure and the repetition of the process until a large industrial cluster is formed. It was through this clustering process that Taiwan's huge industries in keyboards, printed circuit boards, computer mice, PCs, fax machines, calculators, bicycles, sewing machines, and athletic shoes developed.

LESSON 5.2.2: One of the major deficiencies in the industrial infrastructure of the Philippines is the availability of local manufacturers and suppliers of parts and components. This is a major problem that should be addressed immediately.

5.2.3 Takeovers of Foreign Firms:

A strategy adopted by Taiwanese SMEs to acquire a marketing network, known brand names, and state-of-the-art technologies was the takeover of a financially distressed foreign firm. An example f this was the ACER Group's takeover of US-based Counterpoint Computers (which helped ACER acquire minicomputer technology) and of DYNA, the third largest computer dealer in the US (which provided ACER with a marketing network).

LESSON 5.2.3: This is a very feasible and quick way by which SMEs can become vertically integrated and acquire the marketing channels, brand names, and technologies needed to cope with globalization.

6. RECOMMENDATIONS FOR THE PHILIPPINES

Drawing on the lessons derived from the experiences of Korea and Taiwan, we now present the following recommend ations for the improvement of our country's technology management and export competitiveness.

6.1 The Role of the Government:

Aside from insuring a stable and conducive macroeconomic environment for long-term planning and investment, the government should push and encourage local firms to attain world-class standards of productivity and product quality and provide them with adequate educational, technological, informational, and infrastructural support.

6.2 Industry Infrastructure and Industrial Clustering:

The government should promote the development of a balanced and integrated industry structure by encouraging the establishment of industrial clusters consisting of industries liked through vertical (buyer/supplier) or horizontal (common customers, technology, channels, etc.) relationships. Industrial clusters could provide the means for (1) linking large firms with SMEs, TNCs with domestic firms, manufacturing firms with agribusiness and service firms; (2) dispersing industries to the regions and provinces of the country; and (3) focusing the industrial support services of government and academia through cluster-dedicated R&D centers, S&T services, educational and training institutions, financial services, etc.

6.3 Export Promotion:

Our country's export promotion programs should be intensified and provided with a global market assistance network similar to South Korea's KOTRA and Japan's JETRO.

6.4 Foreign Direct Investments:

Our country's industrial development program should not depend mainly on FDIs which view the country as a mere temporary investment base within their global strategy. Nevertheless, as the Taiwanese experience has shown, FDIs could and should be attracted to serve as seeds for industrial clusters. The low-cost, high-quality local suppliers available in the cluster could then make themselves indispensable to the TNC subsidiaries.

6.5 Education and Training:

The government, academia, and the private sector should work together to upgrade all levels of the country's educational system, particularly its programs and institutions for educating engineers, scientists, technicians, managers, and entrepreneurs. Private firms should also institute training programs, on their own or collaboratively with other firms through cluster- based institutes or jointly with educational institutions, for the purpose of developing a world-class workforce that can easily absorb. Adapt, assimilate, and improve foreign technologies or generate technological innovations.

The government should also assist in the development of the country's leading universities into research universities and adopt a massive crash program to increase the country's pool of R&D scientists and engineers to international levels. It should also encourage the establishment of more graduate programs in technology management and the inclusion of technology management courses in degree programs in business, engineering, science, economics, and public administration.

The status of technicians should also be elevated and professionalized by instituting a post-secondary 4-year degree program leading to a Bachelor of Technology (in Software Technology, Airconditioning Technology, etc.) to be offered by Technical Colleges or Polytechnic Universities and by reinventing technicians as "Technologists". Entrepreneurial courses should also be incorporated into the curriculum from elementary to tertiary levels.

6.6 R&D Programs and Funding:

The government, academia, and the private sector should get together to formulate a national portfolio of R&D projects based on a third-generation system of R&D management which would select R&D projects in accordance with (a) short-term, cluster-oriented problems, (b) medium-term, cross-disciplinary, mission-oriented government programs, and (c) long-term, knowledge-oriented, university-based fundamental research.

The government, academia, and the private sector should also increase their R&D investments in order to attain the United Nations" minimum target of 1% of GDP. The government should study and offer various incentive packages that could induce private firms to spend more funds on in-house R&D.

6.7 R&D Organizations:

The R&D institutes of the Department of Science and Technology (DOST) should be assessed for possible reorganization into corporate R&D organizations that can establish spin-off venture companies or enter into joint ventures with private companies similar to Taiwan's ITRI.

The government should also create a government-endowed, market-oriented contract R&D organization similar to the South Korea Institute of Science and Technology or the Fraunhofer Society in Germany.

The government and academia should also assist industrial clusters in creating cluster-based and cluster-dedicated R&D centers jointly funded by the government, academia, and the cluster firms.

6.8 Technology Entrepreneurship and Commercialization:

The government should promote the creation of venture capital firms, study the establishment of a technology park similar to Taiwan's Hsinchu Park, initiate a Spin-Off Support Program, patterned after South Korea's program, to encourage and assist government or university R&D personnel to become technology-based entrepreneurs, and promote the establishment of technology business incubators.

6.9 Technology diffusion and Extension:

The government, academia, and the private sector, should also cooperate in establishing a national network of organizations dedicated to (a) the diffusion of modern technologies among domestic firms, (b) the provision of testing, calibration, and other S&T extension services, and (c) the provision of online S&T information services.

6.10 National S&T Management:

The DOST, DTI, DOE, DOTC, DA, NEDA, and other government agencies should formulate a national technology management framework and institutionalize the practice of technology management in their planning, policy-making, and programming.

In particular, the government should conduct a regular technology forecasting exercise, a regular technology audit of each industry's technological status, and a regular international benchmarking of each industry's technologies as mechanisms for determining each industry's technological lags relative to its foreign competitors.

6.11 Corporate Technology Management:

Philippine firms should also institutionalize the practice of corporate technology management and appoint a Chief Technology Officer or Vice President for Technology Management who would be responsible for corporate technology management.

Philippine firms should emulate the technology management practices of Korean and Taiwanese firms, striving to climb up the technology ladder as quickly as possible in order to achieve global export competitiveness.

7. CONCLUSION

The principal lesson that the Philippines can learn from the experiences of South Korea and Taiwan is that a country or a firm can become an export tiger only if it is also a technology tiger, that is. if it is aggressive, agile, and adept in acquiring, learning, and mastering technologies.

Export competitiveness entails competence in technology management because the latter can provide an exporting firm with the competitive advantage of lower costs (through better process technologies) or better product quality or features (through better product technologies). Philippine firms have not yet developed into export tigers up to now because they have remained technological pussycats. Therefore, if Philippine firms want to become globally competitive export tigers, they should start emulating the technology management practices of South Korean and Taiwanese firms.

At the same time, the government should insure a stable and conducive macroeconomic environment, push for world-class norms and standards in products and processes, provide the adequate educational, technological, informational, and infrastructural support, and adopt an integrated national technology management system.

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