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TECHNOLOGY MANAGEMENT AND CATCH-UP COMPETITIVENESS: WHAT THE PHILIPPINES CAN LEARN FROM SOUTH KOREA AND TAIWAN

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This paper gives a brief introduction to technology management and catch-up competitiveness and describes the technological learning and catch-up efforts undertaken by South Korean and Taiwanese latecomer firms. It also gives an overview of the extent of Philippine firms' technological laggardness and dependence. It then expounds on the lessons in technology management and catch-up competitiveness that the Philippines can learn from South Korea and Taiwan and concludes with a set of recommendations for the attainment of Philippine technological and industrial catch-up.

I. INTRODUCTION

Although the formal recognition of technology management as a distinct field of management is a recent development[1], 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 since the Meiji Restoration in 1868. Then following this Japanese model of technology management, the Koreans and Taiwanese succeeded in industrializing their economies, becoming export tigers, and attaining catch-up competitiveness within 30 years.

In contrast, although the Philippines started its own industrialization efforts in the 1950s, ahead of South Korea and Taiwan by at least ten years, our country today after half a century has not yet attained the status of a newly industrialized country (NIC), much less that of an export tiger, as indicated by its low export growth rates.[2] What is worse is that whereas 50 years ago our country was ahead of South Korea and Taiwan in all aspects of national development, including technological development, today the Philippines is estimated to be technologically behind these two NICs by at least 25 years.

So what is the ingredient or factor that was the key to the successful South Korean and Taiwanese technological and industrial catch-up drives that is missing in Philippine economic development efforts? This ingredient, of course, is the conscious, competent, and concerted practice of catch-up-oriented technology management by the national government and domestic firms.

Therefore, if the Philippine government and domestic firms are really serious in attaining NIC status and technological catch-up, it is imperative that we study how South Korea and Taiwan used catch-up-oriented technology management so that we can learn valuable lessons for our own national development efforts. It is towards this end that this study was undertaken.

This paper is organized as follows: Section II explains what technology management and catch-up competitiveness are all about, while Section III describes the main features of technological learning and catch-up that Korean and Taiwanese latecomer firms pursued to attain industrialization and catch-up competitiveness. Section IV gives an overview of Philippine domestic firms' technological laggardness and

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dependence. The particular lessons in technology management that can be drawn from Korea are then discussed in Section V, while those from Taiwan are given in Section VI. Section VII, presents a list of recommendations that our country should adopt to be able to attain catch-up competitiveness. Finally, Section VIII concludes this paper.

II. THE ELEMENTS OF TECHNOLOGY MANAGEMENT AND CATCH-UP COMPETITIVENESS

Technology can be defined in a narrow sense as *"the engineering knowledge needed to create and produce a new product or process"* or in a broader sense as *"the means for accomplishing a specific task"*. In terms of Michael Porter's value-chain model of a firm (Porter, 1985), we can define a firm's technologies as the ways in which it performs its value-chain activities, as depicted in Figure 1 and Figure 2.

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

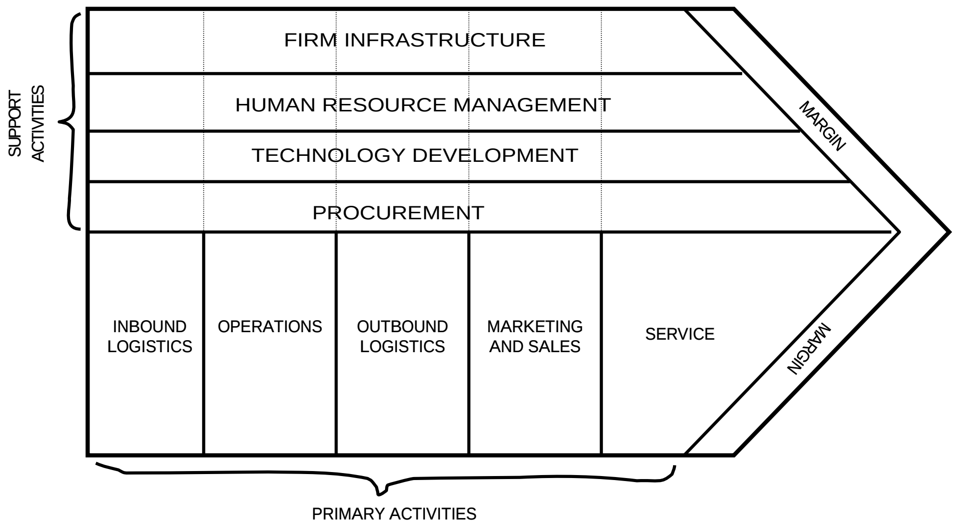
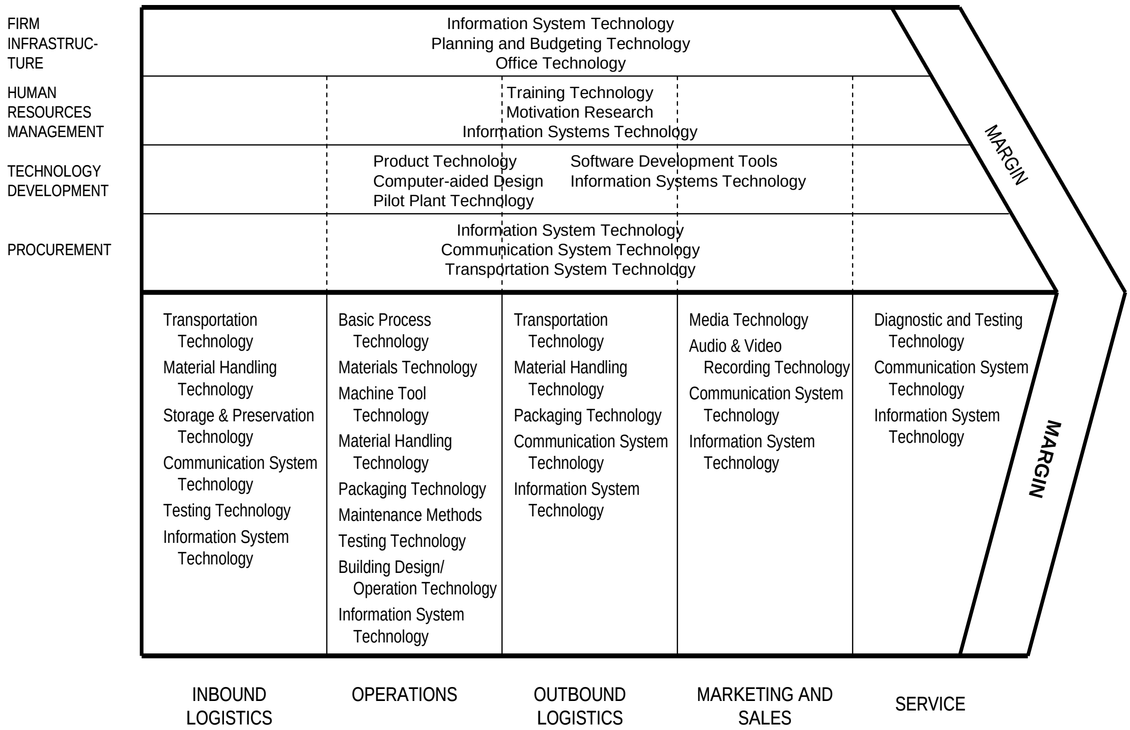


Figure 2
Representative Technologies in a Firm's Value Chain



It is clear, therefore, that technology, broadly defined, pervades all the activities of a firm. And so 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.

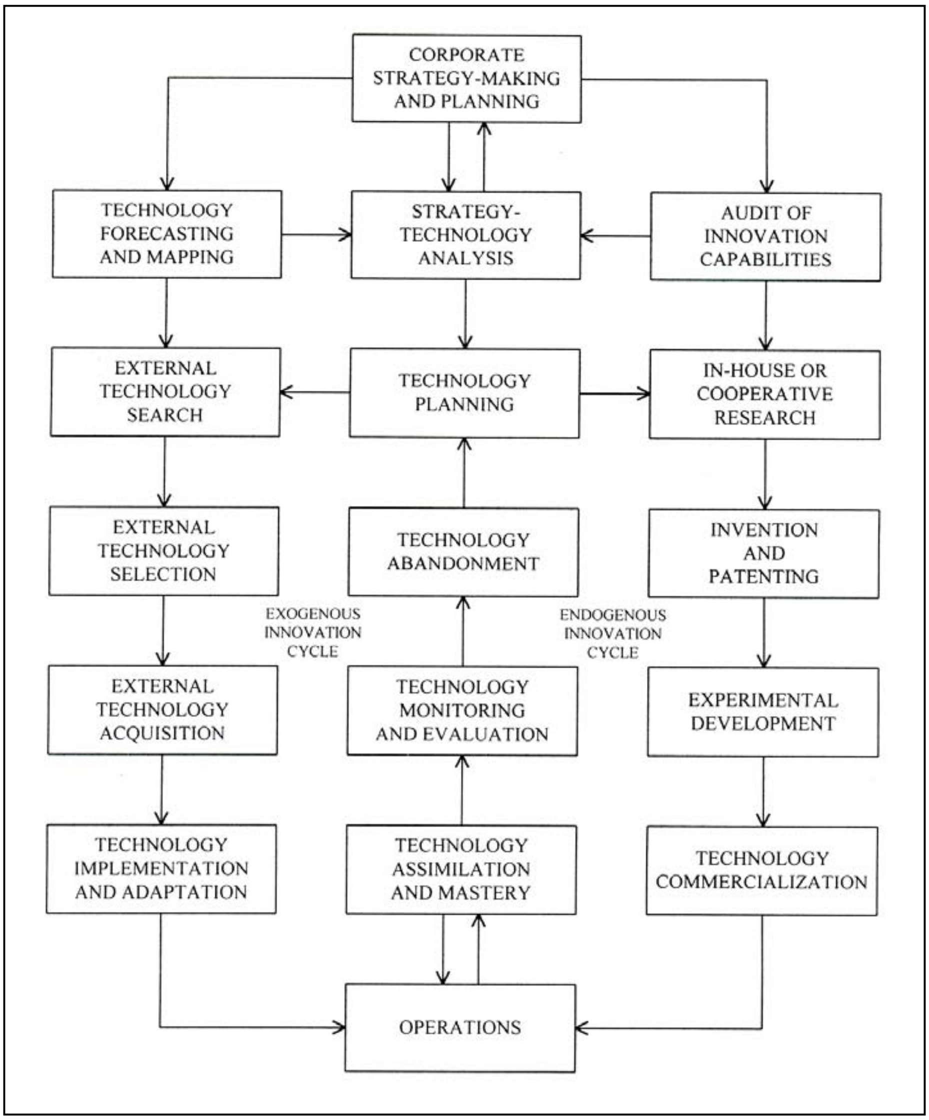
Technology management at the level of a firm can now be defined as the strategic formulation and operational implementation of a technology strategy that informs, and conforms with, the firm's competitive strategy.

Technology management can be pursued through an exogenous innovation cycle from the acquisition to the learning and mastery of an externally sourced technology or through an endogenous innovation cycle from in-house research and development (R&D) to technology commercialization or through a judicious combination of these two approaches as depicted in Figure 3.

If we define a firm's competitiveness as its ability to get customers to choose its product(s) or service(s) 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, i.e., the assessment of the firm's strengths and weaknesses for each of its technologies in terms of two measures: 1) the specific technology's level of technological sophistication or the extent of its proximity to the technological frontier or state-of-the-art; and 2) the firm's level of technological capability or the extent of its technological mastery relative to that specific technology.

Figure 3
Technology Management Framework in Terms of an Endogenous Innovation Cycle or an Exogenous Innovation Cycle



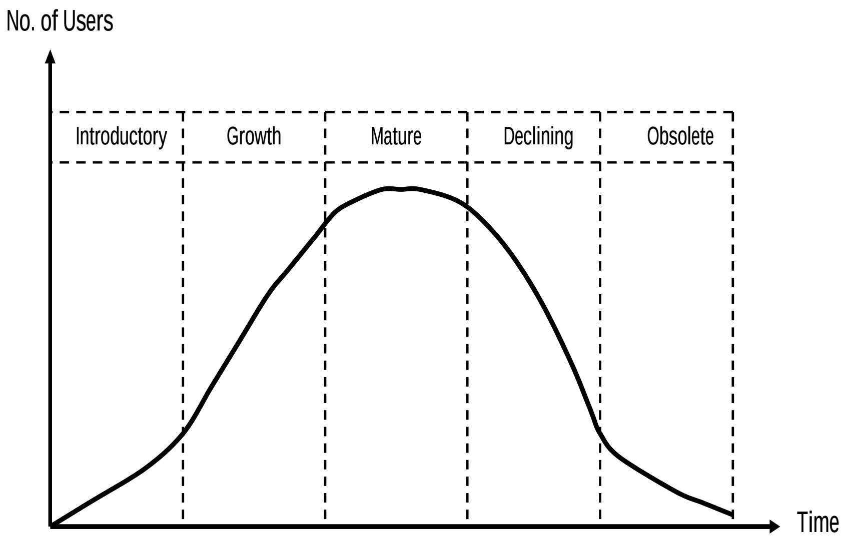
A firm's level of technological capability is indicated by its position or rung in the following technological ladder of capabilities, developed by Posadas (1999):

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. Reconstructive Capability – the ability to reconstruct, without external assistance, a production or service facility following the model of a previous externally acquired facility.
4. Replicative Capability – the ability to reproduce, through reverse-engineering, a local replica or clone 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 or breakthrough technology from endogenous research and development (R&D) and to commercialize it into a novel product, process, or service.

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, pioneer, and leader.

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/mature if it is at the plateau of the curve; d) declining/aging if it is at the downward slope of the curve; and e) obsolete if it is at the terminal segment of the curve.

Figure 4
The Technology Life Cycle



Technological catch-up by a firm in a particular technology is the attainment of innovative to creative capabilities in the technology through a process of technological learning, assimilation, and mastery from "behind-the-technology-frontier". "Catch-up competitiveness" can be defined as *the ability of a firm to catch-up technologically with the world's technology leaders and to compete in international markets*.[3] As explained by the Asian Development Bank (2003), "catch-up competitiveness is based on 'behind the frontier' innovations, involving constant improvements to process and products (and their interfaces), supported by various kinds of technical and engineering capabilities… [and it] depends on entrepreneurship and educational provision, as well as market-friendly institutions and sound macroeconomic management."

We can also use the term "catch-up technology management" to refer to a firm's effective selection, acquisition, development, exploitation, learning, and mastery of the technologies needed to catch-up with the world's technology leaders in its chosen industry. In short, catch-up technology management is technology management geared and oriented toward technological catch-up and global competitiveness.

At the national or governmental level, technology management has been defined by Khalil (2000) as:

> "A field of knowledge concerned with the setting and implementation of policies to deal with technological development and utilization, and the impact of technology on society, organizations, individuals and nature. It aims to stimulate innovation, create economic growth, and to foster responsible use of technology for the benefit of humankind."

Thus, national technology management is concerned with the formulation and implementation of national science and technology policies, plans, and programs.

The scope and concerns of technology management at the macro (national) level and micro (firm) level are shown in Figure 5 relative to strategic management focus and operational management focus.

Figure 5
Scope of Technology Management

	Strategic Management Focus	**Operational Management Focus**
Macro Level	Formulation of National Technology Strategy and S&T Policies and Plans	Management of National Programs in R&D, S&T Education and Training, and S&T Services
Micro Level	Technology Intelligence and Formulation of a Firm's Technology Strategy and Roadmap	Management of Technological Innovation and/or Technology Acquisition and Mastery

III. TECHNOLOGICAL LEARNING AND CATCH-UP BY KOREAN AND TAIWANESE LATECOMER FIRMS

The domestic firms of South Korea and Taiwan that served as these two countries' vehicles for industrial and technological catch-up are examples of what are called "latecomer firms" in the literature (Hikino & Amsden, 1994; Hobday, 1995a and 1995b; Kim, 1997; Mathews, 1997, 2001, 2002).

Following Mathews (2002), we will define a latecomer firm (LCF) as one which meets the following four conditions:

- it is a late entrant to an industry, not by choice but by historical necessity;
- it is initially poor in resources, lacking technology and market access;
- it is focused on technological catch-up as it primary goal; and
- it has some initial competitive advantages, such as low costs, which it can use to leverage a position in the industry of choice.

As emphasized by Hobday (1995a), latecomer firms in South Korea (e.g., Samsung) and Taiwan (e.g., Acer) were initially faced with two sets of competitive disadvantages: *first*, a technological disadvantage arising from their technological laggardness and isolation from the world's technology centers and *second*, a marketing disadvantage arising from their lack of global marketing know-how and their need to overcome export market barriers to entry.

South Korean and Taiwanese latecomer firms or LCFs have used various mechanisms of international technology transfer for linking up with technology owners and their global value chains in order to acquire technologies and access export markets. These mechanisms can be classified into formal ones (involving contractual agreements) and informal ones (not involving contractual agreements):

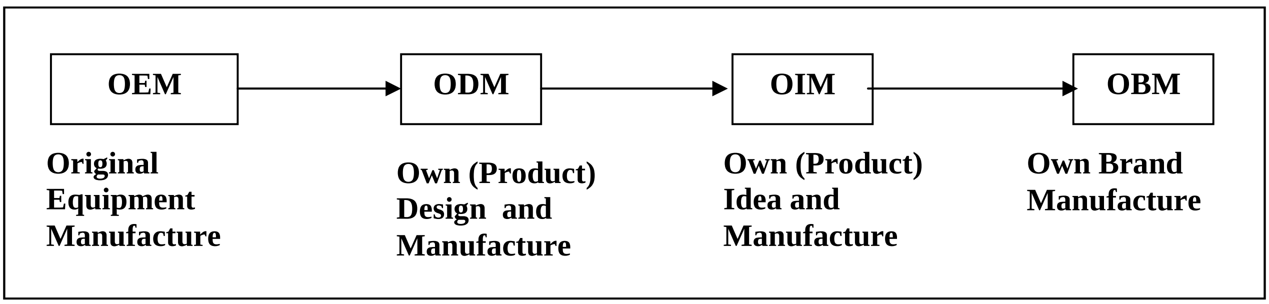
Formal Mechanisms	**Informal Mechanisms**
• Foreign Direct Investments • Joint Ventures • Licensing • Original Equipment Manufacture • Subcontracting/Outsourcing • Mergers & Acquisitions • Cooperative Alliance • Turnkey or BOT Project • Technology Consultancy • Sale of Capital Goods	• Reverse Engineering • Reverse Brain Drain • Tapping Expatriate Experts • Technology Intelligence • Technology Search • Overseas S&T Education and Training • Establishment of R&D Laboratories and Listening Posts Abroad • Technical Study Visits Abroad • International Technical Assistance

The Korean and Taiwanese LCFs were able to overcome their initial shortcomings in technology and marketing by simultaneously acquiring and building up technological and marketing capabilities in accordance with the stage model shown in Table 1, as adapted from Hobday (1995a). These linked stages of technological and marketing learning can also be summarized by the diagram of Figure 6.

Table 1
Stage Model of Linked Acquisition and Build-up of Technological and Marketing Capabilities

Export Marketing Stages	Technological Capabilities
1. Passive importer-pull; Cheap-labor assembly; Dependence on buyers for distribution	1. Basic assembly skills and basic production capabilities with respect to mature products
2. Active sales of capacity; Quality and cost-based; Dependence on 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 own-brand sales	4. Initiation of R&D for products and processes; Product innovation capabilities
5. Push of own brand; Direct marketing to customers; Use of independent distribution channels and direct advertising; Use of in-house market research	5. Competitive R&D capabilities; R&D linked to market needs; Advanced product/process innovation

Figure 6
Stages of Latecomer Catch-up Development



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 the pressure from the government pushed the exporting firms to continuously improve their technologies and upgrade their technological capabilities. In turn, the technological development of 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 1) a stable and favorable macroeconomic environment of low inflation and low interest rates that was conducive to long-term planning and investment; 2) adequate educational and infrastructural support; 3) a competitive market that pushed competing firms to continually upgrade; and 4) a national technology management system which supported technological learning and innovation.

IV. INDICATORS OF PHILIPPINE FIRMS' TECHNOLOGICAL LAGGARDNESS AND DEPENDENCE

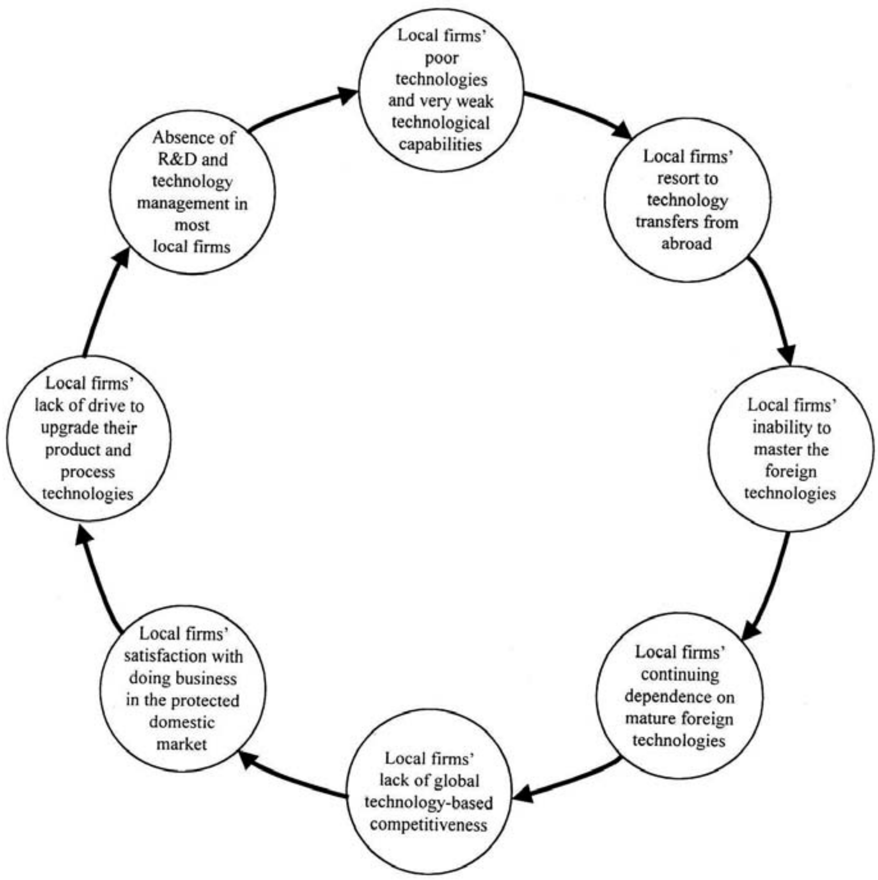
There is a general consensus that in the 1950s the Philippines was second only to Japan, and at least ten years ahead of South Korea and Taiwan, in technological and industrial development. Now, half a century later, the Philippines has been left behind in technological and industrial development by South Korea and Taiwan by at least 25 years as estimated by Posadas (1986).

Although the Philippines today is one of the major exporters of high technology products (principally, electronic products) from the developing world, it is a well known fact that it is able to achieve this high electronic export performance by importing the core components and other raw materials from abroad and then assembling them into finished electronic products with the use of cheap labor but with very little value added (Mani, 2002; Salazar, 1998).

Based on the personal observations and assessments of Posadas and Roque (1994), Philippine domestic firms, except for a handful, have not been able to develop technological capabilities beyond the adaptive and integrative levels with respect to foreign-sourced technologies that range from mature to declining.

Since none has reached replicative and higher technological capabilities (except for one or two), Philippine domestic firms in general have remained mere technology consumers and users that are highly dependent on the acquisition of foreign technologies to meet their technical needs. As a result, Philippine firms have become trapped in a vicious circle of technological laggardness and dependence as depicted in Figure 7.

Figure 7
The Vicious Circle of Technological Laggardness and Dependence Observable in Most Philippine Firms



These qualitative assessments of the technological laggardness and dependence of Philippine domestic firms can be bolstered by certain quantitative indicators of technological development:

- S&T input indicators such as the country's R&D intensity
- S&T output indicators such as the country's share of utility patents in the U.S.

A country's R&D intensity is defined as the ratio of the country's gross domestic expenditures on R&D or GERD to its gross domestic product or GDP expressed as a percentage. It serves as a measure of the country's investment efforts in technological development.

Now based on data from the UNESCO Institute for Statistics (2007) as presented in Table 2, the Philippines in 2002 had an R&D intensity of only 0.11% and a per capita GERD of only PPP$4.70 which are very small compared to those of South Korea and Taiwan and even smaller than those of Malaysia and Thailand. In fact, the Philippine R&D intensity of 0.11% is way below the 1% target set by the

United Nations in 1970 for attainment by less developed countries in 1980.

With regard to the S&T output indicators Filipinos are often touted in the Philippine media to be very inventive, but the statistics of patents granted in the U.S.A. and in the Philippines prove this to be a myth.

According to the statistics of the U.S. Patent and Trademark Office (USPTO 2007a), the percentage share of patents granted to inventions from the Philippines out of the total utility patents (or patents for inventions) granted by the USPTO was a minuscule 0.02% (1/50 of 1%) in 2006 and an even much tinier 0.008% for the 44-year period 1963-2006.

Table 2
Gross Domestic Expenditures on R&D (GERD) of the Philippines and Selected Countries

Country	Year	GROSS DOMESTIC EXPENDITURE ON R&D (GERD)			
		000 Local Currency	000 PPP $	% of GDP	Per Capita (PPP $)
U.S.A.	2004	312,535,430	--	2.68	1,062.2
Japan	2003	15,683,403,000	112,221,817	3.15	878.5
Korea, Rep.	2003	19,068,682,000	22,761,539	2.64	479.6
Taiwan	2003	240,800,000	--	2.50	--
Singapore	2004	4,061,900	--	2.25	--
Australia	2002	12,842,700	9,499,196	1.70	--
China	2004	196,661,000	--	1.44	78.5
Malaysia	2002	2,500,600	1,539,498	0.69	64.2
Thailand	2003	15,499,201	1,260,952	0.26	19.5
PHILIPPINES	2002	**4,493,968**	**372,611**	**0.11**	**4.7**
Vietnam	2002	1,032,560,900	357,104	0.19	4.4
Indonesia	2001	758,045,000	343,868	0.05	1.6

Sources: UNESCO Institute for Statistics (2007) except for the Taiwan data which were taken from Invest in Taiwan (2006)

The cumulative total number of utility patents granted by USPTO (2007a) to inventions from the Philippines for 1963-2006 was a mere 319. Though this was bigger than Thailand's 270 and Indonesia's 168, it was just a tiny fraction of South Korea's 44,125, Taiwan's 58,162, Japan's 658,827, and the U.S.A.'s 2,381,249. So this is a clear indicator of the extent of the Philippines' technological laggardness.

In contrast, Taiwan and South Korea are now the fourth and fifth most inventive countries after the U.S.A., Japan, and Germany based on the number of utility patents recently granted by the USPTO as shown in Table 3. Coupled with the fact that South Korea and Taiwan now have globally competitive high-tech brands like Samsung and Acer, Table 3 shows that South Korea and Taiwan have already attained catch-up competitiveness.

Table 3
Share of U.S. Utility Patents Granted to Inventions Coming from the Philippines

Country of Origin	1963-2002 (% share)	2003 (% share)	2004 (% share)	2005 (% share)	2006 (% share)	Cumulative Total (% share)
U.S.A.	2,044,625 (59.9%)	87,893 (52.0%)	84,271 (51.3%)	74,637 (51.9%)	89,823 (51.7%)	2,381,249 (58.6%)
Japan	520,819 (15.2%)	35,515 (21.0%)	35,348 (21.8%)	30,341 (21.1%)	36,807 (21.2%)	658,827 (16.2%)
Taiwan	35,448 (1.0%)	5,298 (3.1%)	5,938 (3.6%)	5,118 (3.6%)	6,360 (3.6%)	58,162 (1.4%)
Korea, Rep.	25,443 (0.75%)	3,944 (2.3%)	4,428 (2.7%)	4,352 (3.0%)	5,908 (3.4%)	44,125 (1.1%)
China (plus HK)	3,392 (0.099%)	618 (0.37%)	674 (0.41%)	667 (0.46%)	789 (0.45%)	6,055 (0.15%)
Singapore	1,671 (0.049%)	427 (0.25%)	449 (0.27%)	346 (0.24%)	412 (0.24%)	3,305 (0.08%)
Malaysia	306 (0.009%)	50 (0.03%)	80 (0.049%)	88 (0.061%)	113 (0.065%)	637 (0.016%)
PHILIPPINES	**223 (0.0065%)**	**22 (0.013%)**	**21 (0.013%)**	**18 (0.012%)**	**35 (0.02%)**	**319 (0.0078%)**
Thailand	198 (0.0058%)	25 (0.015%)	18 (0.011%)	16 (0.011%)	31 (0.018%)	270 (0.0066%)
Indonesia	142 (0.0042%)	9 (0.0053%)	4 (0.0024%)	10 (0.007%)	3 (0.0017%)	168 (0.004%)
Total U.S. & Foreign	3,414,780	169,023	164,291	143,806	173,771	4,065,671

Source: USPTO (2006)

While the tiny number of USPTO patents granted to inventions from the Philippines is humbling enough, what makes it even more embarrassing is the fact that most of these seemingly Filipino inventions turn out to be inventions filed by Philippine subsidiaries of foreign multinational corporations, as revealed by USPTO (2007b) and shown in Table 4.

Table 4
Recent Ranking of the Top Eight Most Inventive Countries in the World Based on the Number of Utility Patents Granted by USPTO to Inventor Applicants (2002-2006)

Country	2002	2003	2004	2005	2006
U.S.A.	1st	1st	1st	1st	1st
Japan	2nd	2nd	2nd	2nd	2nd
Germany	3rd	3rd	3rd	3rd	3rd
Taiwan	4th	4th	4th	4th	4th
Korea, Rep.	7th	5th	5th	5th	5th
U.K.	6th	7th	6th	6th	6th
Canada	8th	8th	8th	7th	7th
France	5th	6th	7th	8th	8th

Source: Derived by Author From USPTO (2007a).

It might be argued that Filipino inventors would rather file for patents in the Philippines than in the U.S. because of the high USPTO filing fees (more than US$10,000), which could explain the small number of USPTO patents granted to Filipino inventions. So let us analyze the 30-year patent statistics of the Intellectual Patent Office of the Philippines (IPO 2007) as shown in Table 5.

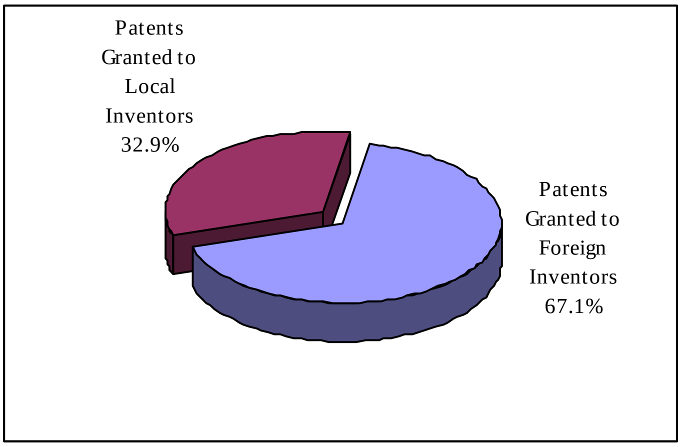
Table 5
Organizational and Individual Inventors from the Philippines that were Granted Utility Patents by the USPTO

ORGANIZATION	2001	2002	2003	2004	2005	Total
Texas Instruments	1	2	3	7	4	17
Fairchild Semiconductor	0	1	4	4	5	14
Individually Owned Patents	3	5	4	1	1	14
Astec International Ltd.	1	2	3	3	1	10
Intel Corp.	0	0	2	3	3	8

Source: USPTO (2007b)

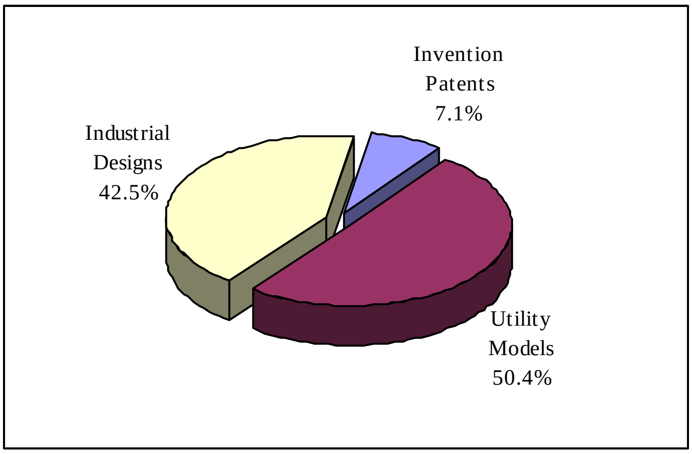
Over the 30-year period 1976-2005, the Philippine government granted a total of 51,119 patents of all types, of which 16,806 (or one-third) were granted to Filipinos (locals) and 34,313 (or two-thirds) were granted to foreigners, as depicted in Figure 8.

Figure 8
Distribution of the 51,119 Philippine Patents of all Types Granted to Local and Foreign Inventors in 1976-5005



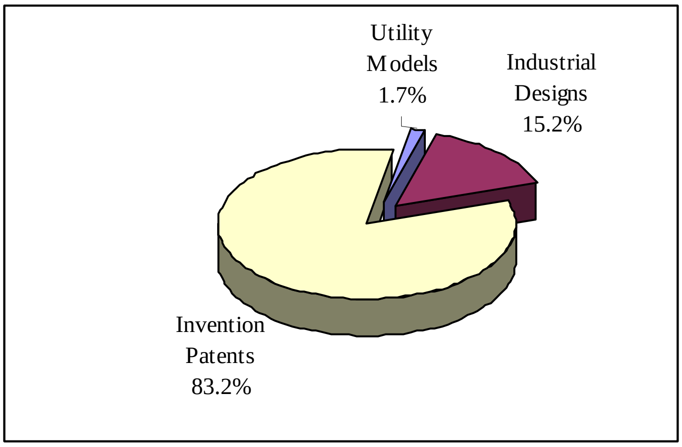
Of the 16,806 patents granted to Filipino inventors in 1976-2005, utility models[3] constituted 8,462 (50.4%), industrial designs[4] 7,144 (42.5%), and invention patents, only 1,200 (7.1%) as shown in Figure 9. Thus, only an average of 40 patents a year were granted by the Philippine government to Filipino inventors for genuine inventions during the past 30 years, while the great bulk of the patents for locals were granted for utility models or incremental improvements (with a yearly average of 282) and for industrial designs or ornamental/stylistic creations (with a yearly average of 238).

Figure 9
Distribution of 16,806 Philippine Patents Granted to Local and Foreign Inventors in 1976 - 2005



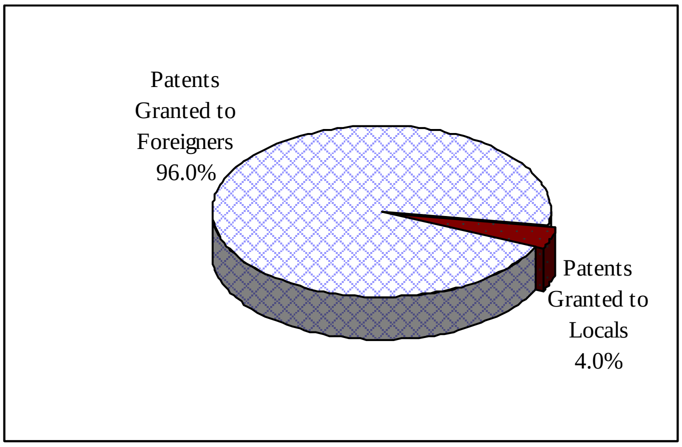
In contrast, of the 34,313 Philippine patents granted to foreigners in 1976-2005, the bulk (28,539 or 83.17%) went to invention patents whereas 5,203 or 15.16% went to industrial designs and only 571 or 1.66% went to utility models as shown in Figure 10.

Figure 10
Distribution of the 34,313 Philippine Patents Granted to Foreign Inventors in 1976-2005



A total of 29,739 invention patents were granted by the Philippine government in 1976 to 2005 with 28,539 or 96% going to foreigners and only 1,200 or 4% going to Filipinos as depicted in Figure 11.

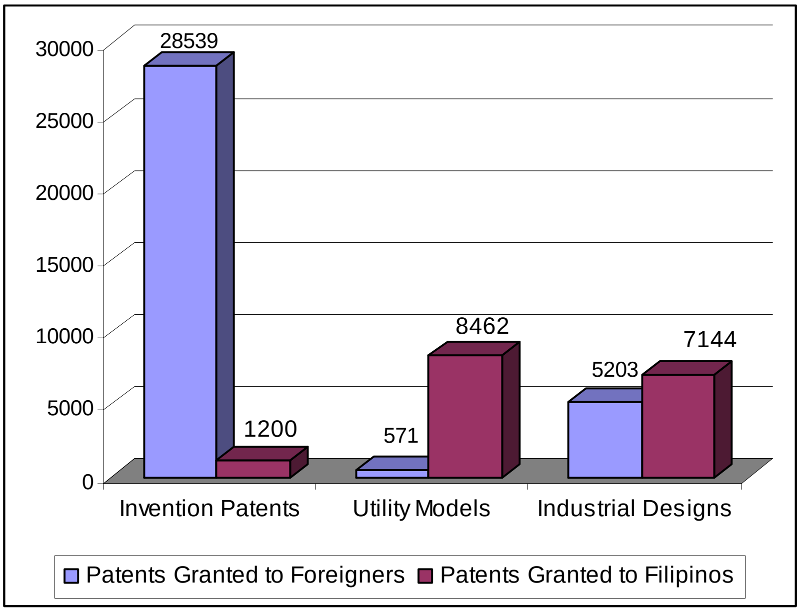
Figure 11
Distribution of the 29,739 Philippine Invention Patents Granted in 1976-2005



The distribution of Philippine patents granted in 1976-2005 as divided among foreigners and Filipinos and as classified into the three patent types is shown graphically in Figure 12.

Thus, Philippine technological capability, as gauged by Philippine patenting performance in the U.S., is way, way behind that of South Korea and Taiwan. Moreover, even by Philippine patenting standards, Filipino inventive performance is very poor. In fact, the total number of Philippine patents (1,200) granted to Filipino inventors in 1976-2005 is just about one fifth of the U.S. patents granted to either Taiwanese or South Korean inventors in just one year (2006).

Figure 12
Distribution of the 51,119 Philippine Patents Granted to Foreign and Local Inventors in 1976-2005 According to Patent Types



The basic explanation for Philippine firms' low level of technological capability is their entrapment in a vicious circle of technological laggardness and dependence. Lall (2003) refers to this technological dependence as "passive FDI-dependent learning." In contrast, South Korea and Taiwan, emulating Japan, practiced what Lall (2003) calls "autonomous learning", that is, the active effort to acquire, assimilate, and master foreign technologies with the aim of rapidly moving up the technology ladder, going from "imitation to innovation" as explained by Kim (1997), and attaining catch-up competitiveness.

V. TECHNOLOGY MANAGEMENT LESSONS FROM SOUTH KOREA

The phenomenal rapid industrialization and accelerated technological progress achieved by South Korea within a period of about 25 years (Amsden, 1989; Hobday, 1995a; Kim, 1993, 1997) can offer many lessons in catch-up 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.

Lessons from South Korea's National Technology Management

The Role of the Government

In the 1960s and 1970s the strong, developmental, interventionist Korean government played a key and effective role in driving and steering the 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: State intervention in the economy can be effective for only as long as the government's leaders and technocrats are competent and incorruptible.

Industrial Policy

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

Lesson: Targeting can be a risky government policy. What the government should pursue instead is the promotion and development of industrial clusters which can integrate and interlink various related and complementary industries as well as large, medium, and small firms.

Export-Oriented Policy

The Korean government in the 1960s and 1970s vigorously pushed Korean firms to upgrade their technologies and achieve ambitious export goals while supporting them with financial, technological, and international marketing assistance. In 1962, the Korean government created the 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 Korean trade associations. tracked export markets and supplied information to foreign buyers and Korean exporters.

Lesson: If a country wants to achieve export competitiveness, its government must vigorously push the exporting firms to continuously improve their product and process technologies to world-class standards while simultaneously supporting them with financial and technological assistance as well as a global network of marketing support services similar to Korea's KOTRA and Japan's JETRO.

Technology Transfer Policy

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

Lesson: If a country wants to attain an independent, self-reliant technological capability, then it should not pursue an industrialization strategy that depends primarily on FDIs; it should instead build up domestic industries and firms as the engines of industrial growth. Too much reliance on FDIs leads to the perpetuation of technological dependence and laggardness.

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 until the 1980s when the importance of SMEs was belatedly recognized and 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: 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 as well as 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.

Education and Training Policy

The Korean government in the 1960s greatly expanded educational institutions at all levels to produce a well-trained, hardworking workforce for industrialization. Then in 1974, the government passed a law that required all industrial firms with 300 or more workers to provide in-plant training. Earlier in 1973, the government enacted a law which decreed that technicians/craftsmen had the same status as scientists and engineers. Since the 1970s, however, the government had started underinvesting in all educational levels, particularly in higher education, resulting in shortages of high-level engineers and scientists and the development of only a few research-oriented universities.

Lesson: 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.

Government Research and Development Institutes

In the 1960s, the Korean government established the Ministry of Science and Technology to manage the country's S&T development programs and 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 by helping firms 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 in the 1980s and 1990s. Their effectiveness, however, has been weakened in recent years because of their stifling bureaucracies and their loss of researchers to universities and corporate R&D centers.

Lesson: 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 non-market-oriented technologies and in the diffusion of technologies to SMEs.

R&D Promotion and Financing

The Korean government promoted domestic R&D activities through two principal mechanisms: direct R&D grants and investments and indirect R&D incentive packages. The first was meant for developing R&D infrastructure and financing R&D in universities and GORDIs. The second, which included preferential R&D loans and R&D tax concessions, was aimed 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 and 2.64% in 2003. 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 75% by 2002.

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

National Mission-Oriented R&D Programs

In the 1980s and 1990s, the 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 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: 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.

Technology Entrepreneurship and Commercialization

In the 1980s, the 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: The establishment of a venture-capital industry and a Spin-off Support Program should be implemented in the Philippines.

Science and Technology Parks

The Korean government created two S&T Parks: the Seoul Science Park in 1966 and the Taedok Science Town in 1978. The latter had fourteen (14) GORDIs, three (3) tertiary-level educational institutions, and more than a dozen corporate R&D laboratories by 1998. However, after almost 30 years of existence, Taedok Science Town had not yet become a dynamic breeding ground for technology-based start-ups like the USA's Silicon Valley or Taiwan's Hsinchu Science-Based Industrial Park.

Lesson: Science Parks, Technology Parks, Research Parks, Science Towns, or Technopolises have been created not only in 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, might be a more promising means of promoting technology entrepreneurship.

Technology Diffusion and Extension

As a belated realization of the importance of SMEs, the 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: 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.

Lessons from South 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) their heavy investment in in-house R&D; b) their strong commitment to the training of their personnel; c) their orientation towards low-cost; high-volume production; d) their early efforts to develop their own products and to market them abroad under their own brand names; e) their drive for growth and willingness to take risks; and f) their strong discipline and fierce competitive can-do spirit. The following are the major lessons that can be learned from South Korea's corporate technology management.

Preparations for Technology Acquisition

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

Technology Acquisition Strategies

Korean firms used different technology acquisition strategies depending on the technology supplier's willingness, the technology's extent of patent protection, and the nature and maturity of the technology. When the technology sought was simple and mature and had expired patents, Korean firms simply reverse-engineered the foreign product to produce clones or knockoffs. When the technology was complex but mature enough (as in the case of cars) and Korean firms were unable to reverse-engineer it but foreign firms were willing to transfer it, then Korean firms entered into a licensing agreement with the foreign technology supplier. When the technology was in the growth stage of its life cycle and had unexpired patents and if the foreign firms were unwilling to transfer it, the Korean firms would collaborate with a local R&D institute or smaller foreign firms to try to crack the technology through advanced reverse engineering as in the case of optical fibers, industrial robots, microwave ovens, electronic switching systems, and personal computers. When the foreign technology was newly introduced and foreign owners were unwilling to transfer it, some Korean firms established R&D laboratories and listening posts in California, bought the technology from distressed small high-tech companies in the USA, or took over foreign high-tech companies. Finally, when the technology was still embryonic or emerging, Korean firms invested heavily in their own in-house R&D and entered into strategic alliances with the TNC high-tech leaders like IBM, ATT, Toshiba, Microsoft, etc.

Lesson: Korean firms’ aggressiveness and adeptness in acquiring foreign technologies should be emulated by Philippine firms.

Technology Assimilation and Improvement

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

Lesson: Again, this Korean practice of assimilating and improving an imported technology should be emulated by Philippine firms so that they could avoid costly dependence on foreign technology suppliers while improving their competitiveness through incremental innovations in product and process technologies.

Corporate R&D

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 Korean-American and other American scientists and engineers. In 1981-1991 Korea recorded the highest growth rate of private sector R&D per GDP with 31.6% as compared to Singapore's 23:8%, Taiwan's 16.5%, and Japan's 8.8%.

Lesson: 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.

Technological Training

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

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

From OEM to ODM to OBM

Starting from OEM (i.e., original equipment manufacture where 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), 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: 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.

VI. TECHNOLOGY MANAGEMENT LESSONS FROM TAIWAN

Taiwan presents a stark contrast to 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 catch-up technology management and export competitiveness based on SMEs offers an alternative to the Korean model based on *chaebols*. Again the lessons from Taiwan (Hobday, 1995a; Hou and Gee, 1993; Chu and Amsden, 2004) will be divided into those pertaining to national technology management and those pertaining to corporate technology management.

Lessons from Taiwan's National Technology Management

The Role of the Government

The Taiwanese government played a less interventionist role in the economy than did the 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: 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.

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

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 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: 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.

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: 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.

R&D Promotion and Financing

Taiwan's gross domestic R&D expenditure as a percentage of GDP was 0.84% in 1979 and increased to 2.5% in 1986. The government's share of total R&D expenditure in 1986 was 60% while that of the private sector was 40%. In 2003, the government was able to reverse the sharing (with 40% for the government and 60% for the private sector) by offering incentives like tax credits and preferential financing and providing technology commercialization services. 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 (Government-Owned R&D Institutes).

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

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: 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.

Science and Technology Parks

In 1980, the government established the Hsinchu Science-Based Industrial Park (HSIP) 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. In 1986, there were already 54 high-tech firms in HSIP with total employees numbering 8,275. By 2000, the number of companies in HSIP increased to 289 with 102,775 employees.

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

Lessons from Taiwan's Corporate Technology Management

Technology Strategies

In contrast to 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: 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.

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: 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.

Takeover 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 of 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: 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.

VII. RECOMMENDATIONS FOR THE PHILIPPINES

Drawing on the lessons derived from the experiences of Korea and Taiwan, we now present the following recommendations for the Philippines' catch-up technology management.

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.

Industry Structure 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 linked 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.

Export Promotion

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

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, certain 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.

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 world-class 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 college 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, Air-conditioning Technology, etc.) to be offered by Technical Colleges or Polytechnic Universities and by reinventing technicians as "Technologists". Courses in entrepreneurship should also be incorporated into the curriculum from elementary to tertiary levels.

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.

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 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.

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 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.

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 modem 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.

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.

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 autonomous technological learning styles and catch-up technology management practices of Korean and Taiwanese firms, striving to climb up the technology ladder as quickly as possible in order to achieve catch-up competitiveness.

VIII. 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 globally competitive only after it attains catch-up competitiveness which, in turn, entails the effective practice of catch-up technology management, i.e., the formulation and implementation of a technology strategy oriented towards attaining technological catch-up through the rapid learning and mastery of externally acquired technologies.

Catch-up technology management at the level of firms, however, has to be pursued within a supporting framework of national technology management that seeks to industrialize the economy rapidly. As emphasized by Linsu Kim (1997), the government has a very important role to play as the facilitator of catch-up technology management. Catch-up competitiveness entails a stable and conducive macroeconomic environment, world-class norms and standards in products and processes, an adequate pool of R&D personnel, an adequate infrastructure, an integrated national science and technology plan and management system, adequate resources for S&T development, and a government dedicated to the attainment of technological and industrial catch-up.

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NOTES

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1. Graduate programs in Technology Management began to be established in the U.S. and in other advanced countries in the late 1980s. In the Philippines, the first Master's program in Technology Management was opened in June 1996 following the establishment of the Technology Management Center at the University of the Philippines Diliman in February 1995.

2. According to the Asian Development Bank (2007), the Philippines had an average export growth rate of 4.10% during the six-year period 2001 to 2006, which was the lowest in Southeast Asia and East Asia.

3. According to the Philippines' Intellectual Property Code (IPC, 1997) utility models are devices that possess novelty and utility but not the inventive step needed for a patent for invention and that are entitled to a protection of only seven years. (Note: What is called a utility patent in the U.S. is the same as what is called an invention patent in the Philippines.)

4. An industrial design is any composition of lines or colors or any 3-dimensional form that can give a special appearance to, or serve as a pattern for, an industrial product or handicraft (IPC, 1997). Industrial designs are protectable for a period of 5 years.