
MANAGING TECHNOLOGY
FOR GLOBAL COMPETITIVENESS
THE PHILIPPINE EXPERIENCE
Edited by
EPICTETUS E. PATALINGHUG
JOSE P. TABBADA
ELVIRA A. ZAMORA

MANAGING TECHNOLOGY FOR GLOBAL COMPETITIVENESS: The Philippine Experience

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Edited by
Epictetus E. Patalinghug
Jose P. Tabbada
and Elvira A. Zamora

UNIVERSITY OF THE PHILIPPINES
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PREFACE AND ACKNOWLEDGMENT

The First National Conference on Management of Technology, with the theme "Managing Technology for Global Competitiveness," was organized and conducted by the U.P. Technology Management Center on October 25-26, 1996, at the Heritage Hotel, Metro Manila, Philippines. The Center's Conference Organizing Committee was chaired by Dr. Jose A. Magpantay of the National Institute of Physics, U.P. Diliman.

The Conference Organizing Committee conveys its deep appreciation to the people and institutions for their support and cooperation in making the Conference a success.

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The views and opinions expressed in this volume are the responsibility of the respective authors and do not necessarily represent those of the Technology Management Center.

The Conference Organizing Committee gratefully acknowledges the assistance of Mr. Gene B. Olivar in the preparation of this volume; the CIDS Staff, particularly Ms. Jocelyn de Jesus and Ms. Rosita Frieda Novenario, for editing this volume; Ms. Ma. Luisa Calugay and Ms. Nancy Pe-Rodrigo for proofreading the text; Ms. Epifania Domingo for doing the preliminary layout; and Ms. Joy Aparis for coordinating with the printery.

its provisions. This is only a matter of about two years. Indeed, we have a lot of catching up to do. Insofar as legislation is concerned, our Congress continues to do its job. Several bills on this matter are pending at the House of Representatives, as well as the Senate.

Our very own U.P. Diliman Technology Management aims to play a key role in forging closer links among government, industry, and academe, to arrive at or, at least, explore strategies to bring Philippine technology to global standards. It began with the First National Conference on Technology Management. While we pursue our goal, let us not lose sight of the spectrum through which technology is brought to the service of society. The roles of each sector should be reexamined and clarified. In the University, for instance, basic research and the atmosphere it engenders should remain a high priority. Researchers should also be encouraged to extend their imagination to possible marketable applications of their work.

INTRODUCTION

Epictetus E. Patalinghug
Jose P. Tabbada
Elvira A. Zamora

MANAGING TECHNOLOGY FOR GLOBAL COMPETITIVENESS

The disappointing performance of the Philippine industrial sector in the past decades has been attributed to several factors, such as lack of a stable macroeconomic environment, poor infrastructure, low labor productivity, and an overvalued exchange rate. In comparison with our Association of Southeast Asian Nations (ASEAN) neighbors, the country's export, investment, and growth performance has fared poorly. Several studies have identified the adverse effects of import-substitution strategy, which was anchored on high tariff, quantitative restriction, and overvalued exchange rate. No structural change took place. Instead, there was a high degree of concentration in manufacturing activities in terms of firms located in Metro Manila dominated incentive availment; and, a bias against labor-intensive firms.

However, in the last five years, policy reforms aimed at increasing the competitiveness and efficiency of the industrial sector have been initiated: liberalization of foreign investment laws; deregulation of the foreign exchange market; liberalization of the airline, banking, oil and telecommunications industries and rationalization of tariff rates. Also, the privatization of public enterprises has been encouraged. Evidently, the macroeconomic environment has tremendously improved, providing a stable environment for the pri-

vate sector. Infrastructure needs are gradually addressed through the involvement of the private sector through such arrangements as the build, operate, and transfer (BOT) schemes. But the problem of poor productivity has remained.

The Productivity Dilemma

The low productivity of Philippine industries raises some questions as to whether the country is on the right road toward NIChood (Newly Industrialized Countries). It also asks whether changes in policies and institutions are needed to address the productivity problem. Likewise, another argument is that technology is an important factor in accounting for growth performance. Thus, an exploration of the relationship between R&D (Research and Development) activities and productivity growth is necessary. However, the existence of a well-developed scientific and technological infrastructure is not a guarantee for successful research. Strong incentives must be in place so that the S&T (Science and Technology) sector is responsive to the changing needs of the industrial sector. A successful technology policy may require, at the onset, a mechanism for the effective transfer and exploration of technologies long utilized in advanced countries.

Plan of the Book

This book is a compilation of papers presented during the *First National Conference on Technology Management*, which was held on 25-26 October 1996. Along with the papers are reactions of experts and leaders from industry, government, and the academe.

This book puts together various policy and empirical studies dealing with the role of science and technology in Philippine development. This is organized into six parts. Part I gives an overview of the state of science and technology in the Philippines. Issues on policy and institutional challenges are discussed in Part II. Part III contains studies on technology, competitiveness, and growth. Methodological and legal aspects of technology management are discussed in Part IV. The relevance of technology in specific industries is analyzed in Part V. Part VI describes the strategic options for global competitiveness.

Brief Description of Papers

Part I

Roger Posadas gives an overall assessment of the state of science and technology in the Philippines. He describes the overall condition of Philippine science as weak and substandard, even on the basis of international standards for less developed countries. Science and engineering education is in a deplorable state because teachers are unqualified, and most of the laboratory facilities are inadequate. He concludes that, with such poor S&T capabilities, the country cannot hope to compete effectively in the 21st century.

Part II

William Padolina discusses the importance of acquiring technological capabilities for efficient production and investment. However, he argues that a full comprehension of the concept of technology must be addressed. Investment in absorptive capability and technology transfer must not rely solely on foreign investment. Local firms must also invest in acquiring technological capability. Exposing domestic enterprises to the strict demands of global competition will warrant technology-based efficiency. He concludes that, in acquiring technological capability, government intervention will still be necessary because the private sector is relatively weak, and market mechanisms are slow. But he emphasizes that the appropriate role of the government is simply to act as facilitator.

Alfonso Aliga Jr. explains the importance of the government-university-industry linkage program. He cites the Japanese example, wherein the government builds research centers, and provides R&D and Ph.D. scholarships to students. The university provides the human resources and facilities to undertake basic and applied research. And, the industry provides the commercial impetus as R&D investor, product developer, manufacturer, and marketeer. He concludes that the name of the game is to bring quality goods to the market on time at competitive costs, and this requires both R&D and technology applications.

Fortunato de la Peña cites six areas where government, industry, and the academe could develop technological cooperation: the es-

tablishment of institutions or programs catering to the needs of industry and government; research and development; training, extension/consultancy, and related services; on-the-job training and other linkage programs; technology utilization/commercialization; and, policy related research on technology. He also suggests exploring other forms of cooperation, such as setting up industry-sponsored laboratories in universities, technology enterprise spin-offs, and industry support for professorial chairs in science and technology.

Part III

Epictetus Patalinghug analyzes the link between technology, productivity, and competitiveness. Productivity estimates in Philippine manufacturing and agriculture for the last 50 years have been disappointing. The contribution of productivity has been inferior to the contribution of inputs in total output. The decline in productivity is attributed to the lack of innovation and to unsound macroeconomic policies. Patalinghug concludes that "social capability" is required before the country can absorb advanced technologies. The concept of "social capability" includes, among others, the number and quality of industrial workers, open markets, strong legal framework, and science-industry-university linkage.

Gwendolyn Tecson examines how technology was acquired, developed, and adapted to build an important segment of the capital goods industry in Japan, Taiwan, South Korea, and China. She also discusses the problems encountered in the transfer process, the necessary conditions for success in technology transfer, and the role of the State in the development of technological capabilities. She concludes that the most important role played by the State in the development of the capital goods industry is in promoting the development of its human resources, on which firm-level technological capability is ultimately built.

Emmanuel de Dios and Ma. Joy Abrenica examine the "European research paradox," or the perceived weak relationship between scientific capabilities and commercial success. They argue that the prevailing explanation for the "European research paradox" does not seem to have been fully articulated, and suggest that a full explanation must involve an examination of specific constraints in

efficiency and strategic behavior faced by innovating firms in particular industries. They concluded that the cost of programs (e.g., European-only consortia) that are extraneous to successful research and technology acquisition, needs to be examined.

Frank Little argues that the Philippines should pursue a policy of accelerated technological change, in order to return to the healthy growth record it experienced until the early 1980s. He asserts that technical shortcomings form the basis of unproductive performance. An important consideration is to transform the organization of industry activity so that it can readily absorb technology. It is the way the industry is organized that determines its productivity. He concludes that globalization represents, at best, only a very partial solution to accelerating technological change, as increasing roundaboutness is a local process. Thus, it is necessary to understand the organizational context needed for technological resource absorption to take place; and to understand the limits of the relationship between technology and output.

Part IV

Jose Magpantay discusses the importance of technology forecasting in managing technological resources of firms and nations. At the macro level, technology forecasting can help identify areas for investment, the corresponding resources required, and the strategies for the application of technology. At the firm level, technology forecasting can assist managers in their technology acquisition and upgrading decisions. He identifies eight different methods of forecasting, conveying that, for every aspect of technology, there is an appropriate forecasting technique. He then illustrates the application of these techniques in the formulation of a national energy plan.

Elvira Zamora outlines the factors contributing to the growth of new technology-based firms. She cites the "spin-off phenomenon" and the role of incubator organizations in promoting technology-based entrepreneurship. She gives a profile of two Filipino "technopreneurs," and concludes that technology-based enterprises are undisputedly critical to economic growth. However, she points out that both government and academic sectors have not demon-

strated commitment to the development of technological ventures.

Ma. Rowena Gonzales presents the salient features of GATT (General Agreement of Tariffs and Trade) and the basic principles behind the Trade-Related Intellectual Property (TRIPS) Agreement, highlighting the protection standards for the different categories of "intellectual property." She concludes that actions concerning intellectual property protection, by all three branches of government (legislative, executive and judiciary), converge in a show of coordination, and that the Philippines must identify and take the optimal path for integrating IPR (Intellectual Property Rights) into its economic development strategy.

Jose Tabbada argues that there is need for "management of technology (MOT)," both as a practice and a field of study. He emphasizes that the need for MOT comes from the realization that the country's poor economic performance may be due to the lack of technological capability, or the failure to manage and master technology. He cites the MOT programs of North America, Europe, and Southeast Asia, and presents two models as bases for the design of programs in MOT. He also describes the MOT program of U.P. (University of the Philippines) Diliman. He concludes that the prospects for MOT in the Philippines are bright, as long as research and practice back it up.

Douglas Williams outlines the preparatory work he has done on international networking on R&D. He stresses the importance of collaboration in university-based R&D, and illustrates this by citing a Canadian program. He also enumerates possible barriers to the success of an R&D consortia.

Richard Smith traces the "history" of MOT and sustainable development, through a survey of earlier studies and reports. He attempts to link the two concepts, using the example of quality management. He also describes current practices in Asia. He concludes that technological collaboration is a mechanism for achieving MOT toward sustainable development.

Nestor Rañeses argues that the use of standards is an important mechanism for achieving high quality and productivity. He describes the process of standardization, and how it affects technology diffusion and international competitiveness. He examines the barriers

to rapid standardization, and proposes an action-oriented systems approach that would hasten the implementation of a progressive standardization program. He concludes that the most preferable mode of setting standards is through industry coalition although under certain conditions, however, government action may be more acceptable.

Part V

Ignacio Pablo discusses two sources of competitive advantage in the food processing industry: lower cost and differentiation. He argues that firms in this industry can simultaneously reduce cost and improve differentiation through innovation and the improvement of technology and existing manufacturing methods. In the food processing industry, innovation may take the form of product changes, process changes, new approaches to marketing, new forms of distribution, and new conceptions of scope. He discusses the role of technology as part of the firm's global strategy. He outlines the steps in strategic technological management, and discusses the role of government in enhancing the industry's international competitiveness.

Pacificador Directo describes the structure of the metal engineering industry, defines its vision and mission, and provides useful industry statistics. His data indicate that the Philippines is thirty years behind Japan in the metal casting industry. Only about 35 percent of the foundries in the country have acceptable applied technology. Directo's investigation shows that a crucial problem of the industry is the antiquated machinery and equipment of most establishments. The industry has responded to this problem through various means, including "equipment complementation" or "facilities sharing." "Common service facilities" is also being explored as a possible stop-gap measure. Directo concludes that most new technologies are known to those in the industry; however, the "proficiency" to apply such technologies is still lacking.

Jose Juliano presents some key facts about the pharmaceutical industry. He emphasizes that R&D and the sustained effort to discover drug innovations drive the industry. This, plus the fact that the industry is characterized by a high level of market competition, makes the acquisition of new technology and the development of

technological capability central to the success or failure of a pharmaceutical firm. In addition, the stringent demands of quality assurance require advanced technology and considerable investments.

Marilyn Eleonor Santiago describes the telecommunications industry as having the most advanced commercial technologies, resulting from beneficial foreign collaboration and partnerships. However, she points out that a key concern is the future use and sustainability of technological development. She identifies some important concerns of the industry, such as inexperience, and the shortage in technically-skilled personnel. A number of short-term solutions have been employed; but, in order to ensure industry competence and continuity, leaders of the industry must take an active part in encouraging manpower education and training. According to Santiago, the industry faces other problems, including renewal, customization of standards, and continued technological advancement.

William Roper describes the development of the iron and steel industry in South Africa. He also outlines some of the most significant developments in the industry, focusing on new process technologies. He discusses the Saldanha steel project as an illustration. He concludes that, in order for South Africa to survive competitively, it has to find new options for steel production using available raw materials.

Johnny Noe Ravalo surveys a few of the more prominent technology-related endeavors in the banking industry. Concensus on the following is, however necessary: standardization of specifications, telecommunications infrastructure, front-end designs and controls, and managing technological applications. He concludes that there is a seemingly unlimited potential to technology, although there are a number of initial stumbling blocks. The experience of the commercial banking industry provides a clear example of how technology can be packaged to benefit participants in the industry, from service providers to service consumers.

Guido Bambagioni explains that the packaging industry may be characterized by cost inefficiencies, resulting in higher prices of locally produced packaging materials. Old technologies and non-availability of local raw materials continue to plague the industry.

Bambagioni describes current practices and the latest developments in the industry, and discusses technology transfer through joint ventures and sharing of R&D activities. He also enumerates issues and problems faced by the industry which require government attention. He argues that industry associations have a crucial role to play, especially in setting up standards. He concludes that the local packaging industry requires quality standards and controls, modern technologies, and skilled manpower to compete globally.

Reynaldo Vea describes four recent developments affecting the maritime industry: rapid development of information technologies; growing recognition of oceans as sources of minerals and energy; growing concern for the environment, and globalization. He argues that at the sectoral level, the industry is not particular about technology management, and that no technology assessment nor planning goes on. He concludes that the development of maritime technologies is a complex process, which is subject to market forces and government intervention.

Florencio Jurado explains the trends in the local automotive industry, and describes Toyota's perspective on productivity and globalization. He presents an industry analysis, indicating opportunities and threats. He identifies the technology needs and concerns of the industry, and presents strategies and action plans. He presents a set of recommendations for developing the automotive industry and enhancing its global competitiveness.

Part VI

Serafin Talisayon argues that a change in the frame of mind of local entrepreneurs is necessary for global competitiveness. He explains that, in order to encourage this new frame of mind, strategic intervention is crucial. He outlines some of the areas where such intervention is possible: inclusion of a course in problem-finding in the U.P. graduate program in technology management; shifting R&D financing toward the private sector; linking up with "frontier companies; encouraging the growth of a "think-tank" industry; and identifying human resources and knowledge-intensive subsectors, and developing niches in identified areas.

Augusto de Leon describes the current challenges brought about

by the changing global economy and offers some strategic options for the local industries. Among these options are: adopting a leapfrogging strategy; moving in all fronts; using a back to basics approach and setting priorities. Leading companies will rise to the challenge, the greater concern is with those organizations which are rigid and resistant to change and new technology.

Finally, Roger Posadas enumerates the features that would characterize the emerging 21st century world. He argues that the proposal to leapfrog the agricultural stage (i.e., to move directly to the post-industrial stage, and to bypass the industrialization stage) is not a viable option for the country. According to him, technology based strategy should first consider two issues: what classes of technology are selected; and how the technology is acquired. To be able to catch up technologically, he proposes mastering technology through reverse engineering of imported key third wave technologies. He concludes that "the development of technology equals the technology of development."

Part I
OVERVIEW

An Assessment of the State of Science and Technology in the Philippines[1]

ROGER POSADAS

Chapter 1

The overall condition of science in the Philippines has remained weak and substandard through the years. It is unable to meet international standards for less developed countries, such as those targets set by the United Nations usually measured in terms of human and financial resources for research and development (R&D) and scientific research outputs. For instance, while the number of R&D scientists and engineers per million ranges from 2,000 to 4,000 in highly developed countries,[2] and 1,000 to 2,000 in newly industrialized countries (NICs), like Korea and Taiwan, the corresponding figure for the Philippines is only 155. This is even less than half of the 1980 United Nations (UN) target of 380 for less developed Asian countries, and is one of the lowest among the members of the Association of Southeast Asian Nations (ASEAN).

The country's 155 R&D scientists and engineers per million translate to about 10,000 R&D scientists and engineers of whom only about 1,000 have doctorates, with those in fields like laser physics, semiconductor physics, and liquid crystals constituting only a handful. This implies that the country does not have a critical mass of PhD researchers to form a self-sustaining research community in most fields in the natural sciences or engineering. The situation is aggravated by the American orientation of Philippine science which

partly accounts for the decision of many scientists who pursue postgraduate degrees abroad to work and settle permanently in America or other countries in the north.

This dismal state of science and engineering education in the country can be traced to unqualified teachers and inadequate laboratory facilities. Statistics of the Institute of Science and Mathematics Education Development (ISMED) reveal that only four percent of high school physics teachers are physics majors. Among Asia Pacific countries, the Philippines has the lowest percentage of graduate students (8.65 percent) enrolled in local graduate programs in science and engineering in 1991. Compared to Thailand, Malaysia, and other countries, the Philippines has the lowest percentage of tertiary and postgraduate students enrolled in science and engineering.

To address this problem, the Department of Science and Technology (DOST) established the Engineering and Science Education Program (ESEP), which hopes to add 3,000 to the country's pool of R&D scientists and engineers in two years through improvements in R&D facilities of selected institutions and the development of human resources in science and engineering at the graduate level. But ESEP is being frustrated by the debilitating brain drain that takes away as many R&D scientists and engineers from the national pool as the number added. To illustrate, the University of the Philippines (UP) College of Science gained 13 new PhDs for the period 1994-1995, but also lost as many. The UP College of Engineering gained one new PhD, but lost four during the same period. Unless the brain drain problem—caused principally by the noncompetitive salaries of government scientists and engineers—can be mitigated, the prospects for the country's human resources development in science and engineering are dim.

Inadequate financial resources for R&D further reinforce this prognosis. While gross domestic expenditures on R&D, as a percentage of Gross Domestic product (GDP), ranges from 2 percent to 3 percent in highly developed countries, and 1 to 1.8 percent in NICs, Secretary Padolina reveals that the corresponding figure for the Philippines, was a low 0.22 percent as of 1992. This is way below the 1980 UN target of

1 percent for less developed countries. Also, the Philippines had the lowest per capita expenditure on R&D in the Asia Pacific region, at 68 cents, in 1984. While the contribution of private industry to the national R&D expenditure ranges from 50 to 80 percent in highly developed countries and NICs, it is only 23.6 percent in the Philippines,[3] indicating that not much R&D is being done by local private firms.

In the Philippines, there are only one or two research laboratories in semiconductors, superconductors, lasers, and other high-tech areas, and none in micromechanics, nanotechnology, artificial intelligence, fiber optics, recombinant DNA technology, composites and advanced ceramics, smart materials, optoelectronics and integrated optics, nonlinear optics, magnetism, fuel cells, and photovoltaics. The country also lacks necessary support facilities agencies for science and technology (S&T) such as a national laboratory for standards, calibration, testing, and analysis; a national supercomputing center and national center for technology monitoring, assessment, and forecasting; a modern, up-to-date science and technology library; a national Science and Technology (S&T) information and documentation center; and, a systematic program for the benchmarking and reverse engineering of technologies in each industry subsector.

In terms of scientific production in 1994 and 1995, the Philippines had the least number of international scientific research publications among ASEAN countries, excluding Vietnam and Brunei. In terms of percentage share of total international scientific publications in 1994, the Philippines had a tiny share of 0.35 percent and a ranking of 51st worldwide, below Singapore, Thailand, Malaysia, and Indonesia. In terms of research productivity, the country is one of the lowest in the ASEAN.

For the past 15 years, the average yearly number of international scientific publications from the Philippines has grown only slightly, while those of its neighbors increased substantially. In the journals covered by the science citation index (an internationally accepted measure of scientific production), the Philippines had a total of 210 research publications in all fields of science and engineering in 1994 and 249 publications in 1995. Were it not for the presence of the In-

ternational Rice Research Institute (IRRI) in the Philippines, these numbers would have been much lower as IRRI's share ranged from 36 percent to 40 percent of the Philippines' international research publications.

Among the S&T institutions in the Philippines, IRRI has produced the largest number of international scientific publications in 1994 and 1995, with a yearly average of 93.5; followed by UP Diliman, 28 (24 from the College of Science alone); Southeast Asian Fisheries Development Center (SEAFDEC), 17; UP Los Banos, 12; Department of Health (DOH), 11; UP Manila, 10; International Center for Living Aquatic Resources Management (ICLARM), 6.5; University of Santo Tomas (UST), with 5; De La Salle University (DLSU), with 3; and Visayas State College of Agriculture (VISCA), 3. The rest of the S&T institutions have a 1 to 2.5 yearly average of international publications.

As noted previously, Philippine science, particularly the natural sciences and mathematics, is largely dependent on American scientific tradition and culture, as shown by the continuing preference of local scientists to pursue doctoral studies in the United States, use American textbooks and equipment, and follow American research trends and directions. In contrast, there is a strong effort to develop an independent scientific tradition and culture in Indonesia, Malaysia, and Thailand. This may be among the reasons for the relative absence of a brain drain problem in these countries.

Philippine technology has largely stayed on the path science has taken. It is still largely backward and dependent on local technological capabilities, being mostly innovative relative to first-wave or preindustrial technologies; mostly adaptive relative to second-wave or industrial technologies; and ranges from theoretical to operative relative to third wave or advanced technologies. First- wave technologies are basically preindustrial. Second-wave technologies are those developed from the industrial revolution up to around World War II (based on the principles of classical physics and classical biology). Third-wave technologies, on the other hand, include essentially the high-tech or science-intensive technologies that depend

on the knowledge of structures, properties, and interactions of molecules, atoms, and nuclear electrons and protons.

As an indicator of the country's level of inventiveness (the internationally accepted indicator of technological output), the total number of patents awarded to Philippine inventions in either the USA or the European markets, from 1983 to 1994, is 52. This is more than that of Indonesia (37) and Thailand (33), but less than that of Malaysia (66), Singapore (213), New Zealand (566), South Korea (3,036), Australia (4,701), and Japan (204,597).

As a consequence of having a backward technology, the Philippines is exporting mostly low-technology products (garments, assembled integrated circuits (ICs), fashion accessories, gifts, toys, and housewares, fresh and processed fruits, shrimp, tuna and seaweed, furniture, and low-end software), in exchange for high-technology products (power-generating machineries, specialized machineries, transport equipment, chemicals, synthetic textile yarns, and components for IC assembly).

The relatively low inventiveness and type of the country's exports and imports indicate the underdeveloped state of Philippine technology. The more specific level of technological capabilities of local firms can be assessed in terms of stages of technological capability: the acquisitive capability (the ability of a firm to acquire the technology), operative capability (the ability of a firm to operationalize foreign technology), adaptive capability (ability to adapt foreign technology to local conditions and materials by making incremental modification of the scale or product design, or inputs and components for routine maintenance and minor repairs), replicative capability (ability to design through reverse engineering, set up, and operationalize the replica of the acquired foreign technology system), innovative capability (ability to make significant major improvements in the process of product design of the acquired foreign technology, thereby producing the latter's next generation), and creative capability (ability to develop, design, and produce an entirely new product or process technology).

In the agricultural sector, technological capabilities are replicative and even innovative, relative to indigenous first-wave technolo-

gies; operative and even adaptive relative to second-wave technologies (green revolution-type from IRRI); and, only theoretical for third-wave technologies (genetic engineering-type).

In the manufacturing sector, technological capabilities range from innovative to creative, relative to indigenous first-wave manufacturing technologies (as in the making of furniture, toys and gifts, gems, and fashion accessories); adaptive in most cases, replicative in some cases, and innovative in a few, relative to second-wave manufacturing technologies (as in the assembly of cars and the manufacture of household appliances, by companies like Philacor and some PHINMA cement companies); and theoretical to operative relative to third-wave manufacturing technologies (the use of flexible manufacturing systems and CAD/CAM industrial robots).

In the transport sector, local technological capabilities are still at the adaptive levels, relative to imported second-wave transportation technologies, such as motor vehicles, ships, and airplanes; and nonexistent, relative to third-wave transportation technologies, such as maglev trains and electric cars.

In the communications sector, local technological capabilities are adaptive, relative to imported second-wave communication technologies, such as copper-based telephone systems; and still operative, relative to imported third- wave communications technologies, such as cellular phones and the Internet.

In the energy sector, local technological capabilities are operative relative to imported second-wave energy equipment, like electric generators and turbines—for which, sometimes firms do not have repair capabilities—and, in some cases, replicative to innovative, relative to some power-generation processes, like the Philippine National Oil Corporation's (PNOC) world-class geothermal plant operations.

In the construction sector, local technological capabilities are adaptive, relative to second-wave horizontal construction techniques, like road building and bridge construction; operative to adaptive, relative to imported second- wave vertical construction techniques for the construction of high-rise buildings; and theoretical to operative, relative to third-wave construction techniques.

On the whole, the Philippines only has a limited, embryonic,

laboratory-level or theoretical knowledge of the third-wave core technologies strategically important in the twenty-first century, such as advanced materials, robotics, genetic engineering, computers and communications, photonics, microelectronics, and molecular engineering. Philippine technology can be characterized as an exogenously dependent technology, with minimal links to local science. It consists mainly of outdated foreign second-wave technologies, licensed or purchased by local firms through commercial technology transfers, and has very few endogenous technological innovations based on local R&D and invention.

As the international community approaches the globalized, digitalized, and high-tech world of the twenty-first century, the Philippines is still saddled with a weak, backward, and dependent science and technology. Its industries by and large have not yet learned to master obsolete nineteenth-century technologies, much less the latest twentieth-century technologies. With such poor S&T capabilities, the Philippines cannot hope to compete effectively in the next millennium unless it begins to change the conditions that constrain the development of the long neglected S&T sector.

NOTES

[1] Much of the statistics and data cited here comes from two UNESCO reports: the *World Science Reports* 1993 and 1996; the report of Secretary William Padolina in May 1996, "The Science and Technology Balance Sheet;" and the book, *The Emerging Technological Trajectory of Pacific Rim Nations*, edited by Denis Fred Simon (Armonk, N.Y.: M.E. Sharpe, 1995).

[2] Japan has the largest number of R&D scientists and engineers, at 4,100 per million.

[3] This figure may still be questionable, however, because not all of these expenditures are in R&D proper.

DISCUSSION

Estrella F. Alabastro

Chancellor Posadas's paper presents a bleak picture of S&T in the Philippines. While it is a fairly accurate depiction, however, we should not lose heart. I believe there are developments that may have positive consequences for S&T. For example, our office used to go around begging for research proposals, but now we are swamped with proposals. Not only are we getting the desired quantity, but the quality itself of proposals has markedly improved. The R&D budget, or the grants-in-aid fund, also has increased considerably.

Apart from an increase in government's budget for R&D, the private sector is increasingly realizing the role of technological innovations in attaining global competitiveness. Companies are recruiting very competent people, like PHINMA, which has several engineering PhDs in the staff. They are favorite customers in the Balik-Scientist Program. Likewise, the DOST is processing more applications from R&D companies that intend to set up operations in the Philippines. These developments are likely to affect the level of private sector investment in R&D.

The issue raised of low level technologies available to industry continues to confront us. However, it is important to recognize that most of the current needs of our industry can be addressed by Second Wave, as well as First Wave, technologies. Nevertheless, we should provide for the future. Academe must be at the forefront of research, providing basic knowledge, as well as scientific basis, for the development of cutting-edge technologies.

The problem of academe is its low absorptive capacity. The limiting factor is not so much the funds or facilities, as these can be addressed very easily, but the time it takes to train and develop competent people. While facilities can be provided in a couple of months, training for a PhD usually takes at least five

years. Accessing external resources to beef up R&D infrastructure is not difficult. This is being done through the Engineering and Science Education Program (ESEP). However, it is the responsibility of the universities to continue developing and retaining the PhDs that trickle in.

Dr. Posadas mentioned the brain drain problem in the UP Colleges of Science and Engineering. I think he was alluding to the transfer of faculty from the university to industry, rather than their flight out of the Philippines for greener pastures abroad. While the resignation of faculty with doctoral degrees is a direct loss for the university, it is not a total loss as far as the country's interest is concerned. In fact, it may even be a gain. Perhaps, we can explore arrangements between the university and industry that will allow the former to retain its faculty, and help the latter meet its needs at the same time.

Ultimately, the university is responsible for providing a working environment that supports people, not only materially, but also psychologically so that they may be able to do meaningful research work. ESEP scholars,for example, invariably articulate two anxieties: 1) Will they be able to live decently when they go back? and 2) Will they be able to do meaningful R&D? These are questions that I think the University, as well as the DOST, will have to address.

I also feel very strongly about the partnership between industry and academe. In developed countries, the creation of cutting-edge technologies is the purview of academic institution, in partnership with industry. Unfortunately, in our country, the links between industry and academe are very weak, if not nonexistent. It is imperative then for academe, industry and DOST to foster and nurture the relationship between industry and the country's universities. DOST should continue to provide funds to improve R&D infrastructure, particularly for basic research. Academe will have to provide competent manpower. And industry will have to collaborate with academe in the development of cutting-edge technologies. I think that we can get somewhere only if we work together.

Part II
INSTITUTIONAL AND POLICY CHALLENGES

Setting the Agenda for Government-Industry-University Collaboration

WILLIAM G. PADOLINA

Chapter 2

We want to assess the current state of research and technology management; and, at the same time, pinpoint the constraints and institutional bottlenecks that prevent it from opening windows of opportunity available under a rapidly globalizing context. Here, one will be exposed to a wide range of ideas and cross-current opinions on the state of industry, and these ideas may not necessarily sit well with some individuals. The task at hand is not easy; but, overall, this is a significant first step toward the creation of a strategic, rational, and coherent approach to technology management.

The only permanent thing in this world is change. Even thinkers, such as Peter Drucker, Paul Kennedy, and Michael Porter, have been advocating the mastery of change in various guises, such as innovation, reengineering, and organizational flexibility. One of the more direct consequences of change is the inexorable trend toward liberalized trade. One would disagree that freer trade is a positive-sum game, and yet some are more likely to gain more than others, for reasons such as broader applications of new technology, shorter product life cycles, and even continuous changes in the organization of production and the use of inputs.

Managing Technology for Global Competitiveness

To become globally competitive, a country must have knowledge of its competitive advantage. Competitive advantage grows out of an industry's choice to be unique. Choosing to be unique means limiting oneself by not doing everything in the industry—in other words, not spreading oneself too thin. In the case of the Philippines, we risk so many prospects for growth. Being seriously tempted to pursue all these great ideas, developing countries now realize that the traditional sources of comparative advantage, like cheap labor and abundant material inputs, are rapidly undermined by development and diffusion of technologies, more efficient utilization of resources, and substitution by new synthetic materials for traditional ones. Even if technological leadership is the least of their concerns, developing and acquiring the technological capabilities needed for efficient production and investment should be at the top of their agenda, if they are to take advantage of the opportunities offered by global competition.

The global technological order is characterized by simultaneous emergence of megatrends. These megatrends suggest that international business competitions would be more pronounced in the twenty-first century, and that the interlocking of the world economic system would become even more complex and dynamic, highlighting trade liberalization and market deregulation. And even small enterprises in developing countries can no longer remain isolated from the interdependent and competitive global system.

Unfortunately, the gap between the technological haves and have-nots is widening. With every innovation coming from the West, we are subject to increasing risk. Fortunately, we have a sincere desire to manage technological progress, and have chosen to compete rather than retreat. The mastery of managing technological change is a must. And yet, despite the progress we may have achieved in the past, we still lack full comprehension of the concept of technology. The problem lies in the blurring of the difference between science and technology. Although science may be a public good, technology is the marketable commodity, with a price attached to it. Science may be the wellspring of technology, but science alone does not lead to economic growth and prosperity. In the market, economy

and enterprise use technology as a means of competition.

A second point is the misplacement of confidence in foreign investment and technology-transfer schemes, without investing in absorption capability ourselves. Our investment strategies assume that we can consume our natural resource commodities forever. As failure of these perceptions becomes more and more evident, we need to scrutinize the issues more systematically.

A third fault is our insistence on using developed-country indicators to measure the index of developing economies. For instance, financial and economic markets in developing countries are largely imperfect, yet we persist in using conventional financial input-output indicators that do not reflect technology management. Thus we fail to address the real problem.

Technological vitality is the basis for international market competition, in which survival of the fittest is the norm. In this technologically dynamic era, a firm without a continual stream of innovations will soon fail to compete. Even the most successful industries have to continuously evolve technologically, in order to satisfy ever-demanding consumers. As such, we can gather the technological needs of a firm for market competition, moving target as higher value addition to achieve technological mastery.

We must note the consequences of our "late-awakening technology" as a strategic weapon for international market competition. The holders of technology will certainly not help create potential competitors. On the other hand, we must recall that a big fish cannot swallow all power to survive, and that with growth comes reliance. We often underestimate ourselves and overestimate the sacred cows among us. Creativity is the fountainhead of all technological innovation, and we have no shortage of creative brain power. Thus, a technology-change management approach, focused explicitly on the strengths and weaknesses of our national techno-economic system, would be a good starting point for breaking the vicious cycle of underdevelopment. We must not lose sight of the fact that it is the individual firms which are the trenches of market competition.

All productive enterprises technologically transform available inputs into an increasing array of goods and services. As technology

is created by human beings, technology development and transfer mechanisms are needed for continuous innovations at the firm level. At the enterprise level, technological resource has become one of the major factors in production. At the national level, technology is not regarded as the engine for economic growth and the strategic variable for sustainable development. Moreover, in the present world where foreign trade is engaged in in unprecedented levels, exposing domestic enterprises to the strict demands of global competition warrants technology-based efficiency. Thus, in an increasingly globalized and interlinked world, economic technology looms as the driving force behind the following: 1) structure of domestic production; 2) advantage in market competition; 3) opportunity for borderless trade; and 4) growth of any people's standard of living.

However, this vital power resides in productive enterprises, and is derived primarily from their ability to introduce technological innovations faster than the rest of the competition. Thus, management of technological innovation is aptly described as the key to sustainable economic development. The most crucial aspect of the program initiated in the DOST is the conscious effort toward heightened partnership in technology development and utilization. It is DOST's policy to encourage both public and private sectors, government, academe, and industry, to enter into collaborative efforts that will increase industrial productivity and improve the quality of production in agriculture, industry, and the service sector. To make this alliance work smoothly, the DOST has been holding consultations and extension programs to define the directions and priorities in R&D, technology transfer, and manpower upgrading. In addition, the DOST is formulating appropriate laws and administrative policies to spur private sector investment in science and technology. Therefore, it is essential that we arrive at a shared strategic technological vision. In the long run, we can only hit our ultimate aim, which is to use technology for competition.

But technology, by itself, is only a means, not the real power. It warrants that we acquire technological capability, including the assimilation and mastery, to better use given resources. Then, a firm will need to develop its technology-appreciation capability by pro-

ducing valuable inputs. And at the top of this learning process, it is the state-of-the-art technology generation that involves the making and commercializing of new technology. Step by step, the technological capability ladder has to be ascended, from utilization to generation-accumulating capability. It means getting to be the industry leader through a lifelong process of progressive learning, and using the acquired competence as a leverage for market competition. In assessing the real strength of an enterprise, it is advisable to consider both prospective and actual technological capabilities accumulated, as present economic growth results mainly from technological capability advancement. It must be emphasized that capability is not a matter of what the firm has, but what the firm does with what it has to improve international market performance. To become successful, technological capability advancement and the corresponding technological component sophistication should be attempted, in an orderly and reinforcing manner.

To sum up, accumulation and technological capability are part of a continuous process of managing technological change and using technology-based corporate competencies to make a business enterprise succeed in the international market. Unlike in developed countries, government participation or intervention is still necessary in the Philippines because the private sector is relatively weak, and market mechanisms are slow to react. But it must be emphasized that the government should act as no more than a facilitator. One approach is the careful mix of competition and cooperation in the market, and the direction and guidance of government. In this case, the role of government must be clear and distinctive. The first significant step was taken in 1992, when restrictions were lifted on a number of foreign exchange transactions. It is foreseen that modern technology is made more accessible through more relaxed arrangements for technology transfer. Second, the dismantling of monopolies and rent seekers (for example, in telecommunications and banking) has resulted in killing interindustry competition. In the battle for market supremacy, it has been discovered that companies which have invested in enabling technology invariably find themselves among leaders in their respective fields.

The wave of liberalization also manifests itself in the government policy on foreign investments. Certain provisions of the 1991 Foreign Investment Act have been amended to expand areas for investment, including new rules allowing 100 percent foreign ownership in sectors not found on the sensitive list. Foreign investments directly affect technological capability by bringing in state-of-the-art machinery and tools from abroad, and by promoting the more relaxed entry of much-needed total inputs. The government facilitates the introduction of new technology into the local production system. In recent years, technology-transfer rules have gradually shifted in character, from being regulatory to promotional. For example, the revised provisions under the Foreign Investment Act stipulate that automatic approval should be granted to payments of technology-transfer arrangements, and/or the transfer of know-how and trade secrets not exceeding 5 percent of net savings. Obviously, for this partnership to bloom, a working relationship must be fashioned, which is one or two steps ahead of the usual consortium approach. Already, a pattern is emerging, in which large corporate commitments to centralize basic research facilities are giving way to decentralized strategies. Nowadays, electronic communications research networking has become more feasible than the traditional concept of research organizations.

It is my hope that this will be a signal of the opportunity to forge a new alliance among academe, industry, and government; and to accelerate the level of technology and research and development in the country to a globally recognized standard of excellence.

The Need for Government-Industry-University Collaboration for Global Competitiveness

ALFONSO A. ALIGA JR.

Chapter 3

The triangle of productivity is about how companies react or respond to, and beat global market competition. This triangle considers three basic components common to both providers and customers. For instance, what do customers want? They want to be served quickly, with quality products and services; and they want to have the lowest price. The same is true for the manufacturer. We want to make our response time as short as possible, by delivering quality products at the lowest cost.

The Japanese have perfected this triangle. In the late 1940s, even before quality became a buzzword they already talked about *statistical process control*. This means, if you make your processes defect-free and error-proof, then you create quality products all the time and costs go down.

It is said that quality is free. A good process is usually measured by the amount of time it takes to do it. For instance, what happens when we encash a check? The actual time we spend for the transaction might only be one minute but if you waited for 19 minutes in the queue, that becomes a 20-minute process. The idea then is to eliminate all the nonvalue-adding aspects of the process.

Once you do that, the operator can perfect his work by rechecking, and thus deliver quality outputs all the time.

However, recent research (Boston Manufacturing Roundtable, 1994) tells us that, to beat global competition, we must address the needs of customers regarding the following major processes: 1) supply, which indicates the flow of materials; 2) order fulfillment, which is primarily an information activity; and 3) product development, which is the focus of attention in the next decade—all converging to transform the raw materials in their products. The research, participated in by about 800 industry practitioners from the United States, Europe, and Japan, also emphasized that *product development* will become the most important process in the next millennium. This view, which is shared by high-tech companies all over the world, also underscores the importance of science and technology, as well as research and development (R&D), in the process.

There are several methods for undertaking *product development*, such as finding new uses for existing technology, creating new technology for old uses (like the Xerox system for photographic reproduction, or laser technology), or discovering new uses for new technology (like radar and Magnetic Resonance Imaging [MRI] for medical applications). If we relate these approaches to the technology stages discussed by Dr. Posadas[1] (ranging from the operative to the creative stages), we can develop new product markets.

Continuous innovation requires considerable R&D in science and technology (S&T). Managing these activities is a continuous and progressive learning process—until a workable product version is created and introduced into the market. For instance, Motorola's cellular phone started out as a two-pound prototype, developing into the pocket-size phone we now have, within a period of twenty years and at considerable research cost.

In the Philippines, even small companies have to do some R&D. Examples include a candy company that makes 15 new products every month, and a fabric company which utilizes one-fourth of its workforce for product development, like making new designs and prints for their fabrics. There is a global company in Cabuyao, Laguna, that makes its own manufacturing machines, where about half of its

workforce are into R&D. They use 20,000 diffusion processes per second for their fabrics and plastic processing. In the artificial flowers industry, about 10 percent of the workers are into new product designing. All these point to the need for product development innovations in order to make headway in the marketplace.

Management of technology involves several steps, but it always starts with identifying what customers want. The search for the most promising developments involves literature research and knowledge sharing, information from scientific publications, and the identification and enforcement of R&D and technology application, at the lowest cost and in the fastest manner.

As Dr. Alabastro mentioned, we must also consider the *brain power* needed to carry out R&D. Business groups say that the future of competition will be determined not so much by market sharing, but by how much of the talent pool can be mobilized.

In our efforts to make use of this pool of brain power, we have to start educating our people. This involves educating our students toward the pursuit of S&T courses, and keeping them there for a long period of time. The UP-Manufacturing Industry Linkage Program is one such step toward this direction.

An article that came out in 1992 tells of a discussion between Akio Morita of Sony Corporation and British Prime Minister Margaret Thatcher when the latter asked Morita some advice for her country. In response, Morita replied that Britain should respect engineers because it was unrealistic to expect true industrial development in a society where engineers are not highly valued. This, in a sense, explains why we have this linkage problem and why we have a need for tripartite activities.

Indeed, Japan's economic development showcases the fruits of strong partnership among three major players: government, industry, and academe. The government plays the motivator of industry and academe. It builds the research centers, and provides scholarships for students to pursue R&D careers or doctorates. Industry provides the commercial impetus as the R&D investor, product developer, manufacturer, and marketer. Academe, on the other hand, provides the brain power and facilities for basic and applied research. In this

tripartite relationship, each player has a role to play and each performs its role well.

The UP-Manufacturing Industry Linkage Program (MLP)

The UP-MLP was founded in 1985, during the Diamond Jubilee of the UP College of Engineering. The program serves as the basic step in generating interest among students to pursue S&T careers. It specifically aims to encourage engineering students to pursue careers in manufacturing. At the time, only 7 percent of engineering and science graduates was involved in S&T careers, five years after graduation. The retention rate was very low, compared to Japan's 68 percent. Therefore, there was, and is, a need to retain engineers and scientists in S&T jobs for a longer period.

From only twelve companies when it started, the MLP now has 20 participating companies, coordinating with the DOST and its agencies, Metals Industry Research and Development Center (MIRDC), and the UP College of Business Administration. Similar linkages have also been established in the University of San Carlos in Cebu, and Xavier University in Cagayan de Oro. The MLP has also introduced a new course in UP, Industrial Engineering (IE) 197, a one-semester course involving plant visits and on-site lectures.

Another MLP activity is the Manufacturing Industry Roundtable, in which joint research projects on industry-specific topics are undertaken by member companies. The topics are related to industry problems, like inventory management, performance measurements in manufacturing, and the technical capabilities of engineers in electronics and semiconductor industries. Specific problems such as these are addressed by specific research activities.

We are now moving toward the creation of a manufacturing entrepreneurship development program, which is a joint undertaking between the College of Engineering and the College of Business Administration of UP. In this program, students at the College of Engineering interact once a week with an *industry professor* who is an executive nominated from a member company

Furthermore, a visiting arrangement was made with the Asso-

ciation for Overseas Technical Scholarship (AOTS), an agency of Japan's Ministry of International Trade and Industry (MITI). In 1995, I was among a 19-member group that visited Japan to observe and learn from their linkage programs.

From that visit, we concluded that Japan's national industrial policy was created not to advance industrialization per se, but to primarily divert the population away from Tokyo. This was their initial concept of regional dispersion. This law also led to the establishment of technoparks and science centers. Technical and vocational schools provided the manpower; universities provided the brain power; and industrial societies and associations provided the funding support.

What then can we do for the Philippines?

- Create technology centers in the regions.
- Create a board that will promote government-industry-academe linkage for each region, where summer internships for students will be organized.
- Set up research laboratories in the different regions through the government's BOT scheme.
- Adopt the concept "experience first before licensure," in granting professional licenses to engineers and scientists.
- Provide more technical and analytical subjects for nonengineering courses.
- Adopt the *technologization* of small- and medium-companies, through big companies and government institutions.
- Enjoin big corporations to make their own technology policies, and share them with others.

Thus, the name of the game is to bring new products into the marketplace *first*, and produce quality goods *on time*, and at *competitive* costs. Corporate commercial performance requires a constant focus on staying competitive and being ahead of everyone else. This requires strength in both R&D and technology application, in terms of inventing, developing, and commercially producing the outputs.

NOTES

[1] See Posadas, pp. 6-9 of this volume.
[2] See Alabastro, pp. 10-11 of this volume.

DISCUSSION

Pablo F. Mangaran Jr.

Mr. Aliga began by citing that the primary consideration for competing in the global marketplace requires satisfying customer needs. This is the *consumer model* that we all know about in marketing management, in which "the customer is king." In the production and services sectors, processes and improvements, such as total quality management (TQM), statistical process control, and the just in time system (JIT) are all aimed at satisfying customer needs and demands. The production process and consumer models show that the final recipients of any product or service are the customers. Customer satisfaction should, therefore, be the primary consideration in product development, otherwise the firm will never get recognition or acceptance in the marketplace.

A study made by Sommers and Markys for the US National Science Foundation supports the belief that the recognition of demand is a very strong factor in successful innovation. Out of 567 respondents, close to half or 45 percent said that market demand is the source of innovation. The rest said it is production (30 percent); technical feasibility (21 percent); and administrative change (4 percent). Thus demand and need (75 percent) are often more important in successful innovation than recognition of technical potential. Therefore, more effective communication should be established among specialists in sales, marketing, production, and R&D, to ensure that such opportunities are not overlooked. This, in a way, reinforces the collaboration process.

Aliga also cites four core processes that winners in the global marketplace should possess: 1) prompt fulfillment of orders; 2) supply of materials; 3) physical transformation; and 4) new product development, which is the area that American, European, and Japanese respondents found themselves weakest in. This is also true in the Philippines.

The innovation process may explain why. The process of fulfilling orders, finding adequate materials supply, and physical transformation are activities in the last stages of production. These final stages are actually systems activities that have been perfected by the Japanese, European, and American respondents. But production itself is just one of nine stages in the innovation process. The first stage is the discovery of the nature of an interesting object, process, property or attribute—and this covers a range of activities from invention to preparation of prototypes and pilot production. This calls for creativity, or bringing into existence a unique concept. The truth is, creativity is a rare commodity.

Not all projects that are begun reach the customers. Some never even reach the final stage because they die along the way. Of several projects thought of in the first stage, only one or two will eventually reach the market.

The innovation process calls for the application of science, engineering, and technological disciplines, but these disciplines are usually not found in firms. This may thus explain the need for government-industry-academe collaboration to push global competitiveness. There are some collaborative processes on a modest scale, such as the De la Salle University (DLSU) collaboration with government and industry. The programs under this collaboration are: 1) the Manufacturing Industry Linkage Program (MLP) at DLSU, which started in 1988 and now has more than 100 firms involved; 2) the DLSU-DOST Engineering Manpower Development Program, which started in 1991; 3) The DLSU-DOST Engineering and Science Education Program (ESEP), with *management of technology* as one of its components, and UP and the Asian Institute of Management (AIM) as the two other flagship schools; and many other collaborations.

Joint research activities are another consideration. The university benefits from the priority given to institutions, in terms of student visits and on-the-job training. The school also benefits from funding support, given for faculty development, purchase of equipment, and the provision of required infrastructure. Thus, the university's prestige is enhanced.

The wide-ranging areas of interest of faculty and their detachment from commercial pressure make them ideal critics of product development. University-based scientists and experts are anxious to keep in touch with the needs of industry and to make a personal contribution to technical progress.

In closing, allow me to quote Anemoti Guru: "Anyone who wishes to know where a country will be in the next century should look not at the pronouncements of politicians, but at the output of its colleges and schools today."

Government-Industry-University Technological Cooperation

FORTUNATO T. DE LA PEÑA

Chapter 4

One of the earliest and more common forms of cooperation in the science and technology sector has been in manpower development. The DOST, for instance, has set up a number of scholarship programs in selected universities. This can be considered as the government's most expensive program in technology development, involving the biggest number of academic institutions. The Departments of Energy and Agriculture have similar scholarship programs in technology, albeit at a lesser magnitude.

This chapter describes the nature of the technological cooperation that has been taking place between academe on the one hand, and government and/or industry, on the other. It emphasizes the following areas of cooperation: (1) establishment of institutions or programs in the university, which will cater to the needs of industry and government; (2) research and development; (3) training, extension/consultancy, and related services; (4) on-the-job training and other related linkage programs; (5) technology utilization/commercialization; (6) policy research on technology; and (7) other forms of desired cooperation.

Establishment of institutions or programs catering to the needs of industry and government

These institutions or programs within the university have been initiated by the university, the government, or industry. Examples are the UP National Engineering Center (NEC) and its component units; namely, the National Center for Transport Studies, the National Hydraulic Research Center, the Training Center for Applied Geodesy and Photogrammetry, and the Building Research Service. Other examples in UP are the national centers of excellence at the College of Science and the Institute for Small-Scale Industries, in Diliman; BIOTECH, in Los Baños; and more recently the National Institute of Health (NIH), including the Health Products Research Institute in Manila. Ateneo de Manila University has the Philippine Institute for Pure and Applied Chemistry (PIPAC). The Mindanao State University has its various centers at the Iligan Institute of Technology. Recently, the Cebu Institute of Technology opened its Multimedia Development and Training Center.

The NEC[1] was established in 1978 as a distinct unit of UP, and was envisioned as the vehicle for interaction between the government, industry, and academe in the pursuit of engineering solutions and knowledge, and the provision of qualified technical manpower for industrialization. It was mandated to strengthen and ensure a steady supply of technical manpower for various fields of engineering, and develop technologies that utilize indigenous and appropriate resources. Its services included continuing engineering education, technical consultancy, research and development, and engineering information.

On the other hand, PIPAC was founded in 1973 by Ateneo Chemistry professors who saw the need to provide the country's industries with essential scientific and technological services in the field of chemistry. Its building and advanced scientific instruments were financed by a grant from the Japanese government, while other major facilities were acquired through a grant from the Alexander van Humboldt Foundation of West Germany. It has operated as a private, nonstock, nonprofit corporation, governed by a board of trustees elected from the business sector, academe, and government.

It has been accredited as a testing laboratory by the Product Standards Agency of the Department of Trade and Industry, and by the Fertilizer and Pesticide Authority.

The Cebu Institute of Technology's Multimedia Development and Training Center is a very recent example of technological cooperation. Established with an initial grant of P6 million from the DOST, the Center is organized to meet the growing need for conversion technologies for multimedia products, such as CD-ROMs and console games. It is envisioned to provide specialized training in multimedia technology to the local community, as well as the whole industrial sector. The Multimedia Development and Training Center aims to upgrade competence in the development of interactive software products which use multimedia technology, involving visual production, sound production, computer 2-D/3-D graphics, 2-D/3-D animation, authoring, and computer programming.

These examples has many things in common. The initiative in setting the centers comes from the host academic institutions; initial support is given by government; and the beneficiary or clientele for services is industry, in general. Futhermore, faculty are directly involved in providing services. In all cases, there is also a desire to be self-sustaining.

While universities could be ideal sites for such centers, however, some factors prevent many from taking similar initiatives. First, they require a core of highly trained manpower, usually the faculty. Second, they require substantial initial investment. And third, they have to be sustainable in the long run. These are precisely the arguments for government to come into the picture, at least, in the initial phases. Universities could play important roles in the technological and industrial development process of the country, as shown in the experiences of developed economies, and even by limited examples in the Philippines.

Research and Development

R&D, as a form of technological cooperation, comes in at least four modes: (1) the government gives research grants to the univer-

sity, or funds for contracted research; (2) industrial firms or industry associations fund research, to be done in the university; (3) government or industrial organizations utilize university faculty or researchers for their organization research; and, (4) the university conducts research, with its own resources or with external funding support (neither from government nor industry), and promotes its utilization by government or industry sector. Technological cooperation in R&D could also come as a combination of the above models, or in other forms.

The DOST is at the forefront of technological cooperation with universities through research grants or contracted research. In many instances, the R&D breakthroughs reported by the DOST have involved universities. In the case of agricultural technologies, the Philippine Council for Agriculture and Resources R&D (PCARRD) has a system of farming out research work to institutions, many of which are agricultural universities and colleges. Breakthroughs in new plant or crop varieties, animal reproduction, crop protection, farming systems, and postharvest technologies have been achieved in universities with research grants from the DOST. R&D accomplishments in the industry and energy sector have also been made in universities, through DOST's research grant system, carried out by the Philippine Council for Industry and Energy R&D (PCIERD).

These R&D achievements are found in the areas of building materials, fermentation engineering, and fuels technologies. The DOST's Philippine Council for Health Research and Development (PCHRD) has also supported university researches (UP), which has yielded local health breakthroughs, like schistosomiasis control, hepatitis-B diagnosis kits, herbal medicine development, and a number of new nutritional products. In aquaculture, the sex reversal technology for tilapia production, and the seaweed production technologies, which have contributed substantially to the local aquaculture industry and now count among the new exports, have been achieved through the DOST's Philippine Council for Aquatic and Marine Research and Development (PCAMRD), and have involved technological cooperation with universities.

The most recent and exciting areas of technological cooperation involving the DOST and the universities are in the fields of

communications, microelectronics, computers, information technology, cybernetics, biomedical engineering, photonics, optics, materials science, biotechnology, and genetics. The DOST's Philippine Council for Advanced Science and Technology Research and Development (PCASTRD) is at the forefront of these efforts which have generated greater interest among other universities to get involved in R&D activities.

There are other government units involved in technological cooperation with universities through research like the Departments of Agriculture, Energy, Environment and Natural Resources, Health, and Transportation and Communications, mostly through contracted research. In UP, most of the research done at the National Hydraulic Research Center, the National Center for Transport Studies, the Building Research Service, and the Training Center for Applied Geodesy and Photogrammetry is contracted research funded by government agencies.

Contract research is also one of the more common forms of technological cooperation between university and industry. In the Ateneo, PIPAC has been conducting research on possible substitutes for imported and synthetic products, from local agricultural raw materials—medicinal products from plants, plant-based oils for fuel, and other agricultural products for pest control. The De La Salle University has been doing robotics and automation R&D, in cooperation with the private sector. The University of San Carlos has done pollution control research for their local industries, like the electroplating industry. The Mindanao State University-Iligan Institute of Technology has been carrying out R&D in ceramics technology, and has been cooperating with Refractories Philippines in Iligan. BIOTECH in UP Los Baños has been doing R&D in partnership with industrial firms, as have the Pilot Food Plant, the National Science Research Institute, the Marine Science Institute, the National Institute of Geological Sciences, and the National Engineering Center in UP Diliman. In UP Manila, the College of Pharmacy is closely linked with industry. The UP Visayas' Institute of Food Processing Technology is likewise actively coordinating with industry. Indeed, the S&T resources and capabilities of our universities, if given ad-

equate support and opportunities, could dramatically bring our R&D productivity to a much higher level. This will eventually lead to better competitiveness of our industries, the birth and growth of more industrial enterprises, and the greater relevance of academic activities.

The following steps toward a higher level of productivity in university R&D are recommended:

- Technological cooperation between government and universities should be more of the contract-research type, in which the responsibility of the university is to deliver the R&D output expected. Project disbursements should be an internal concern of the university.
- Government should match research funds awarded by industry to the university for technology development in priority areas. For example, for a P1 million contract awarded by industry, government should cover at least 50 percent of the amount.
- Government should constantly provide Science and Technology scholarships for faculty development programs of universities which could potentially become centers of excellence in technology. While the operation of universities assumes faculty development as an internal concern, the development of capable scientific and technological manpower, including the training of S&T faculty, is still a national responsibility, at least at present.

Training, Extension/Consultancy, and Related Services

Several universities are now engaged in the continuing education of professionals in various technology areas. UP has the biggest number of centers that offer these on a regular basis. In 1995, for example, the NEC trained close to 3,000 technical personnel from 390 companies and institutions in areas such as construction, commercial and industrial building, manufacturing, distribution, quality systems, materials, management, materials science, computers,

data communications, satellite communications, remote sensing, photo interpretation, geodesy and photogrammetry, energy engineering, substations, transformers, maintenance, waste treatment, and environmental engineering. In addition, there are basic and advanced training courses in transportation and water resources. NEC has a Civil Service Commission accreditation for its course offerings.

The Institute for Small-Scale Industries (ISSI) at UP trains an average of 600 technical personnel a year, in areas such as automation, instrumentation, and process control, as well as basic robotics, with the objective of modernizing and increasing the productivity of small- and medium-sized enterprises. The Natural Science Research Institute of UP trains professionals in chemistry, biology, and biotechnology. UP is also setting up a Center for Industrial Productivity at its campus in Cebu, and this is expected to generate more technological collaboration with industry.

Surprisingly, the most active educational institution in Cebu, in terms of technological cooperation with industry, is a school for technician education, the Center for Industrial Technology and Enterprise (CITE), which offers a three-year nondegree postsecondary Industry Technician Program, using state-of-the-art laboratories in Industrial Electronics, Industrial Automation, Electrical Measurements, and Mechanical Technology. The Center, which is a Philippine-Italian Cooperation Project, has technological cooperation programs with San Miguel Corporation and Procter and Gamble. It provides personnel training, and is engaged in equipment prototyping for industries and technical institutions. The University of San Carlos is also planning the establishment of a Center for Industrial Research, which is expected to provide continuing education and training for professionals in technology areas, and serve the region's growing industrial sector.

Consultancy, if it can be considered a form of technological cooperation, is very much practiced in Philippine universities. Consultancy among faculty members in universities, particularly in engineering and the physical/mathematical sciences, is quite common. However, within the technological cooperation framework with industry, it is still at a relatively low level. A university in Cebu has

reported that faculty of their College of Engineering engage in consultancy work for industries, but arrangements are still made with the university. In other cases, engineering professors do consultancy work for industry through personal or individual arrangements.

An interesting example of government-industry-university technological cooperation is the Manufacturing Productivity Extension Program (MPEP), which was launched by the DOST in 1991 for the benefit of small- and medium-sized manufacturing industries. This involves productivity enhancement consultancy services to manufacturing firms, with funding support from the DOST. The program's target is to cover 500 firms, from 1991 to 1996. Among those involved are the UP, University of Santo Tomas, Adamson University, Polytechnic University of the Philippines, Mapua Institute of Technology, University of San Carlos, University of San Jose Recoletos, and the Cebu Institute of Technology. Feedback from industry regarding this program has been good, and an expanded phase was planned after 1996.

Another area of government-industry-university technological cooperation that can be expanded and strengthened is the setting up of physical facilities in universities, which would render services, particularly testing, analysis, and prototyping, for industrial firms and government agencies. Earliest examples are the Materials Testing Laboratory, the Pilot Food Plant, the Natural Science Research Institute Laboratories, and the Geological Science Laboratories in UP Diliman. Ateneo has PIPAC; the Technological University of the Philippines has its own facilities; and the University of San Carlos has laboratories for testing water quality and instrument calibration. Thus, building and equipping facilities within universities to provide access to industry's much-needed technological services is one area that government should be involved in.

The discussion under this technological cooperation category will perhaps be incomplete without the PhilNet Project. This DOST-initiated project linked ten leading universities via the Internet, and has provided students, faculty members, and researchers access to worldwide information sources.

The following are recommendations regarding these modes of technological cooperation:

- The DTI, the DOST, and the Commission on Higher Education (CHED) should plan an institution-building program that will enable universities to develop their own areas of excellence.
- The three said agencies should also cooperate in the provision of productivity improvement services for various industrial sectors, on a nationwide basis.
- The DOST, CHED, and the Department of Transportation and Communications (DOTC) should have a joint program for improving the communication access of universities, among themselves and with the rest of the world.

On-the-Job Training and Other Linkage Programs

This is one mode of technological cooperation that has become popular and widely accepted. While several universities already have these linkage programs, detailed information is available only for UP, Ateneo, and DLSU. The University of San Carlos, University of San Jose Recoletos, and University of Cebu have also reported similar linkage programs.

While these linkage programs are commendable, we offer the following for consideration:

- The linkage programs should involve small- and medium-sized enterprises (SMEs) because students should learn not only from large and multinational companies. At the same time, these SMEs are more in need of fresh, objective, and innovative inputs. The SMEs that make up the support industries sector for large companies involved in the linkage programs could be a good starting point.
- Students and faculty fielded in the linkage programs should not be limited to those from engineering and management. They should include those from the social and behavioral

Table 1
Industry-Academe Linkage Program of UP, DLSU and Ateneo

FEATURES	UP	DLSU	ATENEO
Title of the Industry Academe Linkage	UP-Manufacturing Linkage Program	DLSU College of Engineering Industry-Academe Linkage (ICL)	Summer Work Practice Program (SWPP)
Initiated by	College of Engineering	College of Engineering	Management Engineering Dept.
Contact Persons	Dr. Rey Vea Dean, CE	Engr. Jesunino R. Rusit Director (ICL)	Ms. Grace de los Santos SWPP Adviser
Date of Establishment	December 1985	May 1987	Early 1980s
Objectives of the Linkage Program	To improve the level and effectiveness and productivity in the manufacturing sector through a well-organized industry-academe linkage program	To have a system whereby industry (companies in manufacturing, construction, electronics and communications, power plants and natural resources exploration & development) and academe cooperate continuously	To serve as the venue for the students to be exposed to actual manufacturing, service and government organizations operations as a supplement to the theories learned in their Management Engineering curriculum

FEATURES	UP	DLSU	ATENEO
	To promote an active linkage between the engineering students of UP, academe, the manufacturing industry, and the government technology agencies so that people from academe (students and faculty) are exposed to the applications of various engineering theories and concepts through actual exposures to manufacturing companies' operations	to improve the quality of engineering students through provision of shop-floor and job-site activities To serve as a venue for the sharing of resources between the industry and academe through its faculty members	
Nature of Linkage Activities	1. Summer Internship Programs 2. Plant Visits 3. Faculty Training 4. Adjunct Professorship or		1. Plant visits 2. Practicum in various functional areas: production, accounting, marketing,

	the concept of having professors from industry 5. Conduct of researches by the Manufacturing Industry Round-table on various problem areas in manufacturing		operations research, statistics, etc.
Institutional Members	1. UP College of Engineering 2. UP College of Business Administration 3. Integrated Microelectronics Inc. 4. Intel Philippines Manufacturing Inc. 5. Johnson & Johnson Philippines Inc. 6. Motorola Philippines 7. Philippine Appliance Corporation	1. Atlas Fertilizer Corporation 2. Avon Products Manufacturing Inc. 3. Caltex (Phils.) Inc. 4. Central Azucarera de Don Pedro 5. Consolidated Industrial Gases Inc. 6. Dutch Boy Phils. 7. Kraft General Foods Phils. Inc.	1. Procter and Gamble 2. Pilipinas Shell and Petroleum Corporation 3. Andersen Consulting 4. IBER Pacific 5. Phinma Group of Companies 6. RAMCAR Inc. 7. Ayala Land 8. Citibank Corporation 9. Hong Kong Shanghai Bank 10. Bank of the Philippine Islands

FEATURES	UP	DLSU	ATENEO
	8. Philippine Electric Corp. 9. Philippine Electrical Mftg. Co. 10. Philips Components Phils. Inc. 11. Phinma Group of Companies 12. Procter and Gamble Phils. Inc. 13. RAMCAR Inc. 14. Resins Inc. 15. San Miguel Corp. 16. SGV Foundation Inc. 17. Vulchem Corp. 18. SGV Foundation Inc. 19. Vulchem Corp. 20. Industrial Technology Development Institute 21. Metals Industry Research and Development	8. Mixed Plant Inc. 9. Nestle Philippines 10. Philippine National Oil Co. 11. Pilipinas Shell Petroleum Corp. 12. Bureau of Research and Standards 13. Philippine Cement Manufacturers Corp. 14. Phinma Group of Companies 15. Analog Devices Phils. Inc. 16. Contel Comm. Inc. 17. Data General Phils. Inc. 18. Equitable Computer Services Inc. 19. Epic Electronics Industries Corp. 20. Globe Telecom Inc. 21. Integrated Microelectronics 22. Intel Phils.	11. PHILAM 12. United Coconut Planters Bank 13. Nongovernment organizations and manufacturing and service organizations

FEATURES	UP	DLSU	ATENEO
		23. LG Collins 24. Philippine Electric Corp. 25. Philippine Global Communication 26. Philips Electronics & Lighting Inc. 27. Pilipino Telephone Corp. 28. Pocketbell-Telectronic System Inc. 29. Precision Electronics Corp. 30. Rohm Electronics Phils. Inc. 31. Siemens Inc. 32. Semigen Micro-assembly and Test 33. SITA 34. Smart Communications Inc. 35. Sun Moon Star Phils. Inc. 36. Artikels International 37. Best Print Textile Finishing Corp. 38. Einsco Company	

FEATURES	UP	DLSU	ATENEO
		39. General Textile	
		40. Jardine CMG Life Insurance Co. Inc.	
		41. Procter and Gamble Phils. Inc.	
		42. Reynolds (Phils.)	
		43. San Miguel Corp.	
		44. Temic Telefunken Micro-electronics Philippines Inc.	
		45. Trinity Steel Prods.	
		46. Universal Robina Corp	
		47. Amkor/Anam Pilipinas 1&2	
		48. Amerton Inc.	
		49. Benedicto Steel Corp.	
		50. Coca Cola Bottlers Phils. Inc.	
		51. Electronics Assemblies Inc.	
		52. Moldtech Phils.	
		53. Motorola Phils.	
		54. Nissan Motor Phils.	

55. Philippine Airlines
56. San Miguel Campofrio Inc.
57. Sekai Electric Mftg.
58. Texas Instruments
59. Toyota Motor Phils.
60. Concepcion Inds.
61. Goodyear Phils.
62. Honda Car Makers
63. Honda Cars Pasig
64. Jag and Haggar Jeans
65. Koppel Inc.
66. National Power Corp.
67. Orthopedic Innovations Phils.
68. Packaging Products Corp.
69. Pan Pacific Service Contractors Inc.
70. Philippine Appliance Corp.
71. Republic Asahi Glass Corp.
72. Solid Mills Corp.
73. Tramat Mercantile

sciences, as the needs of the firms dictate.

- A stronger and more formal linkage program between universities and government R&D institutions should be developed. Theses and dissertations in the S&T areas should complement the work of the government R&D institutions. The government should provide financial support to theses and dissertation work that fall within their priority S&T agenda.
- There should be more government-industry-university technological cooperation for the promotion, generation, and development of creative or innovative work, especially among university students.

Technology Utilization and Commercialization

There is technological cooperation in the area of technology piloting, utilization, and commercialization. In many instances, however, promising R&D results from universities do not go through the full cycle, i.e., up to commercialization, because of several reasons: lack of information on market needs, inadequate facilities for or lack of access to prototype production services, packaging problems, high cost of piloting or prototyping, or lack of continuity in development. The last factor is particularly true in cases involving students.

The UP has embarked on technology parks and technology business incubators program, with the support of the DOST. These are found in Diliman, Los Baños, and Iloilo. Initial experience in Diliman shows that there is no shortage in technology business incubator tenants, and that the incubator tenant type is quite different from the usual researcher type. Why? Because the former is more entrepreneurial. The experience also confirms that technology-based business operations within academic premises benefit both academic and industry sectors. However, business incubator operations are not exactly profitable on the part of the university. An initial assessment shows that the university will not make money out of it, unless it develops a technology park for

larger, more stable companies, in which case the financial returns are to be realized primarily from real estate or property income.

The following recommendations are addressed to government, industry, and universities:

- A mechanism must be drawn to identify R&D outputs that deserve to go through the full cycle of development.
- There must be a financing scheme or source to draw from, for example in the form of venture financing, so that universities can fund product/process development, prototype production, and piloting, payable when financial returns are realized from commercialization.
- High priority should be given to product- or process-oriented R&D.
- Government should go all the way in supporting technology business incubation projects beyond giving initial funding.
- Universities should have their own plans for technology development, and this should be the basis in identifying areas of research by students in science and technology.

Policy-Related Research on Technology

Some universities have been involved in policy studies with specific industry or technology sectors. The NEC has produced studies and policy recommendations in the area of power generation, water supply, and mass transportation systems. It is hoped that, with the inclusion of a Management of Technology component in the Engineering and Science Education Project (ESEP) and the interest generated by the Management of Technology academic programs in UP, there will be more technological cooperation in the area of policy research.

Other Desired Forms of Cooperation

There are other forms of government-industry-university cooperation that should be explored or expanded. The following are highly recommended:

- industry-sponsored laboratories in universities;
- technology enterprise spin-offs involving the university and the private sector; and
- industry support for professorial chairs in science and technology.

There already exists government-industry-university cooperation. However, more universities should be involved. Also greater government support, closer industry involvement, and new forms of cooperation and planning, and coordination are necessary for even more productive undertakings.

NOTE:

[1] The National Engineering Center undertakes research projects which are relevant and responsive to the needs of industry. It has conducted researches, and has acquired the necessary experience to pursue R&D activities in the areas of energy, environmental engineering, hydrology and water resources instrumentation and control, microelectronics, manufacturing materials engineering, and power systems. NEC engages in contract research with various government agencies and private institutions.

The following are NEC's ongoing programs:

Environmental Engineering Research Program

The NEC has an environmental engineering laboratory, equipped with facilities to perform various environmental tests, such as:

- Physical/chemical/bacteriological analysis of water and waste water
- Soil and sand analysis
- Analysis of paint and paint products
- Thermal conductivity of refractory materials, insulating materials, glass, brick, etc.
- Weight and thickness of zinc coating
- Proximate analysis of coal/charcoal
- Heat/acid resistance of waterproofing materials, tiles, etc.
- Chemical analysis of portland cement (type 1)
- Characterization of solid/hazardous wastes

Energy Research Program

In the area of energy, NEC is active in solar photovoltaic (PV) research. It has a solar laboratory, with facilities to test solar PV systems and components. It has also undertaken alternative fuel research, such as gasification, analysis of power systems of various companies, evaluation of rural electric cooperatives, and studies of the economic costs of power shortages.

Manufacturing Research Program

This program has designed and fabricated a prototype of a six-gallon rotary mixer, with speed control. It is used in testing effluent samples for environmental study. A design of an improved mechanical domestic water pumping mechanism has also been completed. The program has a laboratory (Machine and Equipment Design and Fabrication-MEDFAB), which has acquired a machine design software.

Microelectronics Research Program

The program, established in the Microelectronics Laboratory of the College of Engineering, employs its capabilities in design and development work for Application Specific Integrated Circuits (ASIC). A three-phase induction motor controller chip and a STEP remote controller chip have been designed and fabricated.

Among the projects carried out under these programs are:

a. Environmental

- Chemical Hazard Control and Emergency Response Program
- Study on Geothermal Cooling Tower Sludge Treatment and Disposal
- Binding Mechanism of Cement Solidified Nickel Plating Waste Using Ordinary Portland Cement (Type II)
- Toxicity Characteristic Leaching Procedure for Geothermal Sludge and Scale Wastes
- Wastewater Management in Urban Housing Communities
- Urban Solid Waste Management of the Philippines
- Study on Lead Recycling in the Philippines (Environmental Aspects)

b. Energy

- Performance Test on a Modified Vehicle Fueled with Hydrous Alcohol-Gasoline Blend
- Studies on the Gasification of Biomass Fuels with Oxygen-enriched Air
- A Technical and Economic Study of the Prospects of Import Substitution for the Electrical Industry
- Determination of Performance Characteristics of Batteries

for Photovoltaic Application
- Development of Microcomputer Software Programs for Industrial and Commercial Power Systems

c. *Manufacturing*
- Design and Prototype Fabrication of a Straight Line Reciprocating Pump Mechanism with Variable Stroke Level Adjustment for Domestic Artesian Wells for Both Motorized and Manual Pumping
- Performance and Emissions Testing of a Direct-Injection Diesel Engine Dual-Fueled with Natural Gas
- Computer Modeling of Engine Cycles Using Ideal Gas Approximation
- Design and Construction of a Small-Scale Centrifugal Fan Demonstration Unit

d. *Microelectronics*
- Full-custom CMOS Stepper Motor Controller
- Optimized Design of CMOS Operational Amplifiers Using Simulated Annealing
- Intelligent UPS Controller
- MC68HCLL Simulator
- CMOS Cell Compiler
- Field-Programmable Gate Array Based RISC Control Unit
- Field-Programmable Gate Array Based Floating-Point Unit

e. *Electrical Engineering and Electronics*
- Short Circuit and Relay Coordination Studies of Solid Cement Plant
- Survey of Telecommunications Industry Training Needs
- Development of a Low-Cost, Real Time, PC-Based, Low-Frequency Spectrum Analyzer
- Indigenous Design, Development and Testing of Low-Cost Microprocessor-Based Protective Relaying for Industrial Power Systems

f. *Chemical Engineering*
- Development of Scale-up of Lipase Purification System
- Fermentation Engineering for Lipase Production
- Gas Chromatography Analysis of Biogas and Other Fuels

g. *Mining and Metallurgical Engineering*

- Extraction and Purification of Materials for Compound Semiconductors
- Extraction and Purification of Selenium/Tellurium, Zinc and Cadmium, and Sulfur
- Pretreatment of Refractory Gold Ore by Atmosphere Alkaline Oxidation
- Chemical Segregation of Nickeliferous Laterites
- Alternative Methods for the Pre-treatment of Refractory Gold
- Corrosion of Grinding Media
- Sulfuric Acid Leaching of Nonoc (Surigao Nickel) Laterites
- Laterite Reduction with CO/CO2 Gas
- Processing of Sodium/Molybdate from Molybdenite
- Process Evaluation and Upgrading of A.R. Line Materials Center Foundry
- Aqueous Oxidation of Gold-Bearing Pyrites
- Conversion of Arsenic Trioxide to Sodium Arsenate

DISCUSSION

Eduardo R. Magtoto

The cooperation between universities, the government, and industry has been quite extensive, as Prof. de la Pena has noted. Considering that such a working relationship has existed for quite some time, the questions that should now be asked are as follows:

First, to what extent has this working relationship improved our competitiveness? In spite of the the fact that cooperation has existed for some time, previous papers said that we lag behind others technologically. Could there be something wrong in the focus of these activities? If so, what steps must we take so that the cooperative efforts of academe, industry, and government can become more effective in improving our competitiveness? We should be cooperating toward competitiveness, rather than just having cooperative work in itself. How then do we go about determining and selecting the critical researches and services that need support so that there is significant impact on our competitiveness?

In terms of specific areas of government-industry-university cooperation, one requirement mentioned was the establishment of institutions in universities to cater to the needs of industry and government. Given the substantial investment involved, government support is badly needed. These institutions, however, must seek continuing inputs from industry on what it needs, while industry must be ready to utilize the services of these institutions. In addition, inputs from industry must be constant since their needs change over time. It is not enough to have just one meeting and forget about it in the two years. It should be continuing because the process is dynamic.

Furthermore, if substantial amounts of money have been spent by the government in support of R&D, it will be worthwhile to know the impact of these researches on competitive-

ness. For every peso of research assistance given, how much did we gain in costs, additional sales, additional profits, and others? There have been assertions that sometimes these researches were not utilized by government or industry, for one reason or another. Ideally, industry should be preparing to commercialize or utilize the results of research, as they are being completed. It is my understanding that they are doing this in Korea and Thailand.

The role of universities in the development of professionals should be encouraged especially with regards to training, extension, consultancy, and related services. This is good for both the people being trained because they are getting expert advice; and for university personnel, because they will be exposed to actual problems of industry.

Also the establishment of more centers of testing as well as physical and chemical testing facilities, should be encouraged, instead of having a proliferation of a poorly equipped laboratories. The DOST tried to do this years ago, and it is probably still continuing to do so.

On the recommendations for training, extension, and consultancy, a minor amendment would be to add "quality" to "productivity." Quality is actually already assumed when we talk of productivity, but I want to emphasize quality because it is perceived as a problem in many Philippine companies.

Job training is also very important because many employers say that a number of graduates do not have the exposure to equipment and analytical instruments. If students are exposed to the real problems in industry, they are in a better position to appreciate the theories taken up in class.

I also agree with the recommendation to have more training with small- and medium-scale enterprises (SMEs), but the problem is that many SMEs do not want to open their facilities, for one reason or another.

On technology commercialization and utilization, one of the recommendations is to find ways of utilizing inputs from the university, which is a supply-oriented approach. We could also look at the demand-oriented approach, in which researches are

based on the demands of industry, determined through consultations between industry and the university.

The university should work hand-in-hand with industry on plans for technology development in order to pinpoint areas for development.

Essentially, we have had good cooperation in meaningful projects, and we should continue monitoring this.

Part III
TECHNOLOGY AND GROWTH

Technology, Productivity, and Competitiveness

EPICTETUS E. PATALINGHUG

Chapter 5

1. Introduction

Evidence from developing countries shows considerable differences in the intensity with which firms use industrial technology. Firms also differ in how they cope with technological change, i.e., either by continuing adaptation, incremental improvement, internal development, or learning-by-doing. Technology plays a major role in attaining industrial competitiveness, and so it is less relevant to ask whether or not the government should be a key player in high-tech markets. What is relevant now is the question of the most effective forms of government intervention.

This chapter emphasizes the relationship between technology, productivity, and competitiveness. Section 2 reviews the empirical measure of productivity. Section 3 cites the various studies on productivity estimation in the Philippines. It discusses in detail the empirical evidence on various measures of productivity, as well as the trend in total, agricultural, and industrial productivity. Section 4 discusses the link between productivity and competitiveness, and explains the factors behind the slow export and growth performance of the Philippines, compared to its ASEAN neighbors during the last fifteen years. Section 5 elaborates on the diverse literature on technology and competitiveness. Section 6 focuses on the relevance of the catch-up hypothesis. It also relates the technological-convergence hypothesis with the concept

of social capability. Finally, Section 7 analyzes the need for implementing an industrial targeting policy to hasten technology transfer and enable one to catch up faster.

2. Measuring Productivity

The term "productivity" refers to either the total factor productivity (TFP), which denotes the ratio of real output to total real inputs, or the partial factor productivity, which pertains to the ratio of output to a particular input in real terms (e.g., labor productivity, capital productivity, raw materials productivity, and land productivity). For instance, labor productivity growth is measured as the difference between the rate of increase in output and the rate of increase in labor input (Madison 1987).

The various approaches in measuring productivity assume that the excess in the growth of measured output, over the growth of measured inputs, generates a "residual." Productivity studies in various countries have found that the growth of output increases significantly greater than input growth. The residual is considered a measure of shifts in the production function, economies of scale, technological change, advances in knowledge, and improved resource allocation. Nelson (1981) calls the residual a "measure of our ignorance, and accounts for a hodgepodge of factors." The magnitude of the residual is sensitive to how inputs are defined. Quality adjustments in the measurement of input quantities have been made in some studies (Denison 1962; Jorgenson and Griliches 1967). Labor can be classified by education, age, and sex. And capital can be classified into machinery and structures, or by its vintage. Some studies attempt to account for other inputs, such as natural resources, energy, and R&D spending, as separate inputs, in order to squeeze down the size of the residual or "soften the association of technological advance with the residual" (Nelson 1981). Higher estimates of technical progress have been observed in studies where no quality adjustments were made. Quality adjustments reduce the contribution of technical progress, and increase the contribution of measured inputs. This explains the major differences in estimates of total factor pro-

ductivity across time for a given country, productivity estimates among countries, and the contribution to growth among various sources.

One of the objections raised by Nelson (1981) against orthodox literature deals with the assumption of competitive equilibrium, which ignored Schumpeter and Kuznets' characterization of growth as a disequilibrium process. The other major objection he raises deals with the assumption in most productivity models that technological knowledge is a public good, which runs counter to the findings of some studies (based on evolutionary economics) that stressed the important role played by uncertainty in the creation or evolution of new technology, and the existence of differences among firms in technology adopted. Nelson suggests that future productivity studies must depart from the traditional framework where a profit-maximizing firm, facing known factor prices, is operating in an environment of "widely available technological knowledge." Research on the economics of technological change must also focus on the effect of uncertainty, incentives, and property rights on the relationship between R&D and productivity growth. Another area where new direction in productivity research needs reorientation deals with the role of economic environment, and political and social institutions, in enhancing the complementarity among three sources of growth: capital accumulation, education, and technological progress.

3. The Sources of Productivity Growth

Productivity estimates, derived from studies utilizing different methodological approaches, are shown in tables 1 to 5. Table 1 shows Hooley's (1985) productivity estimates for the manufacturing sector, by sub-periods. Hooley's study shows a decline in total factor productivity by 0.15 percent per year, from 1956 to 1980. Hooley explains that the decline in total factor productivity could not be attributed mainly to "inefficient resource allocation among industries," as Williamson and Sicat (1968) suggest. Hooley says that, in addition to the interindustry shift factor, the following factors are equally significant in explaining the decline of total factor productivity in Philippine manufacturing, from 1956 to 1980: (1) the sig-

nificant expansion of government owned and controlled corporations; (2) the sharp rise in oil prices, fuel shortages, and power "outages;" (3) the industry's miscalculation of the duration and magnitude of the decline in output, spurred by the recession from 1975 to 1978; (4) the increased centralization of economic decision making (that encouraged managers and workers to ingratiate themselves with and entertain top decision makers, instead of engaging in efficiency-raising activities); and (5) the absence of research and development in industry, despite windfall gains from the commodity boom during 1972-1974 (Hooley 1985). One of the policies affecting the decline in total factor productivity is the tariff policy on import, which reduced the prices of inputs, from 5 percent to 10 percent between 1956 and 1969. This has made input prices too cheap, compared to their world market levels. Expectably, raw material productivity declined, at 1.36 percent per year, for the period 1956-1980 (Hooley 1985).

From the perspective of this paper, the lack of R&D activities during the import-substitution phase of Philippine industrial growth runs counter to the experience of successful Japanese firms in the VCR industry, which adopted a long-term strategy and outlook and successfully developed their competitive edge through technology (Morone 1989).

Another issue raised by Hooley's study is the implementation of an inappropriate industry targeting policy, which favored poorly performing capital-intensive industries (e.g., petroleum, iron and steel, and industrial chemicals), instead of exploiting the efficiencies of labor-using, import-substituting industries (e.g., food processing, beverage, tobacco, and apparel). According to Intal (1991), the Philippines has followed the Latin American path of economic development, by shifting from the first stage of import substitution (focused on nondurable consumer goods) to the second stage of import substitution (focused on consumer durables, intermediate goods, and capital goods). In contrast, the Asian NICs (Hong Kong, Singapore, South Korea, and Taiwan) have moved rapidly from the first stage of import substitution, to the first phase of export orientation (primarily based on labor-intensive manufactured exports). And, all these NICs are now firmly at the second phase of the export-

oriented strategy (primarily based on capital- and technology-intensive manufactured exports).

Table 2 presents a cross-section of studies in productivity growth in Philippine manufacturing. Studies by Hooley (1985) and Cororaton et al. (1995) show that total factor productivity is attributed more to technical efficiency than to technological progress. The former refers to the movement from current practice to best practice in the industry. The latter refers to the movement of technological frontier over time: in terms of developing new technology; acquiring new technology from abroad through licensing and technical agreement; or adapting new or improved technology through diffusion, learning-by-doing, imitation, or information embodied in the new equipment. The limited evidence on Philippine manufacturing consistently points to a failure in policy and practice of industries which were not able to consider the technology factor in achieving long-run competitive advantage. At best, the evidence indicates that even if some industries are moving toward "best-practice," the "best-practice" itself is way below the best in international standards.

One of the disappointing realities in Philippine productivity research is that although the first hypothesis researchers want to investigate is the empirical relationship between R&D expenditure and productivity, the data series (aggregative or firm-level) on R&D expenditures are either poor or nonexistent. For instance, consider Hooley's attempt (1985) to specify R&D in his productivity regression equation. This valiant but pathetic effort to measure the effect of the R&D variable has produced the expected positive coefficient, but the estimate is not statistically significant. The same result is experienced by the study of Cororaton et al. (1995). In Hooley's case, R&D is defined alternatively as: (1) number of patents applied for in the Philippine Patent Office (compiled by industry); and (2) compilation of research work done for others by industry. Either variable does not capture informal R&D activities of many small enterprises (Hooley 1985; Ranis 1995). The disappointing state of data collection in this area is summarized by the following statement: "Hopefully, at some future date, there will be actual data on

the value of R&D expenditures by industry" (Hooley 1985: 49). But data availability has not improved.

Table 3 presents estimates on productivity studies in agriculture. In all studies covering the period 1948 to 1974, output growth in agriculture has not exceeded 5 percent, even for periods when land was still plentiful. On the other hand, expenditures on current inputs (e.g., fertilizer, agricultural chemicals, seeds, and irrigation services) have grown rapidly during periods when land-man ratios were relatively higher (e.g. 22.5 percent in 1948-60, compared to 9.2 percent in 1960-67). At any rate, the vanguard sector of the economy has been relying more on input growth, particularly in the increase of capital input, both fixed and current, to boost the agricultural output growth performance. The contribution of agricultural productivity has been inferior to the contribution of measured inputs. But the performance of agricultural productivity has been comparatively better than the performance of manufacturing productivity.

At the national level, table 4 shows a cross-section of productivity studies, which identify the contribution of the different sources of economic growth. In percentage points, the contribution of productivity from 1947 to 1982 ranges from 15 to 55 percentage points. However, a recent study (Austria and Martin 1992) covering the period 1950-1987 produces a negative residual—the weighted contribution of measured inputs exceeds the growth of national output. One study (Patalinghug 1984) has made quality adjustment to the labor input. The study's findings quantify the contribution of education to economic growth during the 1960-1984 period, at 6 percentage points. These studies assume the additivity of the different sources of growth.

This brings us to the point raised by Nelson (1981) that "where complementarity is important, it makes little sense to try to divide up the credit for growth, treating the factors as if they were not complements" (p. 1053). Thus, if new capital embodies an advanced technology which requires highly educated technical manpower to operate, it makes little sense to decompose the contribution of education, technological advance, and capital accumulation to growth.

Table 5 presents a comparison of the productivity performance between the Philippines, Taiwan, and South Korea. The following pattern is discernible. First, in the Philippines, the average annual growth rate is, at best, half of Taiwan's and South Korea's. Second, the country's growth in measured inputs contributes largely to the growth in real output. But, in Taiwan and South Korea, output growth is largely accounted for by the growth in total factor productivity. And third, the absolute growth rate of productivity in Taiwan and South Korea is three and five times that of the Philippines, respectively. Fabella (1993) regards this situation as the predicament of "inward orientation (that) leads to low investment growth and low investment growth leads to low productivity and poor competitiveness" (p. 10). But Krugman (1994b) challenges the view of a World Bank study (1993) that the highly performing Asian economies (HPAEs) are fueled by high productivity growth. He thinks the "East Asian miracle" is a myth because growth in measured inputs (investment flows), rather than growth in productivity, artificially fueled their economic progress—reminiscent of the Soviet strategy in the 1960s and 1970s. But some studies argue that while the extensive growth strategy led to the eventual stagnation of the Soviet Union, the same strategy has sustained the rapid growth of the HPAEs. Nevertheless, even if total factor productivity growth is accepted as the engine of growth in the HPAEs, rising capital-output ratios in East Asia are clearly observed (Easterly and Fischer 1995). While more investment flows are better than less investment flows, sustainable growth is not guaranteed unless the complementarities of capital investment and technological advance are demonstrated.

4. Productivity and Competitiveness

International competitiveness is the favorite industrial policy topic in the era of global competition. Krugman (1994a) has admonished everyone to avoid pursuing the confusing issue that a country must be productive in order to compete in the global economy. In Krugman's words, "Productivity and competitiveness have very little to do with each other.... A country whose productivity is low across

the board is not going to have a high standard of living; but that has nothing to do with the fact that it must coexist with more productive nations.... Low productivity relative to other countries is not only a disaster; it is irrelevant... Productivity is important, but international competitiveness has nothing to do with it.... The whole concept of competitiveness is at best elusive, at worst meaningless" (pp. 269-280). The study of Cororaton et al. (1995) supports Krugman's hypothesis. The regression coefficient of the international-competitiveness variable on productivity is not significant. On the other hand, Amsden (1989) insists that the creation of Korean competitiveness in steel depended on higher productivity, instead of lower wages.

Let us turn to the various issues affecting Philippine competitiveness. Fabella (1993) contends that competitiveness is attained by a cheap-peso policy. But, impediments to devaluation-induced competitiveness exist. In another study, Intal (1991), using indices on revealed comparative advantages, documents the deterioration of Philippine competitiveness in the 1980s. He analyzes the role of labor productivity, real exchange rate, and infrastructure in the country's poor export and growth performance, as shown in tables 6 and 7. Table 6 shows that, in terms of trends in labor productivity, the Philippines lagged behind all countries except in agricultural productivity with respect to Indonesia and Thailand. Table 7 shows that China and Indonesia follow a devaluation-induced competitiveness policy, which has made their exports more price-competitive vis-à-vis Philippine exports. At the bottom of this analysis is the need for economic policy reforms to improve the country's international competitiveness.

Development Alternatives, Inc. (1991) data on indices of output per worker, by industry, in selected Asian countries, are shown in table 8. One way of looking at these data is to conclude that Indonesia is gaining vis-à-vis the Philippines in such areas of manufacturing as textile, apparel, footwear, wood, furniture, printing, glass, and electrical machinery. Another interpretation of table 8, especially for firm managers, is that attaining international competitiveness in their particular industry is still possible, despite the lack of

stable macroeconomic policy, rising wage rates, overvalued exchange rate, and low national productivity. However, a firm must find a competitive factor to succeed in a tilted playing field. Morone (1993) argues that globally competitive US firms built global leadership through technology.

The World Bank (1993) attributes the so-called rapid productivity growth among HPAEs to better technology, innovations on the shop floor, gains from specialization and better organization. But empirical estimates of technical efficiency change show that Indonesia, South Korea, Malaysia, and Singapore have not been characterized as shifting rapidly from average practice to best practice. Freeman (1994) indicates that the World Bank (1993) study "denies any role for active industrial and technology policies and has little to say about new technology" (p. 213). A research study on productivity, technology, and competitiveness must veer away from aggregate and country studies. Instead, it must stress how industrial R&D and technology upgrading (e.g., electronic industries in Korea, Singapore, and Taiwan) were complemented by a well-functioning system of innovations that allowed these tigers to eventually catch-up.

5. Technology and Competitiveness

The Japanese historical experience is said to be particularly relevant to many Asian countries. Japanese efforts to bring about a rapid transfer of western technology, at the beginning of the Meiji period, were made under conditions of scarce capital and natural resources, not unlike the situation faced by many developing countries (Rosenberg 1990). The Japanese experience also reinforces the problem faced by innovating firms today, particularly the need to assess alternative technologies available in the market.

"In the Japanese case, the need to adapt foreign technology to domestic circumstances was not understood at first. Dutch water-control technology, for instance, was introduced without considering that, in addition to tidal forces, mountain runoff was a major source of flooding. Similarly, in 1871, the Japanese government imported a vast mechanized silk reeling plant from France. While it

was intended as a model factory, private business discovered that it could not operate such capital-intensive plants profitably." (Rosenberg 1990: 152)

Nevertheless, the Japanese learned from their mistakes. Another lesson is the recognition that the firm is the focal point in the process of technology transfer. In many countries trying to catch up technologically, several research laboratories are set up, but they are not matched by technological capabilities in firms themselves. In Rosenberg's (1990) analysis, the failure of the Council for Scientific and Industrial Research (CSIR) to make any discernible impact on the productivity and efficiency of the industrial sector is due to its detachment from the market needs of Indian firms. The Indian case illustrates not only the importance of building up educational, scientific, and research infrastructure, but also the need to improve the effectiveness of the adoption and commercialization of new technologies.

In addition, the objective of encouraging the development of technological capabilities within firms is consistent with the experience of technologically advanced countries, where technology emerges mainly from corporate research and development (although it is highly dependent on academic research). Technology importation is not merely the purchase of production inputs, and the licensing of production know-how; it also requires a strong capacity for reverse engineering, including informal R&D in the shop floors of small entrepreneurs and innovators.

The role of private-sector R&D in South Korea, as opposed to public-sector R&D, is illustrated in table 9. Private-sector R&D expenditures are four times those of the public sector. In addition, both Japan and South Korea's R&D systems have been changing, in response to the dynamic technological and competitive environment. Table 9 likewise shows South Korea's efforts at achieving rapid technological catching-up. Its R&D expenditures, as a percentage of GNP in 1993, approach the levels of R&D investment in Japan, Germany, and US. The dominant role of corporate R&D in South Korea is shown in table 10, indicating that R&D expenditures in national and public institutions are three times the R&D expendi-

tures in universities and colleges. However, in table 11, the dominant role of federal sources in support of basic research in the US is shown. The percentage of government R&D to the total US R&D reached 67 percent in 1963 (Mowery and Rosenberg 1989), but declined to slightly below 50 percent thereafter. South Korea and the US assign different roles to the private sector in their respective R&D systems. Since R&D in the US is heavily geared toward the military sector, the greater role of the government is observed. But the declining spillover effects of military R&D to civilian and commercial uses have led analysts (Thurow 1992) to conclude that civilian R&D expenditures of the US as a percentage of GNP fall behind those of Japan and Europe.

One of the objectives of the research agenda in the next section is to determine where our firms and industries stand in the technology game. We need to assess where we stand in terms of the following technologies: data-based systems, biotechnology, advanced materials, design and engineering tools, pollution reduction, software, computers, portable communications equipment, chip-making equipment and robotics, electronic packaging, flat-panel displays, materials processing, optical storage, manufacturing processes, superconductors, voice recognition and vision in computers, microelectronics, and magnetic information storage.

The framework in assessing the historical trends in the growth of industrial research must start with the DOST data on employment, scientific personnel, research intensity, and employment concentration in Philippine manufacturing, classified by industry. The objective is to evaluate the laboratory foundations, rather than just their employment in the different manufacturing industries. The hypothesis is that rapid expansion in a given industry could be attributed to the scientific investments or laboratory foundations made in earlier periods.

6. The Catch-up Hypothesis

The catch-up or convergence hypothesis asserts that "in comparisons across countries, the growth rates of productivity in any

long period tend to be inversely related to the initial levels of productivity" (Abramovitz 1986: 386). The hypothesis implies that the larger the technological or productivity gap between Japan and the Philippines, the stronger the Philippines' potential for growth in productivity is and the faster its expected growth rate.

Baumol (1986) argues that the convergence of national productivity and per capita income levels show itself strongly in industrialized market economies, not in less developed countries.

Moreover, in Abramovitz's (1986) analysis, the catch-up or convergence hypothesis is not simple. It has to be qualified because "technological backwardness is not usually a mere accident." The convergence hypothesis is not based on technological backwardness alone. An adequate "social capability" is required for a technologically backward country to absorb advanced technologies. Rapid realization potential needs the strengthening of the educational, institutional, and organizational components of "social capability."

In analyzing the process of technological change in the US machine tool industry for the period 1840-1910, Rosenberg (1963) observes that similar processes and problems in the production of a wide range of disparate commodities (e.g., firearms, sewing machines, bicycles, and automobiles) were encountered. Thus, he concludes that the technological basis in the production processes of different industries was closely related. Rosenberg (1963) calls this phenomenon "technological convergence." Morone (1993) shows that globally competitive Japanese firms were concentrated in consumer electronics, liquid crystal display, microelectronics, copiers, computers, telecommunications, machine tools, robotics, automobiles, and scientific/precision instruments. One of the objectives of future research then is to investigate whether the Japanese experience, or even the South Korean experience, is a confirmation of Rosenberg's concept of technological convergence.

Abramovitz's concept of "social capability" and Rosenberg's concept of "technological convergence" are mutually reinforcing. Its relevance for less developed countries in general, and for the Philippines in particular, is to investigate whether Rosenberg's con-

cept of technological convergence is, or will be, occurring in the twentieth and twenty-first century, respectively.

7. Industrial Policy

Economists disagree on what policies are needed to achieve technological and economic development. The World Bank (1993) and Krugman (1984) have shown that the policy of industrial targeting is not an effective tool for achieving economic development. But Amsden (1989) has strongly argued for the appropriateness of carrying out an industrial targeting policy to hasten technology transfer and enable countries to catch up faster.

Even if industries are tradition-bound, catch-up strategies can still be effective, as long as markets are open and resources are mobile (Nelson and Wright 1992). Teece (1992) suggests a different perspective in assessing technological innovation. To analyze new market opportunities, he suggests avoiding the situation "where firms were first to commercialize a new product, but did not participate in the profits subsequently generated from the innovation" (p. 175).

Based on our literature review, the "leapfrogging strategy," suggested by Talisayon (1994) for the Philippines is misplaced as long as Abramovitz's concept of building "social capability is not addressed first. The suggestion of Lall (1992) that misguided government intervention and political weakness in policy making expose industrial policies to "hijacking" by vested interests is nothing new. It is more appropriate to assess whether the new policy of the Board of Investments -- to require the use of brand-new equipment in at least 21 sectors ("BOI Requires Brand New Equipment in Twenty-one Sectors" *Manila Bulletin*, January 7, 1996)—is consistent with the question: does investment in new technology improve productivity? Or is innovation limited to large firms (Pavitt 1992) that satisfy certain characteristics?

Table 1

Philippine Manufacturing Annual Growth Rates in Partial and Total Factor Productivity, 1956-1980 (In Percent)

	1956-60	*1961-65*	*1966-70*	*1971-75*	*1976-80*	*1956-80*
Output Per Unit Of:						
Labor	5.55	3.27	4.87	0.59	-4.04	2.05
Capital	0.78	2.95	2.89	1.37	2.72	2.15
Intermediate Goods	-0.51	-2.58	-0.26	-1.50	-1.86	-1.36
Total Factor Input	1.18	-0.71	1.22	-0.55	-1.90	-0.15

Source: Richard Hooley, Productivity Growth in Philippine Manufacturing: Retrospect and Future Prospects. PIDS Monograph Series No. 9 (December 1985).

Table 2

Annual Rates of Growth of Input, Output, and Productivity in Philippine Manufacturing (In Percent)

Author(s)	Time Period	Capital	Labor	Intermediate Inputs	Technological Progress	Technical Efficiency	Output
Sicat (1968)	1957-1962	11.4	5.9	N.A.	1.1	N.A.	10.9
Sicat (1968)	1960-1965	4.4	6.6	N.A.	2.4	N.A.	7.6
Patalinghug (1980)	1956-1970	6.1	5.4	N.A.	3.5	N.A.	9.5
Hooley (1985)*	1956-1970	1.9	2.5	6.5	-0.74	-0.18	10.2
Hooley (1985)*	1971-1980	1.1	2.3	5.5	-2.3	-0.30	6.6
Cororaton, et al. (1995)*	1956-1992	1.4	0.97	2.5	-1.7	2.5	5.6

Source: Derived from cited studies.

**Refers to contribution to growth (decline) in percentage points,* growth rates weighted by relative factor shares.

Table 3

Annual Rates of Growth of Input, Output, and Productivity in Philippine Agriculture

(In Percent)

Author(s)	Time Period	Capital	Labor	Land	Operating Expenses	Productivity	Output
Paris (1971)	1948-1967	13.3	3.1	7.4	16.8	0.4	4.2
Paris (1971)	1960-1967	10.9	3.0	6.3	9.2	-0.1	3.0
Crisostomo (1972)	1957-1967	4.9	2.1	1.1	6.2	1.7	3.7
Crisostomo (1972)	1948-1967	6.8	2.5	2.5	10.0	1.1	4.1
Patalinghug (1980)	1956-1970	5.1	0.9	5.6	N.A.	2.1	5.2
Patalinghug (1980)	1956-1974	5.4	-0.9	3.1	N.A.	1.5	3.1

Source: Derived from estimates of cited studies.

Table 4

Contributions of the Different Sources of Philippine Growth

(in Percent)

Author(s)	Time Period	Capital	Labor	Land	Education	Technological Progress	Total	GDP Growth
Williamson (1969)	1947-1955	9	33	3	N.A.	55	100	7.3
Williamson (1969)	1955-1965	25	55	5	N.A.	15	100	4.5
Sanchez (1983)	1960-1973	24	52	N.A.	N.A.	24	100	4.6
Patalinghug (1984)	1960-1982	48	23	N.A.	6	23	100	5.5
Austria & Martin (1992)	1950-1987	87	24	N.A.	N.A.	-11	100	4.6

Source: Caesar B. Cororaton, Benjamin Endriga, Derrick Ornedo, and Consolacion Chua, Estimation of Total Factor Productivity of Philipine Manufacturing Industries: The Estimates. Discussion Paper No. 95- 32, Philippine Institute for Development Studies (November 1995).

Table 5

Contribution of Real Factor Growth and Total Productivity Growth of Real Output (Average Annual Growth Rates)

	Philippines (1960-1969)	Taiwan (1960-1969)	South Korea (1960-1973)
Real Output	0.044	0.089	0.097
Real Factor Input	0.031	0.044	0.055
Total Factor Productivity	0.013	0.045	0.066

Source: Raul Fabella, Efficiency and Competitiveness: The Role of the Exchange Rate. PHILEXPORT/PITO-P Policy Paper (November 1993). These figures were derived from Sanchez' (1983) study.

Table 6
Indices of Average Labor Productivity for Selected Asian Countries: 1975-1990 (1975=100)

Country	*1975*	*1980*	*1985*	*1990*
China				
Overall	100	122	166	203
Indonesia				
Overall	100	126	131	140
Agriculture	100	117	121	113
Manufacturing	100	156	195	227
Malaysia				
Overall	100	125	138	163
Agriculture	100	133	159	182
Manufacturing	100	104	117	161
Philippines				
Overall	100	120	96	104
Agriculture	100	119	115	123
Manufacturing	100	122	107	119
Singapore				
Overall	100	116	147	187
Agriculture	100	114	219	265
Manufacturing	100	114	136	189
Thailand				
Overall	100	118	136	167
Agriculture	100	101	116	118
Manufacturing	100	121	131	165

Source: Ponciano Intal Jr., Taking the Flying Wild Geese to Heart: Economic Policy and Industrial Restructuring Challenges for the Philippines in the 1990s (1991). Unpublished.

Table 7

Real Effective Exchange Rate Indices for Selected Asian Countries: 1975-1990 (1975 = 100)

Country	*1975*	*1980*	*1985*	*1990*
NICs				
Hong Kong	100	110	93	82
South Korea	100	105	105	80
Singapore	100	111	103	101
Taiwan	100	110	93	82
Asian-4 & China				
Indonesia	100	141	162	239
Malaysia	100	125	109	129
Philippines	100	99	101	112
Thailand	100	109	113	115
China	100	116	195	215
South Asia				
Bangladesh	100	132	146	123
India	100	130	129	161
Pakistan	100	115	134	176
Sri Lanka	100	260	221	261

Source: Ponciano Intal Jr., Real Exchange Rates. Price Competitiveness and Adjustment in Developing Asia, 1975-1990, *Asian Development Review* (March 1992).

Table 8

Indices of the Level of Output per Worker for Selected Asian Countries: 1986 (Singapore = 100)

Industry	*Indonesia*	*S. Korea*	*Malaysia*	*Philippines*	*Singapore*	*Thailand*
All Manufacturing	60.68	127.96	50.97	86.06	100.00	63.27
Food	45.23	145.24	59.73	116.23	100.00	64.37
Beverage	59.06	176.74	57.39	120.37	100.00	101.05
Tobacco	31.01	599.34	117.07	160.94	100.00	81.21
Textile	68.50	153.07	54.68	41.37	100.00	42.69
Apparel	99.81	183.07	56.87	64.61	100.00	56.66
Footwear	207.47	239.01	92.55	51.41	100.00	N.A.
Wood	126.11	134.12	53.69	46.75	100.00	15.66
Furniture	70.96	195.37	61.16	41.12	100.00	N.A.
Printing	66.91	157.27	50.24	42.58	100.00	32.74
Chemicals	45.29	95.94	115.44	89.37	100.00	30.60
Rubber	55.19	100.02	77.72	76.71	100.00	110.21
Glass	160.22	179.20	69.68	80.77	100.00	38.81
Machinery	62.67	155.86	46.38	43.19	100.00	41.80
Electrical Machines	94.73	152.63	51.23	76.24	100.00	69.88

N.A. = not applicable

Source: DAI, Philippine Trade and Investment Regimes: A Comparison with Asian Neighbors, Table 31, p. 79 (December 1991).

Table 9

South Korea R&D Expenditures by Sector, 1989-1993

(in million dollars)

Year	Public Sector (%)	Private Sector (%)	Total (%)	% of GNP
1989	829 (20)	3,317 (80)	4,146 (100)	1.90
1990	888 (19)	3,788 (81)	4,676 (100)	1.88
1991	1,093 (20)	4,373 (80)	5,466 (100)	1.94
1992	1,139 (18)	5,189 (82)	6,328 (100)	2.09
1993	1,295 (17)	6,320 (83)	7,615 (100)	2.33

Source: Ministry of Science and Technology, Republic of Korea, *Science and Technology in Korea*: 1995.

Table 10

South Korea R&D Expenditures by Research Institute, 1989-1993
(in million dollars)

Year	*National & Public Institutes (%)*	*Universities & Colleges (%)*	*Private Companies (%)*	*Total %*
1989	746 (18)	332 (8)	3,068 (74)	4,146 (100)
1990	1,029 (22)	327 (7)	3,320 (71)	4,676 (100)
1991	1,203 (22)	383 (7)	3,880 (71)	5,466 (100)
1992	1,329 (21)	380 (6)	4,619 (73)	6,328 (100)
1993	1,599 (21)	533 (7)	5,483 (72)	7,615 (100)

Source: Ministry of Science and Technology, Republic of Korea, *Science and Technology in Korea*: 1995.

Table 11

U.S. Sources of Funds for Basic Research by Sector, 1975-1984

(in million dollars)

Year	*Total*	*Federal Government*	*Industry*	*Universities & Colleges*	*Other Nonprofit Organizations*
1975	4,608	3,139	705	478	286
1976	4,977	3,436	769	475	297
1977	5,537	3,823	850	527	337
1978	6,392	4,445	964	605	378
1979	7,257	5,044	1,091	711	411
1980	8,089	5,559	1,265	805	460
1981	9,217	6,236	1,585	909	487
1982	9,886	6,588	1,805	983	510
1983	10,610	6,970	2,025	1,075	540
1984	11,850	7,775	2,270	1,220	585

Source: David Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth*, Cambridge: Cambridge University Press, 1989.

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DISCUSSION

Emma Teodoro

I represent the Philippine Exporters Confederation (PhilEXPORT), and the electronics sector. While the presentation did not show figures on the electronics sector, PhilEXPORT has been very proud of it because it has been carrying much of our exports; in fact, it has been moving our export volume for the past years. This sector represents more than 2,000 exporters in the Philippines, and many of these exporters are very, very small companies. Large companies comprise account for less than 30 percent. There is, therefore, a need to expand the use of technology among these companies.

But although our export volume has been increasing in terms of value, there is great concern regarding other sectors, such as garments and textiles, jewelry, and accessories. In almost all these other sectors, we need to increase our export volume.

We have seen figures from the macro perspective. If we want to make sure that we have increased productivity, the analysis has to be done on a sectoral level. How then can we bring down the increasing costs of production and, at the same time, increase the value of outputs?

Another major concern is the move toward increasing salaries which, as you know, is now being enforced on a nationwide basis. Some sectors are exempted from this, but in most cases, we have to follow the salary rates prescribed by the Department of Labor.

There is, therefore, great concern in making inputs more efficient, in order to achieve a net increase in productivity. For example, one of the factors that contribute to high cost is *electric power*. Power rates are more expensive here than in our neighboring countries. These are areas needing government intervention.

Among the ideas put forward earlier is that *technology knowledge* may not be a public good. Today, there are changing paradigms

regarding this point, such as cheap access to information use. We have to look at how public information can be accessed by small organizations as well, instead of just the larger organizations that have the money to set up telecommunications infrastructure.

The use of information technology may improve productivity through more automated processes within the organization. Production scales, carried out within the manufacturing workflow, may even increase with the provision of a complete feedback mechanism, thereby increasing the net output of manufacturing processes.

Telecommunications has become competitive worldwide. There was a time when prices quoted in this sector were lower than those in our counterparts in Malaysia, Indonesia, and China. But in most cases today, we are $3 higher on the average. Even in the software sector, our prices are higher than those in India, a major competitor in the software business.

Our costs rise because we have to increase the salaries of our people. The salaries of information technology or computer professionals in the Philippines have been affected by worldwide salary requirements, notably in Singapore and the United States, two countries absorbing most of our technical people. Their higher salary rates have affected our local salary scales, forcing consequent increases in order to remain competitive.

In all, there are so many factors affecting our export industries and although one of the papers argued that there is no such correlation, I hope we could help our export community increase productivity and thereby become competitive.

Technology Policy: Lessons from the East

GWENDOLYN R. TECSON

Chapter 6

There are a number of reasons why a country like the Philippines, used to looking West, should start looking East.[1] Probably the most salient of these is that, being a latecomer economy, it is easier for the Philippines to find affinities with other latecomer economies that had been through a similar catching-up process, but had successfully hurdled the difficulties it entailed. While the title of this chapter may evoke technology policy emanating primarily from the State, the emphasis is on private-sector strategies of technology acquisition. For, contrary to popular belief, the East Asian industrial successes were, for the most part, led by the private sector.

This chapter's unabashed objective is simply to find out how a number of our East Asian neighbors managed to acquire technology and "tamed" it to their economic advantage. Because a number of macro-based, country-specific studies already exist[2] and the lessons for technology development are fairly well known, the present study chooses to probe deeper into these "lessons" by examining it at the industry-level, across countries, and through time. A corollary objective is to draw lessons on how latecomer countries managed to build up an important segment of their capital goods sector, a sector that is highly underdeveloped in the Philippines. The sector is widely perceived as occupying a crucial role in the generation and diffusion of technical change. Rosenberg

(1976) notes that a developing country's lack of a domestic capital-goods sector implies that the country is unable to develop the technological base of skills, knowledge, facilities, and organization necessary in further technical progress.

This explains the choice of the study's point of reference, the machine tool industry, referred to by the Japanese as the "mother-machine" because it builds other machines. Although classified as "Second Wave" technology, the industry has entered the threshold of the "Third Wave," through its adoption of numerical-control technology—a development that has made it somewhat difficult to access, even for the present Newly Industrialized Economies (NIEs). But precisely because it seems to ride the Second and Third Waves, the machine tool industry is an interesting case study for the technology acquisition policy of contemporary developing countries.

Section 2 presents some conceptual considerations on the modes of technology acquisition by a latecomer economy. The section also discusses the problems encountered in the transfer process and the necessary conditions for success in technology transfer arrangements. Furthermore, it tackles the issue of the role of the State in the process of a developing country's improvement of its technological capabilities. Section 3 presents and discusses data on the technology-sourcing experience of four East Asian countries—Japan, Taiwan, South Korea, and China—in the context of their machine tool (MT) industry development. It also provides a brief discussion on the role of the State in the development of technological capabilities in these countries. The final section presents a summary of findings and "learning points" for latecomer countries like the Philippines.

Theoretical Considerations

A. *Sources of Industrial Competence in a Developing Country*

There are two sources of a latecomer country's industrial competence: foreign (through international technology transfer) and domestic (through indigenous technological effort). Foreign sourcing

involves both "vertical" and "horizontal" technology flows. Vertical flows are from industrialized to less industrialized countries (e.g., from the United States or Japan to an NIE), while horizontal ones take place among countries at similar levels of industrialization (e.g., cross-licensing between Japan and the United States, or between Taiwan and the Republic of Korea). In the early years, it is typical for a latecomer economy to depend heavily on the existing backlog of foreign technology. However, economic literature has emphasized the importance of indigenous sources of technological capability, which is not only crucial in the mastery of received technology, but is also considered the wellspring of innovations (Kim 1982).

Modes of Technology Transfer

Fransman (1986) provides a useful categorization of the different modes of technology transfer, depending on whether the transferor is active or passive (Dahlman and Westphal 1982), and whether the transfer is formal (market-mediated) or informal (nonmarket-mediated).

Modes of Technology Transfer

Type of Transfer	Active Role for Transferor	Passive Role for Transferor
Formal (Market-mediated)	Direct Foreign Investment Joint Venture Turnkey Project Management Contract Licensing	Machinery Purchase
Informal (Nonmarket-mediated)	Learning-by-selling	Imitation and reverse engineering Trade Journals, etc. Scientific Exchange

Most discussions have been devoted to the market-mediated mode in which the transferor plays an active role, such as in the traditional forms of foreign direct investment (FDI) with full ownership of a foreign subsidiary, and "new" forms of investment, like joint ventures, turnkey projects, management contracts, and licensing agreements (Oman 1984). The transfer is said to be market-mediated when it normally involves an exchange of assets that carry a price. For instance, in licensing agreements, the licensor can require regular payments in the form of a percentage share of profits or sales. The transferor plays an active role in the transfer, through his influence on the quantity and quality of knowledge transferred, the circumstances under which it is transferred, such as the price of knowledge, and even through restrictions he can impose on its use (Fransman 1986). Licensing agreements typically restrict sales of the product to the domestic market of the transferee.

In the second mode, technology embodied in a piece of machinery is also transferred through its purchase, making it a market-mediated mode. However, in this case, the transferor is generally passive since he cannot exercise much control over the use of the technology. On the other hand, the transferor plays some role in the transmission of knowledge, through the instructions he provides the user, either directly (consultations or hands-on training) or indirectly (manuals).

Third, users of the product have been found to be very important sources of knowledge, such that the transfer can be considered nonmarket-mediated because it is usually acquired for free. This is the case of learning-by-selling, where machinery producers, through contact with actual users of their product, receive suggestions (or complaints) on how to improve its qualities or features. Such consultations, undertaken during the provision of after-sales service or while customizing the product according to a buyer's specifications, often yield ideas regarding incremental innovations on future models. To Japanese machine-tool builders, this has been an important source of knowledge. It provides an added externality to exporting because buyers are usually highly-discriminating and knowledgeable of alternative sources and designs.

The fourth mode of transfer depends almost exclusively on the activity of the transferee. Information comes from imitating products written about in trade and scientific journals and others. The source is said to be passive and the transfer is, on the whole, nonmarket-mediated. Through reverse engineering or imitation, the transferee can replicate the product, adapt it to local conditions, improve on it, or even come up with a better product. Again, the stage of imitation or reverse engineering has been an important phase in the development of machine-building capability in Japan, as well as in the Asian NIEs. Studies on Korea, for instance, have underlined its importance in incremental innovations, which had very important cumulative effects over time (Westphal et al. 1981).

The Crucial Role of Domestic Technological Capability in the Process of Technology Acquisition

The relevance of the different modes of technology acquisition or transfer to the recipient depends crucially on his technological capability. Blueprints may be provided, turnkey plants may be readied, and training may be conducted, but the effective transfer of technology takes place only to the extent that the recipient is able to assimilate and master it. Some authors point out the "tacitness" or "implicitness" in technology transfer. Because of the complexity of technological knowledge, it cannot be transferred completely, i.e., the transferee does not usually receive the knowledge completely, to the degree possessed by the transferor. Thus, the degree of transfer depends largely on local effort, skills, investments, and experience of the recipient; and, the success of the transfer is uncertain, often differing across firms in the same industry. For instance, a recent attempt to measure the length of the infant-industry period in Korea's engineering sector has shown that, for a number of machinery products and integrated circuits, the learning period for the best firms approaches two decades (Jacobsson 1993).

Furthermore, some findings suggest that the conditions involved in attaining dynamic competitiveness are also changing, and the length of the infancy period and associated costs are

becoming greater for late entrants.

The initiative and ability in the use of *passive* modes of technology acquisition depend almost exclusively on firm-level technological capabilities (FTCs). The difficulty lies in the fact that, in certain cases, especially during the early stages of industrial development when FTCs are weak or lacking, these modes cannot constitute the only source of knowledge, and must be complemented by modes of the *active* type. However, over time, previous experience and skills make it possible for a firm to import certain elements of technology, while sourcing the rest locally (Westphal et al. 1981).

But even in the use of the *active* mode, the choice, ranging from an arm's length sale of technology to the establishment of a wholly-owned subsidiary), is also determined by the degree of technological capability required by the transfer.[3]

When the technology buyer has considerable FTC such that additional technology or elements can be acquired without serious bottlenecks for skills within the firm, the possibility will tilt in favor of arm's length transactions. The firm can then scout for new elements of technology to upgrade its products, or arrange for the training of its engineers and skilled personnel. On the other hand, when the needed FTC creates serious human capital bottlenecks, FDI, in the form of a wholly owned subsidiary or a joint venture, is more likely chosen. In cases where a wholly owned subsidiary might itself face serious human capital bottlenecks that may not be sufficiently addressed by the hiring of expatriates or local managers, joint ventures offer the possibility of pooling foreign and local expertise. In between extremes, one could choose licensing agreements, other arrangements for the training of personnel, or the provision of technical advice on design, engineering, production, marketing, and so on. In most cases, the direct and indirect costs of the transfer tend to vary inversely with those for the recipient firm.

Other factors determine the choice of transfer mode, but again, these are contingent on the recipient's FTC. One consideration is the risk distribution arising partly from the asymmetry of information between transferor and transferee. Since the firm that has not yet received the technology cannot know its precise value, there is

a bias toward arrangements which will involve equity share from the transferor. Moreover, there is "moral hazard" involved in the transfer arrangement in cases where the recipient firm, under predetermined pricing agreements, cannot adequately monitor whether technology is in fact being transferred, since it is very difficult to determine the quality of advice and training being extended by the transferor. This would then tend to favor arrangements that would require more commitment from the supplier, as in the case of equity participation or licensing agreements. Such arrangements give a stake to the technology supplier in guaranteeing the success of the technology transfer and hence is an added assurance to the recipient. Financial markets may also prefer to lend to firms that have a track record in having used the technology successfully, and thus tend to favor arrangements in which the technology supplier has an equitable interest in the investment. Smith and Jordan (1990) summarize the importance of technological capability as follows:

"It seems sensible to argue that the technological capability of the recipient firm, relative to that required to master the new technology, will be the most important influence on the choice of technology transfer arrangement, both because this impacts on the uncertainties facing the recipient firm and/or the potential financing institutions and because it affects the requirement for ongoing involvement by the supplier in managing the adoption of new technology."

B. The Role of the State in Technology Acquisition

One of the tenets of conventional neoclassical theory is the generally non-interventionist role of the State. While conventional theory justifies intervention in the presence of externalities, their existence is not considered prevalent, except perhaps in the form of policy-induced distortions found in many developing economies. The role of government is seen as that of doing away with market imperfections (e.g., capital markets), and *getting prices right*. And even when some form of intervention may be justified in view of encouraging industrialization, the incentive policy should remain neutral; that

is, incentives should be granted uniformly, across industries, and automatically.

Perhaps one area where the State's role is considered acceptable—again, because of externalities involved—and crucial in the success of technological acquisition is in the field of *education*. It is hardly a coincidence that countries which have consistently invested heavily in the formation of human capital are also those at the forefront of technological development. And, among developing countries, some economists are concerned that the line separating those who will make it to the "convergence club" from those who won't is inarguably the quantity and quality of investment in human resource development.

Taking the neoclassical theory on the presence of market failure to justify state intervention as a given, Pack and Westphal (1986) nevertheless question the assertion that, for small countries, there are no important externalities other than those associated with investments in labor training or human capital formation. They argue that, according to empirical evidence, technology acquisition requires investments characterized by indivisibilities. In learning to use a known technology, the tacitness of its important elements brings about dynamic economies. Moreover, dynamic economies also arise when the use of technology brings about greater productivity and more appropriate product features. These dynamic economies result in surpluses that are internal to investors, which could also be external in that they accrue to beneficiaries such as users. Even when capital markets are working perfectly, the inability to appropriate all of the surplus leads to underinvestment in technology or its use, making a valid case, they claim, for state intervention.

Lall (1993) has carefully identified specific market failures, including government failure, in industrial technology development. In general, he rejects the simplistic view that firms access and absorb new technologies at no cost. A long and uncertain learning process is involved, depending on the nature of the technology, the efficiency of factor and product markets, and the ability of institutions to provide various technological information and services. In view of the possible widespread existence of such market failures in

developing countries, Lall argues the need for well-designed, economically desirable policy interventions, both selective and functional, in order to promote technology development. In addition to the nonexclusive use of infant-industry development, he stresses the role of government support for skills development, information and technical requirement, financing for industry technology development, and incentive policies for R&D.

Technology Acquisition in the East Asian Machine Tool Industry

To situate East Asian countries in the global machine tool industry, data on world consumption, production, and export trade in MTs (tables 1.a and 1.b) are presented. As a group, developed countries produced about 80 percent and consumed some 70 percent of the world's MTs in 1993. However, as a result of more rapid increases in MT production in certain countries, there have been observable changes over time in the distribution and ranking of countries. Japan, which placed fourth in world MT production in 1979, replaced Germany in the top slot in 1993 while the United States went from 2nd to 3rd place and the UK, from 6th to 8th. Switzerland, though, moved from 9th to the 6th slot.

Rather remarkable was the upward movement of a number of Asian developing countries, in terms of production: China moved from 11th to 5th position; the Republic of Korea, from 19th to 9th; and Taiwan, from 18th to 7th. The combined production of the three Asian NIEs and China almost quadrupled, from 3.4 percent in 1979 to 13 percent in 1993. While this is nowhere close to Japan's 25 percent share nor Germany's 18 percent in 1993, it slightly exceeded the United States' share of 11.6 percent.

The rapid increases in shares of the East Asian economies led by Japan, have reinforced the rising trend in Asian production, in contrast to the declining shares of America and Eastern Europe. Western Europe as a group, however, continued to dominate all country groupings. The pattern of changes in MT consumption over time reflects the different growth rates and trends in industrial develop-

ment. The United States was the main consumer of MT, both in 1979 and 1993, while Japan moved from 4th to 2nd rank. China replaced Germany as the world's 3rd biggest MT consumer; Taiwan rose from 17th to 9th rank; and Korea, from 15th to 6th.

Japan was the world's largest MT exporter in 1993, dislodging Germany. Taiwan ranked 6th, from 15th in 1979; China, 13th from 24th; and Korea, 18th from 27th. Balassa's Revealed Comparative Advantage (RCA) index,[4] shown in table 2 for selected countries, indicates country specialization in MT, relative to world trade in manufactured goods. In 1975, only EC6[5] demonstrated a comparative advantage in MTs, while Japan's RCA was farther from 1.0 than the United States'. However, by 1980, Japan's index rose to 1.5 and showed an upward trend until 1985. The United States' index showed a declining trend until 1985, along with EC6. A slight decline in Japan's RCA was observed in 1991, possibly reflecting the effect of the US voluntary export restraint (VER).[6] In the case of the NIEs and China, RCA indices were on the rise, although only Taiwan demonstrated a comparative advantage in MTs, starting 1980. The most dramatic increase was observed for China between 1985 and 1991.

How did the East Asian latecomer economies manage to acquire the technological competence needed to reach the export stage, and even dislodge some of the traditional developed country producers from the comparative advantage scale?

A. *Sources of Technological Competence*

The Early Beginnings

The "catching-up product cycle model" (CPC model)[7] reverses the vantage point of Vernon's product cycle model, from that of the developed country invention to the developing country imitator. As such, the CPC model starts not with the introduction of a new product, but with its import by the latecomer economy. This is true for the machine tool industry development in East Asia.

The introduction of MTs into Japan came before Japan abandoned its closed-door policy in the 1860s, in the form of imports

from European countries (Netherlands, UK, and France) mainly for its military arsenals. Government procurement thus provided a powerful stimulus to the birth and growth of the industry before World War II.

Similarly, imports of foreign-made machine tools introduced Korea and Taiwan to the technology of MTs. However, Korea's initial attempts at the production of MTs came in the 1970s (KDB Report 1986). For Taiwan, the first Census report of 1954 already listed 19 MT manufacturers, employing 303 workers (Tsai 1992). On the other hand, China's MT industry was said to have had a recorded production of 1,600 units in 1949.

In Japan, prewar demand for MTs came mainly from the military. In particular, preparations for World War II roused the industry from the doldrums of the interwar years. During the postwar era, industry became the main, if not the only, source of demand, especially with iron and steel, automobile, and electrical machinery industries renewing production facilities during the second half of the 1950s. Thus, the MT industry grew hand in hand with the growth of its user industries.

Technological Breakthrough and Strategic "Niching"

A technological breakthrough that altered the course of Japanese, as well as worldwide, MT production was the numerically controlled machine tool (NC-MT).[8] First commercially produced in the United States in 1952, NC-MTs were initially made for use of the US government's aerospace industries and other projects. The subsequent development of private industry, particularly the aircraft and ordnance industries, greatly increased the demand for the product. Developments in the electronics industry paved the way for the production of electronically controlled MTs in the 1960s, and their subsequent expansion in production and demand during the decade. The eventual substitution for more accurate and flexible NC-MTs led to the decline in the demand and production of MTs, especially in developed countries.

In Japan, research on NC-MTs is said to have begun the year after it was first commercially produced in the United States. It was

spearheaded by the AIS Mechanical Laboratory of the Tokyo Institute of Technology, and the Engineering Faculty of the University of Tokyo, and involved private firms as well, particularly Fujitsu and its subsidiary, Fanuc. However, it was the development of microelectronics in the 1970s, particularly the microcomputer-based control units in 1975, that led to the rapid diffusion of the technology (UNIDO 1989).

Behind the rapid development of NC-MTs in Japan was the deliberate pursuit of a business strategy that penetrated the engineering industry with the design of lower performance, small, and cheaper CNC-MTs (computer numerically controlled machine tools) and machining centers. Watanabe (1983) offers plausible explanations for the decision of Japanese MT builders to specialize in NC-MTs that were smaller and less expensive than those produced by the United States and Europe. First, Japan's aerospace industry, which required the larger types of MTs, was underdeveloped. Second, its automobile industry, with its vast subcontracting network of small and medium-sized suppliers of parts and components, was a vital force in its economy. It was believed that MT producers responded to these needs by supplying small-sized MTs, eventually finding a "niche" in the world market.

Imports and Reverse Engineering

Chokki (1986) reports that, before and during World War II, Japanese machine tool manufacturers copied foreign machine tools, especially those from Europe. After the war, they continued to do so, this time with the United States as the main source. With subsidy from the Ministry of Trade and Industry, high-quality MTs were imported, dismantled, and studied for the design and materials used. In the case of the NC-MT, Japanese researchers were said to have carefully studied the report on the first NC-MT developed in an American university. Success at replication[9] and its eventual commercialization led to the phenomenal growth of Fanuc, the recognized industry leader in numerical controls.

For Korea, Westphal et al. (1984) stress the importance of "copying foreign products as a means of enlarging technological capability."

Kim (1982) underlines the reliance of Korea on foreign capital goods imports, "which became a major source of learning through reverse engineering by Korean firms." Likewise, in his study of Taiwan, Fransman (1986) notes that the country relied heavily on reverse engineering, perhaps even more than Japan.

Foreign Licensing and Foreign Direct Investment

The use of informal modes of transfer, i.e., imitation or reverse engineering, has its limits. When new products or processes are involved (especially when intellectual property rights may be violated) or when there is the need to upgrade to more sophisticated technologies and markets, firms find it necessary to enter into more formal modes of technology acquisition. The choice depends on many factors. Perhaps the two most important are the technology holder's preferred mode of transfer, and the recipient's degree of firm-level technological capability. In the East Asian machine tool industry, the contractual mode of foreign licensing seems to be preferred over foreign direct investment.

In Japan, the periods 1962-64 and 1970-73 are considered the "first and second MT technological licensing boom" (JMTBA 1982), although the first licensing agreement was signed as early as 1952, between Tsugami and French MT producer Cri-Dan. Twenty-five and 28 foreign licenses, respectively, or a little more than half the total number of agreements concluded over three decades, were made during these two periods (table 3). The main sources were the United States and Western European countries, principally West Germany and France. In certain instances, Japanese MT builders had to resort to FDI for technological access. However, it always took the form of joint ventures (table 4), and except in one instance, foreigners only held minority positions. The sole exception carried a clause that increased Japanese capital participation to majority ownership in less than five years.

It is evident that FDI was a less frequently used means toward technology acquisition than foreign licensing, by Japan's machine tool builders. It is not clear how much of this was due to the reluctance of the Japanese to allow foreign capital into the industry, if

other means of acquiring technology were available. However, there is indirect evidence that this was the case.[10] Moreover, before 1980, all foreign licensing agreements and FDI have had to be approved by MITI. And, even after the law was liberalized, the CNC-MT industry is said to have remained one of those excluded from FDI (Fransman 1986).

Among the Asian NIEs in this study, Korea has yielded the most abundant data sets, underlining the strong preference for foreign licensing as the technology transfer mode. Table 5 records the technology licensing agreements of the Korean MT industry, between 1969 and 1993, and shows that a rapid succession of agreements came after the first one in 1969, between Tokyo Kikai Kogyo (Dongyang Kakakongup) and Okuma Co. of Japan.

Of the 95 agreements recorded during the period, 32 (34 percent) were concluded in the 1970s (30 of them after 1975), 39 (41 percent) in the 1980s, and 23 (24 percent) during the early 1990s. As noted by Mizuno (1990), the second half of the 1970s was characterized by a supply-side shift in the Korean MT industry. Whereas the industry was dominated by small-scale establishments before 1975, the latter half of the decade witnessed the rise of large-scale MT producers (with 300 or more workers), mostly belonging to automobile-related groups. For instance, in 1974, Changwong Co. was established; followed by Daewoo Heavy Industries and Hwacheon Machinery in 1975, and Kia Machinery in 1976. These and other automobile-related large-scale firms established earlier (Hyundai, Tong-il, Samsung), were the main licensees of MT technology in the 1970s and 1980s. Likewise, NC-MT technology was first licensed in 1974 by Takisawa Machine Co. to Hwacheon Gear Co., while machining center technology was first licensed in 1979 by two Japanese firms: Mitsui Seiki to Daewoo Heavy Industries, and Yasuda Kogyo to Tong-il. Daewoo later entered into another licensing agreement for a machining center in 1985, with another Japanese firm, Toshiba Machines; while Tong-il did the same in 1984 with the German firm, Wanderer. The rapid succession of technical licensing in NC-MTs during the 1980s led to a rise in the ratio of NC-MTs to total MT production.

Whereas Japan acquired its MT technology mainly from United States and Western European countries, Korea obtained it mainly from Japan (89 licenses). Mizuno (1989) reports that the agreements involved not only technology know-how and basic designs, but a considerable amount of training of engineers and skilled workers of the Korean firms, both locally and in Japan. A difference, as Mizuno points out, was that Japan did not require as much training because of its long history of MT-building. Most licensing agreements that Korea entered into, however, involved limitations on the use of the license, especially through export restraints.

In contrast to the extensive use of technology licensing, there were only eight cases of FDI recorded since 1969 in Korea's MT industry (table 6), all of which were joint ventures. Of the eight, five involved Japanese capital participation, making Japan Korea's most important source of MT technology, whether through licensing or direct investments.

Unfortunately, no such comparable data seem available for Taiwan's MT industry. In a survey of nine Taiwanese MT builders (Fransman 1986), however, seven reported having acquired their original design from Japan, and one from Taiwan's government research institute, the Mechanical Industrial Research Laboratory (MIRL). Three firms cited more than one Japanese as source. Majority of the agreements occurred in the 1980s.

Another data set, though not exclusively for machine tools, shows the importance of the "new" forms of investment in Taiwan (table 7). Of the 3376 cases recorded for the manufacturing sector over the period 1962-92, the machinery sector ranked 3rd (15 percent), in terms of frequency of cases; following the chemical industry (22 percent), and the electrical and electronic appliance industry (33 percent). Japan again emerged as Taiwan's main source of technology licenses, in terms of the number of technical cooperation agreements (TCAs).

Taiwan's manufacturing sector recorded 2431 FDI cases during the period 1962-1992. Measured in terms of quantity and value, Japan came out as Taiwan's main foreign investor in the machinery industry.[11] In terms of the relative importance of the two modes, tech-

nical cooperation agreements appear more numerous than FDI approvals (i.e., 58 percent more TCAs than FDI, in the machinery sector). However, it may be misleading to think that these two modes constituted mutually exclusive alternatives for technology acquisition in Taiwan. Since foreign investors allegedly prefer not to include their technology as part of capital equipment to Taiwan, they license it to their subsidiaries (Lim and Fong 1991). Over half of the foreign firms operating in Taiwan reportedly source their major technology from parent companies, with about one-third licensing it from a third party, and the rest obtaining it from the open market or from government institutions. For Taiwan's MT industry, however, there are only two recorded cases of Japanese FDI (see Appendix Table 1 for a complete list of Japanese FDI in Asian MT industries) namely, Takisawa Machine, with a 20 percent share of Taiwan's Takisawa Machinery in September 1971; and Fanuc, with Fanuc Taiwan Limited, in August 1993. The former produces center and NC lathes, while the latter makes CNC—not a machine tool but a very critical component of CNC-MTs. It is said that Taiwan has been unsuccessful at import substitution of numerical controls, leading to its continued and growing dependence on Japan's Fanuc. Moreover, Leadwell, a leading MT producer in Taiwan, has to maintain close contacts with Fanuc, in order to keep its MTs at pace with the latest developments in numerical control technology (Tsai 1990).

In China's case, relevant, though admittedly dated, data are available from a survey by Chudnovsky et al. (1983) on the country's capital goods sector , with emphasis on complex capital goods. The survey, conducted in 1980, included the MT industry and reported data on 19 foreign firms, 11 of which had no foreign technical collaboration. Of the nine technologies introduced for the sample, majority were in the form of manufacturing contracts; a few were through licensing agreements. The difference between the two modes is that under manufacturing contracts, the supplier provides drawings of the basic design of the equipment to be manufactured, without any transfer of design technology (theory, conception, and calculations involved in the design of the machinery). However, both modes include delivery of detailed designs, assistance in dealing with

problems in manufacturing, and personnel training. The technology involved in licensing agreements was said to be advanced relative to China's technological capacity at the time, but was not the case for manufacturing contracts. Since China's MT industry had about three decades of experience behind it then, Chudnousky et al. believed that manufacturing contracts were a means of verifying firm-level technological capacity and gaining international recognition, rather than acquiring essentially new technology, as would have been the case under licensing agreements. The example given is the manufacturing contract for 50 machines with Hitachi Seiki by the Beijing First Machine Tool Factory. At the time of the survey, it was reported that two of the machines produced under the agreement received Hitachi's technical approval.

An example of a licensing agreement cited by Chudnovsky et al. (1983), which did not involve an entirely new technology, but was nevertheless undertaken to catch up with recent developments, concerns the licensing agreement between the Beijing Machine Tool Research Institute and Fanuc, Japan, for NCs and servo-motors over a five-year period starting 1980.[12] Fanuc reportedly provided all the relevant documents, design-related blueprints, and personnel training in the home plant, as well as parts and components, including ICs.[13]

A peculiar characteristic of China's licensing agreements is that, despite China's long experience in the design and manufacture of machinery, these are said to typically cover the whole package of technological elements, from basic design to manufacturing technology. Thus, there seems to have been less attempt to unpackage the technology (and hence to obtain it at lower cost), than other developing countries. Interestingly, according to Chudnovsky et al. (1983), the Chinese prefer to use the agreements to raise their "technological capacities on all fronts," and not only in the area of design. Exposure to all aspects of technology would ensure that not only problems of insufficient design capabilities will be addressed, but also those concerning quality control techniques, testing, factory organization, workers' skill levels, etc. The goal was to upgrade the technological level of the entire sector, including ancillary in-

dustries. Importing the whole package under a licensing agreement was viewed as a means to achieve this goal (p. 127). Whether this is still true about a decade and a half after the authors' survey needs to be determined.

More recent data are presented in table 8, which includes a list of foreign MT firms that have undertaken technology transfer agreements with Chinese firms. From the data, Japan is not seen to be a dominant source of MT technology for China, in contrast to Korea and Taiwan. There are only eight cases of TCAs with Japanese firms, compared with nine from Germany, two from the UK, and three from the United States. What is remarkable, however, is that in Japanese TCAs, either machining centers or other types of NC-MT technology is involved. FDI cases from Japan are seen in Appendix Table 1 (Fanuc), with Beijing-Fanuc Mechatronics, for CNCs (1993); Sodick for EDMs; and, Koyo Machine Co. for centerless grinding machines.

"Learning by Selling"

It was earlier argued that an important source of nonmarket-mediated transfer of knowledge is through "learning-by-selling." Feedback from buyers or users of MT, both foreign and domestic, has been found to be an extremely valuable source of information on product and process improvements. The machinery sector's primary role is to modify, adapt, and innovate capital equipment (Fransman 1986). However, to accomplish this, the sector must acquire basic information on the capital equipment that require alteration. The type of technical change that takes place has been shown to be shaped partly by the valuable information supplied by users of capital equipment (Freeman 1974).

Japan's domestic absorption of its MT products (90 percent in 1993) is one of the highest among developed countries. It is also one of the largest NC-MT users in the world. In particular, small-sized machine shops have provided the main source of MT demand since the 1960s, and are one of the finest examples of feedback in MT–building history. Being generally labor-intensive, small-sized machine users in Japan were particularly hit hard by the sharp rise in wage rates that forced them toward automation to compensate

for the scarcity of skilled labor. In response to their needs, Japanese MT producers developed and eventually decided to specialize in smaller and cheaper NC-MTs, which later proved to be a successful niche for Japanese MT builders in the world's markets.

In a survey of Japanese firms, Fransman (1986) finds that, among nine enumerated sources of improvements, respondents ranked their customers as the most important.[14] Such sensitivity to users' needs was underlined by a high-ranking official of a major MT firm in Japan who, while in charge of the European market, had a chance to compare the attitude of Japanese engineers with those of a European country whose MT industry had already lost much ground in the competitive arena.[15] He noted that Japanese engineers in contact with MT users, especially in the context of after-sales service, received valuable information on the strengths and weaknesses of their machine tools, compared to other producers.[16] Japan's high degree of exposure to demanding American and European markets has undoubtedly contributed much to better-quality designs of MTs, and has eventually catapulted Japan to industry leadership in numerical controls based on, according to Fransman, a "process of incremental improvement." Moreover, an important feature of the machine tool industry—as is true to some extent of the capital goods industry in general—is the MT builder's high degree of usage of their own machines. As such, MT builders get first-hand information on the qualities of their own products, providing them additional data on requirements for incremental improvement and innovation.

Another nonmarket-mediated form of knowledge transfer is the imitation of the desirable features of other firms' machines. Fransman finds "products of competing firms" as the second most important source of improvement in design and selling price, among Japanese MT respondents.

This seems true also for the Asian NIEs. In the case of Taiwan, Fransman's survey indicates that the second most important source of improvements in design and selling price for exporting MT firms is the customer in foreign markets; and, for the entire set of respondents, the customer in domestic markets.[17]

There are no similar data sets for Korea's MT producers. However, the results of a survey of 112 exporting firms conducted by Pursell and Rhee in 1976 (cited by Westphal et al. 1981) indicate that buyers of output, after suppliers of equipment materials, are most frequently cited as a source of technology. And in terms of relative importance as source of information for product innovation, buyers of output have been ranked first among domestic and foreign sources of information. The influence of foreign buyers bears upon the characteristics of the products, with producers modifying their characteristics according to buyers' requests or producing them in accordance with specifications.

In another important study on technological innovations in Korea's capital goods industry, Kim (1982) underlines the importance of users, among different sources of stimulus in the idea-generation and problem-solving stages, from responses of 42 innovating firms.[18] Two-thirds of the sample mention that the user had played "some role in developing the successful innovation." And in about half of the cases, the user is considered as having played a decisive role. Kim thus concludes that users or potential users have been playing the most important role in developing new capital goods in Korea.

Nevertheless, industry analysts like Mizuno (1990) have indicated that in spite of the enormous strides made by the Korean MT industry, its products tend to suffer in price comparisons with Taiwanese MTs, and quality comparisons with Japanese MTs. They concur that this is largely due to Korea's relatively less open trading system in MTs, as compared to Taiwan and Japan.

Thus, one cannot deny the role played by nonmarket-mediated forms of technology sources—particularly the information supplied by their buyers in foreign and domestic markets—which Japan and the Asian NIEs seem to have availed themselves of to a considerable extent. However, behind the ability to take advantage of this technology source lie the large pools of domestic technological capability that MT firms must have been able to to draw from, a topic explored in the following section.

Domestic Technological Capability and R&D Effort

Westphal et al. (1981) note that, in connection with their research on Korean sources of technical competence, "even less information is available about technological effort than about inflows of technology" (p. 27). This is true for all countries under consideration, hence a limit has been set on indirect evidence, through the use of indicators, such as skill composition of workers and product upgrading.

The first indicator is the technical quality of the industry's labor force. Available data for Korea (table 9) indicate that production employees in the MT industry are made up of engineers and skilled labor, with the latter making up about a fourth of total number of employees. Interestingly, medium-sized MT firms (employing 100-199 workers) have shown the highest proportion (33 percent) of engineers to production employees, much higher than proportion (22 percent) of the biggest firms employing more than a thousand workers. In the case of Taiwan, Fransman notes that: "the days when machine tool designers relied on their experience learned on the job are gone for at least the larger Taiwanese machine tool builders, and for these firms, science-based skills are becoming increasingly important."

Indeed, it seems to be truer for countries on the frontier, like Japan. Table 10 shows that the number of university-degree holders in science-related fields in Japan's MT industry is increasing. Design engineering plays a crucial role in any MT firm's ability to go beyond merely copying to developing its own line of MTs. For Japan, the ratio of design engineers to total employees in four MT respondent firms ranges from 10 to 15 percent. A parallel survey undertaken for Taiwan indicates that, in nine MT firms, the ratio of employees in design and development to total employees ranges from 3 to 10 percent (Fransman 1986).

An earlier section described Japan's domestic technological effort at developing a prototype NC-MT after it was first commercially produced in the United States. Jacobsson (1993) presents an interesting example of Korean technological effort at developing its own series of CNC lathes and machining centers. In 1978 Daewoo

Heavy Industries began work on a CNC lathe design. It subsequently developed six different modes, but only the last one, developed four years later, was successfully commercialized. Two years later, in 1984, Daewoo produced its own whole series based on this lathe. In the same year, work began on machining centers based on a German-Japanese technical collaboration. After imbibing technology and increasing the company's design engineers to 100, the firm was said to have simultaneously developed two series of machining centers.

In the final analysis, firm-level technological effort cannot but underpin the success of Asian NIEs in entering and eventually growing into the highly demanding markets for MTs of developed countries, as noted in an earlier section. China and the Asian NIEs were observed to have continually moved up the ranks of the world's top exporters of MTs, matching, and at times surpassing, traditional developed country exporters in technologically sophisticated MTs, such as NC-MTs and machining centers. In 1991, 59 percent of Japan's total imports of machining centers had come from Asian NIEs, and 15 percent from China. Similarly, Taiwan's exports constituted 3 percent of the United States' imports and 6 percent of the EC's imports of machining centers in 1991.

The speed of technological learning may be gleaned from data, such as the figures provided in table 11, which indicate the time it took Asian NIEs to commercialize products embodying transferred technology. Thus, while it took Japan 12 years after the first NC-MT was built (or, alternatively, when the NC-MT technology agreements was first concluded in the country) to first export NC-MTs, it took Korea and Taiwan only seven.

Unfortunately, R&D data in the East Asian MT industries are not readily available. Still, R&D effort is implicit in latecomer economies' capability to absorb technology and eventually become world-class producers of MTs. It is possible that most MT firms in East Asia (except the biggest ones) do not have separate R&D departments. However, it does not necessarily follow that such firms do not invest in advanced technology, or in the upgrading of products or processes. It has been noted that most "inventing" activities are carried out by company engineers while being engaged in other

activities. Studies likewise show that "about as much effort goes into on-line production engineering, after the R&D laboratory has 'signed off' on a new product design, as the laboratory put in." It is difficult to draw the line between tailoring a product to customer specifications, and advancing the technology, especially in industries engaged in the production of custom-built or made-to-order goods—of which the machine tool industry is a good example.

B. *Role of the State in Technology Acquisition: A Comparative Review*

The discussion of the Asian NIEs' MT industry development cannot be complete without mentioning the role played by the State. While it cannot be denied that the private sector plays the key role in the industry's development, the role of State policy cannot be ignored. For in Japan, as well as in the Asian NIEs and China, a deliberate strategy was pursued to develop the industry. Table 12 presents a summary of some of the major incentives granted by the governments of the countries under discussion, directly or indirectly, to their MT industries.[19]

First, the State had been selective; that is, the governments of the three countries consciously singled out the machine tool industry for encouragement and support, possibly in recognition of the strategic role it plays in industrial and technology development. In the case of Japan and Korea, it was in the broader context of their heavy and chemical industrialization strategy that government promoted the development machinery industry development, of which the MT industry is at the heart. For Taiwan, it was done as industries shifted to higher levels of skills intensity.

Second, all three countries used, at some point, forms of infant-industry protection. However, this policy was not used exclusively, but was accompanied by a number of other incentive policies. Thus, these incentives improved firm-level access to finance, acquisition of capital equipment, and assistance in technology acquisition. For instance, in the case of Japan, a government representative was said

to have been present during firm-level bargaining sessions with foreign suppliers, apparently to undermine the technology suppliers. There was also the active involvement of the government in promoting R&D: either directly, through subsidies to firm-level R&D; or indirectly, through state-funded research institutes and laboratories.

Third, although the import protection policy tended to reduce competition from imports, it was countered by the government's expectation of the industry's early entry into export markets. Export promotional incentives, financial or fiscal, were made available. But, equally important was the implicit understanding between government and private sector that the promotional incentives had to be "paid back" in terms of export performance. This assured early exposure to world-class competition, as well as to cost advantages from scale economies. In addition, export activity encouraged technical innovation, and exposed domestic firms to international best practice. It provided an additional source of technology which, because of its informality, was usually obtained free, but proved to be an important basis for incremental innovations.

Japan's policy intervention—typical of its industrial policy—reached the level of rationalization of the structure of production. The MITI, through the Japan Machine Tool Builders Association (JMTBA), encouraged greater specialization and concentration of industrial production, such as in 1968, when a Notification was issued urging manufacturers to discontinue the production of some machines that did not meet certain standards, or were being produced in small quantities (less than 5 or 20 percent of the output of industry or enterprise, respectively).

Lessons from East Asia

With the objective of finding out how our East Asian neighbors managed to acquire technology, we studied the modes of technological acquisition in the machine tool industry of Japan, the Asian NIEs—Taiwan and the Republic of Korea—and China. From the study, a number of "lessons" seem to suggest themselves.

Entry Points: Imports and Reverse Engineering

Japan's introduction to machine tool technology came with imports from Europe during the prewar period, and mainly from the United States after the war. Such imports provided the opportunity for reverse engineering which, as a Japanese author claims, took place before, during, and after World War II. In addition, academe-private sector linkage in research helped push the industry forward: working on the original idea published in a scientific study, research spearheaded by professors in two universities, as well as by private firms, successfully led to the production of the first numerically controlled machine tool in Japan in 1958, six years after its first commercial introduction in the United States.

Following the Catching-up Product Cycle typology, the Asian NIEs and China were similarly introduced to the MT technology through imports, which also provided the occasion for imitation and reverse engineering. This underlines an important first lesson for contemporary developing countries, namely, that the import market, especially for capital goods, must remain fairly open—or at least flexible as in the case of Taiwan—in order to ensure exposure and ready access to world-class products and international best practice.

Market-mediated Modes of Technology Acquisition

Obviously, however, imitation was not enough, neither for Japanese nor the Asian NIEs' MT producers. They had to resort to direct modes of technology acquisition of the market-mediated type. In Japan, some 161 technology licenses were acquired between 1951 and 1974, about half of which were taken out during the periods 1962-1964 and 1972-1973. Benefiting from latecomer advantages a la Gerschenkron, Japan initally relied heavily on the technological backlog with Europe and the United States. Similarly, the Asian NIEs eventually resorted to this mode. Between 1959 and 1993, Korea concluded 94 (recorded) technology licensing agreements, majority of which came from Japan (84 percent); the rest were from the United States and Europe. Taiwan, according to Fransman (1986), relied heavily on Japan. Seven out of nine respondent

MT firms in Fransman's survey obtained their original design from Japan, while only one did through a state-owned research institute.

In moving to more formal modes of technology acquisition, there seemed to have been a preference for technology licensing and other modes of contractual nature. FDI, which required a more active role and longer-term commitment on the part of the technology transferor, was also used, but apparently not to the same degree as technology licensing. This probably reflected a state-strategic policy both for Japan and Korea, which shunned heavy reliance on FDI for fear of encouraging dependence on foreign funds. In the case of Japan, there was some evidence that FDI was allowed only when important technologies were denied licensing by foreign investors, unless stock acquisition was approved in exchange. At the very least, all licensing agreements and FDI had to be approved by the MITI under the Foreign Capital Law. Moreover, it appeared that joint venture was the only form of FDI allowed in the machine tool industry, except in one instance which carried an explicit requirement to increase Japanese capital participation to majority ownership in less than five years.

It must be noted, however, that although a number of MT firms especially in Japan had already transferred their production bases for simple types of MTs to developing countries, such as Thailand and China, there seemed to be some hesitation on the part of technology transferors (at least, among the Japanese MT builders) to do so on a large-scale basis, similar to what had occurred in automobiles and electronics. The level of technological sophistication involved in MT production required a substantial amount of skilled manpower (including management) transfer, an undertaking that majority of Japanese firms still seemed reluctant to do. The above implied that developing countries might also have to rely more on technology licensing and other forms of contractual arrangements to obtain machine tool technology. Depending on the degree and availability of technological capability, they could unpackage the technology to be transferred, as did Taiwan and Korea. Or like China, they might opt to take the entire package, from acquisition of basic

designs to the final assembly of the unit, and even to the production of parts and components.

Nonmarket-mediated Modes of Technology Acquisition

Latecomer economies must also pay attention to the use of other informal modes of technology transfer, especially those that are free (nonmarket-mediated). These refer to technology transferred through: (a) imitation and reverse engineering of foreign-made MTs; and, (b) learning-by-selling. There is ample evidence that Japan and the Asian NIEs copiously used such means. In particular, learning-by-selling turned out to be an important nonmarket-mediated technology source for MT builders in Japan and the Asian NIEs, who gave great importance to information derived from buyers, especially those in foreign markets. Such information has improved firms' ability to undertake incremental innovations, the backbone of technological upgrading in the East Asian machine tool industry. This suggests another reason for encouraging the growth of exports of MTs early in the process of industry growth, and aiming for greater export orientation in the longer term. Taiwan and Korea are known to have started exporting within a decade after the first machine tool came. Analysts point to the greater export orientation of the Taiwanese MT industry as an important reason for the country's greater degree of competitiveness, in contrast to the more domestic market-oriented Korean MT industry.

Technological Upgrading and "Product Niching"

Japan's MT producers' strategic move into smaller, cheaper MTs led to their eventual cost-leadership, and took off in the 1980s as the world's leading producer. The decision was said to have been an initial response to the domestic demand for such MTs from Japan's extensive network of SMEs, especially in the automobile and electronic industries. For the Asian NIEs, the decision to remain at the lower-performance end of the MTs market made them vulnerable to competition from other near-NIEs entering the arena through Japanese FDI. Moreover, in the process of industrial development,

user industries in the domestic markets of the NIEs upgraded their demand for more technologically sophisticated MTs. Thus, there was no other way for NIEs, but to move up to medium-performance MTs. And this seems to be what is happening, given the technologies being imported by Taiwan or Korea. For instance, Korea's list of licensing agreements with Japan indicates that, since the late 1980s, there has been a proliferation of agreements involving machining centers, CNC lathes, and grinding machines, including industrial robots. However, this direction would take them closer to direct competition with Japan, although Japan's MT builders have long been moving upscale. The experience of the East Asian MT builders suggests the usefulness of concentrating in the production of low-performance, simpler types of MTs, before moving on to more complex types. At the same time, the Japanese experience also indicates the importance of looking for "niches" in an environment of strong competition among many developing countries simultaneously pushing for the development of their capital goods industry.

Domestic Technological Capability Building

Regardless of the mode of technology acquisition chosen, however, successful learning will, in the end, depend on the amount of investments in building up domestic technological capabilities. Industry specialists claim that at least 15 to 20 years are required to produce quality workers in the machine tool industry. In particular, design engineering capabilities are crucial to any meaningful development of the industry. Statistics on Japan's MT industry show an unmistakable rise in the proportion of university graduates with science degrees relative to the total number of production workers. In Korea, and possibly Taiwan, a full 25 percent of production employees have formal engineering background. Thus, for the Asian NIEs, moving upward requires more investments in better quality human capital.

This also calls for more R&D resources given the ever shortening lifetime of MTs (about three years or less). In the case of Japan, there has been intense technological effort and investments in R&D,

not only in the MT industry, but also in its major supplier industries, especially in computer numerical controls where a 10 percent R&D-to-sales ratio seems to prevail. R&D effort is also implicit in the rapid development of the machine tool industries of the Asian NIEs.

The Role of the State

The role of the State in the development of Japan's and the Asian NIEs' machine tool industry must be seen in the wider context of their choice of industrialization strategy. Whether such an industry-targeting approach is appropriate for contemporary developing countries remains an open question. What seems to be clear, however, is the importance given by the State to the development of the capital goods industry in the generation and diffusion of technical knowledge. Given this premise, the State in all the countries studied provided incentives in the typical infant-industry fashion. What was atypical, however, was the strong promotional—as against purely protectionist—incentives. In particular, one notes the assistance given to R&D, either directly, through subsidies, or indirectly, through state-funded research laboratories and institutions. Moreover, the provision of export-related incentives, both general and specific to the industry, has helped encourage export orientation, in turn assuring constant exposure to international best practices and providing another important source of ideas for incremental innovations.

In the final analysis, the experience of Japan, the Asian NIEs, and China cannot but underscore the most important role played by the State in the progress of these economies' capital goods industry, namely, the promotion of human resources development, on which firm-level technological capability is ultimately built.

Table 1.a

World Production and Consumption of Machine Tools
1979 and 1993 (Million US$)

COUNTRY	*Production 1979*	*Production 1993*	*Consumption 1979*	*Consumption 1993*
Germany	4,099.9	5,145.3	8,841.9	2,966.1
Japan	2,697.8	7,153.5	1,740.2	3,887.2
U.S.A.	3,890.0	3,275.0	3,266.0	4,765.0
Italy	1,385.7	2,365.6	3,470.1	3,075.4
France	918.1	618.3	1,021.4	954.0
U.K.	1,106.4	1,212.8	1,293.6	1,007.6
Soviet Union	2,892.0	-	3,200.0	-
Russia	-	615.0	-	640.0
Romania	403.6	43.2	-	44.2
Bulgaria	30.0	-	40.0	-
Ukraine	-	518.0	1,280.0	563.6
Germany, D.R.	805.8	-	388.0	-
Spain	313.1	401.2	750.6	349.3
Canada	110.3	399.8	322.2	633.0
Switzerland	797.1	1,354.3	2,011.9	372.4

COUNTRY	*Production 1979*	*Production 1993*	*Consumption 1979*	*Consumption 1993*
Austria	150.8	288.2	272.5	339.8
Netherlands	75.0	69.9	112.3	189.3
Sweden	199.7	167.1	352.4	124.7
Belgium	127.3	172.3	272.7	76.0
Portugal	14.3	24.8	31.6	76.8
Denmark	48.0	40.6	75.4	23.4
Australia	18.0	17.0	14.0	101.0
Finland	-	46.9	52.4	38.5
China	420.0	1,753.4	1,445.5	3,075.4
Rep. of Korea	150.0	622.9	798.4	1,212.9
Taiwan	172.2	1,073.7	922.2	827.1
Mexico	15.5	27.0	24.0	287.0
Singapore	21.3	151.6	89.6	296.8
India	129.0	155.9	221.6	324.0
Brazil	239.8	325.5	350.0	220.5
Poland	684.6	149.1	92.6	200.1
Yugoslav. Rep.	222.5	105.0	367.0	105.0
Argentina	62.0	23.5	30.4	75.1

Czech Republic	357.2	165.0	130.8	116.0
South Africa	20.0	2.0	27.6	45.8
Hong Kong	-	-	28.3	-
Hungary	115.9	11.0	40.6	6.7
Croatia	-	44.2	-	34.1
Slovak Rep.	-	30.0	-	61.0
TOTAL	*22,692.9*	*28,248.1*	*20,816.2*	*25,651.0*

Note: Production and consumption data for 1993 are estimates.

Source: American Machinist, February 1980; March 1994.

Table 1.b
Values and Ranking of Major Exporters of Machine Tools
1979 and 1993 (Million US$; percent share)

Rank	*Country*	*Value of MT Exports 1979*	*Share*	*Rank*	*Country*	*Value of MT Exports 1979*	*Share*
1	Germany	2,460.0	26.4	1	Japan	3,644.2	25.1
2	Japan	1,113.8	12.0	2	Germany	3,329.3	22.9
3	Italy	698.9	7.5	3	Italy	1,391.3	9.6
4	Switzerland	677.5	7.3	4	Switzerland	1,185.0	8.2
5	Germany, D	661.5	7.1	5	U.S.A.	1,010.0	7.0
6	U.S.A.	660.0	7.1	6	Taiwan	687.9	4.7
7	France	479.8	5.2	7	U.K.	488.7	3.4
8	U.K.	468.1	5.0	8	Belgium	308.9	2.1
9	Soviet Union	350.0	3.8	9	France	300.3	2.1
10	Czechoslovakia	265.0	2.8	10	Austria	283.9	2.0
11	Spain	216.2	2.3	11	Spain	240.7	1.7
12	Poland	190.9	2.1	12	Canada	218.0	1.7
13	Sweden	156.7	1.7	13	China	200.0	1.4
14	Romania	130.7	1.4	14	Brazil	196.2	1.4
15	Taiwan	120.0	1.3	15	Singapore	189.3	1.3

16	Austria	113.1	1.2	16	Sweden	183.8	1.3
17	Belgium	110.5	1.2	17	Czech Rep.	123.0	0.8
18	Hungary	89.8	1.0	18	Rep. Korea	110.0	0.8
19	Canada	66.4	0.7	19	Netherland	102.4	0.7
20	Yugoslavia	50.0	0.5	20	Denmark	75.8	0.5
21	Netherlands	39.0	0.4	21	Poland	42.0	0.3
22	Brazil	35.0	0.4	22	Finland	42.0	0.3
23	India	31.0	0.3	23	Slovak Rep.	33.0	0.2
24	China	28.0	0.3	24	Romania	28.0	1.9
25	Singapore	27.7	0.3	25	Croatia	25.1	0.1
26	Denmark	25.0	0.3	26	India	17.2	0.1
27	Rep Korea	22.0	0.2	27	Mexico	15.0	0.1
28	Bulgaria	15.0	0.2	28	Ukraine	12.0	0.1
29	Argentina	12.0	0.1	29	Portugal	8.7	0.1
30	Portugal	4.6	0.1	30	Hungary	8.6	0.1
31	S. africa	3.9	0.1	31	Argentina	6.7	0.1
32	Mexico	1.5	0.1	32	S. Africa	3.6	0.0
33	Australia	1.1	0.1	33	Yugoslavia	0.0	0.0
Total		*9,324.8*	*100.0*	*Total*		*14,531.5*	*100.0*

Source of Basic Data: American Machinist, 1980 and 1994.

Table 2

Revealed Comparative Advantage in Machine Tools

1975, 1980, 1985, 1991

COUNTRY	*1975*	*1980*	*1985*	*1991*
U.S.A.	0.7647	0.6923	0.4167	0.4331
E.C.	1.2843	1.3077	1.2000	0.9808
Japan	0.5686	1.5000	2.1333	1.9231
China	-	-	0.1167	0.7115
Taiwan, China	0.3627	1.2564	1.3167	1.2692
Rep. of Korea	0.0098	0.1923	0.1333	0.1923
Singapore	0.2647	0.4744	0.7000	0.5385

Note: See text for RCA formula.

Source of Basic Data: ADIXT (IDE Statistical Department, Tokyo).

Table 3

MT Technology Licensing Agreements in Japan

1951-1974 (Number)

Time-Period	US	France	W.Germany	Switzerland	UK	Italy	Belgium	*Total*
1952-60	16	9	6	3	1	-	1	36
1961-65	12	2	3	3	-	1	-	21
1966-70	20	10	16	7	2	3	-	58
1971-75	21	4	8	3	2	-	-	38
1976-81	70	30	33	17	5	5	1	161
Total Share (%)	43.5	18.6	20.5	10.6	3.1	3.1	0.6	100

Source: Haha to naru kikai: 30-nen Ayumi (30 Year History of Mother-Machine), Japan Machine Tool Builders Association. 1992.

Table 4
FDI in Japan's Machine Tool Industry
1963-1975

Date Established	*Japanese Firm*	*Foreign Firm*	*Capital (million yen)*	*Foreign Share (%)*	*Major Products*
Aug. 1963	Koyo Co.	Van Norman (US)	72	49	Knee-type milling machine; centerless grinding machine
July 1969	Toshiba Machine	Kearney & Tucker (US)	600	60*	Machining center
March 1970	Shoun Mach. Tool:	Casaneuve (Fr)		20	Automatic profile lathe
	Osaka KK Hasakaya**	Lerma (Fr)	15	30	
May 1970	Murata Machine	Warner & Swasy (US)	50	50	Single spindle automatic lathe
May 1970	Enshu Mfg.	Cross Intl (US)	400	50	Automatic vertical machine; automatic test machine
April 1975	Toyoda Koki	Van Mops (UK)	75	44	Diamond tool

Notes: *In 1973, foreign capital participation would be reduced to 10%.
**20% for each Japanese firm
Source: Japan Machine Tool Builders Association (1962).

Table 5

Technology Licensing Agreements in the Korean MT Industry

1969-1993

Country of Origin	*Date of Agreement*	*Japanese Firm*	*Korean Firm*	*Product Embodying Licensed Technology*
Japan	May 1969	Okuma Corporation	Dongyang Machinery	Certain MT Types
Japan	January 1970	Daisho	Korean Bearing	Certain MT Types
Japan	October 1974	Takizawa Machine	Hwacheon Gear	NC-MT
Japan	April 1975	Okuma Corporation	Dongyang Machinery	
U.S.	May 1975	Allis Chalmers Co.	Samchully	MT chuck
Japan	January 1976	Nihon Kikaiseisaku	Teil (No. 1) Machinery	Gear-working machine
U.S.	February 1976	Blaw-Know Foundtry & Mill M/C	Kang Yun Industry	
Japan	April 1976	Hitachi Seiki	Kia Machinery	Certain MT types
Japan	April 1976	Osaka KK	Hyundai Yang Heng	Grinding, milling machine lathe
Japan	July 1976	Hara Kogyo	Samchully	Drilling machine chuck
Japan	August 1976	Ikegai Tekko	Daewoo Heavy Inds.	Lathes
Japan	September 1976	Kitagawa Kogyo	Samchully	Fine bench lathe
Japan	October 1976	Yamazaki-Mazak	Daikan Heavy Inds.	Lathes
Japan	October 1976	Toshiba Machinery	Daikan Heavy Inds.	Boring, milling machines
Japan	March 1977	Kogawa Tekko	Dusan Machinery	Drilling machine
Japan	October 1977	Nippei Toyama	Kankoku Machinery	Grinding machine

Country of Origin	*Date of Agreement*	*Japanese Firm*	*Korean Firm*	*Product Embodying Licensed Technology*
U.S.	December 1977	Cincinnati & Miraclon	Hyundai Yang Heng	Cylindrical grinding machine
Japan	December 1977	Kogawa Tekko	Hyundai Yang Heng	Radial drilling machine
Japan	February 1978	Hamai Sangyo	Daewoo Heavy Inds.	Milling machine
Japan	May 1978	Makino Milling	Daewoo Heavy Inds.	Universal grinding machine
Japan	May 1978	Nippei Toyama	Kangkoku Bearing	Grinding machine
Japan	May 1978	Toyoda Machine Works	Kia Machinery	Grinding machine
Japan	June 1978	Okamoto KK Seisaku	Hwacheon Gear	Grinding machine
U.S.	July 1978	Kearnev & Trecher	Daewoo Heavy Inds.	Knee-type milling machine
Japan	July 1978	Mitsubishi Jukogyo	Hyundai Motor Co.	Special purpose machines, hobbing machine, gear-shaver
Japan	October 1978	Kitagawa Kogyo	Hwacheon Motor Co.	Lathe chuck
Japan	December 1978	Fuji Kikai Seiko	Kia Machinery	Automobile lathe
Japan	April 1979	Okuma-Howa Machine	Dusan Machinery	Milling machine, CNC profile milling
Japan	December 1979	Howa Kogyo	Hyundai Machinery	Knee-type milling machine
Japan	December 1979	Mitsui Seiki Kogyo	Daewoo Heavy Inds.	Machining center
Japan	December 1979	Hitachi Seiki	Daekan Heavy Inds.	Milling machine
Germany	December 1979	Pitter	Tongil	Automobile lathe
Japan	December 1979	Yasuda Kogyo	Tongil	Machining center

Country of Origin	*Date of Agreement*	*Japanese Firm*	*Korean Firm*	*Product Embodying Licensed Technology*
Japan	March 1980	Enshu Seisho		Milling machine
U.S.	May 1981	USI-Clearing	Daekan Heavy Inds.	Press machine
U.S.	June 1982	MIT	Daekan Heavy Inds.	NC lathe
Japan	May 1982	Ikegai Tekko	Daekan Heavy Inds.	Horizontal boring machine
Japan	April 1983	Junishi Kosakusho	Shinseki Industry	Milling machine chuck
Japan	July 1983	Hitachi Seiki	Kia Machinery	CNC lathe; horizontal milling machine
Japan	September 1984	Shin Nippon Koki	Hyundai Motor Co.	Machining center
Germany	October 1984	Wanderer	Tongil	Machning center
Japan	February 1985	Kitagawa Kogyo	Samchully	Lather; hydraulic cylinder & chuck
Japan	September 1985	Sodick	Daewoo Heavy Inds.	Wire cut EDM
Japan	November 1985	Toshiba Kikai	Daewoo Heavy Inds.	Horizontal machining center
Japan	November 1985	Sodick Co.	Daewoo Heavy Inds.	NC EDM; wire cut machining center
Japan	December 1985	Okuma-Howa Machine	Dusan Machinery	CNC profile milling machine
Japan	July 1986	Dainichi Kinzoku	Kangkoku Machine Tool	NC lathe
Japan	July 1986	Kitawawa Iron Works	Samchully	Hydraulic chuck; hydraulic cylinder
Japan	July 1986	Howa Corporation	Hwacheon Gear	Hydraulic chuck; hydraulic cylinder
U.S.	October 1986	Clering Inc.	Hyundai Heavy Inds.	Mechanical & hydraulic press
Japan	July 1987	Osaka KK	Hwacheon Gear	Horizontal machining center

Country of Origin	*Date of Agreement*	*Japanese Firm*	*Korean Firm*	*Product Embodying Licensed Technology*
Japan	July 1987	Tsugami Specialty	Man Do Machinery	Thread rolling machining center
Japan	November 1987	Fuji Electric Company	Goldstar Inst. & Elec.	PLC
Japan	February 1988	Hishida Company	Han Won Precision	Line center and FMS
Japan	March 1988	Shin Nippon Koki	Hyundai Heavy Inds.	Piano miller
Japan	April 1988	Kasi Fuki Company	Hyundai Motor Co.	NC Gear cutting; machining center
Japan	April 1988	Guwabara Company	Hoe Jun Precision	Cylindrical grinding; M/C
U.S.	April 1988	Allen Bradley Company	Korea A-B Ltd.	CNC system AC
Japan	July 1988	Yasukawa Electric	Doosan Machinery	Industrial robot
Japan	November 1988	Matsuzawa Mft. Co.	Youil Machinery	Universal tool grinder
Germany	November 1988	Gebruder Honsberg	Saeil Heavy Inds.	Machining center
Japan	December 1988	Osaka KK	Samsung Shipbuilding	Machining center
U.S.	December 1988	Connel Ltd.	Samsung Shipbuilding	Mechanical precision press
Germany	January 1989	Siemens	Goldstar Cable	CNC system
Japan	January 1989	Toyoda Machine Works	Daewoo Heavy Inds.	PLC
Japan	February 1989	Fanuc Ltd.	Daewoo Heavy Inds.	Industrial robot
Japan	March 1989	Fanuc Ltd.	Fanuc Korea	Robot controller
Japan	May 1989	Takisawa Machine	Korea Machinery	Machine tool
U.S.	May 1989	AMCA Int'l Co	Hyundai Heavy Inds	CNC lathe (horizontal type)
Japan	May 1989	Kansai Seisakusho	Kuk Je Ki Kong	Gun drilling machining center

Country of Origin	*Date of Agreement*	*Japanese Firm*	*Korean Firm*	*Product Embodying Licensed Technology*
Japan	December 1989	Osaka KK	Hwacheon Machine Tool	Machining center
Japan	December 1989	Ikegai Corporation	Mando Machinery	CNC lathe; machining center
France	January 1990	Somab	Haiduk Machinery Co.	NC lathe
Japan	April 1990	O-Tec	Woo Chang Machinery	Broaching machining center
Japan	April 1990	Yamazaki Mazak Co.	Hyundai Precision	CNC lathe; machining center
Japan	July 1990	Osaka KK	Samsung Shipbuilding	Machining center
Germany	August 1990	Praaewema	Hwacheon Machine Tool	CNC grinding machine center
Japan	September 1990	Nachi-Fuji Koshi	Kukje Diamond	Broaching machining center
Japan	October 1990	Sumikura	Taihan Mfg. Co. Ltd.	Shearing line; sitting line
Japan	November 1990	Nippei Toyama	Kia Machine Tool Co.	NC line center
Japan	November 1990	Nomura Machine Tool	Sang Won Indl. Corp.	Horizontal boring/milling MC
Japan	March 1991	Chubu Koki Co. Ltd.	Kuk Je Diamond Indl.	CNC lathe
Japan	May 1991	Fanuc Ltd.	Hwacheon Machine Tool	Loader robot
Japan	1991	Mori Seki	Samsung Shipbuilding	NC lathe; machining center
Japan	July 1991	Nishida Company	Han Won Precision Machinery	Ball grinding machine
Japan	July 1991	Yasunaga Takkosho	Dae Yong Machinery	Special purpose machine
Japan	August 1991	Fanuc Ltd.	Fanuc Korea Corp.	Electric discharge machine
Japan	April 1991	Otori Kiko Co.	Nambuk Co. Ltd.	CNC bed type milling machine
Japan	December 1991	Kuraki Company, Ltd.	Hyundai Motor Co.	CNC grinding machine

Country of Origin	*Date of Agreement*	*Japanese Firm*	*Korean Firm*	*Product Embodying Licensed Technology*
Japan	April 1992	Shigiya Machinery	Dae Young Machinery	Cylindrical milling machine
Japan	June 1992	Yamazaki Mazak	Hyundai Pree'n & Ind.	Horizontal machining center
Japan	October 1992	Osaka KK	Hwacheon Machine Tool	Horizontal machining center
Japan	October 1992	Hitachi Seiki Co.	Kia Machinery Tool	Horizontal machining center
Japan	November 1992	Fanuc Ltd.	Hwacheon Machine Tool	Loader robot
Japan	June 1993	Seiko Seiki Co.	Hyundai Motor Co.	CNC grinding machine

Source: Mizuno, J. (1990). JMTBA Research Department files.

Table 6

Joint Ventures in the Korean MT Industry

Name of Foreign Firm	*Name of Korean Firm*	*Date of Approval*	*Products*
Dainichi Kinzoku Kogyo Co. Ltd	Han Kook Machine Tools	08/03/1967	Lathe; CNC lathe; planomiller; milling machining center
Southbend Lathe Inc.	Dae Jung Southbend Co.	08/10/1981	Lathe; drilling machining; grinding machining center
Fanuc Ltd.	Fanuc Korea Corp.	01/26/1978	Numerical controller
Nikken Kosakusho Works, Ltd.	Korea Nikken Ltd.	12/31/1986	Milling chuck; tool holders
Miroku Kikai, Ltd.	Korea Miroku Corp.	06/03/1986	Gun drilling machining center
Mr. Tae-Soo Kwon & 2 others	Korea Hojo Manufacturing	08/12/1987	Special-purpose machining center; NC-Machine Tools
Fanuc, Ltd. Hwacheon Machinery Works Co. Ltd. Kolon Trading Co.	Fanuc Korea Corp.	11/23/1987	NC unit; wire-cut EDM
Allen Bradley Co.	Korea A-B Ltd.	07/01/1988	CNC system; AC servo system; spindle drive & motor

Source: JMTBA Research Department.

Table 7

Technical Cooperation by Area and by Industry, Taiwan

1962-1992

Industry	*Total*	*Amer.Sub-Total*	*U.S.*	*Europe Sub-Total*	*Germany*	*Asia Sub-Total*	*Japan*	*ROW*
Food and Beverage	132	28	26	10	-	83	77	1
Textile	76	23	22	6	4	47	46	-
Garment & Footwear	39	15	14	5	-	19	17	-
Wood products	8	-	-	2	-	6	4	-
Pulp, Paper, & prods.	34	12	12	3	-	19	19	-
Leather & Fur prods.	9	3	3	2	2	4	4	-
Plastic and rubber prods.	168	32	32	21	8	127	126	3
Chemicals	751	198	189	150	62	396	374	7
Non-metallic minerals	132	21	20	18	10	92	92	1
Basic Metals & prods	422	53	52	86	31	344	340	4
Mach. Eqpt. & Instruments	490	56	54	86	31	344	340	4
Electronics & Electric Appl.	1,100	358	355	94	21	645	642	3
TOTAL								
Manufacturing	3,376	809	789	447	159	2,097	2,055	23
Percent share	100.0	24.0	23.4	13.2	4.7	62.1	60.9	0.7

All Sectors	3,783	923	898	492	172	2,342	2,277	26
Percent share	100.0	24.2	23.7	13.0	4.5	61.9	60.2	0.7

Source: Statistics on Overseas Chinese and Foreign Investment, Technical Cooperation, Outward Investment, Outward Technical Cooperation, and Indirect Mainland Investment (Investment Commission, Ministry of Economic Affairs. December 31, 1991).

Table 8
Technology Cooperation Agreement of China's Major MT Firms

Chinese MT Firm	*Foreign MT Firm*	*Major Products*
Beijing No. 1 Machine Tools	Hitachi Seiki (Japan); German firm	Universal milling machine; NC plano-miller; machining center
Beijing MT Research Institute	Fanuc Ltd (Japan); KTM (UK)	Machining center; FMC; FMS; EDM
Beijing No. 2 Machine Tools	Toyoda Machine (Japan); Paulo (Italy)	Machining center; EDM; grinding machine
Dalian Machine Tools	Huller Hille (Germany); KTM (UK)	Special-purpose machine; lathe; machining center; NC lathe
Dalian No. 2 Machine Tools	Boehringer (Germany)	Ordinary lathe; NC lathe
Shanghai Machine Tools	Landis (US); Leitz (Germany)	Grinding machine
Shanghai Heavy Machine Tools	German firm	Large-scale lathe; bed-type grinding machine
Shanghai Tool Co.		Cutting tools
Jiman No. 1 Machine Tools	Yamazaki Mazak (Japan); Weiler (Germany), Steinel (Germany)	Ordinary lathe; NC lathe
Hangzhon Machine Tools		Surface grinding machine
Kunming Machine Tools	Deckel (Germany); Shefield (UK)	Jig boring machine; machining center
Guangzhon Machine Tools		Ordinary lathe; NC lathe
Wuxi Machine Tools	Cincinnati Miraclon (US); GMN (Germany)	Grinding machines
Sino-Czech Friendship Factory	Okuma (Japan)	NC lathe
Cheuyang No. 3 Machine Tools	Okuma (Japan)	Five-sided assembly machine

Shanghai No. 3 Machine Tools	Tsugiya Precision (Japan)	OEM; cylindrical grinding lathe
Uluxi Machine Tools	Fanuc Ltd. (Japan)	Centerless grinding machine
Suzhou-Sodick (Hongkong capital)	Sodick (Japan)	Electric discharge machine

Source: JMTBA Research Department.

Table 9

Composition of Production Employees in the Korean MT Industry

1983 and 1991

Employee Category	*1983*		*1991*	
	Number	*Percent*	*Number*	*Percent*
Production Employees	13,757	100.0	9,379	100.0
Engineers & Lower Engineers	2,913	21.2	2,361	25.2
Skilled Labor	10,844	78.8	7,018	74.8

Source: Machine Tool Statistics Handbook, Korean Machine Tool Manufacturers Association, 1985 and 1992-1993.

Table 10

Composition of Employees in Japan's MT Industry by Educational Background

1987-1993

Educational	*1987*		*1989*		*1991*		*1993*	
	Number	*%*	*Number*	*%*	*Number*	*%*	*Number*	*%*
Middle School	0	0	0	0	9	1	1	0
High School	328	58	561	56	805	55	343	44
Specialized Short-Term University	-	-	190	19	258	17	130	17
Degree	241	42	185	18	280	19	232	30
University Degree in Science			68	7	125	8	73	9
University Arts Degree	*569*	*100*	*1,004*	*100*	*1,477*	*100*	*779*	*100*
TOTAL								

Note: Data based on a survey of 23 firms (1987-89); 31 firms (1990-91); and 30 firms (1992-93).

Source of Basic Data: Handbook of Machine Tool Statistics, JMTBA. 1993.

Table 11

Time Lag Between First Introduction and First Exportation of NC-MTs

Country	*Year of Introduction/of NC-MT (Name of Firm)*	*Year of First Exportation*	*Time Lag Between First Introduction and Exportation*
Japan	1958 (Makino Milling)	1970	12 years
Taiwan	1974 (Yang Tei Co.)	1981	7 years
Korea. Republic of	1974 (Niigata, Japan)	1981*	7 years

*The first recorded data on exports were from 1980, but the number of machining centers exported was so small (4 units) that it was most likely not of a commercial nature.

Source: Various sources.

Table 12

Modes of State Intervention in the Development of the East Asian Machine Tool Industries

POLICY	*JAPAN*	*TAIWAN*	*REPUBLIC OF KOREA*
Protection Policy	Foreign Trade Control Law (1949) Import licensing system with restrictions on MT imports if domestic substitutes available After 1970: 25% tariff on certain MTs	Import Approval System 1980: 20% tariff on MTs Higher tariffs for targetted components of machine tools	Import Approval System Approvals by KMTBA*
Industry Promotion Policy-Industry Targetting	Law on Temporary Means for the Development of the Machinery Industry	Ten-Year Economic Plan, 1980-89 Four-Year Development Plan, 1982-85	1973: Long-Term Machinery Industry Nurturing Plan; 1976: Strategy for localization of certain types of machine tools
Financial Incentives	Subsidized interest rates Access to credit at the Japan Dev. Bank, Industrial Bank of Japan, Long-Term Credit Bank	Subsidized credit from development banks, or for stipulated items under the Strategic Industry Fund	Subsidized credit under the above programs

POLICY	*JAPAN*	*TAIWAN*	*REPUBLIC OF KOREA*
Fiscal Incentives	Tax-related measures under various machinery industry nurturing policy		Tax deductions under Long Term Machinery Industry Nurturing Plan Special depreciation allowance, Tax deductions on Machinery of SMEs
Subsidy to R&D	MITI Long-Term Technical Assistance Promotion of joint research MITI Mechanical Engineering Lab. Japan Research Development Corp. Japan Society for the Promotion of Machinery Industry	Industrial Technology Research Institute; Machinery Industry Research Laboratory	State-funded research laboratories
Export Promotion Policy	Special/general export incentives	General export incentives	Special/general export incentives

Appendix Table 1

Japan's FDI in Asian Machine Tool Industries

Host Country	*Japanese MT Firm*	*Company Name*	*Date of Approval*	*Value of FDI (in millions)*	*Main Activity*
Korea	Dainichi Kinzoku	Korea MT Co.	03/1969		MT production
	Fanuc	Fanuc Korea Corp.	05/1978		CNC, wire EDM, CNC drill production sales, maintenance of laser parts
Taiwan	Amada	Amada	09/1984		MT sales service
	Takizawa	Taiwan-Takizawa	07/1971		Lathe production
	Toshiba	Tosei Kikai KK	04/1968		
	Toshiba Machine	Taiwan-Toshiba	06/1989		Maintenance, sales
	Niigata	Taiwan-Niigata	11/1990		-
	Tekkosho Fanuc	Fanuc-Taiwan Corp.	12/1986		CNC production
Singapore	Amada	Amada-Singapore	07/1989		MT sales, service;
	Okamoto	Okamoto-Singapore	01/1975		Surface grinding machine prod.
	Toshiba	Toshiba Machine SEAsia Pte	07/1978		Sales of machine tools
	Niigata Engineering	Niigata Engineering	04/1978		Sales, service
	Fanuc	Fanuc Singapore	11/1979		CNC maintenance, sales

Host Country	*Japanese MT Firm*	*Company Name*	*Date of Approval*	*Value of FDI (in millions except*)*	*Main Activity*
	Makino Milling	Le Blond Makino, Asia Pte. Ltd.	1985	1.13 S$	M/C, wire EDM, center lather prod.
	Mori Seiki	Mori Seiki Singapore Pte.	03/1993	6 S$	Sales, service
	Yamazaki Mazak	Yamazaki Mazak. Sing.	12/1988	0.2 S$	Sales, service, MT components prod.
P.R. China	Fanuc	Beijing-Fanuc Mechatronics	1993		CNC production
	Sodick	Shanghai-Sodick Software	11/1991	*140 Yuan	Software development
Hong Kong	Niigata Engineering	Niigata Engineering (HK)	01/1975	0.3 HK$	Sales, service
	Fanuc	Fanuc HK Ltd.	10/1987	0.5 HK$	CNC maintenance
	Miyano	Miyano Machinery	10/1988	.008 HK$	NC production
Thailand	Osaka KK	Thai OKK Machinery Co.	08/1990	5 Baht	Assembly of MT parts and components
	Okamoto	Okamoto-Thai Co.	07/1988	346 Baht	Surface grinding machine production; sales
	Sodick	Sodick-Thailand	01/1990	240 Baht	Center, NC, boring lathe prod.
	Tsugami	Tsugami Thai	07/1990	10 Baht	Sales, maintenance
	Toshiba	Toshiba Machine (Thailand)	05/1989	8 Baht	Sales, maintenance

Host Country	*Japanese MT Firm*	*Company Name*	*Date of Approval*	*Value of FDI (in millions)*	*Main Activity*
	Niigata Engineering	Niigata Engineering Thai	06/1990	-	-
	Fanuc	Fanuc Thai Ltd.		2 Baht	CNC maintenance
Indonesia	Tsugami	P.T. Pamindo	06/1975	1,317 Rp.	Industrial machinery, car parts production
	Fanuc	P.T. Fanum Pindad Technical Center	10/1988	0.5 Rp.	CNC maintenance, sales
India	Fanuc	Fanuc, India Ltd.	03/1990	-	CNC

NOTES

[1] On the merit of searching for models from Asia, see, for instance, R. Posadas' "The Philippines," ch. 5 of *Technological Independence: The Asian Experience*, ed. S. Chamarik and S. Goonatilake, The United Nations University, 1994.

[2] For an excellent overview of issues and review of technology policies at both industry- and country-levels, see *Technological Challenge in the Asia-Pacific Economy*, ed. H. Soesastro and M. Pangestu, Allen & Unwin, 1990.

[3] The discussion in the following subsection is based mainly on Smith and Jordan (1990), pp. 11-15 in H. Soesastro and M. Pangestu (eds), *The Technological Challenge in the Asia-Pacific Economy*.

[4] A country j's revealed comparative advantage is measured as follows (Balassa 1965) :

$$RCA_j = (X^{mt}_j / X^{mfg}_j) / (X^{mt}_w / X^{mfg}_w)$$

where X^{mt}_j = value of country j's exports of MTs for a given year;
X^{mf}_j = value of country j's exports of manufactured goods for a given year; similarly for w signifiying world values.

A country is said to be specializing, and hence has a revealed comparative advantage in exports of MTs if its RCA is greater than or equal to 1.0. It assumes a relatively open trading system so that countries' export specialization "reveals" their pattern of comparative advantage.

[5] EC6 is made up of the original six members of the European Economic Community (now referred to as European Union). These are Belgium, France, Germany, Italy, Luxembourg and the Netherlands. The data for 1991 cover 12 countries, including UK, Denmark, Greece, Ireland, Portugal, and Spain.

[6] In 1987, the US exacted a VER (voluntary export restraint) on MTs from Japan, Taiwan, Germany and Switzerland, which was supposed to last for five years, i.e., until 1991.

[7] The CPC model is more known by its original name "flying-wild geese pattern of development," first introduced by Akamatsu in 1962.

[8] Numerically controlled MTs operate on a predetermined program,

with data on punched cards or magnetic tapes, being converted into electric pulses that controls the MT's mechanical functions.

[9] Fransman (1986), however, surmises that the researchers involved had gone beyond mere replication by attempting to introduce improvements to the model, as typified by the replacement of vacuum tubes with parametrons at the University of Tokyo.

[10] A memorandum of the MITI's Enterprise Bureau (1960) on the rationale for allowing FDI stated thus:

" ...applications for acquisition of stock for the purpose of participation in management of [Japanese] operations have been handled in an extremely careful manner, and approval has been granted only in the case involving license of an important technology where a foreign investor denies the license unless acquisition of stock is approved in exchange, or in similar cases." (quoted by Fransman 1986: 191.)

[11] For the entire manufacturing sector, Japan's average size of FDI was only about half of that of the US; so that, in terms of number of FDI approvals, Japan comes out on top (53 percent), while the US tops the list when FDI is measured in terms of value (33 percent), with Japan following closely behind (32 percent).

[12] China started building NC-MTs in 1965, but the unreliability of the ICs led to quite unsatisfactory results.

[13] However, Fanuc is reported to have refused licensing a system which was more sophisticated, resulting in the system having to be directly imported from Fanuc, without interface software. However, even so, Beijing First Machine Tool Factory is said to have produced a machining center with a 24 spindle-automatic tool changer (Chudnovsky et al. 1983: 165).

[14] Other sources that respondent firms were asked to rank were: *worker suggestions, suppliers of components/parts, subcontractors, consultants, professional or trade journals, products of competing firms, and government incentives or pressures*. The second most important source turned out to be *products of competing firms*. Sharing third rank were *suppliers of components/parts and professional or trade journals*.

[15] Confirmed by the author during plant visits of major MT-producing firms in Japan.

[16] His comments revealed that Japanese engineers carefully listened to

customers'complaints and suggestions during plant visits for maintenance or repair, thus receiving information which eventually influenced future designs of MTs.

[17] The most important was "products of competing firms." A reverse ranking was found for Japan where respondents ranked this second in importance, after "customers in domestic and foreign markets" (Fransman 1986: 186-87).

[18] The firms were chosen out of 70 domestic enterprises which developed 86 capital goods designated by the Korean government as newly developed innovative machines.

[19] The discussion is based primarily on Fransman (1986) for Japan and Taiwan, and on Mizuno (1990) for Korea.

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DISCUSSION

Ernesto D. Bautista

The article identifies lessons for technology policy, based on the East Asian experience, by examining it on the industry level—across countries and through time. In identifying the lessons, the article underscores the role of the State in technology acquisition, and the importance of a firm's technological capabilities as major determinants of the mode of technology acquisition.

The first important lesson from the successful technology development experience of these East Asian countries is the *importance of the firm and the firm's technological capability in technology acquisition*.

Indeed, the failure to recognize the firm as the central player in the accumulation of technology has been a major shortcoming of technology policy.

The most flagrant example is the former Soviet Union, as well as the other centrally planned economies, where the design and development functions were separated from the private sector. Similar policies have been followed in other developing countries—the Philippines is not an exception. As a result, the largely supply-driven R&D activities have consequently contributed to the problem of commercialization of research results—the usual problem.

The importance of firm and technology development and transfer is in large part due to the tacit nature of technology. A large part of technology involves tacit knowledge, in the form of rules of thumb that are neither costless nor quick. The degree of transfer thus largely depends on the capability of the firm to carry out the various processes embedded in the technology.

Accordingly, the choice of the mode of acquisition of technology transfer depends on whether the firm has the internal capability to manage the new technology without creating serious bottlenecks. When the firm has considerable capability, it

tends to favor arm's-length transactions, in which there are severe informational problems between the supplier and the recipient of technology. The choice will tend to favor transactions with some equity or risk sharing.

The experiences of Japan, South Korea, and Taiwan, with regard to the machine tool industry, clearly point to this. But what the East Asian experience also underscores is that technology policy is as much a policy for technological accumulation, or developing technological capability, as it is a part of the country's industrial policy.

A technology policy is necessary, given the failure of markets in technology development. This includes technology spillover in production and marketing. The presentation also showed the large-scale risks and informational problems that cannot be internalized by single firms.

The last part of the presentation tackled macrorelated issues and the role of the State that underlies the technological development of the East Asian economies. Much of the so-called East Asian miracle is now fairly understood by economists and development practitioners. It is important to highlight the lessons from this experience in the context of technological development, as they underpin the East Asian development experience.

First, technology development was pursued as a part of an industrial policy. The expansion of certain industries—in this particular case, the machine tool industry—was effected by the receptivity to direct foreign investments or imports. Support for particular industries and imports of necessary foreign technology took various forms. East Asian economies invested heavily in human capital education. Support for education, particularly in engineering and science, provided an intellectual infrastructure that facilitated technological transfer.

In some countries, the government promoted technology programs that included science centers offering services ranging from identifying new products to providing research and development work for firms without such facilities. Taiwan and Malaysia developed industrial parks for high-technology industries. Both allowed firms to capture some of the diffused exter-

nalities associated with these industries, as well as lowering entry barriers. Government support to industry and technology acquisition included *active support* and *strategic negotiations*.

By reducing competition among buyers of technology and trying to increase competition among sellers, the government in some countries succeeded in appropriating more surplus associated with the transfer of technology. There have been instances where governments forced other firms to withdraw during the negotiations so that, in effect, there was only one firm negotiating with the buyer. In some cases, the firm acquiring the technology was forced to share that technology with other firms.

While the governments of East Asian countries pursued industrial policies, enterprises receiving related incentives were subjected to *export performance evaluation*. This was a critical part of the strategy; without which, continuous technological innovation would not have had occurred. Not only did Asian countries and their governments use trade to acquire more advanced technology, they also subjected their industries to the rigors of competition through *export orientation*.

Export orientation assured constant exposure to international best practices, and benefited firms with spillovers of marketing and production know-how. For instance, success in producing intermediate goods that required standards typically higher than those prevailing within developing countries. This generated demands for *testing laboratories* and *quality assurance systems*. The contacts established through exporting provided information on where to acquire new technology, as well emphasized the importance of ideas for incremental innovation.

East Asian countries fostered cooperation through the formation of deliberation councils as well as competition by rewarding firms that performed well. Along this line, labor markets were developed to encourage cooperative behavior. *Cooperative behavior* between firms and their employees had been particularly important in facilitating technological change. Because firms guaranteed lifetime employment, and wages were based prima-

rily on firm productivity, the adoption of productivity-enhancing innovation increased profits in the long run. This labor condition made workers less resistant to the adoption of technological innovations that improve firm productivity.

While the presentation provided information on how our East Asian neighbors managed to acquire technology, I believe the lessons from their experiences extend beyond this issue. For the lessons to be appreciated, it is equally important to ask how specific industries in some of the East Asian countries, particularly Japan, managed to strengthen their technological and competitive advantage.

The answer is important as it also leads us to a lesson that interests policymakers trying to understand the underlying competitive strategy of Japanese firms. This forces us to look into other areas, such as the *industrial organization,* and how these shape the competitive advantage of Japanese firms.

One specific lesson from the Japanese experience is that technological upgrading, which enhanced competitive advantage, had something to do with the development of *organizational technology*. In contrast to the arm's length contractual mode of trading in Western countries, Japanese firms rely more on obligational contractual arrangements or relations. Japanese firms have been able to maintain their competitive advantage because of their ability to evolve new organizational or management technology.

For instance, instead of internalizing all the technological learnings within a single company, Japanese firms develop *extensive long-term contractual relations through subcontracting arrangements,* as pointed out by the papers of Dr. Tecson and Mr. Alciga. These contractual relations enable them to reduce coordination problems and, consequently, transactions cost.

There is a view that where there is strong competition among subcontractors, the subcontracting system becomes more efficient than vertically integrated production units. Indeed, in the Japanese case, the strong competitive pressure among subcontractors has led to greater efficiency in the subcontracting network, particularly in terms of the organizational structure; the

development of subcontractors with advanced and specialized technology; integrated inventory controls; and more sophisticated contractual relationships.

Moreover, the frequent interaction among the subcontractor associations allows for the rapid diffusion of new technologies. There is also built-in pressure on the SME subcontractors to improve efficiency because the parent firm usually does not allow adjusting arrangements vis-à-vis subcontractors in the event of cost increases in wage and energy.

This arrangement has facilitated continuous product development, quality improvement, and cost reduction. It has also contributed to the Japanese economy's flexibility and competitiveness, as there are numerous SMEs with the capability to absorb technology and collaborate technologically with the parent firm. This organizational design has enabled them to move up along the technological ladder, and increase their sophisticated product niches. Thus, *product niching was also facilitated by more effective organizational technology*.

In the case of Taiwan, for example, the diffusion of advanced technology was also facilitated by the establishment of the Taiwan Productivity Center. The Center looked for models in the industry which were then used as the bases for the demonstration and promotion efforts of the Center. This resulted in the diffusion of technology across industries. Moreover, the Center assisted the private sector through consultancies in solving firm-specific problems.

The European Research Paradox

Chapter 7

EMMANUEL S. DE DIOS
AND MA. JOY V. ABRENICA

What has been called the "European research paradox" refers to the perceived weak relationship between measures of R&D effort or scientific capabilities, and measures of commercial success:

> Thus we observe a 'research paradox:' for a country to have a relatively high R&D intensity in a sector appears not necessarily to be a good indicator of successful industrial performance. (EC 1994: 17)

> This mobilization (to invest in R&D, education, and co-operation) is all the more necessary as Europe suffers from a paradox. Compared with the scientific performance of its principal competitors, that of the EU is excellent, but over the last 15 years, its technological and commercial performance in high-technology sectors, such as electronics and information technologies, has deteriorated. (CEC 1995: 5)

Therefore, the matter appears to be sufficiently established and important to merit attention and call for redress. The mea-

sures used to establish this relationship consist of comparative trends in the "output" of science and technology, such as the number of publications and patents taken out, in relation to R&D expenditure.[1] The fall in technological-output propensity, as measured by patents taken out, in contrast to respectable "science" performance, is regarded as the telltale mark of the paradox.[2]

This chapter is an attempt to assess the importance and significance of the European research paradox.

Explanations

The prevailing explanation for the European research paradox does not seem to have been fully articulated, although it appears to be based on a *generic* critique: a questioning of the capability of the European research system in general to deliver commercializable research output. After citing the paradox, the Green Paper on Innovation (CEC 1995: 5) considers Europe's inferiority in "transforming the results of technological research and skills into innovations and competitive advantages," a major weakness. This is related to a broader assessment that, in Carlo Rubbia's words, "in America, science is business. In Europe, it is still seen as culture."[3]

The solution for the R&D sector is to increase public support for technological investment, especially in strategic sectors, where Europe is perceived as falling behind, such as information technology and biotechnology. As the Green Paper puts it: "The presence of sectors in which the scientific and technological results are comparable, if not superior, to those of our principal partners, but where the industrial and commercial performance is lower or declining, indicates the strategic importance of *transforming the scientific and technological potential* into viable innovation" (CEC 1995: 5). Hence, both an increase in the scale of R&D effort and a reorientation of research efforts and subsidies are called for.

The theory underlying public support to technological effort is based on the idea that certain technologies (sometimes called "strategic") are crucial to productivity growth, but are difficult to obtain once others have gained a head start. Writers on technology, many

of them European (e.g., Dosi et al. 1988), have argued persuasively that most productivity improvements in industry occur along what are known as "technological trajectories." If, as argued, learning is cumulative along these trajectories, early starters have a leg up, while latecomers have progressively less incentive to join in, thereby foregoing the benefits of productivity growth. For this reason, public support to encourage firms to enter the high-technology sectors may yield long-term productivity benefits. Yet another stream of literature to support policy-activism in R&D is found in the "endogenous growth theory" (Romer 1990; Lucas 1988; Barro and Sala-i-Martin 1995), which gives significance to technological change—hence, to the accumulation of human capital and the generation of knowledge—as the most important source of productivity growth.[4]

Even here, however, if the generic critique were applicable, some caution is warranted regarding policy conclusions to be drawn from it. Some formalizations of the problem (Grossman 1990: 379) would contend that, taking general equilibrium effects into account, a subsidy to innovation would have the effect quite opposite to that intended: it may raise the rate of innovation in the policy-active country, but reduce the number of high-technology goods produced, as highly skilled labor is drawn away from the manufacture of these goods.

In principle, the same theories of the process of innovation cited to justify massive public R&D support may also be interpreted as placing limits on such intervention. For certainly the theory also suggests that, owing to hysteresis and the reinforcement of initial advantage, technological superiority by the leaders may become so pronounced that it is difficult to undo. A point would be reached where subsidies below a certain level are ineffective in erasing the lead and hence wasteful.

This idea is certainly consistent with the observation of European superiority in other industries. It does so happen that chemicals and pharmaceuticals are industries in which European firms collectively have had a head start, beginning with the scientific breakthroughs of the late nineteenth century. Similarly, one may argue, the American and Japanese superiority in electronics and telecommunications is the outcome of a head start in these areas. Without

knowledge spillovers, countries where more industries have had a head start would conduct their own R&D, and enjoy higher rates of technological progress. For example, Japan is supposed to have benefited from this process by establishing an early lead in semiconductors (Baldwin and Krugman 1988).

Nor is the generic explanation of the paradox wholly convincing. For one, it obviously does not apply to the entire gamut of European industries. Data show that in certain industries, notably pharmaceuticals and chemicals, European performance is comparable, if not superior, to those of the United States and Japan. What the generic critique fails to provide is an explanation as to why the *same* R&D system works well in *some* branches, but not in others. This suggests that an adequate explanation must be *specific* to the processes of innovation and commercialization within each industry or sector, since it is not true that all European industries are equally inferior in linking their R&D efforts to commercialization. The answer then cannot neglect factors internal and specific to the nature of the technology and process of research itself.

We suggest that a full explanation of the "research paradox" must involve an examination of specific constraints in efficiency and strategic behavior, faced by innovating firms in particular industries.

Relative Efficiencies

In this section, we pursue the point that the optimal choice of research partner depends on (a) the nature of the technological economies or gains involved, and (b) the nature of rivals' strategic response. The extension of R&D subsidies based on considerations other than pure efficiency can modify the choices of firms regarding R&D partners, but with unintended consequences. (The claims are treated more extensively in the appendix; this section merely sketches the results.)

In the simplest case, consider a situation where a large European firm (firm G) competes with a large non-European firm (firm U), in the matter of investing in R&D. Both firms have the option of making or not a large R&D investment. A single firm making the

investment without a similar response from the other yields a large gain for the active firm and a loss for the passive firm. If, however, both firms are making R&D investments, then redundancy is the result, with even greater losses for both. It is a well-known result (e.g., from Brander and Spencer 1985 or Brander 1995) that if firm *U* is technologically superior *ex ante*, then firm G pursues the passive strategy.

There exists a certain level of subsidy which makes it profitable for G to become active and, because of the credible commitment, possibly drive firm *U* into passivity. A case can be made for a subsidy where the increase in private profits for firm G owing to the intimidation of firm *U* exceeds the cost of the subsidy. This formalizes the idea that national champions can (and in some cases should) be subsidized to become more aggressive in innovation.

At the conceptual level, an R&D subsidy works if it rests on a clear-cut association of rewards with the desired actions. In practice, however, especially in a case with such amorphous outputs as innovation, it is not altogether clear what constitutes an "active" firm policy on innovation and, hence, what to base subsidies on. It is a straightforward result *(Claim 1)* that a public subsidy, which acts as a guarantee, regardless of the action a firm takes, has no effect on that firm's innovation strategy. In this case, a "research paradox" arises, since the subsidy has no effect on the home firm's innovation strategy which continues to be passive, given the technological superiority of the foreign firm. Sharp and Pavitt (1993: 133) conclude that the entire European experience of unconditionally promoting "national champions" through the grant of monopoly status, debt write-offs, and public purchasing contracts, has generally proved to be a failure.

Research Cooperation

Research literature explores the efficiency of research joint ventures (RJVs). The benefits that accrue to cooperating firms are numerous. First, innovation rents are internalized, despite the sharing of information among firms. Cooperation thus creates "club goods,"

by allowing rent to be appropriated and technology to be disseminated efficiently among members. Second, wasteful duplication of effort is avoided as firms coordinate their research activities. Third, the sharing of costs and risks allows firms to overcome barriers of scale and scope, permitting the exploration of more research paths. Fourth, the synergies generated by complementary skills and resources raise the probability of research success. In addition, when the focus of research is basic rather than applied, firms are induced to conduct in-house research in order to transform the shared technology into commercially usable forms.

One of the features of European RJVs, however, is the requirement that they involve firms from several EU countries, and exclude non-EU firms. While the benefits from an RJV are well known, and plausible reasons do exist for both the principle of exclusiveness and multilateralism, nonetheless, current rules begin by implicitly *assuming* that the optimal R&D partnership is between firms from different European countries.

In principle, however, from a purely techno-economic viewpoint, a European firm has *three* typical choices in R&D cooperation: to cooperate with firms with either superior, the same, or inferior level of technological competence. However, the rules of EU RJVs could prevent some of these otherwise natural RJVs from arising.

Suppose that the firm with a superior level is non-European (firm *U*). Let G^0 and G^1 be two EU firms of the same nationality, and with the same level of technological competence; and, let firm *P* be an EU firm with a lower level of competence. Suppose, moreover, that the amount of commercializable output from any RJV varies directly with the product of the technological competence of its members.[5] Then, it will be evident that without any intervention, G^0 would never choose to cooperate with *P*. A level of subsidy exists, however, for which even *P* may be chosen by G^0 (*Claim 2*), but by hypothesis, this configuration yields a lower level of commercializable output. A "research paradox" then results, since the application of the subsidy distorts incentives toward a consortium yielding less commercializable results.

The larger issue, of course, is the judgment call on whether larger

economies are to be reaped from a pure-Europe RJV, or in a mixed (EU, non-EU) venture. An argument can certainly be made that the European attempts to mirror initiatives in other countries led to a good deal of duplication. At least some questioning is warranted regarding the possibilities of trans-European, as against purely European, research cooperation to avoid duplication.

Strategic Behavior

It was suggested above that, without intervention, a potential partner's technological competence would factor in the choice of RJV partner. This tends to suggest that RJVs with leaders will naturally be attractive, if it were not for intervention. This conclusion can be modified, depending on the rival's strategy. The attractiveness of research cooperation will also depend on the anticipated response of technological leaders. In general, observed or anticipated aggressiveness by the (foreign) technological leader serves as an additional motive for cooperating with it, unless R&D subsidies make a partnership with equals or inferiors more attractive. Corollarily, however, a sufficiently inactive policy on the part of the superior foreign rival may make cooperation with equals or inferiors viable *(Claim 3)*.

In many past instances, publicly supported European research programs have been motivated by a desire to mirror or counter initiatives by the United States and Japan, such as the MAC HDTV standard, in response to Japan's MUSE standard; JESSI, in response to the American Sematech; and EUREKA, in response to the American SDI initiative. These may be classified as "aggressive" moves by technological leaders in these industries, which should have motivated *trans*-European partnering. The presence of publicly supported R&D, however, may have moderated, if not reversed, these *ex ante* tendencies, and instead led to pure-EU consortiums. Some exceptions prove the rule: in the case of JESSI, the effort was due to collapse until Siemens was allowed to collaborate with IBM and Toshiba.

Again, because of the differential technological competencies involved and the strategic behavior of rivals, the analysis leads to

the question of whether the subsidies to promote pure RJVs have not led to wasteful duplication and nonoptimal partnering. If so, then once more a "research paradox" results. By contrast, in those industries where rivals are *less* aggressive, pure-EU RJVs would be warranted, although, ironically, the analysis suggests that less prodding is likely needed to induce them to form.

Possible Qualifications

In all of the above, we have not disputed the principle that a case may be made for significant public support for R&D. Only the possibility that original techno-economic motives for promoting R&D may not be achieved if the design of the program is unresponsive to either the technological differences and strategic behavior of the parties involved, leading to wasteful subsidies.

We also suggest, as have others (e.g., Sharp and Pavitt 1993; Foray et al. 1995), that current EU policies on R&D may currently be overburdened with various, sometimes conflicting goals. These require R&D efforts to ensure that the EU has "homegrown expertise" that enables European companies to reap "economies of scale" in R&D through "precompetitive joint ventures," and to narrow technological gaps among member countries. The effect of extraneous goals is related to the theory of distortions in international trade. Just as it is not best practice to redress a negative consumption externality with a tariff (which taxes consumption but subsidizes production as well), deliberately distorting technology policy is unlikely to be the best way to respond to intra-European equity problems. Of course, it might be argued that, in an *n*th-best sense, technology policy could be used to further equity or political goals, but then, the evaluation of the policy must include the achievement of those nontechno-economic goals. If so, there would be no "paradox" at all.

It has been argued that the search for RJV partners must, in principle, be global; and this process is likely to be hindered by considerations, such as nationality, or intraregional equity.

There is, however, room for debate on one point. It is well recognized that research results may affect the payoffs in final market

outcomes; the possibility of subsequent market rivalry may inhibit otherwise cost-reducing research collaboration. How the anticipation of future market outcomes may favorably or adversely affect the formation of precompetitive RJVs has been shown (Abrenica 1995). Indeed, the focus of public support on precompetitive research may be understood as an attempt to get around the problem of second-stage rivalry.[6] In this light, restricting EU research projects to European firms may be similarly understood as an *anticipation* of possible conflicts of interest in a postresearch stage. The implicit judgment is that mixed RJVs (i.e., European, non-European) would be more prone to second-stage rivalry.

The point, however, is simply that the extra costs (or reduction in benefits) from mixed consortiums must be weighed against the inefficiencies of pure consortiums. In particular, it is possible that the gain in technological efficiencies—the *prima facie* motivation for a research consortium—may be overly sacrificed to secondary goals, such as the anticipation of second-stage rivalry, or other goals, including the desire for intraregional convergence.

Policy Implications

The general policy implications derived from this analysis are not new in themselves. They lead to questions regarding the cost of programs that adopt goals extraneous to the success of the research and technology acquisition itself.

For developing countries, taken singly or as a whole, the lesson takes the form of a caveat against prior exclusion and a plea for global search. Most proposals for South-South technological cooperation come from a similar assumption that such cooperation should be restrictive. This is sometimes justified on pure technological grounds, as seen in arguments criticizing inappropriate technologies in developed economies. Such bases for South-South cooperation remain intact, where they can be shown. On the other hand, exclusive technological ventures derived from geopolitical or other reasons will generally be disappointing, from the perspective of their original goals.

The crucial issue is always what each economy or region can obtain from public support to R&D that it otherwise could not have enjoyed under a system of pure private provision. In technology, these externalities ultimately take the form of usable skills and capabilities, embodied in people who participate in either producing or using the generated knowledge. If so, the goal of supporting research should primarily be to enhance the acquisition of such knowledge, from whatever source.[7]

APPENDIX

A Model of Technological Partnering

1. *Promoting National Champions*

We model the rivalry between two firms, labeled U and G, as a noncooperative game with pure and mixed strategies. Firms choose between "active" and "passive" innovation strategies. Let X_{AA} be the profit flow to firm X from its innovation given that both firms choose active strategies; X_{AP}, the profit of firm i if it chooses an aggressive (active) strategy while j chooses otherwise. Analogously, denote X_{PP} to be the profit of firm X when both firms choose to be defensive (passive) and X_{PA} be the profit of firm X if it is passive while the other firm is active.

The matrix of payoffs is given as follows:

G^0		active	passive
	active	G_{AA}, U_{AA}	G_{AP}, U_{PA}
	passive	G_{PA}, U_{AP}	G_{PP}, U_{PP}

It is well known that profits are lower when market competition is tighter. Hence $G_{PA} > G_{AA}$, and $U_{PA} > U_{AA}$ *i.e.*, the best response of i *to* j's aggressive move is passivity. Yet it pays to be active if the rival chooses to be passive, *i.e.*, $G_{AP} > G_{PP}$ and $U_{AP} > U_{PP}$. When both firms slow down their innovation, however, profits are higher, thus $G_{PP} > G_{PA}$ and $U_{PP} > U_{PA}$. If G thinks U will be aggressive with probability q, then G's best pure-strategy responses are as follows: (i) be active if $q > q^*$; (ii) be passive if $q < q^*$, (iii) be active or passive if $q = q^*$, where q^* is given by:

$$q^* = \frac{G_{AP} - G_{PP}}{(G_{PA}, U_{AA}) + (G_{AP}, G_{PP})}.$$

It is easy to show that when G employs a mixed strategy, with probability r of taking an active move, then its expected payoff

increases with r and decreases with q.

Now suppose G^0 is given subsidy s. The changes in the payoffs of G depend on the manner by which the subsidy is applied.

> **Claim 1:** *If G is subsidized only if it takes an aggressive move, then G is more likely to be aggressive. Conversely, if the subsidy is given only when G takes a defensive move, the subsidy induces G to be defensive. An unconditional subsidy (i.e., one given regardless of G's moves) does not change the incentives of G.*

The above proposition follows from the definition of q^*. Thus, q^* falls as s is applied to G_{PP} and G_{PA} only, increases when s is applied to G_{AA} and G_{AP} only, and remains the same when s is applied to all payoff possibilities.

The lesson that emerges from the foregoing is that unless the policy-maker can correctly distinguish between aggressive and defensive moves, then a subsidy can not change the incentive structure of the firm in order to induce it to be more technologically aggressive. Consequently, a more appropriate intervention than direct subsidy is needed to address the market failure problems associated with innovation.

2. *Promoting R & D cooperation*

Two more firms are added to the discussion aside from U and G (now relabeled G^0), namely: G^1 and P. Suppose G^0 has an option of partnering with U, G^1, or P, while the choices available to U are the same, *i.e.*, to be active or passive. Assume that the three possible partners of firm G^0 can be ranked by their technological capabilities: U being first, followed by G^1, then by P.

The payoff matrix of firm G^0 is given below:

		U-active	U-passive
G^0 joins	Firm U	x	a
	Firm G^1	y	b
	Firm P	z	c

Take *Case* 1: Let $x > y > z$, and $b > a > c$.

Claim 2: *Partnering with P is a strictly dominated strategy if x, y > z, and a, b > c. However, a subsidy applied to z and c can reverse the inequality and make partnering with P the dominant strategy.*

When the technological capability of P is weak relative to G^1 and U, then P becomes an unattractive partner to G^0, say because of high coordination cost and weak complementarity. A subsidy can, however, induce a partnership between P and G^0.

Without a subsidy, G^0 is left to choose between U and G^1. In this case, the optimal pure strategies of firm G^0 for given probability q are: (i) partner with U when $q > q^*$; (ii) partner with G^1 when $q < q^*$; (iii) partner with either G^1 or U when $q = q^*$, where q^* is defined as:

$$q^* = \frac{b - a}{(x - y) + (b - a)}.$$

Note that if the partnership of G^0 and G^1 is subsidized, *i.e.* the subsidy is applied to b and y, then q^* increases, and so is the likelihood of G^0 and G^1 cooperating.

Case 2: Let $x > y > z$ and $c > b > a$. In this event, the payoff ranking reflects two things. First, if firm U is active, it is best for G^0 to combine with U to ensure that U does not completely dominate the market. Second, the technological inferiority of P makes it a more attractive partner to G^0 when U is passive. This is because fewer innovations may be expected when G^0 enters into partnership with P than when it combines with G^1. It is therefore assumed that G^0 and P combined is better than G^1 alone, since otherwise G^1 may dominate the market.

Claim 3: *For sufficiently low q, partnership with firm P is optimal. In particular, if*

$$q < \frac{b-a}{(x-y)+(b-a)},$$

and

$$q < \frac{c-b}{(y-z)+(c-b)},$$

then the best pure strategy of G^s *is to partner with P.*

3. *Foreign rival's response to domestic partnering*

Suppose that G^s, G^1 and P are domestic firms, while U is foreign. Suppose further that firm G^s is constrained to partner with either domestic firms G^1 and P. How will the foreign firm respond?

Firm U is uncertain as to who would be the partner of G^s. Denote r the probability that G^s will partner with G^1 and $(1-r)$ the probability that G^s will partner with P. The payoff matrix of firm U is as follows:

		U-active	U-passive
G^s joins	Firm G^1	j	l
	Firm P	k	m

It is reasonable to assume that $j > l$ and $k < m$. Therefore, firm U will choose to be aggressive if

$$r > \frac{m-k}{(j-l)+(m-k)},$$

The following proposition follows from the above analysis.

Claim 4: *To induce passive behavior from foreign rival U, the best pure strategy of* G^s *is to partner with P.*

Clearly, a less aggressive behavior from the foreign competitor may be induced if a weaker partnership is formed. That is, if the partnership of G^0 and P is favored over the partnership of G^0 and G^1, then r is lower, and firm U is induced to take a passive move. Such a policy serves the interest of domestic firms but is obviously at odds with those of domestic consumers.

NOTES

[1] Also called "S&T output propensities."

[2] Whether measures chosen to establish Europe's technological falling behind (e. g., patents per ECU million) is legitimate is another discussion. For example, one would perhaps wonder why the proportion of value-added to business enterprise R&D in each sector was not considered.

[3] Cited in *The Economist*, January 9, 1993.

[4] This literature is cited explicitly by some official documents, e.g., CEC (1995).

[5] As one specification, suppose technological competence of firm i is measured by m^i, and $i = 1, 2$. Then the expected amount of commercializable innovation, from a consortium of firms 1 and 2, may be given by (m^1, m^2). This specification implies that, among other things, an RJV between equals may yield more benefits than a venture between nonequals.

[6] Evidence also exists that fewer research joint ventures occur among directly or indirectly competitive firms than among suppliers.

[7] Sharp and Pavitt (1993:148), for example, argue in favor of a policy that welcomes foreign transplants, as long as they add to the local skills base.

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DISCUSSION

Napoleon Y. Navarro

The United Nations Development Program (UNDP) supports the GAINEX program of the DOST to the tune of $6.5 million over a period of three to five years. Based on preliminary figures by the DOST, the GAINEX costs $82 million over a 10-year period. The GAINEX program is a government intervention, aimed at strengthening the technological capabilities of small- and medium-enterprises in the Philippines. It is one of the most ambitious efforts of the DOST to date. The GAINEX is unique in the sense that most technological interventions had been supply-driven in the past—scientists determined the research agenda and then tried to commercialize their findings. It created a commercialization problem because the research agenda wasn't determined by the market, therefore the scientist ended up trying to "push a string." You can imagine the impact on resources, given the reality that normally 90 percent of patents never get commercialized.

Given 20 or 30 years of this experience, the DOST has responded with a push for demand-driven technological interventions two or three years ago. The fact that it is demand-driven is supposed to be a reassurance. According to the paper of Drs. Abrenica and de Dios--which, incidentally, departs from the usual articles on advanced economics in that it is refreshingly brief, very relevant, and disturbingly insightful--this is not necessarily reassuring.

The Philippines is putting only 0.12 percent of its GNP into R&D efforts. Indeed, the sum is paltry compared to what our neighbors invest, and there might be a need to raise the amount through government intervention. But should we? The authors advise us to be cautious for three reasons:

- First, if government intervention through subsidy is to work, it must have an impact on the innovation strategy of firms. Subsidies must not act as a guarantee, regardless of how a firm behaves.
- Second, if government intervention is to work, it must give incentives for firms to cooperate with those with the most superior technology. Otherwise, subsidies could end up encouraging firms to tie up with inferior firms.
- Third, if government incentives are to work for technologically inferior firms, these should be consistent with the expected behavior of technologically superior firms.

Admittedly, these conclusions were reached with the assumption that we are operating under oligopolistic conditions. One might argue that, given that SMEs comprise 50 percent of the manufacturing sector, their findings may have some or no relevance at all. Despite this qualification, we still have two important lessons on how government resources should be spent.

The first proposition refers to the need to use government subsidies as a leverage, rather than as a guarantee or entitlement for enterprises. In the European experience, these national champions have been coddled through the grant of monopoly status, debt write-offs, and public purchase contracts. As the authors noted, the efforts have amounted to dismal failures.

This is where the article disturbed me. The European practice of fostering national champions is similar to the Philippine policy of fostering export winners, three of which (marine, metalworking, and fruits) have even been included in the UNDP-funded GAINEX program of the DOST.

What the authors are reminding us today is that it is not enough that we give these enterprises technical assistance. If the GAINEX is to work, access to government subsidies must be contingent on the enterprises' observable commitment to take steps in improving itself technologically. Performance-based conditions should play a vital role.

There can be no greater waste of public money than to use subsidies to encourage enterprises to adopt inferior technologies. In the EU experience, subsidies encourage research joint ventures among EU members that would not have been pursued if subsidies had not been available in the first place. In their quest for indigenous technological capabilities, the EU members have ended up subsidizing the development of inferior technology.

Again, this has fundamental implications on the way GAINEX should be handled. Scarce government resources are used to subsidize SMEs' access to technological developments. These technological innovations should at least be superior, whether the source is local or foreign. Indeed, the authors caution us on the dangers of prior exclusion. Nationalism has its limits.

The bottom line is that developing technological capability does not imply reinventing the wheel. Indeed, when we examine the experiences of other countries that sought the development of indigenous technological capabilities, we must marvel at the double talk involved.

Taking aside the issue of comparative advantage, consider Habibie's plan for the development of an Indonesian plane. What is not normally played up is the fact that Habibie and his ilk were once aeronautical engineers in Messerschmitt in Germany; or Malaysia's Proton car arrangements with Mitsubishi of Japan; or Suharto's tie-up with Kia of South Korea. Clearly, our neighbors know when to draw the line between rhetoric and reality.

The need to ensure that the technology being adopted is in fact superior means considerable technology forecasting might have to be done. This entails a capacity that government, the private sector, and academe may not possess today.

A technology-based industrial policy is something the Philippines can no longer disregard. Technology can easily erode the initial comparative advantages offered by factor endowments. Furthermore, given its status as a middle-income developing country, access to developmental grants and concessional loans will soon dry up, and we would have to fend for ourselves as we compete in the global economy.

That we must improve our technological capabilities is a given. The question is how. It is not just a matter of increasing R&D spending. The productivity of that 0.12 percent of GNP matters too, and the indiscriminate use of public money is not going to help.

At the moment, the GAINEX project is the biggest single public effort at improving the technological capabilities of the export industry. Preliminary figures put the total bill at US$82 million, over a 10-year period. The UNDP-funded portion is only US$6.5 million, over a three- to five-year period. Without the proper leveraging of public subsidies in the form of technical assistance, the SMEs may be no more capable today than 10 years down the road.

Technological Change: The Missing Element for Achieving Sustainable Growth in the Philippines?

FRANK M. LITTLE

Chapter 8

At its most basic, this study is about what determines economically sustainable growth. But why should we believe that technological change lies at the root of such sustainability? After all, until the early 1980s, the Philippines had quite a healthy growth record, at least by Australian standards even if not by ASEAN standards: a moderately good growth performance in spite of an abysmal productivity performance. Why should it suddenly become necessary to pursue a policy of accelerated technological change to return to that former pattern of growth? To answer that question, it is helpful to distinguish between growth engendered by overseas demand, and growth that results from domestic competitive pressures.

A classic example of the former is the oil-rich sheikdoms of the Middle East, but few such "supply regions" can expect that sort of continuity of demand and lack of competition from alternative suppliers for their particular products. The sudden collapse of long-standing markets, for example, lies at the heart of the adjustment problems recently experienced by New Zealand with the UK's entry into the European Community in the early 1970s, and

I believe may well lie at the root of the Philippines' growth problems. The classic case of growth through domestic competitive conditions is seen in the Newly Industrialized Countries (NICs) of East Asia. These countries have so transformed some of their own industries that they have displaced the traditional producers within those industries. At the heart of these transformations was the ability to successfully introduce technological change into the industries, and it is these transformations that then permitted the large-scale increases in labor and capital associated with sustainable economic growth.

So how do we move from being a "supply region" to being an economy in which growth is based upon technological change? The first point I want to make is that the introduction of technological change is not really about **technical** change: it is about introducing a process of change through industrial reorganization. It is not, therefore, a technical "fix" for an industry's economic problems.

Let me illustrate my case with an example from industry: the automobile industry. In 1908, when Henry Ford decided to make his dream of every American farmer owning an automobile a reality, he was faced with major problems. Ford's main competitor at the time was Buick, the top producer in the intermediate-price field. Buick produced a more rugged car, and it was this that enabled them to command a premium price for their product. Ford's response was not to sacrifice durability, but to aim for a more productive manufacturing process. Certainly, this process involved a number of technical developments, such as the use of vanadium steel borrowed from Europe and the design of a simpler engine and transmission. However, it was in reorganizing the production process that Ford is most widely remembered. This reorganization included:

- the use of interchangeable parts, an idea borrowed from Cadillac; it was employed to reduce cost, rather than achieve high quality, and
- the organization of production on a continuous basis, rather than by type of machine. This led to the development of

more appropriate machines that were designed to be automatic. Ultimately, this led to the introduction of the moving production line, a concept borrowed from the meat-packing industry.

But just as important was his organization of what might be loosely described as the R&D activity within his company. What he developed was a highly interactive organization.

- Ford developed a high level of internal competition by refusing to precisely define responsibilities. The organization was therefore characterized by a high degree of internal conflict, especially between Couzens–the bottom line watchdog–and Ford himself, who at least in his initial years appeared very keen on improving the vehicle.
- The administration of activity was highly interactive. Both Ford and his senior engineers interfaced directly with the various divisions of the company. They formed what were eventually labelled as "skunkworks," where

  1. managers/engineers operated on the basis of rough drawings, rather than detailed designs; and,
  2. they had to interact with the machinists on the factory floor, rather than a production department, in order to introduce it.

- Management involved people with a wide range of background and skills. According to Nevins and Hill (Ford's biographers), "The largest single role in developing the new system, however, was played by this university trained thinker [Avery], so recently brought in from his schoolroom." (Quoted in Klein 1977, p. 98.]

The result of these endeavors was that, from 1909 to 1916, the price of the Model T fell by 60 percent in current prices, while sales increased by a factor of almost 50. By 1921, Ford's share of the auto

market was 60 percent, and every other car in the United States was a Model T! (ibid.)

Unfortunately, by this time, Ford's personality significantly changed, and a more hierarchical organization was introduced. As a result, the company seemed no longer able to read the indicators of change, despite the increasing competition coming from "enclosed" second-hand cars. Then in 1923, Dodge introduced the all-steel enclosed automobile, and, by 1926, 80 percent of all autos were of this type. By 1927, Ford's share of the market had plummeted to about 15 percent. From the 1930s through to the early 1960s, the number of innovations in the automobile industry fell sharply, while a more rigid hierarchical organization, which had become commonplace in mass production industries, became firmly entrenched in the auto industry. Productive activity was split into separate compartments. R&D, involving both the design of new models and the machinery to produce them, was completely divorced from the factory floor where those models were to be produced. A detailed set of instructions and schedules for mass-producing the new product were then sent to the factory floor. The lessons of the 1910s and 1920s had obviously been lost.

The effect of this form of industry organization was devastating. Although it was supposed to be geared toward minimizing the downtime of the extremely expensive plant equipment, it had the opposite effect.

- Separation of R&D from the factory floor ensured that any change in production scheduling was likely to maximize the number of bugs in the production schedule, while strict functional delineation implied that any problem would require notifying the supervisor, who would then summon the technician. Attempts to buffer the system against breakdowns meant carrying more inventory, and frequently, more workers. Organization was by a "just-in-case" principle.
- Another problem associated with this approach to keeping the assembly line going at all costs was that defects were allowed to pass through, to be corrected in a large

repair area at the end of the line (if, of course, they could still be found after all the trim and components had been fitted).

- Finally, even modifications to existing models, let alone the introduction of a new model, implied a major upheaval in the production line. Not only was the retooling for model changes extremely expensive, but so was the need to specify the production changes in extreme detail to the assembly-line management.

What US and European auto producers had generated was a dinosaur system of management—extremely resource-expensive and unable to adapt to a changing environment, especially the dramatic oil price increases. The interesting point was that part of the solution already existed, but not in the auto industry. In the early 1950s, the senior management of Toyota visited the United States and was impressed by the way supermarkets kept shelves stocked with the products customers wanted in just the amount needed. As Taiichi Ohuo from Toyota explained:

> "A supermarket is where a customer can get (1) what is needed, (2) at the time needed, (3) in the amount needed....We hoped that this would help us approach our just-in-time goal, and in 1953, we actually applied the system in our machine shop at the main plant." (1988, p. 25-26)

But other departures from the US management approach were required before inventory control could be part of a viable alternative approach. It required replacing the US managerial hierarchy with multiskilled management teams to work alongside the production line, i.e., management staff, design engineers, and other specialist skills interacted face to face with factory workers, while enforcing joint decisions directly on the factory floor, just as it occurred in the development of the Model T. Then again, as in the case of the Model T development, machinery much more closely related to specific production requirements for flexibility and adapt-

ability (i.e., can be produced in large volumes and varied types). Thus, Womack et al. (1990) were able to claim that the Japanese production technique was "lean" because:

> "It uses less of everything compared with mass production—half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in fewer defects and produces a greater and ever growing variety of products." (p. 13)

Japanese car makers succeeded in reintroducing the process of change into automobile manufacturing.

The US reaction to increased Japanese competition was basically to look for a technical "fix." This was reflected in the response of Roger Smith, who became chairman of GM in 1981. He asked Isuzu (where GM had held a stake since 1971) how much it would cost them to build a small car similar to what GM was developing, and was shocked to find out that it was slightly less than half the cost GM's engineers had budgeted for. Smith's response was, first, to kill GM's small-car project and instead go into a joint venture with a Japanese company, Toyota. Smith embarked on an extremely ambitious program to invest in automation which in 1985 saw the opening of the highly automated Amtrak plant in Detroit. It was this large-scale switching to automation where Smith pinned his hopes on. However, as table 1 shows, it was not automation that lay at the heart of the differences between Japanese and US car makers. The percentage of welding processes automated in American factories was only 10 percent to 11 percent lower than in Japanese plants in both Japan and the United States, while only an insignificant proportion of assembly-line operations in American and Japanese plants were automated. It was only in terms of the automated painting process that the Americans differed greatly from the Japanese in Japan—almost 40 percent less. In America, it was insignificantly lower—around 25 percent. It was the way the Japanese organized the training,

management, and motivation of their workforce that was key to the difference.

1) The percentage of the workforce in teams: Japanese firms in Japan and America were roughly four times greater than American firms.
2) The number of job classifications was approximately 5.5 times higher in the American firms than the Japanese firms in Japan, and 7.5 times higher than the Japanese firms in the United States.
3) The time spent on training workers, both in the Japanese firms in Japan and the United States, was roughly 8 times what was spent in the American firms.

Thus it was not a surprise that Amtrak was a failure. A year after it opened, the equipment was still unreliable, the plant produced at less than half the rate of car production it was designed for, and management was still unable to reduce inventories to the levels achieved by the Japanese just-in-time system. Eventually, some of the high-tech equipment were removed, and management was reorganized so that more control could be given to teams of multiskilled workers on the factory floor.

Table 1
Not by Robots Alone
Assembly Plant Characteristics*

	Japanese Firms in Japan	*Japanese Firms in America*	*American Firms in America*	*European Firms*
Productivity (hr. per vehicle)	16.8	21.2	25.1	36.2
Assembly defects per 100 vehicles	60.0	65.0	82.0	97.0
Repair area (% of assembly space)	4.1	4.9	12.9	14.4
Stocks (days) +	0.2	1.6	2.9	2.0
Work-force in a team (%)	69.3	71.3	17.3	0.6
No. of job classifications	12.0	9.0	67.0	15.0
Training of new workers (hours)	380.0	370.0	46.0	173.0
Absenteeism (%)	5.0	4.8	11.7	21.1
Automation (% of process automated)				
Welding	86.2	85.0	76.2	76.6
Painting	54.6	40.7	33.6	38.2
Assembly	1.7	1.1	1.2	3.1

*Average for plants in each region. 1989.
+For 8 sample parts.
Source: M.I.T., J.D. Power and Associates. Quoted in *The Economist* (1991) p. 61.

The experience with the auto industry is far from unique. As far back as 1890, the United States had become the leader in steel production; and by the turn of the century, a modern rolling mill was producing as much in one day as a midcentury mill produced in a year. However, the same pattern of ossification that characterized the automobile industry also affected the steel industry so that by 1980, US labor costs per ton of production were more than double Japan's (and more than 11 times that of Korea). Only the UK's steel production showed a dramatically higher labor cost that resulted from very poor productivity and a lower capacity utilization. What had happened was that the steps involved in traditional cold-roll-

ing-rust removal, chemical cleaning, drying, pressing, and cutting had been compressed by Japanese steel producers into a continuous and automated process. Once again, US companies sought joint ventures with their Japanese counterparts, and in Inland Steel's new venture with Nippon Steel at Gary, Indiana, the plant produced in one hour what took 12 days in the older mills.

As with the auto industry, this dramatic improvement in the firm's performance is associated with organizational changes: the management hierarchy has been cut down from 10 to 6 layers, while job classifications have been reduced. At the new LTV-Sumitomo joint venture plant, the job categories have been reduced from 100 to 3— "entry level," "intermediate," and "advanced." Self-managing work teams have been given greater control of the shop floor, resulting in the reduction of the levels of management hierarchy. Similar stories can be described for the mechanical engineering industry. Even the textile and garment industries have not been immune to the just-in-time control system and "tailor-made" orders. Although garment sewing still tends to be labor-intensive, even this could change under the impact of microelectronic sewing machines.

The point I wish to stress is that in seeking solutions to the problem of unproductive performance, it is wise not to assume that technical shortcomings per se lie at the core of the problem. Someone—I think it was Oshima—distinguished between the "hardware" and "software" of technology, suggesting that it was the latter that was much more difficult to absorb because it required changes in organizational systems and traditional thinking. For that reason, I believe that the models and sources of "hardware" transference are not that important as issues. Transforming the way industry activity is organized or managed so that technology is readily absorbed within it is, I believe, the overwhelmingly important consideration. The firm or industry is not the production function beloved of economists, but an organization. It is the way the firm or industry is organized that determines its productivity.

But how does one achieve such transformations? One approach is to assume that the global economy will do it all for you. National differences in innovative capabilities will be submerged under the

productive patterns established by transnational corporations, regardless of national boundaries. The ubiquity of Coca-Cola, McDonald's, and San Miguel referred to in the abstract is perhaps testimony to that role. However, technological change—especially as reflected in the increasing circuitousness of production—is a highly localized process (I shall return to justify that statement shortly). I therefore believe that, at best, the global economy will have only a limited impact upon national innovative capabilities, and that a national policy is, therefore, necessary. Unfortunately, because I am talking to you before rather than after completing the research program, the policy conclusions I shall draw are rather like motherhood statements, and are not sufficiently specific. Nevertheless, I trust that these will give you some indication of the direction the work will take.

So what kinds of initiative should a national policy try to encourage? If the US experience is any guide, joint ventures with a highly productive partner appear to ensure that the necessary organizational transformations can be achieved. However, I am not sure how readily applicable the US experience is to the Philippines. Comments from Japanese involved in joint ventures with Filipino companies have been extremely critical of Filipino management. However, these reports are rather old, and the comments may be dated.

A more serious, longer-term problem associated with joint ventures is the tendency for some overseas companies to maintain their R&D operation in their home country, separate from production in the new plant. Such a separation is, in my view, inimical to maintaining the process of change within the plant, and will eventually lead to the ossification of its production mode. Any arrangement should tie in a major component of R&D into the joint venture to avoid this. But perhaps the major problem associated with joint ventures as a tool for a national policy of accelerated technological change is that it does little to achieve a broader-based tranformation of the economy.

To achieve broader-based impact, similar transformations need to be introduced into the supplier industries. This may be illustrated with the development of the Korean automobile industry. Although

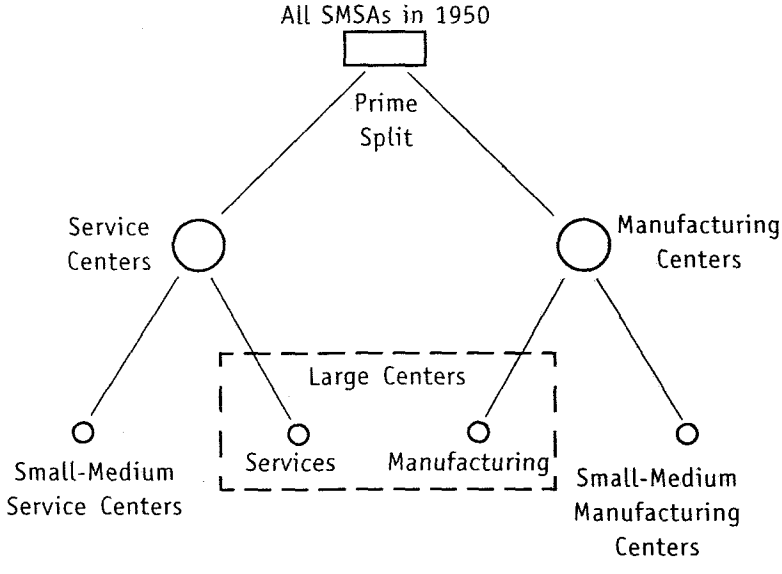
established through technical cooperation with Nissan and Toyota, it initially only involved the assembly of imported parts. However, within a span of 20 years, domestic production of parts for export vehicles became the norm, and locally made advanced technology was introduced into the production process. Despite the lead times that may be necessary (depending upon the industries being transformed), unless such transformations are established within the supplier industries, any joint venture is likely to remain an isolated enclave dependent on cheaper imports of material supplies and equipment, with a decreasing share of its value-added being sourced in the domestic economy. Obviously, tracing the way imports have changed as a share of value-added in the major nontraditional export industries will constitute an important step in the program. But even before any results are obtained, work could be started on determining how a policy for facilitating technological change policy in linked industries might be developed and enforced. This is, I believe, the area par excellence for industry and government cooperation.

A second method for broader-based technological change is the process known as the "increasing circuitousness of production." Here, industries hive off a particular activity, thereby forming a new industry, which then specializes in producing that good or service, and selling it back to the industries that have hived it off. It is reflected in a reduction of the primary inputs of the industry which hives the activity off and an increase in their intermediate purchases as they buy these from the new industry that has been formed. This tendency for intermediate inputs to increase as a proportion of total inputs is one of the "stylized facts" of economic development.

In the United States during the 1930s and 1940s, the process was reflected in the dramatic expansion of the intermediate sales of the utilities industry, at least in part, the result of firms buying in electrical power to drive their plants and equipment rather than relying upon their own power sources. During the 1950s and 1960s, it was reflected in the growth of the intermediate sales of what have been labelled "Producer Services," i.e., industries such as banking, insurance, and other professional and business services. Now the reason I have argued that globalization represents at best only a par-

tial solution to accelerating technological change is that increasing circuitousness is very much a local process—it has tended to occur only in large cities. Let me illustrate this by the research carried out on US towns known as Standard Metropolitan Statistical Areas (or SMSAs).

Diagram 1



GROUPING OF PRODUCER SERVICES CENTERS IN 1970

Diagram 1 shows the grouping or "clustering" of all the SMSAs, according to the similarities in their employment structure, initially for 1950. When all the cities had been grouped, our steps were retraced to arrive at the most fundamental differentiation: the prime split. This shows a predominantly manufacturing group and a predominantly services group. The next step showed each of these groups splitting up, one of the distinguishing characteristics at this level being the SMSAs' size. Both the manufacturing and the service centers showed that certain employment characteristics tended to be cor-

related with size, e.g., aircraft production, communications, and vehicle production tended to be associated with large SMSAs. However, the most startling result came out when the same exercise was carried out in 1970. When the large centers, which could not have been any more different in 1950, were grouped together, they were characterized by employment in what we called "producer services," i.e., banking, credit, insurance, real estate, business, and legal and miscellaneous professional services.

A number of implications may be drawn from this analysis:

- The process of increasing circuitousness appears to occur only in certain types of cities, and is therefore the product of certain local conditions. This suggests that proximity may be a key factor in the generation of activity by this process, a factor globalization is most unlikely to take into account as its production patterns would have been established and divorced from these particular agglomeration economies.

- Another feature is that industries that figured prominently in 1950, but in the meantime had undergone significant increases in labor productivity, such as communications and aircraft and motor vehicle production, no longer tended to characterize the employment structure of any particular city in 1970. The industries had either dispersed throughout the urban hierarchy, or moved to nonurban locations.

- A third feature was that those urban economies such as Youngstown, Ohio, which did not transform themselves into producer services centers, have suffered a sharp decline in economic activity.

One of the disturbing things about the Philippine economy is the lack of growth in producer services, relative to countries like Indonesia and Malaysia (Mehta 1997), and also relative to the growth

of the domestic retail industry growth. This is symptomatic of the absence of increasing circuitousness, and is simply another aspect of the abysmal rate of productivity increase that the economy has experienced and hence, the lack of specialization that tends to occur. Thus both the main points I wanted to make really boil down to one issue—the need to understand the organizational context necessary for technological resource absorption to take place. The relationship between those technological resources and the output they are supposed to generate does not exist in an environment-free world, and therefore cannot transcend the structure in which they are embedded. It is necessary to understand the limits of that structure, and this conclusion applies at the level of the nation just as much as it applies at the level of the firm or industry.

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DISCUSSION

Nimai M. Mehta

Paul Krugman, in what has become a highly contested piece of writing, speaks of the "myth of the East Asian Miracle." Whether or not one agrees with Prof. Krugman's conclusions, his focus on productivity has certainly caught the attention of the profession, as well as those in the industry and government of the region. Frank Little's paper eloquently brings out the not yet clearly understood essence of Krugman's thesis: that economic growth is not simply the accumulation of capital stock. Dr. Little's paper, however, does more than that. It provides a much richer perspective on the nature of the required change in the productive capacity of the economy.

The main point, as I interpret Dr. Little's paper, is that growth enhancing capital accumulation occurs through, and cannot be divorced from, a change in the organization of production. The required organizational change is multidimensional: it includes the relative positioning of work stations on the factory floor; the flow of materials; the structures of authority, teamwork, coordination and supervision within the firm, including the required organizational synergy between production and research; as well as interfirm cooperation between the producer and its suppliers and purchasers. It is in the context of such varied organizational settings that product and technological development are made possible with accompanying increases in economy-wide productivity and growth. Organizational change is, of course, as much a function of cultural and institutional variables as it is a function of appropriate economic incentives.

As an economist, let me say right away that all this is very far from the conventional theory of production functions, profit maximization, and market allocation. Dr. Little, understandably, only hints at this methodological challenge in a rather inconspicuous sentence on page eight of his paper—let me quote:

"The firm is not the production function beloved of economists, but an organization."

This is not the place to initiate a debate on methodology. Nevertheless, a caveat may be in order here. The role of the production function in economic theory is subsumed under the workings of the price system. It is not meant to explain the nature of the firm. And it is with regard to the price system that most policy questions are framed, including those of industry structure, innovation, and technological change. The realization of the true potential of Dr. Little's insights would, therefore, in my view, be contingent upon a well-matched marriage between Dr. Little's own theory of the firm and the logic of price theory. Such an integrated approach would be needed, for example, in evaluating the impact of patents, copyrights, and market-sharing or licensing agreements on product development; or the impact of relative price structures, including exchange rates and protectionist costs, on development of new and "linked industries" would benefit from a more integrated approach.

Having said this, one can still identify in this yet early statement of Dr. Little's research, certain relevant policy warnings. For one, the policy toward industrial research would be warned against viewing technological change as simple "applied science." Rather, the productive use of scientific research is possible only when the corporate and industry-wide technology has developed to such a point that a better understanding of underlying scientific principles promises to lead to consistent technological advance. In addition, both intrafirm and interfirm organizational changes are required that would be conducive to the role of research and development. Two, the paper motivates a healthy skepticism on the impact of globalization on the Philippine economy, which may be lacking the necessary organizational underpinnings. Three, the lack of economy-wide organizational change leads to enclave-type developments as seen from experience with joint ventures in the Philippines. Explicitly initiating, therefore, the Subic Bay enclave-type developments would seem to have less long-term growth value than otherwise thought. Four, discriminatory and ad hoc protectionism between industries would curtail the extent

of "circuitousness of production" that Dr. Little identifies with a growing economy.

To sum up, the value of Dr. Little's paper lies in what it promises rather than what it is at this point. Overall, it has the potential of providing a much richer story of economic growth that could incorporate traditional economic incentives with a study of cultural and institutional change.

Part IV
METHODOLOGICAL AND LEGAL CHALLENGES

Technology Forecasting

JOSE A. MAGPANTAY

Chapter 9

Why Forecast Technology?

The competitiveness of firms and the sustainability of the development of nations in the next century will depend mostly on the dynamism of their technological-innovation systems. Considering the furious pace of discoveries in the sciences, and the diminishing gap between scientific discovery and technological application, firms and nations must actively participate in, or at least be aware of, developments in these areas. Firms and nations must also manage their technological resource as well as or perhaps better than their other resources (such as natural resources, capital, and labor) because knowledge will become the principal source of wealth in the future. This means that, when nations and firms consider their long-term future, whether from the perspective of strategic planning or development, they will have to do technology planning.

Technology planning, like any type of planning, requires a reasonably good "guess," or forecast, in order to be useful. Technology forecasting is the process of projecting the future of a technology, starting from its present state (as measured by its capability, use, and acceptance), to the advances in its basic science foundation. Forecasting also considers the entire gamut of social, cultural, economic, and political forces, in a society that shapes or affects technological developments.

Technology forecasts are useful at different levels. At the macro level, an excellent technology forecast can help map out areas for investment (e.g., what basic industries and manufacturing to develop, and which areas in agriculture to concentrate on); the corresponding human resources, organizations, and infrastructure needed for investment and industry development; and, the strategies for the application of technology (i.e., mode of technology acquisition, and the role of the public and private sectors).

At the firm level, technology forecasting can help managers make intelligent decisions regarding technology purchases (i.e., the right price to pay and when to change equipment, processes, and software); technology development (i.e., what technology to develop in-house, what to acquire, and the best arrangement for acquiring technology); and, the overall target level of the firm's technological capability (whether operative, adaptive, replicative, innovative, or creative). Therefore, for nations and firms, technology forecasts can suggest possible economic and business opportunities from scientific and technological developments.

Two examples clearly illustrate the uses of technology forecasts. The theory of electromagnetism, developed by Faraday, Henry, Maxwell, and Hertz, led to two major technological innovations: telecommunications and electric power generation. Morse and his collaborators (Leonard Gale, Alfred Vail, Francis Smith and Ezra Cornell) immediately recognized the importance of this new science to communications, and invented, prototyped, and developed the telegraph (Copp and Zanella 1993). This event marked the start of the information age, and since then, tremendous developments had taken place in telecommunications. Today, most of the GNP of advanced economies come from the production, analysis, storage, distribution, and control of information—made possible by computers and telecommunications systems.

Electric power generation is another direct consequence of the discovery of Faraday and Henry, as they found that a time-changing magnetic field will induce an electric field. However, unlike telegraphy, which was quickly commercialized, power generation technology had taken about 50 years to realize. Today, 160 years after the discovery,

nearly 100 percent of electric power is still generated using the Faraday-Henry principle. Other technologies of power generation, based on different scientific principles (such as solar photovoltaic and fuel cells), are still unable to compete with the conventional technology. Therefore, it is not an exaggeration to say that, without electric power-generation technology, the tremendous growth of the world economy (which has expanded 20 times since 1900) would not have occurred.

These two examples depict the importance of science and technology in the long run. Both have contributed significantly to the world's development, from the Industrial Revolution, to the present Information Age, and will most likely continue into the next millennium. In telecommunication (telegraphy in particular), the time lapse between scientific discovery and technological innovation was immediate, while power generation had a long gestation period. But once these technologies were prototyped, a few large and a series of incremental technological innovations continuously upgraded the technologies to their present state.

What role did forecasting play in these important developments? The discovery of a new science cannot, of course, be predicted. Either it happens, or it does not. We cannot force nature to reveal more than what it is willing to offer, just as we cannot comprehend things about nature that our present levels of knowledge and intelligence are not ready to grasp. However, once a scientific principle is uncovered, the first step is to recognize the practical application of the discovery.

For telegraphy, this was realized by inventors from various countries: Charles Wheatstone (England), Paul Schilling (Russia), Eduard Weber (Germany), George Le Sage (Switzerland), and Joseph Henry (North America). But, credit largely went to Samuel Morse for he not only "invented" the telegraph (hardware), but also developed the code (software) that made telegraphy a practical and efficient communications system. More importantly, Morse and his collaborators solved the practical problems in making the device work—the innovation after the invention, or what we call "product development."

For Morse and his collaborators to have invested time and money in product development, they must have had a fairly good idea of the product's market value. Convinced of its value, they protected their investment by obtaining a patent. After forecasting the market for the telegraph, Morse and his group used their entrepreneurship skills to sell the idea to the US government. With a $30,000 grant from the US Congress, they laid down the first telegraph line between Baltimore and Washington.

If these historical examples show the importance of technology forecasting, our modern-day era offers even more compelling reasons, as suggested by Martino (1993), namely:

1. to maximize gain from events external to the organization;
2. to maximize gain from events that are the result of actions taken by the organization;
3. to minimize the loss associated with uncontrollable events external to the organization;
4. to offset the actions of competitive or hostile organizations;
5. to forecast demand for production and/or inventory control,
6. to forecast demand for facilities and capital planning;
7. to forecast demand to assure adequate staffing;
8. to develop administrative plans and policy internal to an organization; and
9. to develop policies that apply to people who are not part of the organization.

Crucial Issues

The question on technology forecasting is: Does it make sense? Can we really forecast technological developments? Critics of technology forecasting cite the following which turned out to be erroneous forecasts.

"Heavier-than-air flying machines are impossible."
—*Lord Kelvin, 1895*

"There is no reason why anyone would want a computer in their house." —*Ken Olson, 1977*

"640K ought to be enough for anybody." —*Bill Gates, 1981*

"I think there is a world market for maybe five computers." —*Thomas Watson, 1943*

"But what is it good for?" —*Engineer at the Advanced Systems Division of IBM, commenting on the microchip, 1968*

"There is not the slightest indication that [nuclear] energy will ever be attainable." —*Albert Einstein, 1932*

If these experts and leaders of respective fields, especially the man considered to be the most intelligent in the twentieth century, made such off-the-mark predictions, what then is the use of forecasting?

Forecasts are a guide to the future and all of us, consciously or not, do some forecasting or "guessing." Thus, the choice is not whether to do a forecast or not, but whether to learn how to forecast or not, and how to do it well. Technology forecasting, as part of technology planning, is undertaken because of the basic assumption that some aspects of the technological future can be known, if we know the forecasting methods and do them right.

Mistakes in forecasting, such as those cited, are caused by several reasons. In the case of Einstein, he made the prediction before fission was discovered by Otto Hahn and Lise Meitner, and predictions on technology before a scientific discovery generally fails. The failure of other experts may be due to the tendency of some specialists to be conservative or myopic, believing more in limitations than possibilities because they want their projections to stand on solid ground.

On the other hand, visionaries and futurists, who are not restricted or guided by the established science and technology, generally give freer rein to their imagination, starting from what is

not and building from there. In this sense, Verne (1868) had been more successful in forecasting than the renowned scientist Lord Kelvin (one-time president of the Royal Society of London).

A major scientific discovery is difficult to predict. But once discovered, future technologies can be projected. Errors can be corrected as "two heads are [often] better than one." Forecasting should not be done by a single expert. If incremental changes in technologies can be made by individuals equipped with certain skills in the sciences and mathematics, forecasts of major technological developments are better done by a healthy mix of experts, generalists, visionaries, and social scientists, with maybe one or two eccentric individuals.

The advantage of having a committee is that more information can be made available, and different perspectives can be considered. The disadvantage is that too many experts can spoil the broth, so to speak, and sometimes even erroneous information is considered. There is danger, too, that group dynamics could result in the least common denominator, just to arrive at a consensus, rather than proceed from a well-thought out and scientifically solid prediction. But as can be seen in a later section, there are ways of solving this problem.

Another crucial issue is what to do with forecasts. Since forecasts are generally commissioned, the organization (firm, industry, government agency or country) that commissioned the work should know what the purpose of the forecast is and should make this clear to the forecasters as well. Once work is finished, the organization should evaluate the forecast to determine its relevance, utility, and efficacy.

Evaluation methods exist; an example of which is Martino's interrogation model (Porter et al. 1991). In this method, forecasters and decision makers are made to answer a sequence of questions, designed to ascertain the need for the forecast, the causes of change in the subject forecasted, and the relevance and reliability of the forecast (see table 1).

It is important to remember that forecasts are guides, as the table clearly suggests, and should never be accepted dogmatically.

The organization's leadership must always be conscious of developments that may invalidate or contradict forecasts, even those made by the most credible forecaster.

Table 1
Martino's Interrogation Model of Forecast Evaluation

Interrogation for Need
1. What individual or organization will make the decision, which will be based on the forecast?
2. What information about the future is needed? (This broad question is asked initially to avoid omitting relevant factors.)
3. How much is knowing the future worth? What is the cost of not knowing?
4. Over what time period must the forecast apply?
Interrogation for Underlying Cause
1. In what ways can the subject area change (magnitude, composition, character)?
2. What can cause these changes (technological, economic, managerial, political, social, cultural, intellectual, religious/ethical, ecological factors)?
3. Iterate questions 1 and 2 in Step II, until a set of "fundamental" causes are found. (Produce a causation hierarchy or relevance tree.)
4. What are the key elements (i.e., the "fundamental" causes)?
Interrogation for Relevance
Here, the forecast is examined to see the degree in which it deals with key elements from Step II. There are three categories: (1) relevant and included, (2) relevant but excluded, and (3) irrelevant but included.

Category 2 elements are critical because they must be factored into the forecast. Category 3 elements can be ignored.

Interrogation for Reliability

1. Methods must be identified and clearly described. If they are not or cannot be categorized, the forecast is of unverifiable reliability.
   a. Are the methods replicable by others? If not, results, while not necessarily wrong, cannot be verified.
   b. Are the methods formally consistent? Do conclusions logically follow the premises?
2. Assumptions are used when facts are unknown
   a. What are the assumptions? (Assumptions may include the following: the method used is appropriate to this case; a group will behave in a certain way; or, a data sample is representative of the population.)
   b. Are assumptions adequately defined?
      (1) Is the assumption static or dynamic? Does it apply to a level or to a rate?
      (2) Is the assumption realistic or humanistic? Is it independent of opinion, or dependent on values, perceptions and intentions?
   c. How are assumptions supported? By a law, principle, or axiom? By credible expert opinion? By evidence?
   d. Are the assumptions directly supported by the available evidence? The following criteria should help:
      (1) Static assumptions must be from the state or time specified.
      (2) Dynamic assumptions must be gathered dynamically, with timing and consistent sequencing.
      (3) Realistic assumptions must be as free of human bias, prejudice, and evaluation as possible.
      (4) Humanistic assumptions must be obtained from the behavior of the group or individual in question.
      (5) A law or principle must be applied under circumstances for which it is assumed to apply.

(6) Credibility of experts must deal with their knowledge regarding the case under consideration.

3. Data may be used to support assumptions or as raw material from which a pattern is determined.
   a. How accurate are the data?
      (1) Are there uncertainties of observation?
      (2) Are there uncertainties of measurement?
      (3) Is there a conscious distortion?
      (4) Is there an unconscious distortion?
   b. Does the evidence tend to confirm or deny the assumptions?

Methods

This section is primarily based on the books by Porter et al. (1991), and Martino (1993). Five aspects of technology are forecasted. The table below presents examples for each aspect.

Table 2
Technology Aspects Forecasted

Aspect	Example
Growth in functional capability	Improvements in the clock speed of computers; fuel economy of cars; illumination per watt of lamps
Rate of replacement	Shift from long playing albums to cassette tapes to compact discs; transition from typewriters to computers for word processing
Market penetration	Gradual popularity of Korean-made cars in the Philippine market for 1300 cc, or the lower engine displacement category

Diffusion	Spread of VHS technology, from Europe to the USA to Asia
Likelihood and timing of breakthroughs	Difficult to predict; knowledge of science foundation crucial

The growth in functional capability refers to incremental improvements in technology, while the rate of replacement deals with how old technology is superseded by a new and better one. Market penetration refers to inroads made by a product in a given market, distinct from the diffusion of technology, which on the other hand, relates to the spread of the technology through different markets.

In predicting technology, we may be guided by their history, performance trends, and even by some models. However, there is no guide in predicting the likelihood and timing of breakthroughs in technological development. For example, in 1986, the Science and Technology Agency of Japan carried out a Delphi forecast, where their experts predicted that high-temperature superconductors would be realized only by the year 2003; and their practical applications, not earlier than 2010. Both predictions turned out to be wrong. Before the end of 1986, high-temperature ceramic compounds were discovered and practical applications (in superconducting motors) were demonstrated by 1990.

This shows the extreme difficulty in predicting the likelihood of major technological breakthroughs, especially when the scientific foundation is not known (high Tc superconductivity is still not understood). Nonetheless, the forecast of major technological developments must be done, and is being done, by science agencies in most advanced countries because of the possibility that the forecast might be right. Imagine the benefits that could accrue from a correct forecast.

Another distinct difference between the first four and the fifth aspects of technology is that the former have well-defined measures,

while the fifth is subjective and is only measured after some time (when it is most likely to occur). There are data available to measure the first four, while the fifth can only make use of analogies.

For example, if we were to ask when the unification of the strong interaction with the weak and electromagnetic forces will occur—a matter still unknown in physics—our answer would be, if we are guided by historical unifications of forces, the late twenty-first century. But particle theorists are not daunted by history. As early as 1974 they had proposed a grand unified theory, combining the three forces in a single framework. Unfortunately, this theory and most of its variations remain unproven. Perhaps history is right after all; it is still too early to carry out the next unification.

Table 3
Commonly Used Forecasting Methods

Method	***Brief Description***
Monitoring	Systematic data gathering in science and technology, economics, and other societal factors that may affect a particular technology
Intuitive forecasting	"Genius forecasting," done by the best available expert in the field; committee method, in which a panel of experts from various fields do the forecast; Delphi method, in which panel members do not interact with each other but only with the moderator, who collates and analyzes the panel members' forecast for at least two rounds
Trend extrapolation	Can be modeled mathematically, using linear, exponential, or S-curve growth patterns
Correlation methods	Used when technological development cannot be predicted directly, but is observed

	to be correlated to some other factor(s)
Dynamic or causal modeling	Assumes the real world, or parts of it, can be represented by a model whose state or evolution can be determined analytically or through simulation
Normative forecasting	Based on the premise that technological requirements can be met in order to achieve specific goals
Scenario building	Prediction of possible futures, based on the present, assuming the presence of various factors and the occurrence or nonoccurrence of certain events
Probabilistic modeling	Takes into account inherent uncertainties in predicting the future, by assigning probability distributions for various dimensions of factors that produce change

For every aspect of technology, there is an applicable forecasting method, as described in table 3. Monitoring, which is the systematic collection of data, is not really a forecasting technique, but it is the indispensable starting point of any forecast. It must be done by people who have working knowledge of the technology; and, hence, the capability to filter and organize data. Monitoring can help organizations define potential threats and opportunities, alert management to important trends, and provide inputs to other, more sophisticated forecasting techniques, such as the Delphi method.

Intuitive forecasting goes beyond monitoring. As table 3 indicates, there are several types of intuitive forecasting. "Genius forecasting," despite the limitations of relying on a single expert opinion, is usually solicited in specific cases. The committee method is preferable because of the collective insights derived from a panel

of specialists. However, for this technique to work, there must be a balance between free-flowing and structured discussion so that many ideas can be presented and resolved.

To avoid the problem of any member dominating the discussion, a variation of the intuitive forecasting technique can be applied. This is the nominal group method, in which members of the panel work silently and individually enumerate their ideas. Then their ideas are collected, listed down and discussed by the body for clarification. The panel members again work silently, this time to rank priorities based on the ideas presented. The results are then tabulated and discussed anew by the body, with further clarifications on the criteria amplified or refined. In the last stage, the panel members render their individual final rankings.

The last form of intuitive forecasting is known as the Delphi method. The technique removes all direct interaction between members, and instead allows interaction only through the moderator. The moderator sends out the questionnaire, collates the responses of the members, makes a statistical analysis of the results of each round, and provides the panel members with a summary of the analysis. Panel members, whose predictions lie outside the interquartile range (IQR), are asked to reconsider their positions or defend their predictions. The Delphi method must go through at least two rounds. The efficacy of the method depends on the choice of the moderator (who must be honest and free from bias) and the panel members (who must be experts each in their own field). This is the preferred method today in Japan, Korea, and other advanced countries for forecasting technological trends.

Trend extrapolation assumes that past trends will persist in the future. This assumption is not valid if there are scientific developments with short gestation periods, important technological innovations that can be enforced right away, or sudden changes in the political and economic fields. The advantage of trend extrapolation is that it can be modeled mathematically. In addition, demographic models can be used in cases of competing technologies. The mathematical models in trend extrapolation are either the linear, exponential, or S-curve growth patterns. For instance, the long-term behavior of

particular technologies generally follows the S-curve. The S-curve shows a slow growth in the early stage, increases exponentially in the take-off stage, and then slows down in the mature stage, eventually leveling off when the natural limit is reached. This pattern is best illustrated by the development of lighting technology.

In cases where technological development cannot be forecasted directly but is observed to be linked to some other factors, the method of correlation can be used in forecasting.

Dynamic or causal models determine the evolution of any system, either analytically or through simulation. The underlying ideas come from physics, where, in integrable systems, and given initial conditions (position and velocity) and forces (the causal factors), the trajectory or state of the system, at any given time, can be determined. This is an extreme case of causality and, strictly speaking, does not involve forecasting because everything is predetermined by the initial state and forces. But not even this simple physics analogy corresponds to anything in technology forecasting because forecasting quantification, particularly in relation to societal factors, is difficult. Moreover, how does one express forces—technological, scientific, and societal—in analytic form? Is an analog of Newton's law at all possible to explain technological change?

Note, however, that the (current) absence of a dynamical equation (the analog of Newton's law) for technological evolution, which would be of universal application, does not mean we cannot do any dynamic or causal modeling of technological changes on a case-to-case basis. A particular aspect of technology may depend on specific factors that can be written in the form of an equation. An example given by Martino is the model that predicts the growth of scientific knowledge. This is given by the equation:

$$dI/dt = k (1 - I/L) [N + mfN(N-1)/2]$$

where I is the amount of information (measured in terms of the number of scientific papers published, although cynics may question the assumption that the number of papers has anything to do with information generated) at time t; L is the maximum amount of

information knowable (limit of scientific knowledge in a particular area); and N is the number of people working in that field.

Normative forecasting, in contrast, is a technique in which goals are set under the assumption that the technological requirements can be met to achieve them. This type of method requires a realistic evaluation and forecast of technological and societal factors. The best example is President Kennedy's goal of landing a man on the moon before 1970, which he announced in the early 1960s. The technological requirements of this goal were numerous, such as upgrading the spacecraft for the storage of provisions (air, food, power, water) that would last longer than previous orbital flights, and developing a lunar module that can land safely on an unknown surface. At the same time, the forecast of societal factors, such as the willingness of the American public to support the project despite the cost and the tragedy of Apollo 1, was correctly predicted. The project was a success, and the first man on the moon landed in July 1969.

Scenario building is a forecasting method, where a set of possible futures is built from the present, assuming various factors and the occurrence or nonoccurrence of certain events. With this method, relative qualitative probabilities can be given. The scenarios range from pessimistic to optimistic, or from least probable to most probable. The various types of scenarios are:

- single scenario, which is usually made to catch attention;
- significant-theme scenario, which deals with a group of scenarios exhibiting a range of future possibilities, presented in the form: "if this happens, then these are the possible trends or developments;" and
- bounding scenario, which deals with a group of scenarios but which are built around a central theme, possibly surrounded by slight variations.

The last forecasting method, and surprisingly, the newest technique, is the probabilistic method, which uses quantitative measures. Since forecasting is inherently uncertain, one would think

that probability concepts should have been used much earlier. But the application of probabilistic concepts in forecasting was only done in the early 1980s (Martino 1993).

To put probabilistic concepts in technology forecasting in perspective, let us go back to physical systems and see how uncertainty is incorporated. Causal classical systems are dealt with using Newton's laws. Uncertainty (in the classical sense) is incorporated in two equivalent ways, either through probability distribution, or the introduction of noise.

In probability distribution, P(x) designates the probability of variable x (which may represent position, momentum, or any other attribute of a physical system), such that P(x) dx is the probability for variable x to lie within the range x and x+dx. Measurement results are given by the so-called expectation or averaged values.

Another method of incorporating uncertainty into classical systems is the introduction of noise or stochastic variables to cause fluctuations or uncertainties. In the case of Brownian motion, "white" noise is introduced to simulate the effect of random collisions between Brownian particle with the water molecules. The evolution of the stochastically driven system is given by the Langevin equation, and measurement results are derived by stochastic averaging.

Both methods are equivalent under certain conditions, and proof follows by deriving the Fokker-Planck equation.

In technology forecasting, probabilistic concepts are used in conjunction with other methods. For example, ordinary trend extrapolation is deterministic because, given the historical data and current trend, a precise forecast of future developments can be derived. Uncertainty can be incorporated into trend extrapolation by introducing probability distributions that fit the known data. Then future values are extrapolated by using the distribution functions. The spread in the values computed gives the uncertainty in the extrapolation.

Probabilistic concepts can also be incorporated into particular causal models. For instance, we can introduce a noise to cause the fluctuation or uncertainty and write down the equivalent Langevin

equation of the causal model. Then we can solve the equation by expressing the variable that describes the particular attribute of technology (in the previous causal model, this is information I), in terms of time t and the noise. Averages and correlations are then computed by applying noise averaging (using an assumed distribution for the noise).

In sum, for every aspect of technology, there is an appropriate forecasting technique. Forecasting methods can and should also be applied to particular problems.

Forecasting for an Energy Plan

While this article does not carry out a forecast of energy technologies, it does explain how a technology forecast in energy planning is to be done. (Note that the proposed forecasts here are not connected with the Philippine Energy Plan.)

The objectives of an energy plan should be:

- To develop indigenous sources of energy and maximize their share in the total energy mix;
- To attain self-reliance or, at least, increase technological competence in certain energy technologies; and
- To provide affordable energy to the industries and the public.

These objectives are based on the following facts. At present, indigenous sources contribute only two percent to the country's total energy requirement, and this is mostly in terms of geothermal energy. The Philippines also has very little technological capability in energy, again mostly in geothermal exploration and utilization where we are, however, very advanced. Finally, electricity in the country is among the most expensive in Asia, second to Japan in absolute cost. If the more appropriate indicator were used—energy cost per unit divided by per capita income—electricity here would definitely be more expensive than in Japan. It is therefore necessary

to expand the share of local energy sources while improving technological capacity in certain types of energy technology.

The plan should have a time frame of at least 20 years for a number of reasons. First, planning, design, construction and start-up of power plants have a time frame of three to 10 years, the lower value for fast-tracked gas turbines and the upper limit for hydro and nuclear plants. Second, power plants have a lifetime of 20 to 30 years. Third, the planning, exploration, and exploitation of energy sources take about three to 10 years. And last, the gestation period of scientific discoveries and technological innovations in energy is from five to 50 years.

Thus, a 20-year time frame is long enough to take into account two to three power plant (base loading) constructions, the identification and exploration of one or two new energy sources, and the introduction of some energy innovations and a plan for the utilization of new scientific discoveries in the future. A period of 20 years is also short enough to make reasonable forecasts.

To formulate the plan, we must have a good assessment of our baseline data. The types of data needed are enumerated in table 4.

What then should we forecast, and how should we do it? There are important developments in the sciences. Those relevant to energy are the areas of plasma physics for controlled hot fusion, high Tc superconductors, and photovoltaic devices. Forecasting in these areas can be done by monitoring what the advanced countries are doing, and determining the state of the art. This will guide the premier science agency and energy department in deciding whether and when to start basic researches in these areas or to join international programs. At this stage, considering that we do not have enough practitioners in these areas, it is not advisable to do a Delphi forecast in the area of scientific developments. For now, we should simply monitor the Delphi forecasts made by other countries, and at most seek the advice of a panel of experts to carry out an intuitive forecast.

We also need to forecast the technological developments in the following types of energy sources: nuclear, clean coal, aeroderivative,

fuel cells, green synthesis chemistry, ocean thermal energy, tidal currents, and wind. On the demand side, we need to forecast various technologies for efficient energy consumption. Incremental changes in these technologies can be forecasted using trend extrapolation, even the probabilistic version. Major developments, on the other hand, can be forecasted by monitoring and using a panel of experts as suggested in the area of the basic sciences. Normative forecasting could also be done if, for example, we decide to learn clean coal technology (because it is the most abundant fossil fuel). In this case, we would have to determine the institutions we need to set up, where to learn the technology from, and perhaps propose the necessary legislation.

The forecast of energy demand must look into the per capita consumption, the energy-GDP elasticity, and the consumption per economic sector, and even per industry. This can be done by trend extrapolation, causal modeling, and normative forecasting. Normative forecasting is important in making industries and houses energy-efficient. Efficiency targets have to be set so that the technologies, policy decisions, and programs needed to meet them can be determined.

After forecasting the demand, we need to determine how to supply the energy requirement. For this, we need to look into our local energy sources, such as geothermal sources, natural gas, and coal, to determine how much of their share of the total energy mix can be increased. We can do this by trend extrapolation, scenario building, and normative forecasting. Then we need to look into our energy imports: the forecast of oil and nuclear fuel prices and the suppliers of power generation technologies. We have to determine if it will be worthwhile to learn which technologies and from whom we should learn them. We can apply the same methods used in forecasting the local energy content.

Table 4
Baseline Data Required in Energy Planning

Types of Data	*Components*
Primary energy sources	Production capacity of indigenous sources (oil, coal, natural gas, hydro and geothermal energy); contribution of alternatives, such as biomass, solar p.v.; identified potentials; speculative potentials
Consumption patterns	Overall energy elasticity; per capita energy consumption; energy intensity of agriculture and various industries; energy efficiency of various industries and service sectors
Existing installed structures	Power plants (age, capacity, reliability); refinery/ processing facilities; distribution networks
Technological capability	Design and construction; major components and parts fabrication; exploration, extraction and exploitation; refinery/processing; environmental management and technologies; demand side management and technologies
Support industries	Steel, metal, electrical/electronic, scientific and engineering instrumentations, and machine tool industries
Human resource development support	Tertiary institutions of learning, R&D institutions
Political factors	Institutions/government agencies in the energy sector and their tasks; energy legislation; biases/ inclinations and positions of political leaders (present and upcoming) on energy matters

Economic conditions	Price structure of energy products; trends, such as privatization/free market, or regulated/ controlled economy
International situation	Stability of the Middle East, OPEC, Russia, and China; availability of technology; effect of disarmament on nuclear fuel supply; known global reserves of energy

For power plant technologies, we need to make forecasts of the grid expansion, the reliability of existing power plants, and the mixture of power plant technologies. The reliability of power plants will be determined primarily by historical data (trend extrapolation), unless certain institutional and engineering practices affect the reliability of plants. In this case, normative forecasting can be done, i.e., we target world standards for reliability, and determine ways to achieve them. Grid expansion, besides being an economic issue, is also demographic and political. This can be forecasted through a combination of techniques: trend extrapolation (spread of population); normative forecasting; and even monitoring political events (a powerful politician who has special interest in the community can influence the National Electrification Administration or the National Power Corporation, and even private distribution companies.

The societal context must also be forecasted. This includes the public's attitude toward deregulation (especially now that deregulation is causing a series of price increases); environmental consciousness and responsibility (which will affect the willingness of the public to pay for the higher cost of energy; acceptance of energy-saving measures; bias for or against certain energy technologies; and energy-related legislation. These developments should be monitored closely, as public opinion changes, and government may need to do a lot of explaining to convince the public that its policies are correct.

Finally, the international context also needs to be analyzed. This includes projecting the stability of the Middle East, OPEC, Russia, and China—the world's major energy producers. Monitoring these developments and getting the views of experts are the forecasting methods applicable here. Global energy reserves must also be forecasted, which can be read through trend extrapolation. New major energy discoveries can be monitored, and perhaps forecasted through statistical methods.

Thus, technology forecasting is a new and exciting field, and demands the participation of experts from academe and the private sector. Let me end with the questions Martino raises in his interrogation model: How much is knowing the future worth? And what is the cost of not knowing? The challenge of technology forecasting awaits us and, if we accept the challenge, the very experience will be its own reward, at least for now.

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Technology-Based Entrepreneurship

ELVIRA A. ZAMORA

Chapter 10

A 1993 World Bank study (Harianto 1994) explains the extraordinary success of East Asian economies, particularly Hong Kong, Taiwan, Singapore and Malaysia, as being attributable to three common factors:

- superior accumulation of physical and human capital
- efficient allocation of physical and human resources
- acquisition and diffusion of technology

All of these factors prove the growing importance of technological change. Accumulation of physical and human capital, for instance, comes in the form of spillovers among firms and workers. The emergence of high-technology industries has caused the rate of such spillovers to increase by leaps over recent years.

The efficient allocation of physical and human resources is facilitated by the formation and growth of high-technology firms, which also leads to the development and harnessing of a country's "critical mass."

The economic success of most of East Asia is also attributable to the rapid growth in foreign direct investment (Harianto 1994). The heavier the influx of multinationals into a country, the more likely new technology will be introduced, and generally

diffused through spin-offs and spillovers (Harianto and Sarafian 1994).

In the face of all these developments, it is obvious that any country aiming for global prominence should have technological innovation on its planning agenda. But more important is the ability of a country to sustain its technological momentum. An economy can continue to expand only if technological change is maintained over time.

According to various authors (Oakey et al. 1988; Cornwall and Perlman 1990; and Martin 1994), a nation's capacity to sustain technological change and economic growth is a function of the growth in enterprise formation.

While the creation of all forms of enterprises is expected to contribute to national development, the rate of technological progress in most economies is directly linked with the increasing number of new technology-based firms (NTBFs) (Oakey et al. 1988).

Oakey et al. (1988) cite NTBFs as a key factor in the growth of high-technology agglomerations in Silicon Valley, as well as in the American biotechnology industry. More and more countries in Europe have also taken steps to encourage NTBF formation, since the early part of the 1980s (Oakey et al. 1988).

Factors Contributing to the Growth of New Technology-Based Firms

There are various factors that could influence the formation of technology-oriented enterprises (Utterback 1987; Oakey et al. 1988; Carlsson and Jacobsson 1994). The major ones include:

- strong market pull: the existence of large and/or expanding markets (domestic and foreign), requiring technologically innovative products;
- strong technology push: the presence of new scientific or technological advances and opportunities;
- strong government support: the availability of government incentives and policies that reduce barriers; favorable public sector purchasing policies; strong patent protection; avail-

ability of venture capital; and R&D support;
- existence of stable potential parent firms: the availability of potential tie-ups with established companies;
- favorable culture: the prevalence of a cultural and social environment, conducive to innovative thinking and risk-taking; low social penalty for failure; and
- strong university-industry linkages: the presence of highly informed, R&D-oriented academic institutions that supply industry with viable technologies and technology ideas.

The Spin-off Phenomenon

The spin-off phenomenon is characterized by the formation of businesses as a result of having been in contact with, developed in part of, or as a by-product of an incubator organization.

Incubator organizations, according to Martin (1994), "appear particularly prone to employing individuals who later establish (that is, spin off) successful new companies." Incubator organizations may be government or university R&D facilities, or private firms. Studies in the United States indicate that private companies are more effective incubators than either government or academic institutions (Martin 1994).

The spin-off phenomenon can be characterized further by the following (Martin 1994, citing the results of a study conducted by A.C. Cooper in 1972):

- Exploitation of founder's expertise: Spun-off companies generally take advantage of the founder's technical expertise. This is expected because new enterprise founders usually venture into technologies and markets they already know well.
- Proximity to Incubator Organization: Spun-off companies generally try to locate operations as close to the parent organization as possible, in order to exploit the same network contacts for possible financial and technical support.
- Fluid Stage of Product Life Cycle: Spin-offs generally prosper

in industries that are in the fluid, rather than the later stages of their life cycle. More mature phases in the cycle are normally characterized by cost-reduction, rather than innovative strategies, and therefore do not effectively encourage spin-offs.

- Higher Probability of Spin-offs among Smaller Firms: Contrary to expectations, smaller incubator organizations have been found to be more likely to generate spin-offs than larger organizations. There are several reasons for this. One is the tendency for small organizations to cultivate longer-term aspirations among employees. Another is the early exposure of employees to different functional teams and managers. And finally, the greater amount of contact between the individual and his employer (the small businessman) encourages spin-offs.
- Presence of Motivation Factors: One of the most effective motivators for spin-offs is personal frustration among individuals employed in the incubator organization. With good venture prospects and positive economic climate, it is likely that such individuals will leave the incubator organization and put up their own businesses.

The Technological Entrepreneur

A technology-based firm is defined by Klofsten (1994) as:

> "... one whose strength and competitive edge derives from the engineering know-how of people who are integral to the firm, and upon the subsequent transformation of this know-how into products of services for a market."

This definition clearly indicates that there are characteristics that distinguish a technological entrepreneur (technopreneur) from a nontechnological entrepreneur (Maidique 1982; Klofsten 1994; Tang and Yeo 1994). Among these major characteristics are:

Technopreneurs advocate radical innovation. The risk resulting from such decision requires the entrepreneur to possess a special combination of entrepreneurial, managerial, and technological skills.

- Technopreneurs are likely to set up firms linked to their branch or business fields, where they have previous work exposure. They usually possess a long professional background, in a good range of areas.
- Educational levels vary, but technopreneurs are usually well educated and have strong technical training.
- Technopreneurs are often described as people with a driving force, deeply—often passionately—involved in the development of and with the ability to create something new.

Filipino Technopreneurs

Narciso Tan Sr.

Narciso Tan Sr. is a man who believes that specialization is the key to success in the business world. He likes to venture into things that other people may not even want to consider. He is a fighter who never gives up, even in the face of obstacles. The quality of each product he produces is behind all his success. His perseverance and strength to withstand rejection are amazing.

Being the eldest of six children, Narciso was motivated, at an early age, to contribute to the family income. A son of a failed entrepreneur who tried to make ends meet through trucking services, Narciso only finished high school, graduating with merit from the Don Bosco Technical School in 1958. He finished as a medalist in his class. Narciso did attempt to go to Mapua Institute of Technology to take up mechanical engineering, but only stayed for half a semester. He said, "The things that I will learn in Mapua are only fundamentals of engineering. What I need is the technical application side of it which I do not think the degree will offer." Being impatient to start earning money, Narciso decided to quit school and

venture into the business world. However, he continued to educate himself outside the formal college classroom.

During the short time he was in college, he started working as an apprentice for Delgado Brothers, a company that manufactured metallic religious articles for Don Bosco. After two years of hard work, he was invited to teach at Don Bosco. After teaching for two years, Narciso realized that it was time to start a business. With only P2,000 from personal savings, Narciso cofounded the Bosconian Philippines, with nine other colleagues from Don Bosco, starting out their small-scale operations with rented machines in the garage of an associate. It was the first company in the country to manufacture the extrusion punch, a component used by Eveready to manufacture batteries. By sourcing the extrusion punch from Bosconian Philippines, Eveready saved on costs of holding inventory, transportation, and importation.

After two years as president and chief technical officer of the company, Narciso decided to give up his share for P280,000. It was during his stint at Bosconian Philippines that he experienced difficulties associated with accounting and administration, and realized the complications of going into business.

Narciso felt the need to start a business by himself. He not only wanted a simple business, but a specialized one with little or no competition. He believed that to maintain a healthy economy, exports must at least equal imports. He did research on the kinds of high-value goods the Philippines constantly sourced from other countries. Narciso felt that he had to concentrate on the mechanical and electrical industries, for which most of the capital equipment were imported due to the absence of any local technology source. Determined to achieve his goal, Narciso decided to manufacture extrusion punches, tools and dies (progressive and compound), inspection jigs, fixtures, and commercial and industrial components. His company, NER Industrial Services Corporation (NERISCOR), also offered related services, including heat treatment and repair and rewinding of motors and controls. Most of the company's clients belonged to the tools and dies, metal stamping, and car manufacturing industries.

Besides NERISCOR, Narciso put up two other companies; one in Mandaluyong, specializing in submersible pumps being sold nationwide; and the other in Santa Rosa, Laguna, specializing in the inspection of jigs and fixtures for car manufacturers, such as Volvo, Nissan, Toyota, and Mitsubishi.

Over the years, Narciso's belief that quality overrides quantity has never wavered—the reason he never compromises on quality. Being a generous man, Narciso also tries to help people who work for him start their own business and be entrepreneurs like himself. He has helped set up two such companies in Antipolo for former employees, and has provided them with start-up capital and machines.

Through his string of successes, Narciso believes that being physically fit is also a crucial part of being successful. He stresses the importance of hard work and commitment. Even without a college degree, he continues to improve himself by going abroad and learning from other people's work, after which he shares his experiences with his technical staff and children.

Samuel Cruz

Robotics in the Philippines? The commitment to upgrade the low-technology status of the manufacturing sector has inspired Samuel Cruz to pioneer the creation of robots and mechanized instrumentation. Sam is the president and brains behind Robotics and Mechatronics Industries (RMI), which specializes in high-technology robots and automation development. He believes that the manufacturing industry must automate and use robots in order to compete in the global marketplace.

"We are now in the age of mechatronization, when modern equipment and machinery are no longer just mechanical, electronic, or computerized. It's a new field altogether, where all three are part of one product," Sam explains. He gives as examples the latest car models, featuring innovations in mechanical engineering, electronic instrumentation, computerized directional, and brake systems.

After working for robotics and automation companies in the United States and other Asian countries for more than 15 years,

Sam was surprised to find, upon his return, that the Philippines was so far behind in automating its manufacturing sector. "The status was primitive," he recalls. "We had not gained in-house skills to properly adopt modern manufacturing strategies. Our engineers were still intimidated by transfer and conveyor lines and communicating with each other by computer. We were fearful of robots, when in reality, they are partners at work. It is a wrong notion to pit robots against workers because they actually complement each other."

The realization prompted Sam to accept a job offered by Dean Sevillano Olano Jr. of De La Salle University (DLSU) in Manila, to head the manufacturing engineering department's product design unit. It was at DLSU that Sam and his staff did initial work on robotics and automation. Later he put up RMI with friends and colleagues, and spearheaded the application of robotics and automation in local industries.

Established in 1991 with a capital of P10 million, RMI has the primary objective of educating and persuading businesses to adopt high-technology R&D as a tool to develop industry. So far, the company has not only convinced a number of local firms to automate; it has proved that high technology firms are good business. Since its inception, RMI has chalked up an impressive list of clients, big high-technology firms like Intel, Motorola, Westar Technologies, and Sharp.

The company started by participating in fairs and exhibits. After their initial project with Intel, the success of the enterprise skyrocketed. Sam's strategy was to deal with big companies first. Sam believed it would be easier to convince smaller local companies after they have seen RMI's track record. True enough, firms both large and small started engaging the services of Sam and his staff of 18 scientists and engineers, all professors, students, and alumni of DLSU.

One of RMI's projects was the dinosaur animatrons at the Star City Complex Jurassic Park exhibit. The theme designs were approved by Hollywood director Steven Spielberg. RMI installed robots to assemble IC chips, assist in the chemical plating process of chips, and transport PC boards from one place in the factory to another.

A handicraft factory has also ordered robots to spraypaint its baskets, while a poultry farm will soon be using RMI robots to feed chickens and pick eggs.

Part of RMI's competitive strategy is the training it provides. Sam teaches his staff to change their way of thinking. "They have to develop technical guts—to accept the fact that we can do it, that we can excel in high-technology fields, such as robotics and mechatronics. We tell them to believe in themselves."

Second, the company teaches its staff the technical aspects of operation. Mechatronics is not taught in universities and technical schools. DLSU and RMI are now cooperating in order to upgrade the skills and knowledge of their staff and workers. Consequently, the company has discovered that its young staff is very creative, and can easily develop new designs and processes.

Sam has even put up another company.

He had also long wanted to change the way engineers work. "We have too many pencil-pushing engineers. Our more than 50 years of Filipino engineering have not resulted in designing and building the Light Railway Transit (LRT) System. All this has got to change."

The results of RMI's training efforts are reflected in the way they sell their services to clients. They do not have a catalogue of robots or machines from which customers can select and order. Their approach is more personalized. The company has a core team of consultants and engineers who study a particular problem.

RMI does not have a dealership for its robots and machines. Everything is custom-built to meet specific client needs. This flexibility makes it possible for the company to cater to both small and big businesses wanting to automate their production processes.

Conclusion

The role of technology-based entrepreneurship in the growth of an economy is critical. Besides providing a vehicle for technology diffusion, it also helps in the development and proper allocation of a country's human resources.

There are numerous accounts of successful entrepreneurs in the

technological field. Unfortunately, there remains a gap in terms of visible and demonstrated commitment from the national government in support of technological ventures. The academic sector has likewise yet to meet expectations with respect to the role it should be playing in the country's crusade toward technological progress.

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GATT and Intellectual Property Protection

MA. ROWENA R. GONZALES

Chapter 11

I. Introduction

The General Agreement on Tariffs and Trade (GATT) had an accidental birth. Shortly after the end of World War II, 50 countries agreed to draft a charter for an International Trade Organization (ITO), under the auspices of the United Nations (UN). The ITO, as articulated in the Havana Charter, was envisioned to be a permanent organization for trade regulation; thereby, totally obviating the destructive trading blocs that spawned a devastating world war.[1] The idea of a super trade body was first brought up in the Bretton Woods meetings, in 1944. At the time, two other international bodies were proposed; namely, the International Monetary Fund (IMF), and the World Bank (WB), for regulating international finance.[2] However, unlike these two institutions, the ITO did not become a reality. The lead proponent of the ITO, US President Dwight Eisenhower, failed to get enough votes in Congress to approve the Havana Charter.[3] Consequently, out of the 50 countries that had earlier agreed to create the ITO in response to the initiatives of the United States, only 23 countries provisionally accepted some of the ITO rules, in order to avail of 45,000 negotiated tariff concessions.[4] Together, the draft rules of the ITO and the tariff concessions became known as the General Agreement on

Tariffs and Trade (GATT). The GATT came into effect on January 1948.[5]

The provisional nature of the GATT gave rise to two notable characteristics. First, since it was governed by mere protocol, the GATT was not viewed as a full-fledged intergovernmental organization. As such, the participants were called "Contracting Parties," not "Members."[6] Second, the agreement had a "grandfathers rights" provision, which allowed a contracting party to exempt all its laws legislated prior to its accession to the GATT.[7]

The GATT may be subdivided into four main parts:

Articles 1-2 consists of the Most-Favored Nation (MFN) policy, and obliges all the Contracting States to bring down tariffs without exception;

Articles 3-23 contains the National Treatment clause, and other substantive obligations of the Contracting Parties. It also sets the terms and conditions for joining the GATT;

Articles 24-34 consists mainly of procedural provisions, which are applicable to all Contracting Parties.

Articles 35-39 pertains to the special status of developing countries, within the GATT structure.[8]

In its 40-year provisional existence, the GATT had eight negotiating rounds. From the first to the sixth round, negotiations focused on lowering tariff barriers. Subsequently, during the seventh round held in Tokyo, nontariff barriers were included in the negotiations, and agreements were made regarding subsidies and countervailing measures, as well as technical barriers to trade.[9] The eighth and latest round of trade negotiations was called the Uruguay Round. It was concluded on December 15, 1993, seven years after talks started.[10]

The Uruguay Round may be considered a landmark. First, it created a permanent World Trade Organization (WTO) to replace the provisional GATT, providing a powerful monitoring and dispute settlement mechanism within its structure. Second, the Uruguay

Round included nontraditional fields of intellectual property protection and services in its framework of international trade.

II. GATT and the TRIPS Agreement

By 1984, the United States had become increasingly dissatisfied with IPR protection. This was, in a large part, due to the successful lobby made by several of its domestic industries. In particular, the pharmaceutical and designer-clothing sectors attributed enormous losses in revenue to IP violations.[11] The United States was unhappy with the lack of enforcement of IPR by the World Intellectual Property Organization (WIPO), the United Nation's specialized agency tasked with administering intellectual property conventions.[12] The WIPO hardly promoted new international norms on IPR protection because of provisions in both the Paris and Berne Conventions, which required unanimity in the interpretation of the Conventions' application.[13]

On September 23, 1985, US President Ronald Reagan called for the improvement of intellectual property protection in his action program on trade policy. Thereafter, in April 1986, his administration issued a white paper, outlining its programs on IP and trade issues, and directing the following measures:

1. enact and enforce domestic legislative and administrative initiatives to improve protection under the US laws;
2. accelerate bilateral consultations and negotiations with other countries, including taking actions under US trade laws, against countries where US rights were violated; and
3. use multilateral initiatives, such as the GATT and other international organizations, to improve protection of IPR, by negotiating improvements in existing norms.[14]

It came as no surprise that, in the same year, at the start of the multilateral trade negotiations in Punta del Este, Uruguay, the IPR issue was brought up. Many developing countries opposed the inclusion

of IPR into the GATT agenda, arguing that the framework of protection, especially for patents, was foreign to the legal traditions of most developing countries. They argued that the inclusion of IP rights in GATT would be superfluous, since these rights were already given protection by the existing international conventions of Berne and Paris. Besides, the WIPO, which took care of administering these conventions, was considered the rightful forum for discussion of new norms on intellectual property protection.[15] Those who favored the subject's inclusion anchored their arguments on the premise that the abuse of IPR discouraged investments in research and development, and denied incentives to the right holder. Moreover, adequate IPR protection promoted a regime, conducive to more direct foreign investments.[16]

During the December 1988 Ministerial Meeting at Montreal, the issue of incorporating IPR into the GATT structure remained unresolved. Resolution on the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement was deferred for further consultations along with Agriculture, Safeguards, Textiles and Clothing.[17] The proposed WTO Agreement did not allow for any reservations, such that countries participating in the Uruguay Round had to decide whether or not to remain outside the global trading system. However, when the negotiations drew to a close on December 15, 1993, the Agreement on TRIPS had become Annex 1C of the Marrakesh Agreement Establishing the World Trade Organization (WTO Agreement), and 116 government representatives decided to sign the final act of the Uruguay Round.[18]

The inclusion of IPR in the multilateral trading system, including the establishment of a more efficient mechanism for the enforcement and settlement of disputes, was perceived by many developing countries as a victory for the industrialized nations. This perception, however, was tempered by the Round's promise of allowing greater world market access for cheap labor-intensive products of developing countries. The initial fears concerning TRIPS were further allayed when developing countries saw the possibility of long-term gains, based on a global trading system governed by rules, and not by the unilateral desires of a few powerful nations.[19]

III. Overview of the TRIPS Agreement

The WTO Agreement came into effect on January 1, 1995, along with the TRIPS Agreement. However, no member is obliged to apply the provisions of the TRIPS agreement before the end of one year, from the WTO Agreement's entry into force.[20] Furthermore, developing countries (including economies in transition, from centrally planned to a free-enterprise economy), and least developed countries are given grace periods of four and 10 years, respectively, and thus may delay the performance of their TRIPS obligations until the years 2000 and 2006.[21] The grace periods have no application to: 1) National Treatment (Article 3) ; 2) Most-Favored Nation Treatment (Article 4); and, 3) WIPO Multilateral Agreements on Acquisition or Maintenance of Protection (Article 5).[22] Consequently, all contracting parties must enforce Articles 3, 4, and 5 of the TRIPS Agreement, starting January 1, 1996. The Philippines, a developing country, will have to meet its TRIPS obligations by the year 2000, except for said articles which must be complied with, starting 1996.

While the WTO Agreement promises many benefits, consisting of a bundle of tariff and nontariff concessions from various contracting states, it would be instructive for the developing countries to look closely at the experience of developed countries concerning TRIPS, possibly as a harbinger of things to come. Early last year, the United States brought an IPR case against Japan before the WTO. The United States charged that the rights of US music recording companies and performing artists, over music royalties, were being violated by Japan, when the latter, aligning its legislation with the TRIPS Agreement, enacted a law granting protection to neighbouring rights, retroactive to 1971.[23] According to the United States, the Japanese legislation was short of the 50-year period of protection guaranteed by the TRIPS Agreement. It insisted that the new Japanese legislation should retroact to 1946, and not only to 1971. This meant giving protection to phonogram producers and performers for music starting 1946, thereby including the recordings of Elvis Presley, the Beatles, and other so-called classics. The United States further claimed that it was losing half a billion dollars a year on unpaid music royalties, as a

consequence of Japan's new legislation.[24] Japan, on the other hand, claimed that it did not violate TRIPS because it came well within the TRIPS provision, exempting a country from compliance, with a 50-year protection period. This position, according to Japan, had the approval of both the United States and the European Union, during the Round's negotiations.[25] The European Union had since joined the US in complaining to the WTO, putting its record industry loss at US$120 million a year.[26] However, the dispute seemed to have become moot and academic. Japanese Prime Minister Ryutaro Hashimoto made a surprise announcement, after meeting with US President Clinton in February 1995, that Japan would amend its copyright law, and bring it into line with the western countries.[27] Suffice to say, the said move will surely affect the record market of Japan, which is the second largest in the world, accounting for US$6 billion, or 17 percent of global sales in 1994.[28] It is estimated that the sale of pre-1971 recordings, in Japan, accounts for 7 percent of the total sales of recordings.[29]

The Philippines could face a similar IPR suit by the year 2000. In such an event, the possible fallout in the Philippine music industry could be tremendous. It would be prudent, therefore, to explore the country's options, during the grace period allowed by the TRIPS Agreement. The University in particular, being both a generator and user of intellectual property, must clearly define its role in a post-TRIPS environment. In facing the challenge of TRIPS, the University will have to draw on a wide variety of disciplines, including law, business, economics, science, and engineering.

A. *Basic Principles*

The TRIPS Agreement is anchored on two basic principles: the National Treatment, and the Most-Favored Nation treatment principles. National Treatment[30] requires a member country to give the same treatment to the nationals of other member countries as it gives to its own nationals, with regard to the protection of intellectual property. The word "national" does not necessarily pertain to citizenship, but has been expanded to include persons, natural or

legal, who have a close attachment to other member countries.[31] National Treatment has the objective of placing foreigners, with respect to IP-related activities, on equal footing with the local population.

The second basic principle is the Most-Favored Nation (MFN) treatment,[32] enunciated in Article 4 of the TRIPS Agreement. It means that any advantage, privilege, favor, or immunity, granted by a member state to another, should be extended to all other member states. This provision has the objective of ensuring that no discrimination occurs against nationals of other member countries.

In scope and subject matter, certain derogations to these two principles are permitted. In the case of copyrights, National Treatment has a wider reach than neighboring rights. The TRIPS Agreement accords National Treatment to other rights not provided under it, but which are recognized under the national law of the member state.[33] On the other hand, the TRIPS Agreement limits national treatment concerning neighboring rights to those rights specifically granted under the said Agreement.[34]

B. Scope and Standards of the TRIPS Agreement

The most comprehensive intellectual property convention, the TRIPS Agreement consists of 72 articles, and is divided into seven parts, namely: Part 1 - General Provisions and Basic Principles; Part 2 - Standards Concerning the Availability, Scope, and Use of Intellectual Property Rights; Part 3 - Enforcement of Intellectual Property Rights; Part 4 - Acquisition and Maintenance of Intellectual Property Rights and Related Inter-Partes Procedures; Part 5 - Dispute Prevention and Settlement; Part 6 - Transitional Arrangements; and, Part 7 - Institutional Arrangements and Final Provisions. The term "intellectual property" is limited to seven categories,[35] identified in Part 2 as: copyright and neighboring rights, trademarks, geographical indications, industrial designs, patents, layout designs or topo-graphies of integrated circuits, and undisclosed information or trade secrets.

Many of the protection standards for these different categories are based on the substantive provisions of existing intellectual property

conventions, such as the Berne (1971), Paris (1967), and Rome Conventions, and the Treaty in Respect of Integrated Circuits, which the TRIPS Agreement incorporates by reference.

1. Copyright and Related Rights[36]

The adequacy of the Berne Convention in providing basic standards for copyright protection was recognized during the Uruguay Round.[37] Since the substantive provisions set forth in the major intellectual property conventions were already incorporated in the TRIPS Agreement by reference, few rights and obligations were added.

The concept of rental rights is a new addition. The Agreement states that "Members shall provide authors and their successors the right to authorize or to prohibit the commercial rental to the public of originals or copies of their copyright works."[38] The obligation to provide for rental rights is limited to the commercial rental of computer programs and cinematographic works. In the case of computer programs, it is necessary that the program itself be the essential object of the rental. In the case of cinematographic works, two conditions must concur before a Member state becomes obligated to grant rental rights: 1) there is widespread copying of the cinematographic works; 2) the first condition materially impairs the exclusive right of reproduction of such works, granted by the Member state to its authors.[39]

Moral rights are excluded from the TRIPS Agreement.[40] Consequently, it appears that under the Berne Convention, the obligation to indicate sources, in relation to permissible free use of a literary or artistic work, is not within the coverage of the TRIPS Agreement.[41] With respect to new technologies, computer programs, whether in source or object code, are classified and protected as literary works. TRIPS further clarifies that databases or other compilations of data are protected under copyright provided that, by reason of the selection or arrangement of contents, they constitute intellectual creation.[42]

The TRIPS Agreement basically follows the standards set by the Rome Convention. Performers have the option to prevent the fixation of their unfixed performance, and the reproduction of such

unauthorized fixations. Producers maintain the right to enjoy or prohibit the direct or indirect reproduction of their phonograms. Broadcasting organizations have the right to prohibit the fixation, the reproduction of such fixation, and the rebroadcasting of their broadcasts by wireless means, as well as their communication of the same to the public of television broadcast.[43] Rental right has also been provided to producers of phonograms, and other right holders in phonograms.[44] A major departure of the TRIPS Agreement from the Rome Convention is the 50-year period of protection, granted to both performers and producers of phonograms.[45] Under Rome, the term of protection for all right holders has been set at 20 years.[46] However, broadcasting organizations, maintain the same term of 20 years, under the TRIPS Agreement.

2. Trademarks

A fundamental rule in the registration of a trademark is the capacity of the logo to distinguish the goods and services of one undertaking, from other undertakings. Even if a logo is not distinctive of the relevant goods and services, it may still be registrable as a trademark, on the basis of use.[47] However, its actual use cannot be made a pre-condition to the filing of an application for its registration.[48] In determining registrability, knowledge by the public of the trademark, as a consequence of its promotion, will be considered.[49] Furthermore, a Member may require a mark visible to the naked eye, although such characteristic of visual perceptibility is not mandatory for registrability, under the TRIPS Agreement.[50]

The protection of well-known marks, as enunciated in the Paris Convention (1967), is extended to the TRIPS Agreement.[51] This protection also applies to well-known service marks.[52] Under Article 6bis of the said Convention, countries of the Union protect a mark, used for identical or similar goods "considered by the competent authority of the country of registration or use to be well-known in that country," from trademarks which constitute "a reproduction, an imitation, or a translation, liable to create confusion." Even if only an essential part of the mark is reproduced or imitated, the protection of Article 6bis applies. The TRIPS Agreement extends

the protection granted by the Article to "goods or services which are not similar to those in respect of which a trademark is registered, provided that use of that trademark in relation to those goods or services would indicate a connection between those goods or services and the owner of the registered trademark, and provided that the interests of the owner of the registered trademark are likely to be damaged by such use."[53] If a member country requires the use of a trademark for purposes of maintaining a registration, non-use of a mark can only be made a basis for cancellation if the mark has not been used for at least three years. [54] And even if it has not been used for three years, a trademark owner may still maintain the mark's registration, if the non-use is attributable to obstacles, independent of the will of the trademark owner.[55] A trademark can live indefinitely provided it is renewed, at least, every seven years.[56]

The conditions for licensing and assignment of trademarks may be determined by a member country. However, it cannot allow for the compulsory licensing of trademarks.[57] Neither can it deprive the trademark owner of the right to assign the trademark. The assignment can occur with or without the transfer of the business to which the trademark belongs.[58]

3. *Geographical Indications*

Geographical indications are defined, under the TRIPS Agreement, as "indications which identify a good as originating in the territory of a Member, or a region or locality in that territory, where a given quality, reputation or other characteristics of the good is essentially attributable to its geographical origin."[59] The Paris Convention has no definition of geographical indications, but makes reference in its Article 10 to the term "false indication of the source." The use of geographical indications to falsely state the source of goods, in order to mislead the public, constitutes unfair competition, and subjects these goods to seizure in the country of importation.[60] Certain exceptions to the grant of protection are recognized, such as when the geographical indication has been used continuously for at least 10 years, prior to April 15, 1994.[61] Special protection is granted to geographical indications identifying wines and spirits.[62] Under the

TRIPS Agreement, a registry for the notification and registration of geographical indications of wines must be negotiated in the Council for TRIPS.[63]

4. Industrial Designs

New or original industrial designs are given a minimum protection of 10 years.[64] A Member has the choice of denying protection to designs which, although original, have been dictated by technical or functional considerations.[65] In addition, a Member may secure protection for textile designs, in view of their extremely short life cycle and large quantity, either by means of a formality-free copyright law, or a registration-oriented design law.[66]

5. Patents

Under the TRIPS Agreement, member countries are enjoined to make available patent protection for inventions in virtually all areas of technology.[67] This has certain exceptions, consisting of: a) inventions, the commercial exploitation of which will endanger public order or morality; b) diagnostic, therapeutic, and surgical methods for the treatment of humans or animals; c) plants and animals, other than microorganisms, and essentially biological processes for the production of plants and animals, other than nonbiological and microbiological processes.[68] Members are given the choice to determine the type of protection granted to plant varieties which may either be the patent system, an effective sui generis protection system, or a combination of both.[69]

A product patent grants the patentee the exclusive rights to prevent others from making, using, offering for sale, selling, or importing such product.[70] A patent over a process, on the other hand, grants the patentee the right to prevent others from using that process and the product directly obtained from it.[71]

The applicant for an invention patent must disclose the invention, in a sufficiently clear manner, so that it can be replicated by a person skilled in the art.[72] Information concerning foreign applications and patent grants on the same invention may be required by the member country where the patent application is lodged.[73]

Compulsory licensing and unauthorized government use of the patented invention or process are allowed, subject to certain well-defined conditions, for the protection of the patent holder, such as the payment of adequate remuneration, and the availability of judicial review by a distinct higher authority.[74]

The term of protection for invention patents shall last for no less than 20 years from the filing date.[75]

6. *Lay-out Design in Integrated Circuits*

By itself, the TRIPS Agreements does not define "integrated circuit" or "layout-design," but incorporates, by reference, the main substantive provisions of the Treaty on Intellectual Property in Respect of Integrated Circuits (IPIC),[76] including its definition of terms. Integrated circuit means "a product in its final form or an intermediate form, in which the elements, at least one of which is an active element, and some or all of the interconnections are integrally formed in and/or on a piece of material and which is intended to perform an electronic function."[77] Layout-designs (topographies) means the "three-dimensional disposition, however expressed, of the elements, at least one of which is an active element, and of some or all of the interconnections of an integrated circuit, or such a three-dimensional disposition prepared for an integrated circuit intended for manufacture."[78]

The unauthorized importation, sale, or distribution for commercial purposes of: 1) a protected layout-design; 2) an integrated circuit, in which a protected layout-design is incorporated; or 3) an article incorporating an integrated circuit only insofar as it continues to contain an unlawfully reproduced layout-design will be considered unlawful by the member state.[79] However, such acts will not be considered unlawful, where the person performing them had no knowledge and no reasonable ground to know, when acquiring such layout-design, integrated circuits, or articles, that these were unlawfully reproduced, or incorporated with unlawfully reproduced design.[80] Furthermore, "Members shall provide that, after the time that such person has received sufficient notice that the layout-design was unlawfully reproduced, that person may perform any of the acts with

respect to the stock on hand or ordered before such time, but shall be liable to pay to the right holder a sum equivalent to a reasonable royalty such as would be payable under a freely negotiated license in respect of such a layout-design."[81] Other acts not requiring the authorization of the right holder pertain to the reproduction of the protected layout-design for private use, for the sole purpose of evaluation, analysis, research, and teaching by a third party.[82]

Protection for layout-designs may take different forms. They may be protected by a special law or by means of a copyright, patent, or unfair competition law.[83] Protection should be for at least ten years.[84] For Members requiring registration as a condition for protection, the tolling of the period starts from the "date of filing of an application for registration or first commercial exploitation wherever in the world it occurs."[85] For Members granting automatic protection, only the "date of first commercial exploitation wherever in the world it occurs" is significant.[86]

7. *Undisclosed Information*

The TRIPS Agreement categorizes undisclosed information, more commonly known as "trade secret," as a form of intellectual property. This is the first time that an international convention grants explicit protection to this category.[87] Under the Paris Convention, the unauthorized disclosure of trade secrets is not specifically referred to, but may be considered an act of unfair competition defined as "any act of competition which is contrary to honest practices in industrial or commercial matters."[88]

In order to avail of the protection, the information should: 1) be a secret; 2) as a consequence of being a secret, have commercial value; and, 3) reasonable steps have been taken to keep it a secret by the persons lawfully in control of such information.[89] Member states are required to protect undisclosed data from unfair commercial use. The submission of these to the government agencies is a condition to the grant of a license for marketing pharmaceutical and chemical products. However, the member state may disclose such data when necessary, for the protection of the public.[90]

8. Enforcement

A significant departure of the TRIPS Agreement from other international agreements on intellectual property is the inclusion of the requirement for member countries to provide effective means to enforce the rights of intellectual property rights holders.[91] For the first time, rules on domestic enforcement procedures and remedies have been negotiated in the international arena, a matter traditionally reserved to municipal law.[92] The TRIPS Agreement contains provisions, spelling out substantive and formal rules on fair and equitable procedures, evidence, injunctions, damages, and other remedies.[93] Provisional measures intended to prevent infringements of any intellectual property and preserve relevant evidence on alleged infringements are also included.[94] An entire section is devoted to border-control measures, to ensure that infringing activity is nipped at the source, or at the point of introduction.[95] A distinction is made between infringement in general, and willful trademark counterfeiting or copyright piracy on a commercial scale. Members are enjoined to apply criminal procedures and penalties to the latter, in contrast to the civil sanctions mandated for small-time infringers. However, over-enthusiasm in protecting intellectual property rights can lead to the harassment or abuse of legitimate traders. Thus, as a safeguard, the TRIPS Agreement gives considerable attention to the rights of traders, providing for provisional civil judicial measures. These include the lodging of a security, or equivalent assurance, by the applicant, the limited duration of suspension of the goods' release by customs authorities, and the indemnification of the importer/owner upon wrongful detention of the goods. [96]

9. Dispute Settlement

Dispute settlement in TRIPS is conducted through the integrated dispute settlement system of the World Trade Organization (WTO), which is built on the old dispute-settlement mechanism of the GATT.[97] States with trade-related intellectual property disagreements must first engage in consultations with each other, to try to resolve their disputes. In the event consultations fail, the parties may bring

the matter to a panel of three to five independent persons, which, as a body, will inquire on the issues and determine the rights in the controversy.[98] A panel report will then be submitted to the Dispute Settlement Body (DSB). Should there be disagreement on the panel report, recourse may be made to an Appellate Body.[99] Once the DSB adopts the findings of this Body, the decision becomes final. If after a decision has been rendered and the other party refuses to comply, the aggrieved party may retaliate against the latter by imposing legal measures on the other party, such as the withdrawal or suspension of concessions.[100]

A highlight of the dispute-settlement provision of the TRIPS is the reverse or negative consensus rule. Under this system, a panel report will be considered adopted "unless a party to the dispute formally notifies the DSB of its decision to appeal or the DSB decides by consensus not to adopt the report."[101] This method promises to be more effective than the "positive consensus" rule, which required acquiescence by the losing party before any action could be taken for redress.

IV. Conclusion

The joining of trade and intellectual property protection in the international scene reverberates in the local arena. Actions concerning intellectual property protection, by the three separate and independent branches of government, converge in an apparent show of coordination. Several legislative bills on intellectual property protection are currently pending and under debate in Congress. Most of them seek to align municipal IP laws with the TRIPS Agreement. In 1993, President Fidel V. Ramos has created the Presidential Inter-Agency Committee on Intellectual Property Rights (PIAC-IPR), to monitor public compliance with IP laws. The committee also conducts seminars to call the public's attention to the importance of IPR. In 1995, the Supreme Court has issued Administrative Order 113-95, which designated 48 special regional and municipal courts for cases concerning violations of intellectual property rights within their jurisdiction.

The Harmonizing Effect of TRIPS

Although many of the substantive norms in major IP conventions are presented as setting minimum requirements for the protection of intellectual property under the TRIPS Agreement, such norms actually present very high standards of protection for developing countries. Dr. Ulrich Schatz has observed: "this minimum is defined in such detail and is so close to the maximum existing in most advanced countries that TRIPS amounts to a treaty for world-wide harmonization of intellectual property laws at a very high level." In a world composed of very rich and very poor countries, any talk of harmonization of laws, however limited, is bound to be controversial. Indeed, throughout the negotiations of the TRIPS Agreement, this issue proved to be the most contentious. The question of whether or not to include any talk of substantive norms on IP in the TRIPS negotiations has met strong opposition from developing countries, claiming that "harmonized international standards would often be inappropriate to their social and development needs and that, in any case, WIPO and other specialized organizations were the proper place to discuss them."[102] However, a globally harmonized intellectual property system would diminish trade distortions, lead to increased efficiency in the distribution of goods and services, lower prices, and improve the quality of goods and services available to majority of the world's consumers. The debate will probably continue for a long time, even as the TRIPS Agreement and the other agreements negotiated under the Uruguay Round are tested in the contracting parties.

The idea of a permanent International Trade Organization (ITO) was born in 1944, after a devastating world war. Conceived as an instrument of peace, the ITO did not become a reality, but led to the formation of the GATT, which was to remain provisional for a long time.

It is interesting to note that, before the turn of the millennium, an idea born more than half a century ago would see fruition in the WTO. However, it remains to be seen whether the objective of lasting peace through regulated trade could be achieved. The TRIPS

Agreement is but one of the many agreements forged under the WTO Agreement, during the seven-year Uruguay Round negotiations. As in other international negotiations: concessions, compromises, and accommodations have been made by the various participating governments. The length of time and breadth of scope of the negotiations should be indicative of at least two things, concerning the current political landscape in the international arena. First, developing countries are not as powerless as one might suppose. Neither are the developed countries invincible. Second, there are a lot of "talking points," which unite the interests of more than a hundred governments. On these points, perhaps, pivot the real essence of globalization: integration through multilateral negotiations.

As a contracting party to the WTO Agreement, the Philippines must identify and take the optimal path for integrating intellectual property rights into its economic development strategy. This is certainly not an easy task. But neither does it lie in the realm of the impossible.

NOTES

[1] Philip Evans and James Walsh, *The EIU Guide to the New GATT*, United Kingdom: The Economist Intelligence Unit Limited, 1994, 8.
[2] Ibid.
[3] Ibid., 9.
[4] World Trade Organization, *Trading into the Future*, WTO Information and Media Relations Division, 1995, 8.
[5] Ibid.
[6] The EIU guide, 9.
[7] Ibid.
[8] Ibid., 130.
[9] *General Agreement on Tariffs and Trade: What it is - What it does*, GATT Information and Media Relations Division, 1990, 9.
[10] The EIU Guide, 7.
[11] Ibid., 38.

[12] Emery Simon, "U.S. Trade Policy and Intellectual Property Rights," 50:3 *Albany Law Review*, Spring 1986, 601. Speech delivered during the Symposium on Intellectual Property held at Saratoga Springs, New York, June 4-6, 1986. The author was then the Director of Intellectual Property Office of the United States Trade Representative.

[13] Article 33(1) of the Berne Convention provides:

"Any dispute between two or more countries of the Union concerning the interpretation or application of this Convention, not settled by negotiation, may, by any one of the countries concerned, be brought before the International Court of Justice by application in conformity with the statute of the Court, unless the countries concerned agree on some other method of settlement. The country bringing the dispute before the Court shall inform the International Bureau; the International Bureau shall bring the matter to the attention of the other countries of the Union."

The Paris Convention, which is the major multilateral industrial property treaty, is less clear on the unanimity principle. However, successive revision conferences seem to have adopted the said principle. See the article of Sam Ricketson, "The Future of the Traditional Intellectual Property Conventions in the Brave New World of Trade-Related Intellectual Property Rights," 26 *International Review of Industrial Property and Copyright Law*, June, 1995, 892.

[14] Emery Simon, "U.S. Trade Policy and Intellectual Property Rights," see note 12.

[15] Mark Damschrode, "Intellectual Property Rights and the GATT: United States Goals in the Uruguay Round," 21 *Vanderbilt Journal of Transnational Law*, (1988), 398.

[16] The EIU Guide, 37.

[17] Carlos Alberto Primo Braga, "The Economics of Intellectual Property Rights and the GATT: A View from the South," 22 *Vanderbilt Journal of Transnational Law*, (1989), 251, note 37 .

[18] The EIU Guide, 7.

[19] Ibid., 1.

[20] Article 65(1), TRIPS Agreement.

[21] Ibid.

[22] Article 65(2), TRIPS Agreement.

[23] "U.S. Takes Music Piracy Charge Against Japan To WTO," *International Herald Tribune*, February 10-11, 1996, 9. See also Christopher Heath's article "All Her Trouble Seemed So Far Away: USA v. Japan Before the WTO," 12:1-3 *World Bulletin*, January - June 1996, 41.

[24] "U.S. Takes Music Piracy...," 1.

[25] "U.S. Talks Tough to Tokyo on 'Legal' Music Piracy," *International Herald Tribune*, February 7, 1996, 1 and 4.

[26] "EU, US Act on Japan's Piracy," *Financial Times*, February 23, 1996, 4.

[27] "Tokyo Agrees To Extend Music Copyright," *Financial Times*, February 28, 1996, 12.

[28] "EU, US Act on Japan's Piracy," *Financial Times*, February 23, 1996, 4.

[29] Heath, "All Her Trouble Seemed So Far Away..." 12:1-3 *World Bulletin*, 1996, 41.

[30] Article 3(1) on National Treatment states:
"Each Member shall accord to the nationals of other Members treatment no less favourable than that it accords to its own nationals with regard to the protection of intellectual property, subject to the exceptions already provided in, respectively, the Paris Convention (1967), the Berne Convention (1971), the Rome Convention, or the Treaty on Intellectual Property in Respect of Integrated Circuits. In respect of performers, producers of phonograms and broadcasting organizations, this obligation only applies in respect of the rights provided under this Agreement. Any Member availing itself of the possibilities provided in Article 6 of the Berne Convention. (1971) or paragraph 1(b) of Article 16 of the Rome Convention shall make a notification as foreseen in those provisions to the Council for TRIPS."

[31] Footnote 1 of the TRIPS Agreement states:
"When nationals are referred to in this Agreement , they shall be deemed, in the case of a separate customs territory Member of the WTO, to mean persons, natural or legal, who are domiciled or who have a real and effective industrial or commercial establishment in that customs territory."

[32] Article 4 on Most-Favored Nation Treatment states: With regard to the protection of intellectual property, any advantage, favour, privilege, or immunity granted by a Member to the nationals of any other country shall be accorded immediately and unconditionally to the nationals

of all other Members. Exempted from this obligation are any advantage, favor, privilege, or immunity accorded by a Member:
a) deriving from international agreements on judicial assistance or law enforcement of a general nature and not particularly confined to the protection of intellectual property;
b) granted in accordance with the provisions of the Berne Convention (1971) or the Rome Convention authorizing that the treatment accorded be a function not of national treatment but of the treatment accorded in another country;
c) in respect of the rights of performers, producers of phonograms and broadcasting organizations not provided under this Agreement;
d) deriving from international agreements related to the protection of intellectual property which entered into force prior to the entry into force of the WTO Agreement, provided that such agreements are notified to the Council for TRIPS and do not constitute an arbitrary or unjustifiable discrimination against nationals of other Members.

[33] Article 5(1) of the Berne Convention (Paris Act of 1971), the major treaty on copyright, states:
Authors shall enjoy in respect of works for which they are protected under the Convention, in countries of the Union other than the country of origin, the rights which their respective laws do now, or hereafter grant to their nationals, as well as the rights specially granted by this Convention.

[34] Article 3(1) xxx In respect of performers, producers of phonograms and broadcasting organizations, this obligation [National Treatment] only applies in respect of the rights provided under this Agreement. xxx

[35] Article 1(2) states:
"For the purposes of this Agreement, the term ` intellectual property' refers to all categories of intellectual property that are the subject of Sections 1 through 7 of Part 2." This coverage excludes other kinds of intellectual property, such as utility models and petty patents.

[36] The TRIPS Agreement uses the term "related rights" to pertain to the rights of performers, producers of phonograms, and broadcasting organizations, respectively as to their performances, phonograms, and broadcasts. This term is equivalent to "neighboring rights," the term

often used by the World Intellectual Property Organization (WIPO).

[37] "The TRIPS Agreement: An Overview," a lecture prepared by the World Trade Organization Secretariat, 4.

[38] Article 11, TRIPS Agreement.

[39] Ibid.

[40] Article 9(2) TRIPS Agreement.

[41] A WIPO study makes the following observations: Under Article 2, paragraph 2 of the TRIPS Agreement, "Nothing in Parts 1 to 4 of this Agreement shall derogate from existing obligations that Members may have to each other under... the Berne Convention... Consequently, it would seem that a Member of WTO which is not party to the Berne Convention will not have to apply the provisions of the Berne Convention on moral rights and rights derived therefrom, while a Member of WTO which is party to the Berne Convention will have to apply those provisions, not only with respect to nationals of Members of WTO which are party to the Berne Convention, but also with respect to nationals of Members of WTO which are not party to the Berne Convention (Article 3) and most-favored-nation treatment (Article 4) of the TRIPS Agreement. However, it would seem that disputes concerning the adequacy of moral right protection could not be the subject of WTO dispute settlement procedures since such procedures are- in the field of intellectual property- only available for disputes under the TRIPS Agreement." *Implications of the TRIPS Agreement on Treaties Administered by WIPO*, WIPO:1996, 14-15.

[42] Article 10(2), TRIPS Agreement.

[43] Article 14, TRIPS Agreement.

[44] Ibid.

[45] Ibid.

[46] Article 14, Rome Convention.

[47] Article 15(1), TRIPS Agreement.

[48] Article 15(3), TRIPS Agreement.

[49] Article 16(2), TRIPS Agreement.

[50] Article 15(1), TRIPS Agreement.

[51] Article 2(1) of the TRIPS Agreement states: In respect of Parts II, III, and IV of this Agreement, Members shall comply with Articles 1 through 12, and Article 19, of the Paris Convention. 1967.

[52] Article 16(2), TRIPS Agreement.
[53] Article 16(3), TRIPS Agreement.
[54] Article 19(1) ,TRIPS Agreement.
[55] Ibid.
[56] Article 18, TRIPS Agreement.
[57] Article 21, TRIPS Agreement.
[58] Ibid.
[59] Article 22, TRIPS Agreement.
[60] Article 10(1), Paris Convention.
[61] Article 24(4), TRIPS Agreement.
[62] Article 23, TRIPS Agreement.
[63] Article 23(4), TRIPS Agreement.
[64] Article 26(3), TRIPS Agreement.
[65] Article 25(1), TRIPS Agreement.
[66] Article 25(2), TRIPS Agreement.
[67] Article 27(1), TRIPS Agreement.
[68] Article 27(2)(3), TRIPS Agreement.
[69] Article 27(3), TRIPS Agreement.
[70] Article 28(1), TRIPS Agreement.
[71] Ibid.
[72] Article 29, TRIPS Agreement.
[73] Ibid.
[74] Articles 30 and 31, TRIPS Agreement.
[75] Article 33, TRIPS Agreement.
[76] Article 35, TRIPS Agreement.
[77] Article 2, Treaty on Intellectual Property in Respect of Integrated Circuits.
[78] Ibid.
[79] Article 36, TRIPS Agreement.
[80] Article 37(1), TRIPS Agreement.
[81] Ibid.
[82] Article 35 of the TRIPS Agreement, in relation to Article 6(2) of the Treaty on Intellectual Property in Respect of Integrated Circuits.
[83] Article 35 of the TRIPS Agreement, in relation to Article 4 of the Treaty on Intellectual Property in Respect of Integrated Circuits.
[84] Article 38, TRIPS Agreement.

[85] Ibid.

[86] Ibid.

[87] *The TRIPS Agreement - An Overview*, a lecture prepared by the World Trade Organization Secretariat, p. 7.

[88] Article 10 bis (2), Paris Convention.

[89] Article 39(2), TRIPS Agreement.

[90] Article 39(3), TRIPS Agreement.

[91] Article 41(1), TRIPS Agreement.

[92] *The TRIPS Agreement - An Overview*, p. 8.

[93] Articles 42-46, TRIPS Agreement.

[94] Article 50, TRIPS Agreement.

[95] Articles 51- 60, TRIPS Agreement.

[96] Articles 53 - 56, TRIPS Agreement.

[97] *The TRIPS Agreement - An Overview*, p. 13.

[98] Article 8(5), *Understanding on Rules and Procedures Governing the Settlement of Disputes*, Annex 2 of the WTO Agreement.

[99] Article 17, *Understanding on Rules and Procedures Governing the Settlement of Disputes*, Annex 2 of the WTO Agreement.

[100] Article 22, *Understanding on Rules and Procedures Governing the Settlement of Disputes*, Annex 2 of the WTO Agreement.

[101] Article 16(4), *Understanding on Rules and Procedures Governing the Settlement of Disputes*, Annex 2 of the WTO Agreement.

[102] John Croome, *Reshaping the World Trading System*, Switzerland: World Trade Organization, 1995, 133.

DISCUSSION

Emma C. Francisco

The presentation by Attorney Gonzales was concise and informative enough to give an overview of TRIPs and the present state of IP protection in the Philippines. As far as the pending legislation is concerned, both the Senate and Congress plan to consolidate the three independent bills on patents, trademarks, and copyrights.

In the Senate, Senator Raul Roco, who was the chairman of the Subcommittee on Intellectual Property under the Committee on Trade and Commerce, has consolidated the three bills and proposed the creation of the *Intellectual Property Office*. The creation of this office seeks to rationalize, harmonize, and provide IP decisions or rulings, and make them more consistent. This contrasts what is happening now, where some IP practitioners or owners would have to choose between the Bureau of Patents or the courts.

The Intellectual Property Office will render decisions as far as the IP question is concerned, which are appealable with the Supreme Court. The basic features mentioned in Attorney Gonzales's paper still remain, except for some policy matters introduced by Senator Roco. One of these is the performers' rights. The rights of employees to their intellectual property are improved as, under the present law, intellectual property created by an employee belongs to the employer. Under the consolidated bill, the IP would belong to the employee.

In the House, the three bills have also been consolidated, but with few technical exceptions. Congressman Manuel Roxas III, who heads the committee that prepared the consolidated bill, has not included the creation of the Intellectual Property Office, although he has not gone against it.

Internationally, IP Offices are being fortified by their respective governments. Looking at the profile of IP Offices in

the ASEAN region, particularly that of Singapore, we can see that they are very far ahead of us.

As far as the TRIPS is concerned, we are doing our best to comply with obligations, except that, right now, we have patents, trademarks, and copyright laws to contend with. Other laws to enforce these obligations have been presented to Congress. Although we have until the year 2000 to fully comply with obligations, in a democratic society like the Philippines, the preparation and the passage of these laws will take some time.

Meanwhile, what do we do? We look at the developed countries now undergoing the TRIPS review process in the WTO, and most of them have submitted their national laws, in compliance with their TRIPS obligations. As a developing country, the Philippines would like to take the opportunity/advantage of these submissions by seeing how we could design our own IP laws to substantially meet our obligations. At the right time, we have to decide whether we want a TRIPS level solely, or a TRIPS plus level of protection for all IPs under it.

Management of Technology as a Field of Study

JOSE P. TABBADA

Chapter 12

Introduction

What is management of technology (MOT)? Is there a need for MOT as a practice and a field of study?

In this article, I will argue that there is a need for MOT, both as a practice and a field of study. Considering the requirements of globalization and the imperativeness of national economic survival and growth, mastery or the proper management of technology is very important. Moreover, there is a growing realization of the need for MOT, and our potential to undertake or provide it.

This article will discuss the important features of a good program on MOT, and illustrate these with the new program of UP Diliman. Finally, some of the requirements for the sustainability of MOT will also be presented.

MOT as Practice and Field of Study: Nature and Scope

Kanz and Lam (Gaynor 1996: 6.27) provide what is perhaps the most concise and yet flexible definition of MOT (or technology management, in their terminology):

> "... about getting people and technologies working together to do what (they) want. (It) is a collection of systematic methods for managing the process of applying knowledge to extend the range of human activity and produce defined products (goods or services)."

The key words are: people, technologies, and what they want. MOT is about making people harness technology to achieve an organization's goals. Using technology includes activities, such as technology innovation and development, technology selection and transfer, technology commercialization, technology adoption and adaptation, and technology upgrading.

MOT is not the same as any of its individual parts, processes, or phases. It is more than research and development (R&D), although a firm's R&D is a logical starting point if one wants to look for its MOT capability. MOT is not limited to technological innovation (in the Schumpeterian sense of a radical technological breakthrough). Incremental, process-type innovations are, in fact, as important as radical innovations for competitive advantage, as the Japanese experience shows.

As an academic discipline, MOT is thus the study of the methods in managing the process of applying knowledge for the purpose of extending the range of human activity, and producing goods and services. Put in a slightly different way, MOT is "research and education on how to [m]anage the technology component of individual life cycles, [c]apitalize on process technology to gain a competitive advantage, and [r]elate and integrate product and process technologies." (Cory, in Gaynor 1996: 2.1)

The Global and National Imperatives for MOT

As stated earlier, the need for MOT in the Philippines derives from both global and national imperatives.

Two principal and interrelated trends characterize contemporary economy: globalization and rapid technological change. These

developments are likely to continue, and even intensify, in the first quarter of the new millennium.

Globalization is shown in the rapid growth of international trade, finance, and investment; the reduction of national barriers to international trade and investment; the increasing multinationalization of firms and production; the formation of supranational, including regional and subregional, economic blocs; and the shrinking of the world through developments in telecommunications and transport technologies, among others. Technological change is evident in the rapid introduction and obsolescence of products and production processes; the substitution of synthetic for natural materials; and the changing economic fortunes and competitive positions of firms, industries, and countries.

This is not to say that these two developments are not entirely new. Bukharin, a farsighted Marxist theoretician, recognized the trend toward globalization (but also the opposite tendency toward nationalization)in his classic work, "World Economy and National Economy," written in 1918 (Radice 1975).

The revolutionary role of technology/technological change under capitalism was central to Marx's analysis of that mode of production. Interest in technological change and innovation was kindled by Schumpeter in the interwar period, and was revived in the postwar period by economists who were dissatisfied with the dominant neoclassical economic paradigm that treats technology/ technological change as an exogenous factor in models of economic growth.

What is new in the foregoing processes of globalization and technological change, however, is the scale and speed with which they are happening, as well as the profoundness of their implications for local and national economies, sectors and industries, cultures, and social institutions and individuals.

National response to rapid technological change and globalization has taken two principal forms. One response, advocated by an assortment of industrialists, "nationalists," and remnants of the Leftist Movement, is to withdraw from the global economy and attempt to insulate the domestic economy through protectionist measures

passed off as "safety nets." This group seeks to revert the economy to failed import substitution policies of the 1950s.

The other response is to accept the ongoing globalization as largely given, and design and enforce public economic and technology policies, as well as manage the domestic economy, in order to seize opportunities and maximize the benefits of increased participation and integration in the global economy. Proponents of this view the enhanced competitiveness of Filipino firms and industries as the key to successful participation in the new world order.

The latter is, in our view, the appropriate national response. Successful participation in the ongoing globalization requires mastery of technology. In order thus for the Philippines to succeed in the new world order, it is necessary for the country's firms, entrepreneurs, and managers to master and manage technology for competitive advantage. Efforts of the private sector in this direction, however, need supportive public policies on technology and innovation.

The Need for MOT

The need for MOT in the Philippines has been recognized by academe, government, and industry. It has been pointed out, for example, that the country's poor economic performance may have to do with lack of technological capability, or the failure to manage and master technology.

Evidence of the country's failure to manage technology for national advantage abounds. High-yielding rice varieties have been "discovered" by scientists of the International Rice Research Institute in Los Baños, but agricultural productivity in the Philippines remains one of the lowest in Asia, compelling the country to import rice and corn from Thailand and Indonesia almost annually.

The Philippines is one of the first Asian countries to embark on a domestic car manufacturing program (the Progressive Car Manufacturing Program, the precursor to the current Car Development Program), but almost all countries in the region (e.g., Korea, Malaysia, and Indonesia) have overtaken the country in terms of the stage and scale of their car manufacturing opera-

tions. A relative latecomer, Malaysia, has in fact set up an assembly plant in Pangasinan!

Official recognition of the need to enhance domestic capability in managing technology came with the inclusion of an MOT component in the Engineering and Science Education Program (ESEP), a program funded by a loan from the World Bank, and administered by the Department of Science and Technology (DOST). Under the MOT component, a number of faculty members from the Asian Institute of Management, De La Salle University, and the University of the Philippines were provided with scholarships to pursue graduate programs in MOT in Australia, Europe, and the United States. Under the same program, faculty of the three institutions took short-term training courses abroad.

Also under the ESEP-MOT program, foreign academics were asked to conduct seminars and short-term training programs on MOT subjects, like manufacturing management, environmental management, and strategic technology management. In the pipeline is a UNDP-supported program for the next five years, on the design and conduct of short-term training courses in MOT for government, business, and industry executives.

Sometime in mid-1994, a workshop was convened at the UP Diliman with participants from industry, government, private consulting firms, and academe on the need for and prospect of setting up a "think tank" on technology management, along the lines of, for example, the Office of Technology Assessment of the US Congress. This initiative was spurred by the belief that, in order to catch up with its economically dynamic Asian neighbors, the Philippines needed to do more in the area of technology management. The workshop produced a consensus on the need for technology management but little agreement on the institutional form(s) it should take.

Evidence of the growing realization of the importance of MOT can also be seen in some recent studies. AIMCON 1995, a study commissioned by DOST and funded by the UNDP, focuses on the enhancement of the country's competitiveness in the marine, fruits, and metals industries. More specifically, the study has sought to identify

the technology needs of the three industries and recommend policies, institutional arrangements, and human resources development programs/projects for greater competitiveness. The study also includes an MOT component.

The second study, Technonet Asia 1993, is a policy research and advocacy report on improving the access of enterprises to technology. The study reviews the macroeconomic environment, policy framework, and institutional arrangements for the transfer of technology to the Philippines, noting, in particular, that these were not liberal enough (at the time). Included are a number of case studies on actual technology transfer in selected Philippine industries (chemicals, food processing, etc.).

With financial assistance from the DOST, some 30 local case studies on MOT have been prepared by faculty members of UP, AIM, and De La Salle, in 1992. These studies fill a gap in local MOT literature, and help in the teaching of MOT courses.

These initiatives show the growing awareness of the role of technology and/or technological change, and the need for mastering technology, which is central in MOT, as a positive factor in the country's industrial growth and development.

MOT as a Field of Study in Other Countries

Japan's success in duplicating, and even surpassing, the economic and technological performance of industrialized Western countries provides the inspiration of MOT programs. This is evident in the proliferation of studies on Japanese management style, innovation system, industrial policy and practice of "selective targeting," lean production and "just-in-time" inventory management, flexible manufacturing systems, quality circles, and other technology-oriented policies and institutions. Surprisingly, MOT is not offered as a field of study in Japan.

The absence of MOT as a field of academic study in Japan contrasts with the mushrooming of MOT programs in North America, Europe, and Southeast Asia. The United States has at least 13 universities offering either separate MOT programs or traditional MBA

programs, with MOT as an added area of specialization (Gaynor, 1996: Appendix A).

The most prominent programs are those of MIT and Georgia Institute of Technology, two universities known for their strong engineering programs. In Canada, Queen's University has recently offered an MOT program in lieu of its regular MBA program; other Canadian universities (e.g., McGill University) have MOT-like concentrations in their MBA programs.

In Europe, Sussex University, through its Science Policy Research Unit (SPRU), offers one of the oldest and most established research and academic programs on MOT. The Sussex program has a distinctly social science base and interdisciplinary character, although a recent revision of the SPRU curriculum put more emphasis on the managerial aspect of technological innovation. The University of Manchester has masteral and doctoral programs in MOT which are more oriented toward engineering than the Sussex programs.

The University of Limburg in Maastricht, through its Maastricht Economic Research on Innovation and Technology (MERIT) program, offers graduate and short-term courses on technological innovation. The program has a strong economics and international trade orientation. Roskilde University in Denmark also offers interdisciplinary masteral and doctoral programs in MOT. There is also an innovative doctoral program on technology and innovation, involving a number of schools and research institutes based in different European countries.

Graduate business schools in Europe, such as the INSEAD in France, have added MOT as an elective or area of specialization in their regular MBA programs. Other business schools offer a course or two on MOT.

In the Asia-Pacific region, MOT programs are offered in Australia, Singapore, and Thailand. In Australia, the University of New South Wales, Queensland University, and Griffith University offer MOT programs under or in close collaboration with their engineering faculties. Their programs have a strong engineering and technological orientation. The University of Wollonggong offers an MOT

program patterned after the Sussex program, with emphasis on social sciences.

The National University of Singapore (NUS) offers a one-year MS (Management of Technology) program, under its Faculty of Management. Nanyang Technology University offers a joint engineering- business oriented MOT under its MBA program. The Nanyang MOT program relies heavily on industry practitioners as lecturers; its students, mostly part-time, are sent by private firms. The Asian Institute of Technology in Bangkok offers MOT as a field of specialization in its MBA program.

Some Considerations in the Design of a Program on MOT

Two general approaches are evident from the MOT programs surveyed. The first, which can be called the "European model," is the social science-oriented model, offered by Sussex, Roskilde, and Wollonggong. Typically, the program is an interdisciplinary MA or PhD, with technology policy/management, or industrial policy, as area of specialization.

The second model, which may be called the "American model," is a business management-oriented program offered either as a separate degree program (i.e., MS in MOT), or as a field of specialization in the regular MBA program.

While the two models differ in some ways, they have a common denominator in their multi- or interdisciplinary character. The European model has more of this feature than the American model. This is necessary because technology management is multidimensional. There can be no greater mistake that a policymaker or business manager can make than to treat technological change as a purely technical matter, to be left entirely to technologists or technicians. Therefore, MOT programs must consciously bring together not only theoretical and practical insights of different disciplines, but flesh-and-blood academics from various disciplinary specializations.

But the existence of a common denominator should not obscure the fact that, at least in the Philippines, there are two distinct groups in need of formal MOT training. On the one hand are the policymakers,

planners, and analysts in government, including those in the legislature and the departments of science and technology, energy, public works and highways, transportation and communications, and trade and industry.

However, this group's needs are different from those of the second group, the managers of business and industry, those who actually make the strategic and operational decisions on what technology to introduce, what modifications (including organizational modifications) to make, how much resources to allocate, and when to phase out obsolete technology and shift to another technology.

The former provides the policy framework and the regulatory regime for the management of technology; the latter makes the actual decisions on technology.

The MOT Program of UP Diliman

Responding to the perceived need for advanced education, research, and consultancy services on MOT, the UP Board of Regents, in a February 23, 1995 resolution, approved the establishment of the Technology Management Center in UP Diliman, offering graduate programs in MOT. In June 1996, after months of intensive course preparation, including a series of workshops and consultations with representatives of industry, academe, and government, the Center started offering the diploma and master's programs in technology management.

The programs are multidisciplinary, and handled by faculty members from nine different disciplines and units at UP Diliman: science, engineering, business administration, public administration, economics, political science, small-scale industries, Asian studies, and home economics.

The programs consist of core courses and electives in the area of specialization. The core courses aim to introduce models and theories of technological change and national development, as well as the socioeconomic and cultural contexts of change. They also aim to equip students with necessary analytical and managerial skills and foundations.

The core courses in the diploma and master's programs are: Science, Technology, and National Development; Technological Innovation; Program and Project Management; Management of R&D; and Financial Analysis for Technology Managers. The first two courses are contextual courses, the next two are managerial foundation courses, while the last is an analytic course.

After the core courses, students in the master's program have the option to pursue one of two areas of specialization: business-industry management and public policy. The former is primarily intended to enhance the managerial capabilities of managers. The latter is intended for policymakers, analysts, and decision makers in government planning and policy making agencies, as well as line agencies, like the DOST and the Department of Trade and Industry.

Streaming into separate public policy and business-industry management options is a unique feature of the program. Most universities with MOT programs offer one or the other field of specialization, but not both. The UP Diliman program recognizes that the need is not just for technology-oriented business managers, but also for policy analysts, policymakers, and planners in the public sector.

For, unlike in more advanced countries where technology policy and institutional framework, as well as technology infrastructure, already exist, and where the private sector has had extensive experience in local technology innovation and related activities (e.g., R&D), technology is still considered a public good which calls for government intervention.

Prospects for MOT

Our fearful forecast is that there will continue to be a need for MOT in the Philippines as it needs to catch up with more developed economies. And even when the country has done that, it will still need MOT to maintain its position or keep its closest competitors at bay. Any way it is looked at, the prospects of MOT are bright.

More seriously, sustaining a program is problematic, perhaps more so than initiating it, and this is particularly true of MOT, which is a

new field. After the novelty wears off and the initial enthusiasm dies down, the more difficult tasks have to be done: keeping interest alive, seeing to it that resources are augmented and support continues to be generated, and making marginal improvements in the program to keep it attuned to outside developments.

Specifically, for an academic program on MOT to survive, it must be backstopped by research and practice. A steady supply of teaching materials, such as firm and industry studies, must be generated to keep students and instructors abreast with ever-changing developments. At some point, studies and experiences must be summed up for their lessons, so that the frontiers of knowledge on technology management can be pushed forward.

Ultimately, the MOT program will survive if the clients continue to find it relevant to their needs.

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DISCUSSION

Francisco P. Bernardo

There are many reasons why the Philippines has fallen behind its Asian neighbors, and I agree that two major factors which can contribute to economic recovery are: 1) the development of technological capabilities; and 2) the effective management of technology, particularly in the commercialization of technology in which Japan excels.

The examples given by Prof. Tabbada highlight the fact that we might be talking of some directions of technology. Rather than be technical, we seem to miss that commercialization of technology is one of the aspects we need to develop.

What then is this cornucopia called technology? How can we determine the specific technologies needed? Where can we get these technologies? How can these be adapted to the local environment? What are the cost-benefit implications of acquiring state-of-the-art technologies? It would be regrettable were we to obtain technologies we don't really need, and miss out on vital ones that can make us globally competitive. The definition, transfer process, and evaluation of importing or developing technologies do require scrutiny and study.

A simplified version of identifying specific technologies and how these can be effectively transferred require the comprehension of their form. If the specific technology is *embodied in things*, then its transfer is straightforward, like physical possession or physical relocation. If it is *embodied in people*, like skills, then these can be developed through supervised practice. But if technology is *embodied in a system*, then it will involve structures, policies, rules, etc.

According to the book of Endel-Jakob Kolde, entitled *International Technology Market and Developing Country*:

"Technology is any device or process used for productive purposes. To become productive, technology requires productive application.

No piece of machinery, factory, or farm can function without being operated. Human participation is inherent in the productive capability of any conceivable technology.... Without managerial know-how to use it effectively, no scientific device is marketable as an economic good.... Quite unlike commodities and capital, technology is not depleted or its supply diminished when transferred or used. Once produced, technology is an inexhaustible supply until obsolescence."

Today, Asian economies have exhibited the most dynamic vibrancy and growth, without comparison anywhere in the world. Maybe this has been enhanced by the relative peace that has prevailed in our region. Maybe this is Asia's era.

Dr. Frederick Betz, the author of the book *Strategic Technology Management*, divides the 300 years of world industrialization into:

a) the industrialization of Europe which began in 1765;

b) the industrialization of North America which began in 1865; and

c) the industrialization in Asia which began in 1964.

Japan's industrialization began as early as 1865. However, technology development was diverted to military application that led to World War II. The United States, which allowed the importation of goods from developing countries during the Cold War would now become an aggressive competitor in supplying the needs of the domestic markets of less developed countries. This would be manifested by the aggressive entry of large multinational companies into our backyard. And the recent pressures to remove trade barriers and create a "level playing field" would open up markets for multinationals, perhaps at the expense of struggling enterprises.

I agree with Prof. Tabbada that we cannot continue *to insulate our domestic economy through protectionist measures passed off as "safety nets,"* in the face of pressures coming from the APEC, WTO and the like. All we are asking for is a level playing field, and the reasons are obvious. If we are to survive and achieve further economic growth, we must possess competitive technologies that can either

be outsourced for expediency, and/or developed locally. Again, this predicament highlights the need for education and training programs in the field of management of technology.

Another emerging trend is the serious concern for the protection of the *environment*. Germany, Austria, and Sweden are some of the countries that prefer to import products using environment-friendly raw materials, production processes, and product packaging. The question is: Are we ready for this? Do we have the capability to comply?

It is a sad reality that most of the existing manufacturing facilities in the Philippines are not only old and use low-level technology, but harmful to the environment as well. Maybe national policymakers can legislate appropriate incentives and sanctions for sustainable economic development, without having to sacrifice our environment and natural resources. Do we have the means and resolve to compete in the global market?

We need to be innovative in disseminating technology management. The challenge is to show the chief financial officers of companies how much money goes down the drain as process waste, and how much more can be saved if waste is eliminated.

Thus, in order to be competitive, industrial firms must be prepared for battle. They should have strategic attitudes and competitiveness, corporate cultures, and core competencies. The key lies in new product innovations, production processes, and services to market, and we must consistently deliver better value to customers by looking at the quality, productivity, and price. To be environment-friendly might mean less cost and additional exports with the proper technology. All these require new engineering and science, combined with systematic planning for the future. Technology change needs to be managed. We need industry, education, and clean government to work together toward this end.

Without doubt, comprehending the intricacies of global competitiveness will support the proposal to adopt management of technology as a field of study in the Philippines, as well as in the region.

International Networking in R&D

DOUGLAS WILLIAMS

Chapter 13

The presentation consists of three parts. The first part is a brief review of my paper on "Lessons learned from the evaluation of Science and Technology Policies and Programs." These main lessons are directly relevant to two of the principal issues being addressed at this conference, which are: What public policies will best stimulate innovation? What forms of collaboration between government, industry, and academe will work best?

The second part is a general overview of the course on Management of R&D that I am developing. The third part is on international networking which begins with a discussion on the distinction between networking (information exchange) and collaboration (working together on the solutions to problems). Collaboration is a subset of networking. The article deals mainly with collaboration since much more is known about it, and because it is also more important.

Collaboration is first discussed for university-based R&D, using a Canadian program, the Networks of Centers of Excellence (NCE), as an example. The NCE program is a deliberate attempt by the Canadian government to promote collaboration, and it has had a major impact on the participating researchers. In turn, this has greatly improved the research conducted. An evaluation of the NCE program has determined that this is the program's most

influential feature. However, the NCE involves collaboration only at the national level, hence, the program managers are resisting pressures to broaden the program focus such that it includes more international collaboration.

Another recently evaluated program is the Human Frontier Science Program (HFSP), which is a good example of collaboration in university-based R&D at the international level. International collaboration is required as a condition of program funding, and it is the main unique feature of this program. The collaboration has had two types of benefits for the research:

- It has enabled the participating researchers to work with leading researchers worldwide; and
- It has exposed the researchers to different perceptions on science and science culture.

The high level of collaboration has been found critical to the success of the research projects.

Collaboration in government-based R&D is rare, even between agencies of the same government. At the international level, there seems to be two main types of collaboration:

- Huge international efforts which have discrete, separable parts (e.g., the Space Program, the Fusion Program); and,
- R&D that is necessary to resolve border issues (e.g., acid rain, Great Lakes pollution).

Generally, collaboration in industry R&D takes the form of research consortiums. Studies have shown that the main reasons for consortiums are to:

- share the costs of the R&D;
- share the risks of the R&D;
- increase access to a broader range of expertise; and,
- provide a mechanism for increasing the core competencies of participating organizations

There has been a great deal of study on the effectiveness of technology transfer in research consortiums (from the consortium to the member companies). The most effective mechanism appears to be the placement of "guest workers" in the consortium. The involvement of top company and consortium managers in technology transfer activities is also a key success factor.

The number of international industry consortiums has been increasing rapidly in recent years. For example, the number of US companies involved in international R&D consortiums has more than tripled since the mid-1970s. A major reason for this is that western multinationals have joined forces with companies in newly industrialized countries (NICs), in order to exploit markets there; and, as a result, they have become subject to host country pressure for technology transfer and local R&D. Two of the potential barriers to technology transfer in these cases, in addition to the usual barriers, are:

- the potential lack of fit between the two organizations (e.g., in terms of size, financial resources, and technical experience); and
- the possibility that the learning capability of the NIC company may not be adequate for appropriating the benefits of the R&D.

DISCUSSION

Amelia C. Ancog

We are all aware that research and development activities cannot thrive in isolation, and apart from the mainstream of social change. For research and development, especially in science and technology, it is important to foster innovations and creativity not only in the academe, but also in the production sector. Dr. Williams cites the value of international networks and collaboration, based on the learning and expansion of his researcher and scientist contacts.

One cannot but agree with him on the value of face-to-face interaction among researchers and scientists. Collaboration projects are *enabling endeavors* that contribute a sense of cohesiveness among scientists, researchers, and even industry leaders, as well as a deeper appreciation of the problems, obstacles and, sometimes, successes in technology development and transfer. This is the reason why collaborative projects, undertaken bilaterally between two countries, result in the establishment of strong ties not only between the scientists, researchers, and technologists, but also between the institutions and countries that have become partners in development efforts.

The Industrial Science and Technology Working Group of the Asia Pacific Economic Cooperation (APEC) recently approved an important mechanism for international collaboration which will facilitate the mobility of scientists, technologists, and researchers among the 18 APEC members. Membership is limited to the governments of the economies represented. Nevertheless, there are projects that involve the private sector, such as Technical Working Group on Standards and Conformance, which agreed on the minimum and maximum criteria for standards and conformance. This is very important for global competitiveness because, as barriers are removed, products flow from developed to developing economies and vice-versa. But the developing economies

will face a problem unless their products conform to internationally acceptable standards.

These developments in APEC have great implications for regional and international R&D since there is an increasing trend toward the involvement of the private sector in R&D and technology development.

In relation to international R&D, it should also be noted that APEC has established what is now known as the APEC Study Centers in each economy. These centers will undertake collaborative researches on matters affecting the region. Such study centers are already in place in Australia, Canada, Chile, the People's Republic of China, Indonesia, Korea, Mexico, New Zealand, Philippines, Singapore, Chinese Taipei, and the United States. In a number of economies, a consortium of academic institutions comprise the APEC Study Centers. Appropriate departments or ministries are also included as components of the Centers.

In Korea, for example, the APEC Study Center is led by the Korea Institute for International Economic Policy, which manages a consortium of six universities and seven research institutions. These universities are Konkuk, the Korea Maritime, Pusan, Seoul, National Sogan, and Yon Seil. The research institutions are Korean NHK Economic Institutes, Korean Transport Institute, Korean National Tourism Corporation, Korean Development Institute, the Korean Institute for Economic Policy, and Korean Educational Development Institute.

In Canada, the APEC Study Center is handled by the Asia-Pacific Foundation of Canada. In the Philippines, the APEC Study Center is a consortium of eight universities and one research institution; namely, the Asian Institute of Management, Ateneo de Manila University, De La Salle University, Mindanao State University, University of Asia and the Pacific, University of the Philippines School of Economics, University of San Carlos, and Xavier University, and the Philippine Institute of Development Studies, under the sponsorship of the Department of Foreign Affairs and the Commission on Higher Education.

The role of the APEC Study Center in international R&D, networking and collaboration is very crucial because, as the region

moves toward trade liberalization and facilitation, policy researches on trade and industry, and technology transfer become increasingly important. Side by side with developments in trade is the formulation of the macroregional framework for economic and technical development in the Asia-Pacific region.

These developments in APEC imply that international R&D will become more active within the framework of regional groupings, focusing on economic, political, and social issues, such as the use of clean technology, disaster management, and the mediation of trade disputes (which are also relevant to technology transfer).

The APEC experience has, in fact, been preceded by successful collaboration in the ASEAN region. Science and technology in the ASEAN has successfully concluded projects on nonconventional energy, a collaboration with the European Union of ASEAN on Remote Sensing Improvement, Natural Resources Management and Environment, and the Use of Satellite Capabilities, and conducted through the ASEAN-Canada Cooperation on Solar Energy.

It is therefore worth noting that international R&D is no longer solely done on a bilateral basis, but is often pursued within a wider framework of regional undertaking. In a number of cases, the private sector is almost always an active partner of the government, enabling scientists in the public sector to participate in regional researches.

It is also noteworthy that the ASEAN Committee on Science and Technology, which is chaired by the Philippines, is expanding its relationships at the international level. It is guided by strategies in establishing a strong S&T network, infrastructure, and programs for human resource development, as well as developing a linkage with the private sector and industry. As a consequence, R&D collaboration and networking in the ASEAN will not only be with present dialogue partners, but also with future partners, such as the Federation of Russia.

To conclude, as the world becomes a global village, international R&D will utilize more regional mechanisms, and it is not far-fetched to think that future scientists and researchers will

be called *global scientists*. These individuals will be endowed with, and bound by the quest for knowledge, and innovation and services.

All of us must march bravely to the next millennium, and leap beyond the national arena, into developments in dynamic regions such as the Asia-Pacific region. We should meet the challenges of the future, and carve the niches that would enable our scientists, researches, technologists, and institutions to contribute to peace and development.

Management of Technology for Sustainable Development

RICHARD K. SMITH

Chapter 14

Economic growth has long been pursued as a primary policy objective of both developed and developing countries. Since the mid-1950s, with Robert Solow's pioneering work on the residual, economists have recognized the importance of technology in fostering such growth (Solow 1956). With the emergence of management as a field of academic study and practice in the latter half of this century, it is inevitable that technology should be managed, as well. Research, teaching, and practice in this area have come to be known as management of technology (MOT).

History of MOT

The history of MOT, at a national level, will differ from country to country. In Canada, Davis and Smith trace the roots of current MOT activity to the 1960s (Davis and Smith 1995). At the international level, one of the first steps in this direction came in the mid-1980s, through a conference and subsequently a book titled *Management of Technology: The Hidden Competitive Advantage* (National Research Council 1987). The book's premise is that there

is an overlap between the expertise of businessmen and engineers, that would greatly benefit from careful attention.

According to the book, MOT "links engineering, science, and management disciplines to plan, develop and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization." The key premises are that: 1) scientific and technical disciplines must join forces with management disciplines; and 2) the goal of the collaboration is to improve the performance of the organization. In sum, MOT has fuzzy boundaries, and definitions of the content and contours of the field vary. However, the center of gravity is clearly in the engineering and administrative disciplines (Davis and Smith 1995). Business-paradigm MOT is largely problem- or issue-oriented, without restricting or explicitly favoring particular disciplinary approaches.

The International Association for Management of Technology (IAMOT) conference has papers on S&T policy, processes of technological innovation, strategic planning, technology transfer, R&D management, entrepreneurship and new-venture management, product and process innovations, technological innovation in organizations, quality and productivity issues, MOT in manufacturing and the service industries, managing information technology, human and social issues, education and training issues, economic analysis of innovation, and MOT methodologies. The conference draws participants from a variety of disciplines. However, the focus of the conference is closer to engineering management than to social science-based administrative disciplines.

It is important to emphasize that even "business-paradigm" MOT contains a wide variety of activities, with varying content and styles, ranging from highly integrated strategy-oriented teaching and research to narrowly focused technical problems with a management dimension. As De Vos observes:

"Somewhere between these extremes are blends of MOT material with the more established teaching disciplines, such as engineering (including automated design and manufacturing), information technology, organization theory, research management, innovation,

marketing, total quality management, business policy, and so forth." (De Vos 1990: 39)

Although this is the dominant view of MOT research, it is important to note it is but one paradigm of technology management research. Others include the theoretical, labor process, and social-science paradigms (Salter and Wolfe 1990). In this broader conceptualization, management of technology includes science and technology (S&T) policy, management of innovation, innovation and the labor process, industrial policies and strategies, the geography of innovation, standards and standards writing, technology assessment, and risk management.

Since the early 1990s, management of technology has emerged as a field of study and practice, with an international association for practitioners (IAMOT), a division within the Academy of Management (TIM–the Technology and Innovation Management division), and numerous government initiatives throughout the world. In Canada, for example, the national research funding agencies cooperate with the private sector to jointly fund a network of research chairs, "Chairs in the Management of Technological Change." Universities around the world have established teaching and research programs in this area, aided by the field's formal recognition by the American Association of Schools of Business in the early 1990s.

Asian nations' interest in technology management dates back, at least, to 1992, when the Pacific Economic Cooperation Conference (PECC) Science and Technology Forum on human resource management held a workshop on training technology managers in Jakarta, Indonesia. A follow-up meeting in Singapore a year later has resulted in the publication of a book, *Developing Technology Managers: Comparative Pacific Rim Strategies* (Minden and Poh-Kam 1995). The University of the Philippines' Technology Management Center, created in 1995, and its subsequent development of diploma and master's programs are indications of the interest on the topic here in the Philippines. The recent announcement of a Society for the Advancement of Technology Management in the Philippines, as well as the "First National

Conference on Management of Technology" are further indications of the national support for MOT.

History of Sustainable Development

Sustainable development is a term widely used in international circles, but its link to the management of technology has not been discussed until recently. The history of sustainable development lies in two areas: development studies and environmental issues.

Development Studies

According to Mowlana and Wilson, literature on development can be traced back as far as the fourteenth century, in the works of Ibn Khaldun, a Tunisian and an Islamic scholar. Ibn Khaldun used the Arabic term *ilm-au-umran* to define a new science of development, showing the dynamic relationships between nomadic, tribal, rural, and urban societies. One of the first thinkers to emphasize the benefits of peaceful relationships between nations, Ibn Khaldun recognized the importance of communication, common goals, economic, and culture exchange, as prerequisites to peace.

The next major stage in the study of development came from the political, economic, and social thinkers of the seventeenth to nineteenth centuries, including Tönnies, Comte, Weber, and Durkheim. These scholars considered development in terms of the transformation, from the rural, communal, and agrarian society, to the urban, rational, contractual, and industrial nation-state system emerging at the time.

Adam Smith, David Ricardo, and Karl Marx also contributed to the understanding of development as an economic process. Adam Smith introduced the concept of unlimited technical progress, while Ricardo's theories of comparative advantage helped explain the growing trade and commerce between Europe and the rest of the world. Both Smith and Ricardo wrote during the so-called classical period of economic and sociopolitical development: 1750 to 1917. This classical model of economic development as national production included: 1)nationalism and

imperialism; 2) industrial and technical revolution; 3) economic growth and materialism; 4) democracy and individual rights; and 5) bureaucratic and rationalistic forms of organization.

Development thinking was greatly shaken by several events in the first half of the twentieth century, including the rise of Bolshevism and fascism, the Great Depression, and the new economic theories of John Maynard Keynes, which advocated a proactive role of the government. Marxism and its twentieth century variants, such as critical theory, also posed significant challenges to the inevitability and positive character of economic development.

After World War II, the term "development" was further broadened to include: 1) modernization, nationalism, and political development; 2) economic development and technological diffusion; 3) imperialism and underdevelopment; and 4) revolution, liberation, and human development. The term came to be used for a broad range of political, economic, social, psychological, cultural, and ecological phenomenons, in almost all levels of human activity.

In 1972, Robert McNamara, World Bank president, provided a new perspective on the importance of a social dimension in economic development. Two successive "Decade for Development" by the United Nations saw increases in gross national product (GNP), accompanied by unemployment, rise in inequality, and increased levels of poverty, as reflected in malnutrition, starvation, and illiteracy rates. Economists came to realize that development included much more than just growth. From this emerged a sociology of development that considered the importance of cultural and social changes, which accompanied economic change.

Environmental Studies

The World Conservation Strategy of 1980, published by the International Union for the Conservation of Nature and Natural Resources (IUCN), the United Nations Environment Program (UNEP), and the World Wildlife Fund, provided the first milestone for environmentally sensitive development. Gro Harlem Brundtland's report for the World Commission on Environment and Development (WCED, or "The Brundtland Commission") provided the next ma-

jor step, and a straightforward definition for sustainable development.

Sustainable development issues identified by WCED (1987) included: 1) population and human resources; 2) food security—sustaining the potential; 3) species and ecosystems—resources for development; 4) energy—choices for environment and development; 5) industry—producing more with less; and 6) the urban challenge.

According to WCED, the pursuit of sustainable development requires 1)a political system that secures effective citizen participation in decision making; 2)an economic system that provides solutions to the tensions arising from unharmonious development; 3) a production system that respects the obligation to preserve the ecological base for development; 4) a technical system that works toward new solutions; 5) an international system that fosters sustainable patterns of trade and finance; and 6) an administration system that is flexible, and has the capacity for self-correction (Elliott 1994).

These challenges were a part of the agenda of the so-called Earth Summit, the 1992 UN Conference on Environment and Development in Rio de Janeiro. This meeting brought together 118 heads of state, in order to move the environmental issue firmly to the center of development planning, economic and social policy planning, and decision making. The key outcome of the meeting was Agenda 21. This was an agreement on a "program of cooperative international work for the sustained and responsible development of our planet as we prepare ourselves for the challenges of the twenty-first century."

Since the 1992 Earth Summit, the UN has published a guide to Agenda 21: "The Global Partnership for Environment and Development." The guide states that the achievement of Agenda 21 will require "a global partnership for sustainable development, where all nations will need to make political, social, and economic commitments, both individually and globally, to ensure the allocation of essential means for a viable and sustainable human future" (United Nations 1993).

According to the United Nations, improving communication and cooperation among the scientific and technological community, decision makers, and the public can help enforce more effec-

tive strategies for environmentally sound and sustainable development. National scientific and technological activities should be more responsive to sustainable development needs, as part of an overall effort to strengthen national R&D systems.

Other recommendations in the UN report include the suggestion that the base of scientific and technological knowledge, built up in industrially advanced nations, should be shared with the developing world to ensure a rapid transition toward environmentally sound and sustainable development. At the same time, indigenous knowledge must be integrated with modern systems.

The report suggests the need for indicators of sustainable development, in order to provide a solid base for decision making at all levels. These indicators are seen as the first step toward a self-regulating and integrated economic and development system. The report suggests that, as part of such a system, acquired traditional and local knowledge would be recognized, recorded, analyzed, and utilized according to the report. The constructive use of indigenous knowledge, by itself and in combination with modern knowledge, could create new options for sustainable development.

Defining Sustainable Development

Given its history, it is not surprising that sustainable development has been defined in many ways. According to the World Commission on Environment and Development (WCED 1987), sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with present and future needs. "Humanity," the definition continues, "has the ability to make development sustainable—to ensure that it meets the needs of the present, without compromising the ability of future generations to meet their needs."

Other definitions include:

1. "The term 'sustainable development' suggests that the lessons of ecology can, and should, be applied to economic processes." (Redclift 1987)

2. "In principle, such an optimal policy (sustainable growth) would seek to maintain an acceptable rate of growth in per capita real incomes, without depleting the national capital asset stock or the natural environmental asset stock." (Turner 1988)
3. Sustainable development is "the challenge of meeting human needs for natural resources, industrial products, energy, food, transformation, shelter, and effective waste management, while conserving and protecting environmental quality and the natural resources base, essential for future development." (CERF 1996)

The common theme of these definitions is "development in harmony with local and international ecological, economic, and social imperatives." (WCED 1987)

Sustainable Development in Asia

Recent sustainability initiatives in Asia include an Asia-Pacific Economic Cooperation (APEC) discussion paper on sustainable cities, and the Asian Development Bank's report on Economic Policies for Sustainable Development. The ADB report notes that, although economic and environmental policies are often closely linked, those linkages are seldom recognized (Lugo 1996).

The APEC report, which was issued in Manila, looks mainly at sustainable cities. It suggests a clearinghouse for the exchange of scientific and technical knowledge. Other needs include information exchange, technology transfer, and enhanced partnerships between the private sector, nongovernment organizations, and public institutions (Lugo 1996).

The need for linkages and information exchange underscores the importance of communications and cooperation for sustainability. The range of issues, including "ecological, economic, and social imperatives," further suggests the role of multidisciplinary approaches to sustainability issues. Management of technology practitioners, combining engineering and business expertise, have experience in

multidisciplinary problem solving. The challenges of sustainable development, however, go well beyond technical or financial issues, as noted in the WCED (1987).

Management of Technology and Sustainable Development

The management of technological change and innovation is an essential element in competitiveness. But competitiveness in the coming decades must include global environmental considerations. For example, it has been suggested that environmental impact rulings could become one of the major nontariff trade barriers. The open economies of free trade-oriented nations stand to be affected by such changes. The Canadian fur and timber industries, for example, are already feeling the impact of these implementations. Some analysts suggest that, in the twenty-first century, we will see competitiveness move from concern for being "better, cheaper," to being "better, cheaper, greener" (Doern 1990). Changes in corporate goals, and possibly entire product lines, will require dramatic shifts in thinking in all levels of the economy.

Some of these shifts are already apparent among businesses. Pilko & Associates reports that in a recent survey of 200 senior executives in the United States, 90 percent said that environmental considerations were part of their strategic-planning process. DRT International has surveyed 250 European companies, and found that almost three-quarters have specific plans to improve environmental performance. A 1991 report from the Canadian Federation of Independent Business states that 99 percent of their members is concerned about the state of the natural environment, and that 60 percent has made, or is about to make, significant changes in operations to respond to environmental concerns.

MOT and Sustainable Development—An Example of Quality Management

To see how MOT might become involved in environmental issues, we can look at the link between "quality" and "environment"

under way at the Canadian Standards Association (CSA). The CSA has been working to develop environmental management systems that draw on the structure of, and are compatible with, the ISO 9000 series of Quality Management Standards (CSA 1992). While "quality" is a term currently in vogue, there is a growing recognition that it is more than just an idea—it is a force in business. To partly explain, this is the link between quality and life-cycle analysis.

While we now speak of product life cycles in terms of formulation, development, and deployment, an alternative view is to look at the environmental life cycles for products. This approach examines the environmental cost over the entire life of the product from resource stage to final disposal. In this concept, products and services are viewed as systems with inputs (raw materials and energy) and outputs (waste and usable products). Within the system, there are six stages: 1) raw materials acquisition; 2) manufacturing, processing, and formulation; 3) distribution and transportation; 4) use, re-use, and maintenance; 5) recycling; and, 6) waste management. Recent studies suggest that the two approaches (product life cycle and environmental life cycle) are merging to some extent. Ottman has described how "companies must integrate environmental planning into their overall business strategy" (Ottman 1992), and Casey gives examples of companies that have taken the lead in reducing product packaging and "reaped significant benefits" (Casey Jr., 1992).

According to the ISO standards, quality has four facets: "definition of product needs," "product design," "conformance to product design," and "product support." MOT specialists will be called upon to assist in the design, manufacture, and distribution of product and service systems that meet the demands of the modern consumer. Whether this pertains to products that last longer or are easier to recycle will depend on circumstances, but we can be assured that demands for quality will not lessen.

Proctor & Gamble (P&G) is a company that has taken the "Total Quality Management" route to environmental responsibility. Their chairman of the board and chief executive, Edwin L. Artzt, has said, "We have a global challenge to lead the improvement of how we operate—not only in business, but also in education, government,

medical care, and the environment—so that we put the resources we have to their fullest and wisest use" (Fortune/ASQC 1992). P&G is a participant in the Global Environmental Management Initiative (GEMI), "a group of 20 leading companies, dedicated to fostering environmental quality worldwide, [where it is] a pioneer in the application of total quality management principles to environmental improvement" (ibid.).

In many cases, the response to a sustainable development imperative will be a technological one. Northern Telecom, for example, has led the way in producing electronic circuits without the use of chloroflourocarbons (CFCs). Not only is this a leading environmental move, but it is resulting in dramatic savings (BCSD 1992; Schmidheiny and BCSD 1992). Goods are now being delivered in easily recyclable packaging. Even transportation and distribution systems are being modified to handle goods that are less "packaged" than before.

Corporations in the twenty-first century will find it essential to be able to innovate and operate competitively, and operate in an environmentally responsible manner at the same time.

Technological Collaboration for Sustainable Development

While there is little doubt that practitioners of technological management will be called upon to deliver sustainable solutions in the coming years, current scholarship does not address how these solutions are to be arrived at. Here, technological collaboration is proposed as a mechanism for merging management of technology skills with sustainable development demands.

Following Dodgson's 1993 definition, we consider technological collaboration to include "any activity where two or more partners contribute differential resources and know-how to agreed complementary aims" (Dodgson 1993: 13). Using this definition, we could include collaborative research consortiums, joint ventures and strategic alliances, and shared R&D and production contracts.

Although not initially intended to cover collaboration for sustainability, the motivations of a technological collaboration are remarkably complementary to those of sustainable development. For

example, Dodgson notes three common assumptions that underpin collaboration: the belief in positive sum gains (the partners can achieve more together, than individually); reduced environmental uncertainty (which can extend beyond technical and market environments, to the natural and social environment); and flexibility.

The field of technological management can, in a sense, be regarded as an attempt to systematize technological collaboration between two professional and academic sectors by bringing engineering and business together in an ongoing and organized way. At both the national and firm level, this collaboration has been promoted in terms of financial reward, usually in the form of increased "competitiveness." The theme of this conference, for example, "Managing Technology for Global Competitiveness," is typical in this regard. And while competitiveness is a necessary aspect of life at present, it may not be sufficient.

Competitiveness, narrowly defined in technical or economic dimensions, does not address the social and ecological imperatives that just as surely imperil our existence as any global competitor. It is time to add sustainability to our list of reasons for managing technology and collaboration. Alternatively, "competitiveness" can be understood more broadly to include the human and ecosystem dimensions, frequently missing from these discussions. Either way, the challenge will be to consider a much broader set of issues that interact in ways that may confound even the most adept.

Earlier research by Niosi identified three factors responsible for the rise of technical cooperation: widespread use of electronic components and computers; biotechnology; and, advanced materials (Niosi 1996). All these lead to greater complexity and a qualitative increase in the need for scientific inputs. It seems reasonable to assume that sustainable development issues will have a similar, if not greater, impact. Technological collaboration, therefore, is the most likely scenario, or mechanism, in the successful management of technology for sustainable development. Greater skill in managing collaboration will be an essential part of success in sustainable development.

The challenge is how to foster more and better technological

collaboration among MOT professionals who seek sustainable development. As an example, the APEC Human Resources Development Working Group of the Business Management Network, along with the Max Bell Foundation, Asia Pacific Foundation, and Simon Fraser University in Canada, sponsored an international workshop on "Crosscultural Management of Technical Collaboration," in August 1996. The goal of the workshop was to design training modules for executive education. Participating countries included the Philippines, Japan, Singapore, Hong Kong, Australia, United States, and Mexico. The participants prepared case studies in the design of courses. Each participant, by contributing a case study, gained the rights to use all of the materials. It was hoped that the cases and course materials will be continuously improved, and the results will be shared among participating countries.

Conclusion

In this article, the history of the management of technology and sustainable development was traced, and the current practice in Asia was briefly described. The connections between sustainable development and management of technology were noted, with examples drawn from quality management. The article suggested that the gap between financial and technical problems normally encountered by MOT professionals, and social and ecological problems, more likely to occur when sustainability issues are considered, will require new ways of exchanging information and expertise. Technological collaboration was suggested as a mechanism for achieving management of technology toward sustainable development. An example of executive education for managing technological collaboration in a crosscultural environment was used to illustrate a way for these mechanisms to be enhanced.

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DISCUSSION

Manuel S. Gaspay

Dr. Smith was trying to provide a review of concepts and their development, as they relate to an understanding of the management of technology for sustainable development. He tried to emphasize the importance of technology in sustainable development. Let me now elucidate what sustainable development is, and how we can improve techniques in enhancing the role of technology.

Let me clarify the framework of Dr. Smith. Technology is the simplification of the concepts of development, primarily as a process of economic growth.

Despite the attempts to qualify the understanding of development as more than just a process of economic growth, the reality is that we still look at aggregate economic growth as a very important indicator of how we are faring, with regard to development.

The economic profession has offered a useful framework of the economic role of technological change. The paper mentions Robert Solow's treatise, which identifies technological change through the residuals of the production function.

We have traditionally looked at economic growth, basically, as a process of inputs, one of which is capital. You have the aggregate output, which may be indicated by the GNP and GDP. Technological change accounts for the upward shifts of dysfunction—getting more output for the same amount of input.

Labor and capital inputs are further classified into natural capital (traditionally perceived as land) and man-made capital (machines and others). Technological change is simply a way of improving the transformation of these inputs into output.

Economic growth using this framework can be explained as the expansion of the input base. This is why we are always looking at the amount of investments, as it is an indication of

the expansion of the capital base, leading to output and growth.

The other important thing is the continuous improvement in technological change, which is the transformation of capital inputs to form an aggregate output.

Technological change covers both engineering and organizational improvements. In organizational improvements, we are looking at institutions, political and social relationships, and other organizations for the production of the aggregate output. This is the classical framework, used by economists to look at the process and role of technological change in development.

The role of natural capital has been emphasized lately, and it is this emphasis that has encouraged talks on sustainable development and concern for the environment. What is emphasized is not only the products in the aggregate output, but also the so-called *bads,* or the pollutants produced.

The framework is still the same, but development experts are now focusing on the fact that natural capital is being consumed, in the process of production. There was a time when natural capital, like land, was thought to be indestructible, while money spending was considered as the consumption of capital. The fact remains that pollutants are also being produced.

This is a simplistic way of looking at the role of technology. It abstracts from the fact that distribution issues are also paramount in the concept of development. But, it is a useful way of initially looking at the role of technology in sustainable development.

Going into the management problem, we must be clear about the different assumptions in the development of a framework for analyzing the management of technological change.

Right now, environmentalists are talking about two very different points of view: the *anthropocentric,* and the *ecocentric.* The anthropocentric point of view looks at man as able to control the environment and his destiny; and the ecocentric point of view holds that man must only look at himself as a small part of the whole ecosystem.

Under these different assumptions, environmentalists develop frameworks for the management of technological change.

The view that land is limited, population and demand are increasing, and there is no solution to the problem has been modernized into the *deep-ecology view.* With this framework, environmentalists see a limited replaceability between natural capital and man-made capital. This view also sees a very exhaustive body of technical knowledge. They also see an externally driven population growth process and an insatiable consumptive pattern, which is basically the demand problem. The result is an incompatibility between fixed resources and a very greedy human race. They see technological change as having a very small role—perhaps limited only in population control measures.

At the extreme opposite is the optimistic point of view, in which environmentalists see unlimited substitutability. For example, man-made capital can replace natural capital. Some of the processes are seen as reversible, like the recovery of a denuded forest through the application of capital. These environmentalist also believe in rational individuals who will adapt procreative and consumptive behavior and demands to the scarcity of nature and its products.

Hence, technology, and its management, is very important in removing limitations. Engineering and organizational innovations can be applied to reduce pollution, as well as conserve and enhance natural capital. We must, therefore, improve the use and raise the efficiency of the transformation function.

As always, the mainstream view is somewhere between the reversible and irreversible processes. Some natural capital are difficult to replace. Technological change must be carefully analyzed because it can bring unforeseen harm. There are so many unknowns, as in the side effects of chemical substitutes.

It is recognized that there are some institutional and behavioral inertia. Changing the way we do things may be too late, at a certain point. The expansion of the knowledge base and its integrative application are therefore very critical.

How do we acquire and develop technology? One way is the

market approach. Technology is bought and sold primarily through the market system; therefore, the impetus to develop should come from the private sector.

There is also the *institutional* or *central planning approach,* in which technology is developed as an act of political will. A sufficient government budget is devoted for technology innovations. Bilateral and multilateral exchanges and protocols are developed. Technology developed through professional associations is another approach.

The principle of managing technology must rise, from a mere reductionist approach, to a more holistic and integrative framework. We can look at the management of technology at the practical level, which is well within the area of *sustainable development regulation*. Regulations affect the way technology is developed, applied, and managed.

Paramount to all these approaches is the recent development of *Philippine Agenda 21,* which has been approved by the President. Once applied, policies, including those in science and technology, will be reviewed and influenced, in terms of their consistency with the goals of sustainable development—environmental protection and equitable distribution, at the macro level.

Another important macro level instrument is the development of an *environment* and *natural resource accounting system.* It will provide us with a new way of auditing aggregate performance in sustainable development.

At the micro level, we have the *environmental impact assessment system,* which screens out unsustainable projects. Under this system, the country will not allow pollutive and unsustainable technologies. Such projects will not be given *environmental compliance certificates.*

The enforcement of environmental and pollution laws, and market-based instruments have recently been criticized by the media as a license to kill. Actually, it is just an application of the *polluters pay principle*. This will correct the pricing system, requiring firms to pay for their pollution.

Finally, another government initiative would be the devel-

opment of technologies favorable to environmental protection and enhancement. Right now, this is being done through foreign consultants. We also hope to develop environmental services consultants in the Philippines.

Standardization, Quality Assurance and Global Competitivenes

NESTOR O. RANESES

Chapter 15

Introduction

To become globally competitive, it is incumbent that Philippine industries have comparable and superior quality, aligned and harmonized with the standard nomenclature and tools of international trade. With the global market and fast-paced technology realization processes, comparative advantage will hinge greatly on the ability of products to surpass customer expectations. Exceeding customer expectations requires that we continuously provide products and services that are consistent, reliable, delivered on time, wherever they are needed, and at competitive cost.

The International Standardization Organization (ISO) defines quality as the totality of features and characteristics of a product or service that bear on its ability to satisfy the stated or implied needs of customers. Quality control refers to the operational activities undertaken by organizations to control the quality of products and services. Quality assurance embraces all planned or systematic actions necessary to provide adequate confidence that products or services will satisfy requirements for quality. Productivity,

on the other hand, is defined as the efficient use of resources, labor, capital, land, materials, energy, equipment, and information in the production of goods and services. High productivity means high-value high-quality products with the optimal amount of resources employed to produce them. Quality and productivity are the natural related end-results of the elimination of wastes in all phases of the production cycle, and the employment of the most efficient processes and manufacturing methods.

The use of standards is one of the mechanisms for achieving high quality and productivity; and, consequently, enhancing competitiveness. It is widely regarded as one of the effective ways of reducing technical barriers to international trade, and improving export competitiveness. Standards assist in the acquisition and application of required technology, by enabling countries for industrial development. They also provide sources of best commercial practices (BCP), and smoothen transition to total quality management processes.

This paper hopes to provide a clear understanding of the process of standardization, as it affects technology diffusion and international competitiveness; examine the barriers to rapid standardization; and propose an action-oriented systems model that will hasten the competitiveness of a developing economy like the Philippines, through progressive standardization.

This paper is an offshoot of an investigative inquiry and review of the evolution of the standardization system in the Philippines, conducted in 1994 by the author, in connection with a project on technological competitiveness. The study consists of reviews of previous related studies and reports on standardization, notably: the JICA-supported study on the National Standardization and Industrial Quality Control Improvement Program in the Republic of the Philippines (1990); the work of Rosen et al., *A Comparison of Approaches for Setting Standards for Technological Products* (1988); focused surveys of standards developing bodies and institutions, including industry users; and, interviews and private communication with researchers, promulgators, users of standards, as well as government functionaries involved in standardization.

Standards and their Nature

Standards are ubiquitous. The term standard is used to describe a multiplicity of activities, and assumes many forms. Standards can be practices, norms, laws, treatises, covenants, specifications, or control documents. Product standards may be categorized into two principal groups: standards of quality and standards of uniformity. Quality standards spell out the minimum levels of acceptable quality; products either pass or fail. Uniformity standards deal with sameness. They deliberately reduce product variety.

Standards can also be deemed as categories of control documents, specifying quantity, extent, quality, value, and methods of activities. Technical standards are defined as voluntarily agreed-on codification of form, functioning, quality, compatibility, and exchangeability of methods, products, processes and services. The General Agreement on Tariffs and Trade (GATT) Code on Technical Barriers to Trade defines technical standards as technical specifications approved by a recognized standardizing body for repeated or continuous application, with which compliance is not mandatory. The ISO and the United Nations Economic Commission for Europe define them as technical specifications or documents available to the public, drawn up with the cooperation and consensus or general approval of all groups affected, based on the consolidated results of science, technology, and experience. They are aimed at optimizing community benefit, and approved by a body recognized on the national, regional, and international levels. Technical regulations are specifications as to the form, construction, performance, and other characteristics or attributes of products, services, processes, and methods included or referred to in public law; and have the purpose of serving the public interest, with respect to health, safety, environmental, and consumer protection.

There are many other ways of classifying standards. Among them are by: geographical coverage (international, regional, and national); area of application (industrial, service, safety, health, environmental, and quality); stage of production (design, and performance); nature of enforcement (mandatory, and voluntary); technical function (basic

standard, terminology, product, service, safety, health, or even engineering standards); or economic function (information, variety reduction, and compatibility and quality standards). These categories are by no means mutually exclusive and collectively exhaustive.

The ISO has classified standards into eight types, namely:

1. Basic standard - a standard having a wide range of coverage or containing general provisions for a particular field.
2. Product Standard - a standard specifying some or all of the requirements to be met by a product or a group of products, in order to ensure fitness for purpose
   a) Performance standard – a product specifying requirements for one or more performance characteristics.
   b) Descriptive standard – a product specifying requirements for one or more descriptive characteristics.
   c) Variety control standard – a standard aimed at variety control, generally containing a series of selected values or attributes of a product.

3. Service standard – a standard specifying some or all requirements to be met by a service, in order to ensure fitness for purpose.
4. Safety standard – a standard aimed at the safety of people and goods.
5. Interface standard – a standard specifying requirements concerned with the compatibility of products or systems, at their points of communication.
6. Standard of supplier data – a standard containing a list of characteristics, for which values or other data are to be stated by the supplier.
7. Terminology standard – a standard concerned exclusively with terms, usually accompanied by their definition and sometimes by explanatory notes, illustrations, examples, etc.
8. Testing standard – a standard concerned exclusively with test methods, sometimes supplemented with other provi-

sions related to testing, such as sampling, and the use of statistical methods and sequence of lots.

The *raison d'être* of standards generally includes the following primary functions and benefits:

1. Provide common understanding of technologies - symbols, marks, labels, and codes
2. Eliminate wastes – material, human, technology, information, energy, and equipment
3. Minimize unnecessary costs – unnecessary variety of processes, materials, methods, and work procedures
4. Define fitness for use – methods, processes, systems and procedures for product assurance, and process quality
5. Reduce cost of information and learning – interchangeability and substitutability of parts, components, and assemblies
6. Protect the consumers and the general public – quality, safety, environmental, public health regulations, and specifications
7. Facilitate a permanent corporate quality improvement system – ISO 9000 standards for quality assurance system
8. Provide sources of applicable technology for immediate application – information on basic definitions, metrology, materials, dimensions, production processes, quality control testing and inspection, and best practice methods.
9. Reduce technical barriers to trade – harmonized regulation and nomenclature.
10. Speed diffusion of technological products – certainty for market entrants, and less risk of purchases for consumers.

Product standards are considered most crucial for complimentary products (e.g. compact disc players depending on compact discs, and VCRs requiring video tapes); when interconnections are important (e.g. local area networks, telephone systems, and appliances); and, when learned practices and expectations are present (e.g. au-

tomobile transmissions, QWERTY typing archetype keyboard). (Rosen, et al. 1988)

Standards are not significant for stand-alone products which are not contingent on common practices of users. These products are bought regardless of the availability of quality standards, and for which uniformity standards are not required. In fact, they thrive on diversity of designs, and may need only features and characteristics consumers find appealing. (Rosen et al. 1988, 11).

Quality assurance, or system standards, aims to provide confidence that organizations supply products and services with consistent quality, and protects public interest.

Tracing its roots from the US military assurance standards, such as the Milo 9858 (which was published in 1959 and recently made obsolete), the popular use of quality assurance standards became more pronounced with the publication of BS5750, by the British Standards Institute in the early 1980s. Today, the ISO 9000 series is considered the most popular quality system standard. The series has won international acceptance and credibility. It is reported that more than 100 countries have subscribed to the standards. While the standard is not a legal requirement in the foreign market, it assures that a fundamental and uniformly worldwide quality system is in place. It defines the specific criteria a quality product can consistently be expected to achieve, and builds the foundation for a total quality management infrastructure.

The ISO 9000 series comprises both guideline and requirement standards. ISO 9001, 9002, and 9003 are the three requirement standards; while 9000, 9004, 9004-1, and 9004-2 are the guidelines for selection and use. ISO 9001 is the most stringent of the three, with 20 specific requirements for quality assurance. The requirements are couched in general terms, such that they can be used for multiple industries and services. The elements of the ISO standards are shown in table 1.

Another quality-system standard is the ISO 14000 series. It is a single set of international environmental management standards, intended to eliminate multiple registration, inspections, certifications, labels, and conflicting requirements. The ISO 14000 is a ge-

neric series of standards, blending environmental requirements for companies around the world. BS 7750: Environment Management Systems is considered as the origin of the ISO 14000. The series attempts to harmonize the environmental requirements for industries worldwide, and promotes a common approach to environmental management for any company, regardless of size and location. It has been created under the guidance of ISO Technical Committee 207 (TC207). Table 2 defines the ISO 14000 series standards.

Table 1
Cross-Reference: ISO 9000 Requirement Standards (1994)

ISO ELEMENT	*9001*	*9002*	*9003*
1. Management Responsibility	Yes	Yes	Yes
2. Quality System	Yes	Yes	Yes
3. Contract Review	Yes	Yes	Yes
4. Design Control	Yes	No	No
5. Document and Data Control	Yes	Yes	Yes
6. Purchasing	Yes	Yes	No
7. Customer Supplied Product	Yes	Yes	Yes
8. Product Identification and Traceability	Yes	Yes	Yes
9. Process Control	Yes	Yes	No
10. Inspection and Testing	Yes	Yes	Yes
11. Inspection and Equipment	Yes	Yes	Yes
12. Inspection and Status	Yes	Yes	Yes
13. Control of Nonconformance Product	Yes	Yes	Yes
14. Corrective and Preventive Act	Yes	Yes	Yes
15. Storage, Handling, Shipping and Delivery	Yes	Yes	Yes
16. Control of Quality Records	Yes	Yes	Yes
17. Internal Quality Auditing	Yes	Yes	Yes
18. Training	Yes	Yes	Yes
19. Servicing	Yes	Yes	No
20. Statistical Techniques	Yes	Yes	Yes

Note: The strength of each element of each standard may vary.

Table 2

ISO 14000 Series Standards

EVALUATION STANDARDS FOR ORGANIZATION	
· ISO 14000	Environmental Management Systems - General Guidelines on Principles, Systems, and Supporting Techniques
· ISO 14001	Environmental Management System - Specifications
· ISO 14010	Guidelines for Environmental Auditing - General Principles of Environmental Auditing
· ISO 14011/1	Guidelines for Environmental Auditing - Audit Procedures Part 1: Auditing of Environmental Management Systems
· ISO 14012	Guidelines for Environmental Auditing - Qualifications Criteria for Environmental Auditors
· ISO 1401x	Environmental Site Assessments (still in draft form)
· ISO 14031	Evaluation of the Environmental Performance of the Management System and Its Relationship to the Environment
· ISO 1403x	Evaluation of the Environmental Performance of the Operational System and Its Relationship to the Environment (still in draft form)
EVALUATION STANDARDS FOR PRODUCT	
· ISO 14020	Goal and Principles of All Environmental Labeling
· ISO 14021	Self-Declaration Environmental Claims
· ISO 14024	Environmental Labeling - Guiding Principles, Practices, and Criteria for Multiple Criteria-Based Practitioner Programmes (Type I) - Guide for Certification Procedures
· ISO 14040	Environmental Management - Life Cycle Assessment - Principles and Practices
· ISO 14041	Environmental Management - Life Cycle Assessment - Life Cycle Inventory Analysis

- ISO 14042 Environmental Management - Life Cycle Assessment - Impact Assessment
- ISO 14043 Environmental Management - Life Cycle Assessment - Life Cycle Improvement Assessment
- ISO 14060 Guide for the Inclusion of Environmental Aspects in Product Standards
- ISO 1405x Terms and Definitions - Guide on the Principles for ISO/TC 207/SC6 Terminology (still evolving)

Note: These standards were being developed by TC 207 as of May 1995.

To be sure, standards are not without drawbacks. When standards are so entrenched, the introduction of superior standards may be stifled. Rosen et al. (1988) liken being stuck with an obsolete standard to the notion of switching costs in economics. Switching costs are installed on future changes in a uniform standard. Examples of these obsolete product standards are the QWERTY typewriter keyboard, television broadcast 525 line standard, and the MS-DOS operating system. The massive installed base of these products makes changing standards difficult. Besides being stuck with an obsolete standard, incentives for advancing technology are also nullified. Interests are often diverted to process innovations and production efficiency improvements.

Standards can either be purposefully planned or set through competitive market processes (Rosen et al. 1988). Standards can be set by one or a combination of the following alternative modes: 1) government actions; 2) industry coalitions; 3) free market forces; and 4) industry leader actions.

There are three ways by which the government can set standards. First, the government can set standards by fiat or decree. An example is the Letter of Instruction 1208 (1982), which mandated the standards for electrical materials, electrical parts, and electrical accessories to prevent fires. Second, the government can set standards through its immense purchasing power. The government can force suppliers to conform by procuring only those products and services that meet their standards. As an example, government supplies should only come from Bureau of Product Standards (BPS)-certified products. Third, the government can suggest standards to private industry. Government-set standards can be enforced because they are backed up by law, objective, and can foster long-term national goals. There is a downside to this method. First, they may serve parochial-political, rather than market-driven purposes. Second, the slow promulgation of standards may unwittingly foster inefficient and technologically obsolete standards.

Industry can cooperate to set standards for the entire industry. Governments can catalyze or actively intervene in the setting up of industry-based standards. Rather than interfirm competition, industry

coalitions have the advantage of being able to move and promote the entire industry. They also facilitate wide acceptance and deployment, since the power of standard-setting is in their hands. Moreover, they set a pattern for future cooperation. The disadvantages of industry coalition are: the disposition to political maneuverings and competitive positioning, which inhibit technology diffusion; dominant firms that see no benefit in cooperating may not coalesce; and industry-set standards may lack specificity, resulting in incompatible and inflexible standards.

Free market forces permit manufacturers to introduce technologically competitive standards. The dominant standard is selected by customers, and licensing by other manufacturers. The main advantages of a market-based approach are: 1) allows the most efficient standard to dominate; 2) allows the market, rather than the government or industry, to dictate the standard; 3) provides the broadest opportunity for new entrants; 4) offers the most flexibility for changes; and, 5) is the most responsive to the market. However, the disadvantage is that it may result in many orphaned consumers. In addition, the chosen standard may not be a superior technology. The process can also be very slow.

The dominant seller or buyer can exert pressure for a favored standard. Through market dominance, a leading manufacturer can dictate a standard with token resistance. Likewise, a single large supplier can apply pressure in favor of a preferred standard. The most important advantages of this mode are that it yields few orphaned consumers, and promotes rapid diffusion of the chosen standard. The disadvantages are that the choice of standard may not be based on technological superiority, but on expediency or cost; and the industry leader may stop others from using the standards it has set through copyrights or other legal means.

Rosen et al. (1988) present a comprehensive comparison of the alternative modes of achieving technological product standardization, with matching examples and annotation of current status (Table 3). Using 10 criteria derived from innovation, technology, and diffusion literatures to construct a multicriteria analytic framework, the following conclusions are reached:

1. Managing standards is preferred to letting the markets decide;
2. Coalitions offer the greatest advantages, with the fewest adverse effects;
3. Active government intervention in standard-setting is preferred in some special situations, like national defense technologies, when there are fragmented markets (i.e., markets consisting of many small buyers and sellers, where coalitions are least likely to prosper), or where the direction of technology development is ambiguous.

Table 4 shows the relative ranking of alternative modes of technological product standardization, based on the ten criteria by Rosen et al. (1988).

Evolution of Standardization in the Philippines

It was reported that national standardization activity in the Philippines started as early as 1947, with the publication of a number of national standards in the *Official Gazette*. However, the methodical and systematic formulation of Philippine standards commenced only in 1964, with the enactment of Republic Act 4109, which created the Bureau of Standards. During that period, national standardization activities were concentrated on regulating import and export of goods. In 1982, the Letter of Instruction 1208 was issued by the President of the Republic of the Philippines, mandating the formulation of standards for electrical materials, electrical parts, and electrical accessories to prevent fires.

Executive Order 913 was issued by the President of the Philippines in October 1983, to prevent the dumping of substandard products, and smuggling of inferior products, which may damage the textile and garments industry. It also imposed strict control over offenders, against legislation pertaining to trade and industry. In the same year, a manual for standards was published by the Department of Trade and Industry (then Ministry of Trade and Industry). It aimed to show concrete policies for the development and formulation of

standards, through the coordination of Technical Committees. The manual had five parts, namely:

- Part 1 – Aims and Principles of Standardization
- Part 2 – BPS Committee Organization and Preparation
- Part 3 – Working Procedure in Preparing Standards
- Part 4 – Guide for the Preparation and Editorial Practice of Philippine National Standards
- Part 5 – BPS Guidelines in the Preparation and Arrangementof Minutes

Part 1 described the aims, effects and standardization scope, relation of legislation to standards, objectives of the Product Standards Agency (PSA, predecessor of the Bureau of Product Standards or BPS), and other related items. Part 2 described the essential principles and policies affecting the composition of the Technical Committees, as well as their subcommittees and working groups. Part 3 presented the procedure to be followed by the different technical committees, sub-committees, and working groups in preparing the Philippine National Standards. Part 4 provided rules and recommendations for presenting, arranging, drafting, and editing of the Philippine National Standards, to promote uniformity in style and arrangement. Part 5 presented the guidelines for the preparation and arrangement of the Minutes of the Technical Committees, including the maintenance of records.

In accordance with Republic Act 4109, Standards Administrative Order (SAO) 20-3, Series 1987 was promulgated by the Department of Trade and Industry, granting the Product Certification (PS) mark licenses to producers and manufacturers. SAO was a regulation that revised and expanded the detailed rules pertaining to the conventional certification system.

Table 3

Advantages, Disadvantages and Examples of Alternative Modes of Achieving Technological Product Standardization

MODE	*ADVANTAGES*	*DISADVANTAGES*	*EXAMPLE*	*CURRENT STATUS*
· Government	· Decisions on objective criteria · Decision based on national well-being · Decisions legally enforceable (if flat-based)	· Poor response to market conditions · Low flexibility for changes · Political influence on decision process · Slow decisions	· Metric system (France · Metric system (USA) · 9-mm Ammunition (USA) · ADA software (USA) · Videotex (France) · Smartcards (France) · Medical testing equipment calibration standards (USA) · Standard clothing sizes · TRON operating system (Japan)	· Nationwide acceptance · Very slow diffusion · Currently in dispute · Reluctant industry acceptance · Currently being installed nationwide · Currently being installed nationwide · Partial acceptance in industry · Not in use in developmental stages
· Coalitions	· Responsive to market needs	· Decision process is slow and vulnerable to partisan influences	· Compact disc · RS-232 interface · CD-V disc	· Rapidly increasing sales · Wide diffusion · In developmental stages

MODE	*ADVANTAGES*	*DISADVANTAGES*	*EXAMPLE*	*CURRENT STATUS*
	· Willing to abide by own decision · Set patterns for future cooperation · Few orphaned consumers	· Decision can be difficult to enforce · Standards may lack specificity	· High definition TV · Smartcards · Unidata computer operating system 8-mm video	· Stalled in negotiations · Stalled in negotiations · Withdrawn from market · Limited diffusion
· Free Market	· Most responsive to market · Fosters high performance standard · Broadest opportunity for new entrants · Most flexibility for changes	· Win may be based on marketing skill, not superior technology · Many orphaned consumers · Slow process	· Quadraphonic stereo · Videotex (U.S.) · Dvorak keyboard · Gas auto engine · Beta, Video 2000 VCR formats · VHS-VCR format · CD-ROM	· Withdrawn from market · Very slow diffusion and used primarily in special markets · Limited to special uses · Wide diffusion · Limited diffusion · Wide diffusion · Very slow diffusion, used primarily in special market

· Industry Leader	· Rapid diffusion of chosen standard · Few orphaned consumers	· Choice of standard may be based on expediency or cost, not superiority of technology · Leader may try to protect standard from use by other manufacturers	· MS-DOS · MAP based robotics · Lotus 1-2-3 style user interface	· Rapid and wide diffusion · Wide diffusion · Wide diffusion

Source: Rosen et al. (1988)

Table 4

Relative Ranking of Alternative Modes of Achieving Technological Product Standardization on Selected Criteria

CRITERIA	*MODE*			
	Government	*Coalition*	*Free Market*	*Industry Leader*
· Speed of Standard-Setting Process	Slow	Slow	Very Slow	Very Fast
· Degree of Certainty Provided to Buyers and Sellers	Very High	High	Very Slow	Low
· Level of Competiton Generated	Very Low	High	Very High	Low
· Degree of Power to Enforce Standard	Very High	High	Very Low	Low
· Speed of Standard Acceptance by Market Participants	Very Fast	Fast	Very Slow	Slow
· Number of Standards Coexisting in the Market	Usually One	One/Few	Many	One/Few
· Potential for Antitrust Problems	None	Very Possible	None	Possible
· Flexibility for Changes After Standards have been Set	Very Low	High	Very High	Low
· Degree that Standard Selection is Based on Technology Performance	Very Low	Very High	High	Low
· Tolerance for Coexistence of Multiple Standards	Very Low	High	Very High	Low

Source: Rosen et al. (1988)

On July 26, 1987, Executive Order 133 was issued, redefining the functions of the Bureau of Product Standards. Included in its major functions were: 1) review of products contained in the critical imports list; 2) promulgate rules and regulations for dissemination of International System of units (SI); 3) establish standards for all Philippine products; 4) participate actively in international activities on standardization, quality control, and metrology; 5) ensure the manufacture, production, and distribution of quality products for the protection of consumers; 6) test and/or analyze standardized and unstandardized products, for purposes of product standard formulation and certification; 7) extend technical assistance to producers, to improve the quality of their products; and 8) maintain consultative liaison with International Organization for Standardization (ISO), Pacific Area Standards Congress (PASC), and other international standards organization.

On December 2, 1987, the Secretary of the Department of Trade and Industry issued Department Administrative Order 10 (DAO), Series 1987, creating the Philippine Standards Council (PSC), with the primary functions of recommending national standardization policies for the promotion of agroindustrial efficiency, productivity, and growth; proposing guidelines for identifying and prioritizing products for national standardization; instituting measures for coordinating standardization activities of government and private entities; and initiating appropriate actions for promoting the wide usage of Philippine National Standards in manufacturing, trading, purchasing, engineering designs, and other needs. The council was composed of heads and senior representatives of the Philippine Chamber of Commence and Industry (PCCI), the Philippine Standards Association (PHILSA), the Philippine Technological Council (PTC), Industrial Technology Development Institute (ITDI), Bureau of Food and Drugs (BFAD), Procurement Service Office (PSO), the Bureau of Product Standards (BPS), and other organizations or individuals who had specialized technical expertise, with the Undersecretary of Trade and Industry for Regional Operations as council chairman.

Implementing the Guidelines on Government Procurement of BPS-Certified products took effect on January 1, 1988. The guide-

line was a joint memorandum circular of the DTI, the Department of Budget and Management, and the Commission on Audit. Its aim was to require government procurement of BPS-certified products, with priority on public safety and economy. Furthermore, Executive Order 359 was issued on June 2, 1989, to strengthen the government procurement of BPS-certified products. With the executive order, all national government offices, national universities and colleges, and government-owned or controlled corporations were enjoined to abide by the policy of government procurement.

Department Administrative Order 4 (DAO) also took effect on July 1, 1988, to assure the enforcement of the import control clause stipulated in the provisions of Republic Act 4109 and Letter of Instruction 1208. The DAO prescribed the rules and regulations on the issuance of import commodity clearances to import shipments.

Pursuant to the provisions of Republic Act 4109, LOI 1208, EO 913 and EO 133, the Bureau of Products and the Bureau of Customs, with a mandate stipulated under RA 1937 and 4109, and Presidential Decree 1464, mutually agreed to effectively monitor the quality of imported products covered by mandatory standards and certification.

In 1992, Republic Act 1394, or the Consumer Act of the Philippines, mandated the protection of consumers against hazards to health and safety, and deployed product quality and standardization to other government agencies. BPS was mandated to oversee consumer product quality and safety, metrication, labeling, packaging, and liability. It also mandated the Department of Agriculture to assume responsibility over agricultural products, quality, safety, labeling, and packaging. For the quality, safety and labeling of food, drugs, cosmetics, and health devices, the responsibility was given to the Bureau of Foods and Drugs of the Department of Health.

Table 5 chronologically summarizes the acts and regulations relating to industrial standardization.

Table 5

Acts and Regulations

ISSUANCE	*SUBJECT MATTER*
1) Republic Act (RA) 4109 (1964)	· Creation of the Bureau of Standards
2) Letter of Instruction 1208 (1982)	· Formulation of standards for electrical materials, electrical parts, and electrical accessories to prevent fires
3) Standards Manual (1983)	· Adoption of the Manual as the Philippine National Standards
4) Executive Order (EO) 913 (1983)	· Prevention of dumping of substandard products and smuggling of inferior products which may damage the textile and garments industry
5) Executive Order 133 (1987)	· Define functions of the Bureau of Product Standards
6) Department Administrative Order 10 (DAO) (1987)	· Establishment of the Standards Council of the Philippines, to strengthen the National Standardization Activity
7) Standards Administrative 20-3 Order (SAO) 1987	· Industrial Standard Certification mark of the Philippines to the producer
8) Implementing Guidelines on Government Procurement of BPS-Certified Products (1987)	· Government Organizations to procure BPS Certified Products
9) DAO 4 (1988)	· Revised Rules and Regulations, concerning the issuance of Import Commodity Clearance
10) Memorandum Concerning Joint Procedure for Testing of Imports Regulated with mandatory Standards	· Cooperation between the BPS and the Bureau of Customs to prevent inferior and hazardous imports
11) Executive Order 359 (1989)	· Strengthen the government procurement of BPS-certified products

ISSUANCE	*SUBJECT MATTER*
12) Republic Act 7394 Consumer Act of the Philippines (1992)	· Protection of consumers against hazards to health and safety · Mandate the DTI for consumer product quality and safety, metrication, labeling, packaging, and liability · Mandate the Department of Agriculture on agricultural products' quality, safety, labeling, and packaging · Mandate the Department of Health on the quality, safety, and labeling of food, drugs, cosmetics, and devices

Industrial Standards System in the Philippines

The industrial standards system in the Philippines is anchored on three important building blocks, namely: the Philippine National Standards (PNS); the Philippine Standards Certification Mark System (PS Certification Mark System); and, the Import Commodity Clearance System (ICC).

The Philippine National Standards (PNS) are national standards, established and adopted since 1983. Standards Administrative Order (SAO) are standards established between 1965 and 1981. As of September 1995, some 1,945 PNS standards have been established, consisting of both mandatory and voluntary standards. Mandatory standards are standards, the application of which has been made mandatory by regulation. About 6 percent of the present PNS standards are mandatory.

The PS Certification Mark System consists of voluntary and mandatory certification. It is designed to promote the safety of consumers and the maintenance of fair trade. It is based on the PNS standards and other product standards, such as the code of practice and labeling methods designated by the BPS.

The ICC system aims to prevent the national distribution of inferior imported goods. Imported goods are inspected and checked whether they meet PNS, and international or foreign standards adopted by BPS, before being cleared by customs. The ICC certificate is issued to goods meeting the applicable standards. The initial target products for the ICC system have been electric wires, electrical materials, electrical parts, electrical products, fire extinguishers, and other products under the mandatory certification of the PS Certification Mark System.

The Bureau of Product Standards (BPS) of the Department of Trade and Industry is the central administering body of standardization in the Philippines. It is responsible for the development, implementation, and coordination of all standardization activities in the Philippines. Specifically, it is mandated to develop standards, certify and test products, certify quality management system, and accredit laboratory and training, promotion, and technical

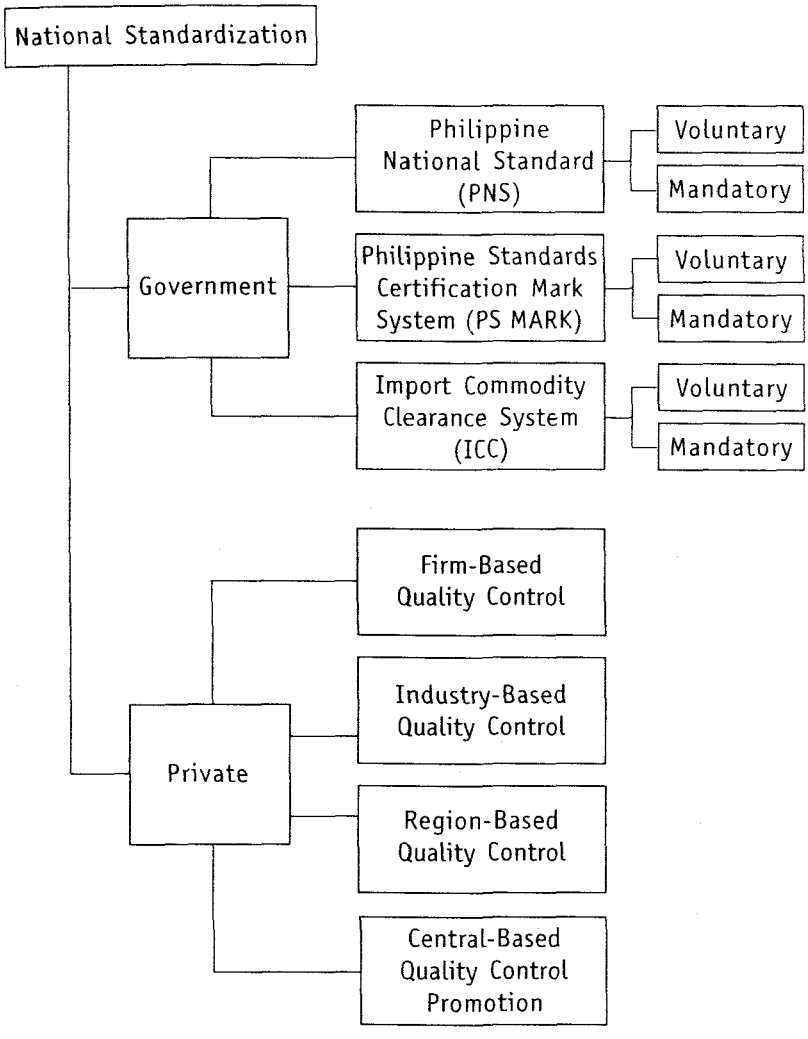
information. The BPS central organization is composed of four major divisions, namely: Standards Development Division; Standards Promotion Division; Quality Control Assistance Division; and Standards Conformity Division. In the regions and provinces, the Industrial Development Division of the regional and provincial offices of DTI executes the activities of the BPS.

On an annual basis, BPS formulates an Action Program for Standardization, comprised of inputs from the Philippine Standards Council, relevant government organizations, major industrial associations, experts, consumer organizations, and other interested parties.

Standardization efforts of the private sector greatly hinge on the market (domestic or export), size of the enterprise (small, medium, large), and industrial structure. For domestic producers, there is very little standardization activity because the market is primarily driven by low income consumers. For exporters, most of the products are determined by the specifications of the buyers, rather than the national standards of the Philippines. Firms that use imported technology normally maintain and upgrade the quality of their products, and are very positive to the standardization activities of government (BPS, 1993, 1994). Other modes of standardization initiatives include industry level participation, such as discussions with BPS on the administration of standards, joining Technical Committees for Standards Formulation, Planning, and Implementation of programs for the improvement of technology and quality, and industrial associations and chambers of commerce.

The generic structure of the Philippine Standard System is shown in Figure 1.

Figure 1
Generic Structure of the Philippine Standards System



The Philippine National Standards

The Bureau of Product Standards uses the Technical Commit-

tee method in standards formulation. Patterned after internationally accepted procedures, the establishment of national standards is carried out in accordance with the Standards for Formulating National Standards of the Philippines, consisting of the following general steps:

1. Draw standardization work program
   - Review all existing national standards and scan priority standard needs
   - Form a technical committee (TC) with specific group assignments
   - Form subcommittees and working groups whenever necessary

The members of the technical committees, subcommittees, and working groups are chosen from interest groups, such as trade or industry associations, professional organizations, academe, government agencies, consumer groups, and the BPS. Each technical committee has a maximum of 15 members. Membership to technical committees is by invitation and referral, and is limited to qualified and competent senior officials appointed by the Secretary of Trade and Industry.

2. Prepare draft standard
   - Examine existing international standard
   - Consult with sectors concerned
   - Prepare draft standard
   - Submit draft to TC for intensive deliberation
   - Reach consensus
   - Issue TC draft standard
3. Review the committee draft standard
   - Forward to BPS director
   - Circulate draft to all parties concerned, for comments and suggestions
4. Review comments on committee draft
   - Collect all comments on the committee draft

- Forward to BPS technical staff
- Evaluate comments
- TC reviews comments

5. Conduct public hearing on modified standard
   - TC prepares modified standard
   - Conduct public hearing for further comments and suggestions
6. Approve and promulgate national standard
   - Prepare final draft standard
   - Secretary of Trade and Industry approves promulgation as a national standard
7. Publish national standard
   - Publish mandatory standard in the *Official Gazette* or a newspaper of general circulation
   - Print and circulate voluntary standard

The annual production of PNS standards averages about 133 standards per year, from 1983 to 1994, except for 1984 and 1990, which yielded comparatively low annual production—78 and 83 standards, respectively.

Manufacturing engineering, textile and leather technology, construction materials and building equipment, petroleum and related technologies, agriculture, paper technology, and electrical engineering comprise 53 percent of the total PNS standards. Manufacturing engineering accounts for the highest, at 11 percent.

On the average, the BPS has formulated about 45 standards in the last five years, while 75 standards have been adopted from international and other foreign standards. It has been noted that the adoption of international and foreign standards has been increasing yearly. ISO and ASTM standards are the dominant sources. Other sources of adopted standards include American National Standard Institute (ANSI), Australian Standards (AS), British Standard Institution (BSI), Department of Transportation, USA (DOT), International Electrochemical Commission (IEC), Institute of Electrical and Electronics Engineers (IEEE), Japanese Industrial Standards (JIS), Japanese Automobile Tire Manufacturer's Association (JATMA), Institute

of Petroleum (IP), National Fire Protection Association (NFPA), Society for Automotive Engineers (SAE), Tire and Rim Association (TRA), and Underwriter's Laboratories, USA (UL).

The BPS has also forged agreements with local organizations, capable of formulating standards. Among them are: Construction Industry Authority of the Philippines (CIAP), Compressed Gas Association of the Philippines, Inc. (CGAP), Bureau of Food and Drug (BFAD), Agricultural Machinery Testing and Evaluation Center (AMTEC), Philippine Airconditioning and Refrigeration Engineers (PARES), Philippine Standards Association (PHILSA), Philippine Toy and Novelty Manufacturers' Association, Inc. (PTNMA), Philippine Liquefied Petroleum Gas Association, Inc. (PLPGA), Postharvest Horticulture Training and Research Center (PHTRC), Philippine Society of Mechanical Engineers (PSME), and Philippine Textile Research Institute (PTRI). Unfortunately, the contribution of these organizations to the production of standards has been minimal.

By usage, approximately 40 percent are product standards, while the remaining 60 percent are testing methods, terminology, or implementation standards. According to its life cycle, PNS standards can either be developed, revised or amended, or adopted. New developed standards are standards issued for the first time as a national standard; amended standards are modified versions of existing standards; and adopted standards are new standards derived from local or foreign standards.

For the last five years, the adoption of international standards has outpaced the development of new standards by a ratio of about 3:1. The average static cycle time of developing a new standard is estimated to be about 6 to 10 months. Revising a standard takes 5 months, while adopting a standard takes 0.5 month.

As a general rule, standards should be reviewed every five years. An examination of the life distribution of PNS standards reveals that 58 percent are five years old or less, while 42 percent exceed the five-year review period. The latter figure suggests that we may be stuck with obsolete standards.

Table 6
Classification of Philippine National Standards

CODE	*CLASSIFICATION*	*NUMBER*
C	· Manufacturing	154
F	· Textile and Leather Technology	129
Q	· Construction Materials and Building Equipment	119
K	· Petroleum and Related-Technologies	116
G	· Agriculture	83
O	· Paper Technology	81
D	· Electrical Engineering	79
N	· Rubber and Plastic Industries	67
P	· Paint and Color Industry	67
L	· Metallurgy	60
I	· Chemical Technology	59
A	· Generalities, Terminology, Standardization, Documentation	56
M	· Glass and Ceramics Industries	54
H	· Food Technology	50
E	· Road Vehicle Engineering	46
B	· Environment Protection, and Safety	40
J	· Mining and Minerals	37
T	· Metrology and Measurement, Physical Phenomena	24
Y	· Wood Technology	23
R	· Social Services, Company Organization and Management, Administration, Transport	19
U	· Fluid Systems and Components for General Use	17
S	· Health Care Technology	11
Z	· Housekeeping, Entertainment, Sports and Clothing Wear	11
V	· Information Technology and Office Equipment	10
W	· Image Technology	9
X	· Packaging and Distribution of Goods	9

Dissemination of standards is done by the BPS through different promotional media. Among them are the publication and distribution of publications (e.g., *Catalogue of Philippine National Standards*, *BPS Quarterly*, and the *BPS Annual Report*); exhibitions; national meetings to promote standardization (the second week of October is National Standardization Week); press releases; library services; and government procurement of BPS-certified products.

In the JICA study (1989), only 17 percent of 310 firms surveyed have indicated their knowledge of the PNS; 52 percent do not know about it, while the rest have chosen not to respond. In a 1994 AIMCON Survey, 23 percent of 100 firms have indicated their use of PNS standards.

Philippine Standards Certification Mark System

The goals of the certification mark system are to elevate the quality consciousness of manufacturers, protect consumers, and promote the development of industry, by third-party certification to standards of quality, performance, and safety. The PS mark license issued by the BPS certifies that a factory is able to continuously satisfy national standards, or international/foreign standards adopted as national standard, based on the results of strict factory assessments and product tests conducted by the BPS or DTI regional/provincial offices (BPS, 1993,1994). The license is permanent, unless it is revoked due to an infraction of its conditions.

The conditions of the license are:

1. Product must meet PNS or other standards approved by BPS;
2. The PS mark is to be used only on subject product;
3. Licensed party must observe rules of RA 4109 and EO 913;
4. Licensed party must allow assessor of BPS or DTI to audit factory operation;
5. Licensed party must maintain an acceptable quality and control system;

6. Subcontractor licensees assume quality of partly finished product;
7. Changes in the factory must be reported to BPS;
8. Factory reassessment is required for factory transfer; and,
9. PS mark license may not be lent to a third party.

All product standards are subject to PS mark certification. Mandatory PNS are subject to mandatory certification. An annual follow-up inspection is conducted by BPS or DTI regional/provincial offices, to verify compliance with the requirements of the license.

As of December 31, 1993, the PS mark license holders by product fields are:

• Building Materials	170
• Electrical Products	93
• Chemical Products	38
• Consumer Products	190
• Fresh and Processed Foods	45
TOTAL	*536*

Some 120 licensees, or approximately 19 percent of the total current PS mark license holders, are subject to reassessment.

In terms of use and deployment, the JICA study (1990) has revealed that only 29 percent are PS mark license holders, while 79 percent are not. In the AIMCOM survey (1994), only 8 percent are PS mark licensees, 55 percent are not, while 37 percent do not know about the PS mark.

Import Commodity Clearance System

The main objective of this system is to prevent the distribution of poor quality imported goods in the domestic market. Under it, imported products are inspected to check whether they conform with PNS, or the applicable international or foreign standard approved by BPS before clearing customs. The Import Commodity Clearance (ICC) is only issued to products meeting the standards.

Covered by the ICC system are electrical wires, electrical materials, electrical parts, electric accessories, fire extinguishers, fire extinguishing systems, fire extinguishing accessories, and all mandatory PNS standards or those covered by international or foreign standards approved by BPS, such as ISO, IEC, DIN, BSI, JIS and ANSI.

By the end of 1993, 169 companies have been issued IC:

Product Category	*No. of ICC*	*Firms Issued*
• Consumer Products	117	335
• Electrical Products	51	62
• Building/Construction	1	1
TOTAL	169	398

Some 224 ICCS, or 56 percent of all ICCS issued to 38 firms (22 percent), are used on LPG steel cylinders.

Barriers to Rapid Standardization

The standardization system in the Philippines is clearly government-dominated, with induced participation from the private sector. Inherently, there is a multitude of institutional barriers, as well as systematic factors associated with this mode of standard-setting, which inhibit rapid standardization and quality improvements. Also, the economic level of development and the prevailing state of technology in the Philippines affect the speed and the direction of standardization.

Economic Environment

At present, the demand for substandard goods persists in the domestic market. Most manufacturers still respond to this demand as if there is no incentive at all to improve quality and standardize. This market is predominantly driven by consumer affordability.

In the case of exporters, majority of their products are manufactured according to the standards and specifications prescribed by

the buyers. These manufacturers are strongly predisposed to depend on the specifications of the buyers or on foreign standards, rather than national standards (BPS 1993,1994). For example, most of electronic parts, garments, toys, food items, and other exports are manufactured on the basis of buyers' consignments or standards.

At the current level of the Philippine economy, the strategic value of standardization has not been fully appreciated. The overall strategic role of standardization, vis-à-vis the overall economic development of the country, is ambiguous. The alignment of the basic program of industrial standardization supporting national economic development, the national industrial plan, and the national technology plan seems to be clearly delineated for the scrutiny and understanding of all stakeholders, especially the private sector, which will be using and enforcing the standards.

While the Philippines has national standards comparable with other developing countries, standards in the strategic basic industries are wanting. In particular, the JICA study has identified the need to set standards in basic industry for new materials (machinery, electrical, and electronics); interfacing and compatibility standards (e.g. assembly industry, screws, bearings, belts, pipings, symbols, dimensions, tolerances, processing accuracy, sizes, and forms); common and basic fields (statistical method, measurement, and quality control); and export industry fields.

Another inhibitor is the treatment of standards as a regulatory tool, rather than as a developmental instrument.

On the other hand, growing consumer consciousness on consumer protection, liability, environmental preservation, and sustainable development gives a strong push for quality and standardization. Globalization of the marketplace and rapid technological turnovers boost standardization.

Systemic Factors

Relative to industrialized countries, the Philippine production and stock of standards are very low. It has been observed that the number of national standards is positively correlated with the de-

gree of industrialization of an economy. For example, the United States had about 89,000 standards in 1989; Japan had 129,478 standards in 1988; Germany had 20,580 standards in 1988; and Great Britain had 10,600 BSI standards in 1989 (UNIDO 1994). In 1995, the Philippines had only 1,945 standards, a small number compared to those of industrialized countries.

This low production and rate of standards formulation can be attributed to the following causes:

1. *Mismatching of standards requirements with standards produced*

   There is an apparent gap in the standards required by industry and the general public, and the standards being produced by the Bureau of Product Standards. Because of this, there is lack of pressure and urgency to produce new standards. It takes at least 10 months to develop a new standard. The current system of the national standardization action programs appears to be passive, conservative, and tangentially aligned to the overall economic goals of the Philippines. With this passive process, the direction is often diverted by pressure groups, who are more vocal in providing inputs to the standardization thrusts, rather than focused on what is strategically important and supportive to overall national objectives. This situation creates the maldistribution, lack, absence where needed, inapplicability, or non-utilization of standards.

2. *Anemic sourcing of standards*

   The sourcing of standards is currently limited to the research and investigation conducted by the Research and Investigation Group of the BPS. Scope of research and investigation covers a broad field, including food, electricals, chemicals, machinery, and building. It involves

the collection and study of similar foreign standards and technical literature, including required testing and evaluation. Being a member of ISO, BPS has access to the standards of the 91-member countries of the standards body, and the international standards of ISO and the International Electrochemical Commission (IEC). While access is available, their adoption as national standards depends on whether they align with the themes established by BPS, or whether there is capability to ensure conformance.

3. *Lack of information and understanding of standards*

While standards are supposed to be common, public awareness is very low. This is evidenced by the low compliance rate with standards in certain sectors, exacerbated by the mindset that standards are purely residual and regulatory in nature. Currently the PNS, the PS Mark System, and the ICC are promoted via regular publications of BPS, training seminars, exhibitions, dialogues, and consultancies. The lack of a total marketing strategy, for selling standards as tools for improving quality and productivity, and advancing technology, contributes to the industry's indifference and low conformity. This lack of appreciation does not create a perceived need for standards.

There is also a lack of understanding of the strategic value of quality management and limited quality practices being enforced in small- and medium- enterprises. The operation of a quality system, according to ISO 9000, helps improve the efficiency of an organization, and enhance its competitiveness, growth, and profitability in domestic and foreign countries.

The Philippines has adopted the ISO 9000 Series Standards as Philippine National Standard (PNS) 1000 Series Standards, ISO 10011 as PNS 1100, and EN 4500

Series Standards as PNS 1500 Series Standards. PNS 1000/ISO 9000 Series Standards refers to a set of guidelines for developing a documented quality system, and encompassing the necessary organizational structure, responsibilities, procedures, and resources.

Some firms are not aware of ISO 9000 quality assurance standards. On a national scale, about 100 companies have been certified to PNS 1002:1990/ISO 9002. Only two of the 100 firms surveyed are ISO-certified. Six firms have indicated that ISO certification is under way, while the rest have not responded. Firms engaged in marine and fruits are not aware of ISO 9000. BPS has launched the third-party quality system to PNS 1000/ISO 9000 Series Standards on April 30, 1992 (Department Order 3). In 1995, it has relinquished its certification function, in favor of certifying body accreditation.

At present, there is only a handful of qualified private ISO certifying bodies and ISO assessors. There are also human resources required for the documentation and setting up of quality systems needed by the ISO standards. At the minimum, it is estimated that the Philippines will need at least 1000 qualified assessors, based on the requirements of the 10 priority sectors identified in the Philippine Medium-Term Development Plan, consisting of animal food ingredients, cut flowers, livestock and poultry, fresh and processed fruits, fresh and processed vegetables, gourmet items, electronics, gifts, toys and housewares, fishery and marine products, and metal and engineering products.

4. *Lack of cooperative effort among standard-developing institutions*

While BPS is the central administering body for standardization, there are other competent institutions that have the capacity and capability to formulate standards.

However, their contributions have been insignificant, with the exception of the Philippine Textile Research Institute (PTRI) and the Construction Industry Authority of the Philippines (CIAP), which have contributed at least 10 standards each for the last five years. The active participation of professional organizations, industry associations, and government research and development institutes has been confined to membership in Technical Committees. Involvement of expert organizations and individuals is lackadaisical, at best.

Lackluster participation of private organizations and government institutions is limited to membership in technical committees, subcommittees, and working groups. Among these institutions are MIRDC, ITDI, FDC, PTRI, PIPAC, BFAD, UPLB, Institute of Food Science, industry associations like the Philippine Association of Air Conditioning and Home Appliances, professional organizations, and academic institutions.

5. *Lack of competent testing facilities of international calibre*

BPS has about 30 accredited testing laboratories, mostly concentrated in Metro Manila. Of these, 25 are privately-owned, while 5 are government-run. Interestingly, 7 of these laboratories (23 percent) are accredited for the testing of LPG cylinders only. Regional testing capabilities are poor and limited. Laboratory accreditation of BPS has been stationary at two laboratories per year, for the last five years. International credibility of existing laboratories is very limited. Only a handful of the existing laboratories have international acceptance. One of them is the Food Development Center, which is accredited by the US Food and Drug Administration; the Japanese Ministry of Health and Welfare; and the Australian Inspection Bureau. Owing to this deficiency, testing often has to be done abroad, which

lengthens the cycle time of standards development.

In food, testing laboratories are concentrated in the National Capital Region. These are the National Food Authority in Quezon City, SGS Far East Limited (Phils) in Makati, Labtest in Makati, Food Development Center in Bicutan, ITDI Food Division in Bicutan, Bureau of Food and Drug Administration in Alabang, Philippine Coconut Authority Laboratory in Quezon City, the University of the Philippines College of Home Economics Food Processing Plant in Diliman, and the Institute of Food Science and Technology at UP Los Baños.

For metals, the Metals Industry Research and Development Center (MIRDC) is accredited by BPS for metal testing as a testing laboratory under the PS Certification Mark System. Its Analysis, Testing, and Inspection Division (ATID) is working for ISO 25 accreditation. Two extension offices have been set up in Region 7 and 11. However, shortage of competent personnel, inadequate maintenance of test equipment, and streamlined testing systems and procedures stymie the provision of fast and credible testing services.

The PTRI is an accredited laboratory for textile and textile products and is also the public testing laboratory of the International Wool Secretariat (IWS). Testing facilities are deemed adequate, but inferior to existing textile technology in other countries.

The Bureau of Product Standards, which is the Philippine national standardization body and main inquiry body for the Agreement on Technical Barriers to Trade under GATT, has established the National Accreditation System for Calibration and Testing Laboratories on February 21, 1994. The aim is to unify the existing laboratory accreditation systems of the BPS and the ITDI, in order to recognize the competence of calibration, and test laboratories in accordance with established national and international standards, such as the ISO/IEC Guide

25-General Requirements for the Competence of Calibration and Testing Laboratories.

6. *Shortage or lack of competent human resources on standardization*

The current standardization system requires a tremendous amount of man-hours of research, investigation, formulation, testing, and confirmation and deployment of standards, most of which are short in supply. The present staff of BPS can only be expected to produce at least 50 standards per year, based on existing workloads. The formation of Technical Committees is severely hampered by the availability and commitment of qualified technical experts. It has been reported that Technical Committee meetings are canceled 30 percent of the time because of poor attendance, causing delays in the preparation and review of standards. In addition, most other personnel involved in standardization in other institutions have been schooled in engineering and sciences, and lack the formal education and training.

There is a perceived lack of skills and knowledge on quality and productivity. Formal courses on quality control are not part of the school curriculum. Most quality skills are learned on the job. There are training institutions and laboratories that regularly offer short-term training on productivity and quality management. However, training programs are not standardized. The skills certification system is administered on a limited scale, and there is no national accreditation of training institutions.

In the survey conducted, about 39 percent have indicated the need for technical training on quality control, standardization, and productivity improvement. It also reveals that existing standard developing bodies are confronted with inadequate trained personnel. Most of the skills on standards development have been learned on

the job, or obtained from short-term training programs offered by training institutions or laboratory institutes. Some of these training programs are on productivity, quality control, calibration/metrology, and analysis/tests. The Food Development Center (FDC), PTTC, and the PIPAC offer regular three-to-five-day training programs on productivity, quality management, calibrations/metrology, analysis/tests, and quality control for the food industry. The PTRI and the PTTC offer regular training programs on fiber testing and evaluation, yarn testing and physical testing of textile products, fabric and garment inspection, and quality evaluation of fabric and garment for exports.

The MIRDC provides regular training on corrosion, dimensional metrology, basic non-destructive testing, industrial calibration, failure analysis, chemical analysis of metals, and foundry quality control. These programs are offered at least three times a year.

The Productivity Development Center has set up the Philippine Quality and Productivity Training Institute, specifically to assist small- and medium- enterprises by offering training programs on productivity and quality improvement. The BPS and the PSQC also have regular training programs on quality control and productivity.

The University of the Philippines Institute of Small-Scale Industries, and the Department of Industrial Engineering and Operations Research have been providing industrial quality control education through their industrial quality training course and graduate program.

For skilled workers, the skills certification system is being administered by the National Manpower Youth Council (NMYC), the MIRDC, and some privately-run technical institutes, such as Dualtech, Don Bosco, and Meralco Foundation Institute.

7. *Lack of coordination in the implementation and deployment of standards*

The JICA study reports that the enforcement of standardization in industries is unclear, and the necessity for standardization has not sunk in. This is further confounded by the lack of definitive criteria for mandatory standards, as against voluntary standards.

8. *Lack of technology guidance on quality*

There is a lack of technology guidance on productivity and quality improvement for small- and medium-scale industries. About 90 percent of the companies surveyed are not aware of, and have limited access to current quality and productivity technologies. Technology guidance facilities and support are limited. In the AIMCON study, the major reasons for acquiring technology are to improve quality (55 percent), and increase competitiveness (48 percent). There are very few competent and reliable consultancy groups dealing with quality and productivity technologies.

9. *No quality screening of export products*

There is no legislation that enforces export inspection to screen the quality of export products. There is also no fish and marine inspection board. The US Department of Health reports that a considerable number of detained shipments from the Philippines have been caused by filth, missing mandatory labeling requirements, and decomposition.

In the 1970s, the Export Inspection System, which was primarily visual, was introduced in the Philippines, and applied to all export products. It was subsequently abolished in 1981 because it was causing delays in the export procedure, and was thus considered ineffective.

In the Philippines, FDC is an accredited export-certifying body by the US Food and Drug Administration. However, export certification is voluntary.

10. *Lack of system for updating standards*

An integral part of standards update is to ensure that standards are regularly reviewed to prevent them from becoming obsolete. The present system does not allow an effective mechanism for the regular and consistent update of existing standards.

11. *Ill-structured standardization process flows*

While the three components of the Philippine Standard System (PNS, PS Mark, ICC) appear to be well-structured, the relationships and integration of these components are not well-defined. They don't operate as interdependent systems. Moreover, the lack of clear visibility in the overall economic planning process vitiates the true contribution of standards to industrial and technology development. Because of these ill-defined connections, standardization processes become disjointed bureaucratic processes of government, thereby contributing to the lesser production of standards.

Proposed Systems Model for Product Standardization

To systematize the standardization system, two conceptual models are proposed. The first model prescribes a hierarchically-based alignment of standards development, with the overall economic, industrial, and technology planning processes. The model aims to achieve the visibility, priority, and urgency of standards being developed (Figure 2). The second model describes the flow of the promulgation of standards, with built-in provision to update existing standards (Figure 3).

Figure 2.

Hierarchical Annual Standardization Planning and Review Process

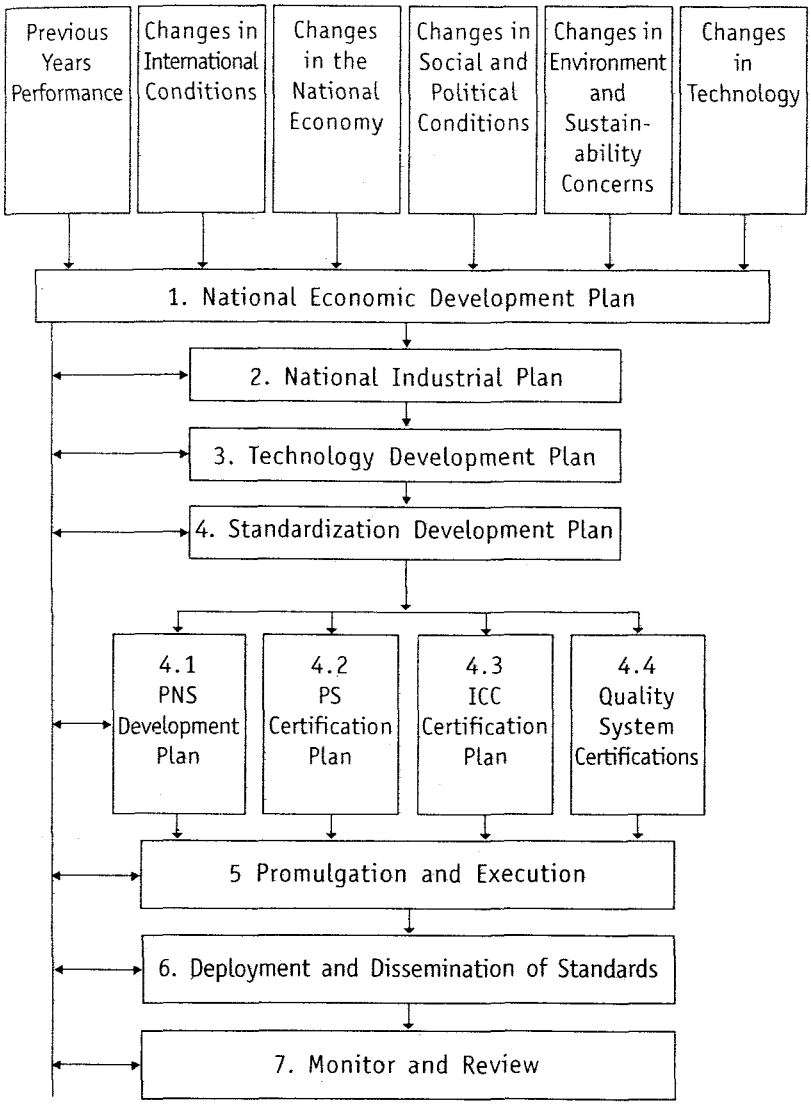
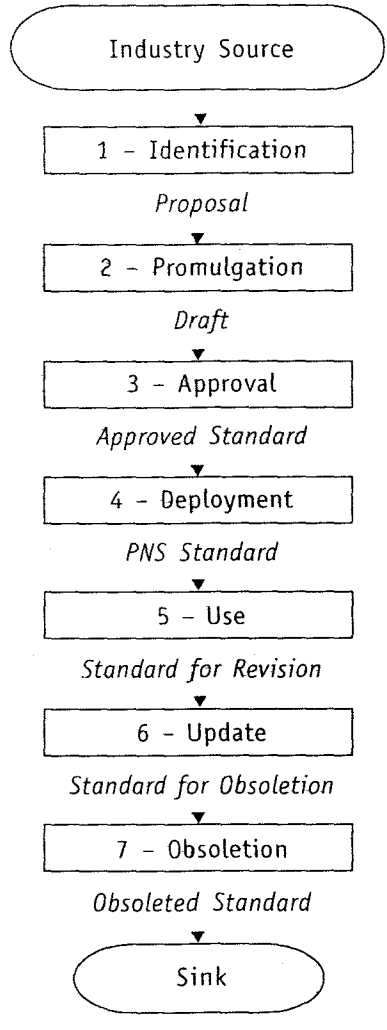


Figure 3

Process Flow for the Development of Philippine Product Standards



Conclusions and Recommendations

It has been shown that standardization is necessary to improve quality, advance technology, and achieve international competitiveness. Four modes of setting standards exist, with industry coalitions as the most preferable; albeit under some conditions, government action appears to be more acceptable.

The Philippine standardization system has three components: the PNS, the PS Certification System, and the Input Commodity Clearance System—all of which are government-dominated. The production and stock of existing standards is comparatively low, and this is attributed to a legion of systemic causes, among which are the mismatching of required standards with what are produced; anemic sourcing of standards; lack of information and understanding of standards; lack of appreciation of standards as quality and productivity improvement tools; persistent mindset that views standardization as purely regulatory; lack of cooperative efforts among standard-developing institutions; lack of competent testing facilities of international calibre; shortage or lack of competent human resources on standardization; lack of coordination in the deployment of promulgated standards; lack of system for updating standards; and ill-structured standardization process flows.

The adoption of the following countermeasures is recommended:

1. Define and align the annual standardization process with the overall industrial and technology plan.
2. Define and integrate the PNS, PS Certification System, and the ICC System into an integrated whole, and formulate an integrated standardization plan (ISP). The period of the plan should be at least 10 years, with an annual review and strong private-sector involvement.
3. Strengthen the current structure of standard-developing bodies by forming a strong network of both private-sector organizations, as well as government institutions, such as the academe. Decentralize the Technical Committee method. Assign nodes of competence, with each node being

responsible for a particular product family. For example, for textile and garments node, PTRI can take the lead, with the participation of industry associations, chambers of commerce, academics, and textile and garment experts.

4. Institute a consistent and sustained promotion of standards as quality, productivity, and technology management tools. This can be done by developing courses on standardization and quality control in engineering, science, and business schools.
5. Internationalize the PNS, the PS Certification, and the ICC system. To be internationally-competitive, the PS mark has to be internationally accepted. This can be done by internationally accrediting testing laboratories.
6. Set up a clearinghouse of standards for manufacturers, on a regular basis. This clearinghouse should provide the latest standards available in the international market. This should be done on an active and fast medium, like the Internet.
7. Undertake aggressive and systematic research on standards with strategic value to the Philippine economy. Access to ISO, IEC, Asian and Pacific Standards Network, and the Manufacturing Standards Network should be maximized.
8. Promote the ISO quality management certification system to hasten better understanding of standardization, customer satisfaction, and advance production standardization.
9. Finally, a sustainable institutional structure should be set up. Two options can be considered. One is to create the Philippine Standards Network System (PSNS), administered by the Bureau of Product Standards, with direction from the strengthened Standards Council of the Philippines. The other option is to establish a more powerful Standards Development Authority (SDA), which should have complete responsibility over all standardization activities in the country. This body should be quasi-governmental.

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DISCUSSION

Carlos I. Sumera

To begin, there are some statements made that should be corrected. There is a diagram in which quality management is somewhat different from standardization. Quality management is actually part of standardization. They are not separable. When you talk of standardization in terms of providing technical specifications or guidelines toward achieving a certain level, either in production or quality; then quality, management system, or environmental management system is part of standardization.

Second, the ISO 9000 series are all standards. I got the impression that there is a difference between ISO 9000 and the ordinary product standards we developed. This shows that there is a prevalent perception of standards being regulatory in nature. However, the adoption of international standards is the best way to fast-track development.

We have asked the same questions, in terms of the number of standards and why we are very far behind our Asian neighbors, let alone the developed countries that had a good headstart by at least a decade. Formal standards work in the Philippines started only in 1983. And though we are admittedly far behind, we are more productive in terms of the speed in developing standards. What would then explain the sluggishness?

This is because of resources. Our Asian counterparts, such as the Malaysian Standards Organization, the Productivity Standards Organization of Singapore, or the Thai Industrial Standards Institute, have 300 to 1,000 technical people doing nothing but developing standards. At the BPS, we have only 77 people, including the support staff. We are on limited hiring because of strict budget allocations. This is why we strongly believe in one of the recommendations—a stronger participation of the private sector.

So far, there has been only one industry association with

which the BPS has established a solid linkage for the development of industry standards, and this is the Philippine Association of Paint Manufacturers (PAPM).

While we do have linkages with other industry associations, these deal only with the *implementation*, not the *development*, of standards. This is why we have begun to aggressively court and convince these industry associations to start their own standards development work.

The Consumer Act also delegates standards development work to other first-level government institutions, like the Departments of Agriculture, Health, Trade and Industry, and Energy. Another problem is the mindset of both public and private organizations that standards development is best left to only one institution, which, in this case, is the BPS. We have to change this mindset. This is already being done slowly, through the Department of Environment and Natural Resources, which is starting its own standards development process.

Steps are already being undertaken by the BPS to address these concerns. A lot of soul-searching has been done, and a lot of difficult decisions have been made. We have bitten the bullet, so to speak. We are enforcing whatever corrective actions are needed, in the parlance of ISO 9000, in order to make sure that these issues are properly addressed and resolved soonest.

Part V
INDUSTRY IMPACT

Managing Technology in the Food Processing Industry

IGNACIO S. PABLO

Chapter 16

Individual firms, not nations, compete in international markets, although, of course, nations or countries play a significant role in the process. Michael Porter identifies competitive forces that determine industry competition, whether domestic or international: 1) *the threat of new entrants*; 2) *the threat of substitute products or services*; 3) *the bargaining power of suppliers*; 4) *the bargaining power of buyers*; and 5) *the rivalry among the existing competitors*. These forces determine industry profitability by shaping the prices firms can charge, the costs they bear, and the investment required to compete. The threat of new entrants can limit the overall profit potential in the industry. New entrants bring new capacity, and seek significant market shares; and, thus push down profit margins. Powerful buyers or suppliers bargain away the profits for themselves. Fierce rivalry among competitors erodes profits by requiring higher costs of competition, in the areas of advertising, sales expense, or R&D. Fierce competition can even lead to the passing on of profits to customers in the form of lower prices. This can aggravate the erosion of the firm's profits.

Knowing these five forces will serve as a foundation for the firm to develop a competitive strategy. Developing a competitive strategy is basically developing a broad formula on how a business

should compete, what its goals should be, and what policies are needed to realize these goals. Strategy can also be viewed as building defenses against competitive forces, or finding positions in the industry where the contending forces are weakest. Positioning is the embodiment of the firm's overall approach to competition, and its very essence is competitive advantage.

There are two basic types of competitive advantage applicable to the food industry: *lower cost* and *differentiation*. Lower cost is the ability to design, produce, and market a comparable product more efficiently than competitors. With prices at, or near, competitor levels, lower cost translates into superior returns. This can be done by producing comparable products at very low cost and employing low-wage but highly productive labor forces and modern process technology, purchased or licensed from foreign suppliers. Differentiation is the ability to provide unique and superior value to the buyer, in terms of product quality, special features, or after-sales service. Competing with differentiation strategies can involve high product performance, reliability, and responsive service. Differentiation allows a firm to command a premium price, which will result in high profitability if costs are comparable to the competitors'. Either of the two types of competitive advantage can be translated into higher productivity. To be both cheaper and differentiated relative to competitors is difficult, although not impossible, to achieve. The effort to be comparable to competitors on these attributes can be easy, but the provision of unique performance, quality, or service can be inherently costlier.

Firms can improve technology such that it can simultaneously reduce cost and improve differentiation. However, competitors will imitate and force a choice on which advantage to emphasize. Any successful strategy must pay close attention to both types of advantage, while maintaining a clear commitment to the superiority of one. Firms gain competitive advantage from conceiving new ways to conduct activities, and employing the new procedures, new technologies, or different inputs. One example in manufacturing industry concerns the Swiss chocolate companies. They rose to prominence by pioneering new product formulations (among them, milk choco-

late), and new processing methods, such as *conging* (continuous stirring) which substantially improved product quality.

Creating Advantage

Firms create competitive advantage through innovation— discovering new or better ways to compete in an industry, and bringing their products to the market. Innovation can be manifested in product changes, process changes, new marketing approaches, new forms of distribution, and new conceptions of scope. Innovators not only respond to possibilities of change, but also force it to proceed faster. Vigorous innovation in reality is more mundane and incremental rather than radical. It is more dependent on the accumulation of small insights and advances than on major technological breakthroughs. It often involves ideas that are not "new," but have never been persistently pursued. The food industry is one of the few industries where the dynamism of a product is a must.

In international markets, innovations that yield competitive advantage anticipate both domestic and foreign needs. On the other hand, innovations that respond to peculiar concerns or circumstances of the home market can actually retard international competitive success.

Choosing a Global Strategy

Global focus requires worldwide concentration on a segment of the industry that is poorly served by broad-line competitors. Competing globally can make entirely new industry segmentations because serving a worldwide segment provides enough volume to capture economies of scale.

Smaller companies, not just large ones, can compete globally. Small- and medium-sized companies compete for a substantial portion of international trade, especially in Germany, Italy, and Switzerland. They often focus on narrow segments, or compete in relatively small industries.

Small-and medium-sized companies tend to employ export-based

strategies, with only modest foreign direct investments. With limited resources, smaller firms face challenges in gaining foreign-market access, understanding foreign-market needs, and providing after-sales support. One approach is to deal with agents or importers, distributors, or trading companies. Another approach is to work through industry associations to create a common marketing infrastructure; organize trade shows and fairs; and conduct market research. Cooperatives, for example, have been integral to the export success of Denmark's agriculture-based industries. More recently, smaller firms have been allying with foreign firms in order to compete globally.

Much has been said about technology being an integral partner to global competitiveness. This section of the article will try to present and highlight the role of technology in the five competitive forces that determine competition.

Technology and Competition

Technological change plays a major role in industry structural change, as well as in creating new industries. It is a great equalizer that often erodes the competitive advantage gained by well-entrenched firms, and propels others to the forefront.

There has been a growing misconception regarding the relationship between technological change and competition. Technological change is often viewed as valuable for its own sake. Any technological modification a firm can pioneer is believed to be good. Competing in "high technology" industries is widely perceived as a ticket to profitability. High technology does not guarantee profitability. Many high-technology industries are less profitable than some low-technology industries on account of their unfavorable structures. Not all technological change is strategically beneficial because some may undermine a firm's competitive position and industry attractiveness.

On the other hand, other so-called low technology industries are viewed with pessimism and disdain. Because of the many recent successes of foreign competition, much of which was brought about

by technological innovation, companies are encouraged to invest more in technology.

All firms utilize a large number of technologies. Everything that a firm does involves technology, despite the dominance of one or more technologies in the product or the production process. Any scientific merit, or prominence in the physical product, brought about by technology, is nothing and has no significance unless it has tremendous effects on the firm's competitive advantage or industry structure.

Technology and Industry Structure

The overall industry structure can be determined by technology itself, if the technology employed becomes widespread. Diffused technological change can potentially improve or erode industry attractiveness. Even if technology does not yield competitive advantage to any one firm, it may affect the profit potential of all firms. Technological change that improves a firm's competitive advantage may worsen it, as it is widely imitated. The potential effect of technological change on industry means that a firm cannot set technology strategy, without considering the structural impacts.

Technology and Entry Barriers

Technological change is a powerful determinant of entry barriers. It can either raise or lower economies of scale. Flexible manufacturing systems often have the effect of reducing scale economies. It can raise economies of scale in the technological development function, by quickening the pace of new production and its introduction, or raising the investment required for a new model. Technological change can lead to other absolute cost advantages, such as low-cost product designs. It can also alter the amount of capital required for competing in an industry. For example, the shift from batch to continuous process technology in producing cornstarch and corn syrup has significantly increased the capital requirements in corn wet milling.

Technology and Buyer Power

Technological change can shift or alter the bargaining relationship between industry and its buyers. The role of technological change in differentiation and switching costs is instrumental in determining buyer power. It can also ease backward integration by the buyer, which is a key buyer bargaining lever.

Technology and Supplier Power

Technological change can shift the bargaining between an industry and its suppliers. It can eliminate the need to purchase from a powerful supplier group, or force industry to purchase from a new and powerful supplier. Technological change can also allow a number of substitute inputs to be used in a firm's product, creating a bargaining leverage against suppliers. For example, the can industry, which is a support industry to food manufacturing, has benefited from fierce competition between aluminum and steel companies, brought on by the technological change in aluminum cans. Technology investments by firms can also allow the use of multiple suppliers, by creating in-house knowledge of supplier technologies. This can eliminate dependence on any one supplier.

Technology and Substitution

The impact of technology on substitution is one of the most recognized effects on industry structure. Substitution is a function of the relative value to the price of competing products, and the switching costs associated with changing them. Technological change creates entirely new products, or product uses, that substitute for others; such as fiberglass, for plastic or wood; word processors, for typewriters; and microwave ovens, for conventional ovens. It influences both the relative value/price, and switching costs of substitutes. The technological battle over relative value/price between industries producing close substitutes is the heart of the substitution process.

Technology and Rivalry

Technology can alter the nature and basis of rivalry among existing competitors in several ways. It can dramatically alter the cost structure and, hence, affect pricing decisions. For example, the shift to continuous process technology in the corn wet milling industry has also raised fixed costs and contributed to greater industry rivalry. Another impact of technology on rivalry is its effect on exit barriers. In some distribution industries, automation of materials handling has raised exit barriers, as the materials handling equipment is specialized. Hence, what were once general-purpose facilities have become specialized and capital-intensive.

Technological Change and Industry Boundaries

Technological change plays an important role in altering industry boundaries. The boundary of an industry is often vague because distinctions between an industry's products and substitutes, incumbents and potential entrants, and incumbents and suppliers or buyers are often arbitrary. However, the key is that, regardless of where one chooses to draw industry boundaries, technological change can broaden or shrink them. It widens industry boundaries in many ways. It can reduce transportation or other logical costs, thereby enlarging the market's geographic scope. Technological change that reduces the cost of responding to national market differences can help globalize industries. It can also enhance product performance, thereby bringing in new customers. Ultimately, technological changes can increase interrelationships among industries.

It is erroneous to think that technological change always improves the industry structure. It is just as likely to erode it. If entry barriers are raised, powerful suppliers are eliminated. If industry is insulated from substitutes, then it can definitely improve industry profitability. If it leads to more buyer power or lowers entry barriers, it may do the opposite by destroying industry attractiveness.

Role of the Firm

Creating or gaining competitive advantage and sustaining it in the global market would require honest-to-goodness effort, primarily on the part of the firm, as it is on the front line of international competition. Companies must increasingly compete globally.

Steps in Strategic Technological Management

1) *Identify all the distinct technologies and sub-technologies in the value chain.* Every value activity involves one or more technologies. The starting point in managing technology is to identify all the technologies and sub-technologies, no matter how mundane, of the firm or its competitors. A firm must gain a similar, if not deeper, understanding of the technologies in its suppliers' and buyers' value chains, which are often interdependent. Firms often focus on product technology, or on technology in the basic manufacturing operation. They ignore technologies in other value activities, and pay little attention to the technology for developing technology.

2) *Identify potentially relevant technologies in other industries or under scientific development.* Technologies often come from outside an industry, and these can be a source of discontinuous change and competitive disruption in an industry. Each value activity must be examined to see if applicable outside technologies exist. Information systems, new materials, and electronics should always be thoroughly investigated. All three have a revolutionary impact in creating new technologies or allowing new combinations of old technologies.

3) *Determine the most likely path of change in key technologies.* A firm must access the likely direction of technological change in each value activity, and in buyer and supplier

chains, including technologies whose sources are unrelated to the industry. No technology should be assumed mature. Its sub-technologies may be changing, but maturity may only be a sign of the lack of effort in technological innovation.

4) *Determine which technologies and potential technological changes are most significant in competitive advantage and industry structure.* Not all technologies in the value chain will have significance in competition. Significant technological changes are those that meet the following tests:

- Create a sustainable competitive advantage
- Shift cost or uniqueness drivers in favor of a firm
- Lead to first-mover advantages
- Improve overall industry structure

A firm must isolate these technologies and understand how they will affect cost, differentiation, or industry structure. Supplier and buyer technologies are often among the most important in this regard. Critical technologies will be those with a major effect on cost or differentiation, and where a technological lead is sustainable.

5) *Assess a firm's relative capabilities in important technologies and the cost of making improvements.* A firm must know its relative strengths in key technologies, as well as the realistic assessment of its ability to keep up with technological change. Pride should not obscure such an assessment, lest a firm squander resources in an area with little hope of contributing to competitive advantage.

6) *Select a technology strategy, encompassing all important technologies, that reinforces the firm's overall competitive strategy.* Technology strategy must reinforce the competitive advantage a firm is seeking to achieve and sustain. The most important technologies for competitive advantage

are those that help a firm sustain its lead, where drivers of cost or differentiation are skewed in its favor, or where technology will translate into first-mover advantages.

Included in a firm's technological strategy are:

- A ranking of R&D projects that reflects their significance in competitive advantage. No project should be approved without a rationale, describing its effect on cost and/or differentiation.
- Choices on technological leadership or followership in important technologies.
- Policies toward licensing that enhance overall competitive position, rather than reflect short-term profit pressures.
- Means of obtaining needed technology externally, if necessary, through licenses or other means.

7) *Reinforce business unit technology strategies at the corporate level.* While technology is ultimately linked to individual business units, a diversified firm can play two key roles to strengthen its overall technological position. The first is to assist in monitoring technologies for possible business unit impacts. A corporate group can invest in identifying and analyzing all streams of technology which might have wide impact, and then feed that information to business units.

The second key corporate role in technological strategy is in finding, exploiting, and creating technological relationships among business units.

The following specific actions at the corporate, sectoral, or group levels can strengthen a firm's overall technological position:

- Identify core technologies of the corporation that impacts on many units.
- Ensure that active and coordinated research efforts are

under way, and that technology migrates among business units.
- Fund corporate research in important technologies to create a critical mass of knowledge and people.
- Use acquisitions or joint ventures to introduce new technological skills to the corporation or invigorate existing skills.

Role of Government

Government plays a critical role in global competition because it influences competitive advantage. The proper role of government policy on industry is to stimulate dynamism and upgrading. It should also support its industries in entering new sectors where higher productivity can be achieved. The government should aim to create an environment in which firms can upgrade competitive advantages in established industries by introducing more sophisticated technology and methods and penetrating more advanced segments. Government policy should have a direct hand in improving the pool of advanced and specialized human resources, scientific knowledge, economic information, infrastructure, and other factors of production.

Government Policy on Science and Technology

The overriding principle in addressing technology should be to create an innovation policy, and not just a science and technology policy. The commercial innovation policy should go beyond technology, and must include action toward competition, regulation, and other pertinent areas.

Some characteristics of an effective policy are:

1) *Existence of a match between science and technology policy, and the patterns of competitive advantage in the nation's industry.* The appropriate policy toward science and technology must be consistent with the mix of competitive

industries, stages of competitive development, and the capacity of its firms and research universities.

2) *Emphasis on research universities, instead of government laboratories.* Economic upgrading is encouraged when government investments in R&D are heavily oriented toward research universities. University research offers more benefits by stimulating a rising level of productivity in an economy.

- First, new generations of scientists and technicians are trained in research and state-of-the-art problems.
- Second, the diffusion of research is facilitated by the relative openness of the university setting.
- Third, university research institutes and laboratories are fertile incubators of new businesses, as professors and students see ideas with commercial potential. Directing tremendous research funds to government laboratories is less likely to benefit the industry. Research in government labs is often far removed from commercial applications; diffusion is difficult; and researchers are less disposed to understand market needs, or think in an entrepreneurial manner.

3) *Specialized research institutions, focused on industry cluster or crosscutting technologies.* Internationally leading industries are often associated with specialized research institutes or university departments, often located in close proximity. These research institutions create a natural focus on solving industry problems and prompting more vigorous individual company research efforts. Trade associations play an important role in many nations, funding and even creating specialized research institutions.

4) *Research contracts.* Research contracts between firms and government research institutions or universities introduce market discipline, and facilitate more fluid interchange. The government can provide or match funds, or partially

underwrite costs. Encouraging industry to seek research contracts is a good means to support research in small- and medium-sized companies.

5) *Explicit dissemination mechanism.* Research in government laboratories and government-sponsored university research will not be diffused without explicit mechanisms. In Denmark, a well-developed system of government-paid agricultural consultants is a major force in disseminating new agricultural technology.
6) *Encouragement of research activity within firms.* The most important innovation comes from R&D. Firms themselves must apply technology to the needs of their industry. The government can provide the necessary encouragement in undertaking research activity. One way is to provide direct research grants or subsidies to firms. Another is by providing tax credits. The most effective means to directly encourage industry R&D seems to be to partially subsidize research contracts between firms and research institutions, particularly for small firms, as well as generously support universities.
7) *Primary emphasis on speeding the rate of innovation, rather than slowing diffusion.* The emphasis in R&D policy is realized through collaborative efforts; firms acting individually will underinvest in R&D because they cannot appropriate all the benefits.

Cooperative projects are only beneficial under the following conditions:

- First, they should be in areas with more basic product and process research. To catch up on state-of-the-art advances, the areas involved must not be connected to the firm's proprietary sources of advantage.
- Second, cooperative efforts should constitute only a modest portion of the firm's overall research.
- Third, cooperative research should only be indirect, and

take place through separate and independent entities, to which majority of industry participants have access.

- Fourth, the most useful cooperative projects often involve fields that impinge on a number of industries, and require substantial investment in R&D.

DISCUSSION

Quintin L. Kintanar

Countries like the Philippines choose carefully the products and services in which they can be competitive. This competitiveness aims to provide a real and distinctive advantage—a competitive edge in supplying the same products and services, with at least the same chances in an open field.

An example is the use of a colloidal product from seaweed called *carageenan*. This product is not yet easily acceptable in most markets. Although it is well accepted in the United States and Canada, it still has problems in the European market. Different technologies are used for the varying characteristics of carageenan, resulting in selected market acceptance.

The technology we use to produce natural-grade carageenan involves a shorter process that bypasses certain filtering and refinement stages. As a result, the product is cheaper by 40 percent, which is a distinct competitive advantage.

However, the European Union, will not accept carageenan that has more than two percent of *acid insoluble matter*, which is actually cellulose, and is not removed in the Philippine process. This is where S&T comes in, as studies were subsequently done on Philippine natural-grade carageenan.

Toxicological studies have been performed to check on the mutagenicity, carcinogenicity, and other related aspects of carageenan. These studies are prerequisite tests on new food products or additives, prior to market introduction. The results of a joint BFAD-UP study on carageenan have been presented to the Joint Expert Committee of the WHO and FAO, eventually concluding and classifying carageenan as a good and safe product.

Every food product to be introduced into the world market should be backed by adequate scientific and technological studies, in order to prove its efficacy.

We are on the verge of convincing the European community

that our carageenan is as good as, if not better than, other similar products in the market. The multiplicity of its uses is very surprising, since it is used not only in food, but also in pharmaceuticals and cosmetics as an additive.

Thus, in order to be competitive, we must have an edge, even in terms of raw materials. For instance, it is only in the Philippines where carageenan grows in farms. Elsewhere, it is gathered in the wilderness. In addition, we have the technology for growing this seaweed as well as for extracting carageenan.

The competitive edge will come in the form of better technology, and those countries with more efficient and productive technologies will always have this edge. Of course, other factors are also important, such as better management, better organizational structure, and greater technical expertise.

Managing Technology in the Metal Engineering Industry

PACIFICADOR C. DIRECTO

Chapter 17

Defining the Metal Engineering Industry

Industry Groupings

The Metals and Engineering Industry is divided into three major groups: the Iron and Steel Group, composed mainly of large steel mills that process and produce flat and long steel products on a continuous production basis; the Mechanical Engineering Group (or Metal Engineering Group, for proper distinction), composed mostly of small-and medium-sized shops that process all industrial alloys, usually on an intermittent basis, producing engineered and custom-built products; and the Nonferrous Metal Group, composed of large and medium-sized mills that process and produce extruded or drawn aluminum and copper-alloys products on a continuous basis. While there is a lot of interlinking among the processes, the aforementioned groupings, from the economic viewpoint, are the three very distinct groups in the metal engineering industry.

The Iron and Steel Group (or simply Steel, since Iron is still nonexistent) is composed of steelmakers, steel-rollers, rerollers (galvanized sheet producers), wire drawers, wire rope makers, electrode makers, pipe and tube makers, and tin can manufacturers.

Their major downstream consumers are the Construction, and Shipbuilding Industry Sectors.

The Engineering Group is composed of foundries and diecasting shops whose major downstream consumers are the machinery, automotive, and appliance industry sectors. Of these, the machinery sector is the largest, made up of the agricultural machinery and the industrial (power and ancillary) machinery subsectors.

The Nonferrous Metal Group is composed of the copper smelter, copper rod mills, copper wire mills, aluminum extrusion mills, and aluminum or copper tubing mills. Their major downstream consumers are the pressworking plants, and the Construction, Automotive, and Appliance Sectors.

Definition of Terms

• Processes

Steelmaking – The production of semifinished steel products, like slabs and billets, from steel scrap, either by conventional casting in metal molds or by the continuous casting process.

Rerolling – The production of galvanized steel from cold-rolled steel coils or sheets, including the production of tinplates for can-making, thin brass or aluminum sheets.

Drawing – The production of steel wires and wire products, like welding electrodes, wire ropes, and common wire nails.

Pipemaking - The production of steel pipes and tubes, black or galvanized.

Metalcasting – The production of metal castings, in general (the process is called metalcasting, and the product is called metal casting), but which may be subdivided into founding and diecasting:

Founding – The production of metal castings of any alloy, by pouring the molten metal into disposable sand or refractory molds.

Diecasting – The production of metal castings of nonferrous metals, by introducing metal into nondisposable metal molds or dies, either by gravity or high pressure.

Forging – The production of hot-worked (forged) products from steel blanks or billets, through the use of mechanical or power hammers.

Tool & Diemaking – The fabrication of steel forging- and cutting-dies for forging and stamping operations, including the fabrication of tools, jigs, and fixtures in machining and assembly, and the making of molds for the forming processes.

Machining – The machine finishing of rough casting and forgings into specified dimensions to fit as parts or components of finished products.

Pressworking – The stamping or deep-drawing of sheetmetal parts, through the use of mechanical or power presses.

N-F Casting – The casting of nonferrous (aluminum or brass) ingots, through the use of metal molds, to produce slabs or billets; or, the continuous casting of wire rods for subsequent rolling, extrusion, or drawing.

Mech. Working – The rolling, extrusion, or drawing of nonferrous metals into sheets, bars, structural shapes, wires, or tubings.

- **End Products (where Forming, Construction, Fabrication, and Assembly are implicit)**

Containers – Tin cans for packaging, products of the packaging sector's canmaking subsector.

Vessels – Marine vessels, such as ships, launches, barges, and small boats, the main products of the shipbuilding sector.

Structures – Buildings and bridges, the main products of the construction sector.

Vehicles – Self-propelled equipment, like motor vehicles and heavy equipment, including railway equipment, which are the main products of the automotive sector.

Appliances – The main products of the appliance sector, like refrigerators, freezers, room air-conditioners, cooking ranges, and stoves.

Housewares – Kitchenware, gadgets, and devices like pots and pans, corn mills, meat grinders, and gift items, such as figurines and vases, which are classified as a subsector of the metal manufactures sector (NES).

Machineries – General machineries, machines, and equipment, which are the main products of the Machinery Sector. These are further classified into the following:

- *Agricultural* – Machinery used for farm production, like power tillers, hand tractors, harvesters, and rice mills.
- *Mill* – Machinery used for heavy industrial production, like cement making machinery, mining equipment, saw mill machinery, steel mill machinery, sugar mill machinery, and refinery equipment.
- *Factory* – Machinery used for light industrial production, like foundry equipment, machine tools, woodworking machines, printing machinery, textile machinery, and sewing machines.
- *Industrial* – Machinery used as ancillary equipment in agro-industrial production like engines, electric motors and generators, power pumps, and air compressors.

Vision and Mission Statements

The Metal Engineering Industry states its *vision*, as follows:

"We believe in the vital and strategic importance of the Metal Engineering Industry in the industrialization of our country, and in the vast potentials and capabilities of our people."

"We envision the ultimate development and further advancement of this industry, making it stand equitably side by side with the best in the world and contribute its share in the economic prosperity of our country for the general well-being and happiness of our people deep into the next century."

And its *mission* is stated, as follows:

"Imploring the aid of Divine Providence, we commit ourselves to earnestly work together toward our chosen goal. We shall tap all possible sources of technology that can be adopted and adapted for the improvement of our processes and products, implement effective programs for the continuous development of world-class skills in our workforce, and work synergistically with government for the attainment of a business climate conducive to higher productivity, better profitability and lasting stability in our industry."

"Ours is an enduring industry that will always be entrepreneurial in spirit, global and self-propelled in character, and truly Filipino in heart, soul, and mind."

The Metal Engineering Industry at Present

The metal engineering industry is composed of two major sectors: metalcasting and metalworking. These two are like unidentical twins who, though distinctly different from each other, are quite

inseparable and interdependent. They have been jointly responsible for the advancement of every industrialized country in the world. The metalcasting sector is upstream to the metalworking sector, and provides much of the cast-metal raw materials for the latter's processing. As such, the quality of the product of the metal-working sector greatly depends on the quality of the castings of the metalcasting sector. No amount of sophisticated processing by the metalworking sector can make a good product out of a poor casting by the other sector. It is, therefore, quite logical and imperative to develop both sectors simultaneously.

The Metalcasting Sector

• *The Sector's Role in Development*

The metalcasting sector (composed of foundries and diecasting shops) is the taproot of the metal engineering industry, and is an export-oriented industry. It directly serves the construction and the shipbuilding industries, besides indirectly serving the automotive, appliance, and machinery industries, by providing raw materials for their machine shops. A cursory check at the history of all NICs shows that their success is partly, if not mainly, due to their highly developed metalcasting industry, as most metal parts and components originate from this vital industry.

• *Statistics on the Metalcasting Sector*

A brief presentation of statistical information gives a clearer idea of the present state of this industry. The geographical distribution of foundries is given in table 1.

Table 1

Geographical Distribution of Foundries, 1995

Region	*No.*	*%*	*Region*	*No.*	*%*	*Region*	*No.*	*%*
NCR	117(93)	57.9	IV	11 (5)	5.4	IX	4 (3)	2.0
CAR	2 (2)	1.0	V	0 (0)	0.0	X	3 (0)	1.5
I	12 (4)	5.9	VI	18 (13)	8.9	XI	6 (4)	3.0
II	0 (0)	0.0	VII	24 (17)	11.9	XII	1 (1)	0.5
III	2 (4)	1.0	VIII	0 (0)	0.0	ARMM	2 (2)	1.0
						TOTAL	202(148)	100.0

Note: Numbers in parenthesis are 1987 figures for number of foundries.

The number of foundries in NCR and Regions 1, 4, and 7 increased significantly in 1995. This indicates a semblance of growth, as gleaned from the increase in the number of players in the sector.

The classification of foundries, based on the metal alloys they cast, is shown in table 2; and, according to the size of their companies, in table 3.

Table 2
Classification of 202 Companies, 1995

Alloy Cast	*Number*	*Percent*
Gray Cast Iron	106	35.6
Ductile Cast Iron	13	4.4
Malleable Cast Iron	4	1.3
Cast Steel	33	11.1
Cast Bronze	66	22.1
Cast Aluminum	70	23.5
Unknown	6	2.0
TOTAL	**298*	*100.0*

*** Double counting is inevitable as some companies cast more than one alloy.**

Table 3
Company Size Classification

Category	*1995*	*1987*
Micro **	9.6	—
Cottage	21.2	42.6
Small	38.4	41.2
Medium	21.2	5.4
Large	9.6	10.8

**** There was no "Micro" category in 1987.**

Table 4

Summary of Annual Production of Metal Castings***

(in tons per annum)

Alloy	*1987*	*1988-89*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*%CGR*
Gray cast iron	63,012	na	85,012	336,550	225,568	252,174	208,714	261,310	25.2
Ductile cast iron	na	na	1,131	832	689	1,612	1,560	1,691	8.4
Mall cast iron	na	na	na	na	na	516	184	66	-64.3
Cast steel	60,412	na	11,616	12,276	12,276	10,956	9,273	8,763	-5.5
Cast bronze	5,846	na	30,162	12,804	12,804	14,388	8,382	6,085	-27.4
Cast Aluminum	13,167	na	16,380	16,450	16,450	17,500	38,780	48,087	24.0

***based on the results of an industry survey made by the MIRDC in 1995.

Table 4 gives a summary of the annual production of metal castings over a six-year period, from 1990 to 1995. Note that gray iron, ductile iron, and aluminum have positive growth rates, while malleable iron, steel, and bronze have negative growth rates. Ductile iron is on the rise, and is eating into the markets of both malleable iron and steel. This is not unexpected because ductile iron's mechanical and physical properties are equal, if not superior, to those of malleable iron and steel. This is the primary reason why ductile iron has grown tremendously at the expense of malleable iron and steel in the developed countries.

• *Level of Development of the Metalcasting Industry*

In a way, the level of development of ductile iron could be a measure of the development of the metalcasting industry. The present stage of development of ductile iron could be indicative of the level of development of its metalcasting industry.

This is illustrated in table 5, which is a comparison of Philippine (1995) and Japanese (1985 and 1965) metalcasting industries.

Table 5
Comparison of Philippine and Japanese Foundries

Alloy Cast	Phils. (1995) %	Japan* (1985) %	(1965) %
Gray cast iron	35.6	54.2	62.9
Ductile cast iron	4.4	26.7	16.0
Malleable cast iron	1.3	4.6	5.5
Cast steel	11.1	8.4	11.7
Cast bronze	22.1	1.6	2.3
Cast aluminum	23.5	4.5	1.6
Unknown	2.0	—	—
TOTAL	100.0	100.0	100.0

* The Soekizai Center of Japan, *Annual Statistics of Materials Process Industries,* August 1990.

Table 6

Summary of Ratings of Selected Foundries* (only 114 of 202 companies were rated)

Rating		Gray Iron		Ductile Iron		Mall. Iron		Cast Steel		Bronze		Aluminum		TOTAL	
	Points	*No.*	*Share %*	*No.*	*Share %*	*No.*	*Share %*	*No.*	*Share %*	*No.*	*Share %*	*No.*	*Share %*	*No.*	*Share %*
3A	19-20	11	17.5	7	58.4	2	50.0	12	52.2	6	13.0	10	17.5	48	23.4
2A	16-18	8	12.7	3	25.0	2	50.0	1	4.3	6	13.0	3	5.3	23	11.2
A	13-15	13	20.6	1	8.3	0	0	7	30.4	5	11.0	8	14.0	34	16.6
B	10-12	18	28.6	0	0.0	0	0	3	13.1	15	32.6	19	33.4	55	26.8
C	7-9	13	20.6	1	8.3	0	0	0	0.0	14	30.4	17	29.8	45	22.0
		63	100.0	12	100.0	4	100.0	23	100.0	46	100.0	57	100.0	205	100.0

Legend: Class 3A Foundry = 19-20 points: has very good or sufficient control (good technology
Class 2A Foundry = 16-18 points: has good or adequate control (acceptable technology)
Class A Foundry = 13-15 points: has fair or just enough control (fair technology)
Class B Foundry = 10-12 points: has poor or inadequate control (poor technology)
Class C Foundry = 7- 9 points: has very poor or insufficient control (very poor technology)
*Summarized from the MIRDC Metalcasting Study of 1995.

Table 5 shows that the *Philippines is more than 30 years behind Japan, in the metalcasting industry. The Philippines in 1995 had not even reached Japan's 1965 level.*

• *Rating of Foundries*

A rating of some of the foundries in the Philippines indicates the level of technology applied in their operations. The ratings, shown in table 6, are based on their technical capability to produce quality castings. This rated capability is based only on their existing equipment for production and quality control which indicates the level of applied technology. Other factors, like manpower skills and quality control/rectification methods, have not been included due to their inaccessibility.

From table 6, about 30 percent of the gray iron foundries is of high A quality rating, while 70 percent is of fair A and poor B/B ratings. In ductile iron, more than 83 percent of the foundries is of high A rating, while all the malleable iron foundries are of high A rating. Again, more than 56 percent of the steel foundries is rated high A, while only about 26 percent of the bronze and 23 percent of the aluminum foundries is rated high A.

Overall, only about 35 percent of the total foundries could be considered as having acceptable applied technology. The rest have below par applied technologies. They may know or be aware of new technologies, but these are not being applied and manifested in their operations.

Foundries with low ratings need the most assistance. This would help upgrade their capabilities and consequently their ratings; thereby strengthening their positions in the industry.

The Metalworking Sector

The metalworking sector is engaged in the transformation of metal raw materials into usable products, such as machines and their parts and components, transport equipment, agricultural machinery, and tools and implements. It also produces articles, like cutlery, metal furniture, and household appliances. The sector could be con-

sidered as the trunk (or backbone), upon which all other industries of the economy are anchored. Machines, machinery, and equipment, which invariably involve metal parts and components, come from this sector.

• *Statistics on the Metalworking Sector*

The number of establishments in the metalworking industry are given in table 7, sourced from the *1994 Philippine Yearbook*.

Table 7 shows that:

- Establishments with less than 10 workers and belonging to the small enterprise category make up 85 percent of the total, while the rest consists of medium-sized and large firms. (Large firms may only be 15 percent of the total number of firms.)
- In terms of employment, companies with more than 10 workers account for 81 percent of the sector's workforce.

Economic statistics on the metalworking sector are shown in tables 8 and 9, taken from the *1994 Philippine Yearbook*.

Using the following formula:

Materials/Services + Value-Added = Value of Output

the percentage share of each column item in table 8 is computed and incorporated in the table. The same is done for table 9.

In table 8, with a value-added share of 60.41 percent of output, the amount plowed back to fixed assets is only 1.84 percent. Compensation to labor amounts to 19.74 percent.

In table 9, with a value-added of 31.16 percent output value, the amount plowed back to fixed assets is 3.89 percent. Compensation to labor amounts to only 9.00 percent. Larger companies have a lower value-added than the smaller companies in table 8, which probably

Table 7

Number of Establishments Engaged in Metalworking

Subsector	Companies with <10 workers		Companies with >/= 10 workers		GRAND TOTAL	
	Number	*Employment*	*Number*	*Employment*	*Number*	*Employment*
Mechanical Machinery	1,335	7,480	460	20,076	1,795	27,556
Electrical machinery	55	236	208	58,078	263	58,314
Transport equipment	280	1,585	210	17,363	490	18,946
Furniture/fixtures	29	224	28	1,048	57	1,272
Fabricated metal products	6,059	18,851	415	25,175	6,472	44,026
TOTALS	**7,758**	**28,376**	**1,321**	**121,740**	**9,077**	**150,114**

Table 8
Statistics for Establishments with Less Than 10 Workers
(in PhP Thousands)

	Compensation	*Value of Output*	*Materials/Service*	*Value-Added*	*Addition to F/A*
Mechanical machinery	114,938	413,469	173,780	239,686	13,673
Electrical machinery	3,120	9,492	3,366	6,126	600
Transport Equipment	28,178	210,080	135,999	74,081	2,307
Furniture/fixtures	2,535	16,154	12,305	3,849	—
Fabricated metal products	243,126	1,336,165	460,599	875,566	19,889
TOTALS	391,897	1,985,360	786,049	1,199,308	36,469
SHARES (%)	19.74	100.0	39.59	60.41	1.84

Table 9
Statistics for Establishments with 10 or More Workers
(in PhP Thousands)

	Compensation	*Value of Output*	*Materials/Service*	*Value-Added*	*Addition to F/A*
Mechanical machinery	757,547	4,819,054	3,142,273	1,676,781	223,682
Electrical machinery	3,203,091	32,798,258	21,797,754	11,000,054	1,574,188
Transport Equipment	849,948	18,170,327	13,693,602	4,476,725	596,523
Furniture/fixtures	32,063	176,108	97,928	78,180	15,027
Fabricated metal products	914,120	7,998,859	5,293,618	2,700,241	80,880
TOTALS	5,756,769	63,957,606	44,025,175	19,931,981	2,490,300
SHARES (%)	9.00	100.0	68.83	31.16	3.89

means that they spend more on materials and services. The lower labor compensation share indicates that they are more mechanized, using higher technology levels, and have relatively less personnel.

Technology-related Problems of the Industry

Technology has three facets: knowledge, skill, and proficiency. Knowledge is acquired through schooling, information, or training; skill is acquired through training, or application; and proficiency is acquired only through application—constant application. In the Philippine context, it is safe to say that knowledge in metal engineering technology is not wanting. About 90 percent of engineers, technicians, and skilled personnel is aware and possesses some knowledge of new technologies. About 75 percent of them possesses the necessary skills. However, only 25 to 30 percent has acquired the necessary proficiency. This sets the local metal engineering industry behind the rest of the ASEAN countries, if not the whole of Southeast Asia. This is mainly due to the lack of modern facilities in industries.

Generally speaking, a crucial problem is the antiquated machinery and equipment of most of the establishments. *Although new technologies may be known,* these find difficult application on dated equipment.

In metalcasting, the most "progressive" foundries are still in the "jolt-squeeze" stage of molding—producing molds at the *maximum rate* of 20 to 25 molds per hour, per machine, while Thailand foundries now produce molds at a minimum rate of 120 molds per hour, per machine. This situation cannot hold up in today's foreign market requirements of hundreds of thousands of pieces per item in one order. The market would be the domestic market requiring custom-built castings. The technology is there, but it cannot be applied.

In metalworking, most of the machine shops are still equipped with conventional machine tools—15 to 30 years and even older. This fact has made the Philippines a lucrative market for reconditioned, second-hand machines, those already phased out five or 10 years ago by the supplier countries. While several tool and die shops

have upgraded their facilities, notably in machining and grinding, the sector has generally not advanced as fast as its counterparts in the Asian region. The sector finds it difficult to attain the accuracies required by present-day precision parts.

Response of the Industry

Like a good mechanic who has to make a dilapidated machine run, even if he has to put it in crutches, the metal engineering industry has been doing what it can—even if these are only stop-gap measures.

To get around the lack of sophisticated and expensive machines and facilities, a system of "equipment complementation," or "facilities-sharing," has been conceived by the Metalworking Industries Association of the Philippines (MIAP), whereby a shop need not purchase its own expensive machines if these are found in some other shops and available for leasing during the machines' idle times.

Alternatively, the idea of "common service facilities" is also being considered, whereby a facility with all the needed up-to-date machines, like wire-cut EDM, EDM die-sinking, and heat treatment facilities, could be set up and made available, for a fee, to whoever needs them.

Although the need to modernize facilities is recognized, the metalcasting sector still harbors a wait-and-see attitude due to the lack of financial sources. This, however, could be very costly considering the vast opportunities created by Japan's phaseout of most of its foundries and their relocation to other countries in Asia. For its part, Thailand is already working toward meeting Japan's metalcasting needs by modernizing the industry. Indonesia is closely following suit. The Philippines, however, is not even on the horizon.

More Serious Problems

But the metal engineering industry has more serious problems other than technology. These problems push technology needs down the priority list. Consider the following:

• *Manpower*

Manpower attitudes and skills are high on the problem areas. In spite of the dearth of skilled manpower, labor continuously harasses management when a company starts to export its products on the mistaken notion that it now makes a lot of money. Often, however, the company barely breaks even in exports, yet it needs to go into it in order to keep production going and the labor force employed.

In the metalcasting sector, the shortage in skilled manpower is glaring. This is shown in table 10.

Because the present foundry training facilities produce only 80 skilled workers a year, the Philippine Metalcasting Foundation Inc. (PMFI), in cooperation with the Philippine Metalcasting Association Inc. (PMAI) and Quezon City Polytechnic (QCP), plans to set up a Foundry Technology Training Center, which is expected to produce about 565 graduates and skilled workers per year. However, the slowness of government response is appalling, to say the least.

Although there are no hard data, shortage of skilled manpower is also very much felt in the metalworking sector as manifested by the persistence with which the MIAP is conducting training seminars, which are incidentally very popular among metalworking shops. The MIAP is closely coordinating with the Technical Education and Skills Development Authority (TESDA) in this regard. It has set up Trainors' Training Programs with TESDA to upgrade technology instruction in technical-vocational schools.

If the present situation continues, the Philippines could be eased out of the industrialization race. This is a reality that the country must face if nothing is done about the present situation.

• *Materials*

Another significant problem is the supply of raw materials and manufacturing supplies. About 90 percent of these is imported, usually from competitor countries. Thus, the reliability of supply cannot be assured, as their priority would be the domestic demand. If the Philippines is expected to compete, this situation should be viewed with grave concern, not only by the industry, but by those that will be affected.

Table 10

Estimated Number of Direct Workers Needed in the Metalcasting Sector

(1995-2000)

Alloy	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*%CGR*
Gray cast iron	4,577	5,730	7,174	8,982	11,246	14,080	25.2
Ductile cast iron	565	612	664	720	780	846	8.4
Mall. cast iron	167	167	167	167	167	167	0.0 *
Cast stell	1,427	1,349	1,274	1,274	1,138	1,075	-5.5
Cast bronze	2,842	2,063	1,498	1,088	790	573	-27.4
Cast Aluminum	3,022	3,747	4,647	5,762	7,145	8,859	24.0
Unknown	258	258	258	258	258	258	0.0 *
TOTAL	12,858	13,926	15,682	18,181	21,524	25,858	15.0
New workers	----	1,068	1,756	2,499	3,343	4,334	41.9
Graduates per year (from BNSAT, CSCST, and MIRDC)	----	80	80	80	80	80	0.0 *
NET SHORTAGE	-----	988	1,676	2,419	3,263	4,254	44.0

*For lack of reliable data, the growth rates for these are assumed at zero (0.0%) percent.
All the others are based on the growth rates of Table 4.

A more sincere political will is needed to alleviate this serious situation. There is a need to develop more indigenous sources of materials; otherwise, the Philippines will forever be "under" the supplier countries. Meanwhile, importation of materials should be made cheaper, to the extent of making import duties zero, similar to Taiwan. Incentives "before" the processing of the product, like zero duties and low taxes, are more effective than incentives "after" processing, like tax holidays.

• *Electric Power*

A problem that is so subtle it is barely discernible, but which can easily wreak havoc for sophisticated equipment, is the unreliable electric power supply. Fluctuations in voltage disrupt operations, if not severely damage very expensive computer-controlled equipment. In view of this, many establishments have chosen to defer the purchase, installation, and use of such machines until they could be assured of a steady and reliable power supply. Being safe is often better than earning profit, especially when the risk is too obvious and expensive.

Unfortunately, the unreliable power supply can only be solved by the National Power Corporation and the other electric utilities. There is thus a need for better electrical power service, as this is the major source of energy.

Conclusion

In the metal engineering industry, most new technologies are actually known, in other words, "knowledge" exists. To a lesser degree, "skill" also exists. The real problem is the actual application of these technologies in an industry in need of sophisticated equipment. Because of the unavailability of such equipment, the technologies could not be applied. "Proficiency," which is the productive and more important facet of technology, is nonexistent. The industry sorely needs assistance in this area.

The industry considers these problems as more crucial than technology because technology is not really wanting. The economic factors

besetting the industry are the real culprits—responsible for the Philippines' inability to stay at par with its neighbors.

Where to from here, Philippines?

DISCUSSION

Rolando C. Viloria

The metal engineering industry cuts across a vast field of industrial activities. It covers almost all productive sectors in the economy, such as mechanical machineries, electrical machineries, transport furniture and fixtures, and the fabrication of metal products. Some 9,000 establishments, employing nearly 150,000 people, are engaged in this sector. Just like any industry, the metal engineering sector is exposed to global competition. Because economic theory has formally acknowledged technology as an engine for economic growth, strategies in the accumulation of innovation-based technology become a prerequisite to international competitiveness. In short, technology is a key factor in international trade.

But is the technology being managed in this sector both in the macro and micro or firm levels? For purposes of discussion, technology may be defined as a system of knowledge, techniques, skills, and expertise in organization used to produce, commercialize, and utilize goods and services that satisfy social economic demands. All business activities, for that matter, use technology as a tool, differing only in their sophistication.

Technology also includes other tools or means, considering that innovative effort does not only include investment in physical assets, but also intangible investments, like training, technical assistance, organization, and information systems. There are four dynamically interrelated components that comprise technology as a means for production. The elements of productive technologies are available in four distinctive forms; namely, *technoware, humanware, infoware,* and *orgaware.*

First, the object-embodied physical facilities called technoware include such things as tools, equipment, machinery vehicles, etc. In business enterprise, technoware changes through peri-

odic substitution. In general, the degree of technoware sophistication corresponds to the increasing complexity of physical facilities for transformation operations and other functions. In this aspect, the foremost constraint affecting the metal engineering industry is the use of outdated, refurbished, and manually operated technoware. These physical facilities have adopted mostly reconditioned, second-hand equipment, that are about 10 years old or older. The technoware is inadequate for the export market, and will no longer be appropriate for future domestic needs. In the metal engineering industry, only a small segment of the metalworking sector, particularly the tool and dye making subsector, has adequate facilities.

Second, the human-embodied facilities called humanware include skill, craftmanship, expertise, dexterity, and creativity. No amount of substitution building, technical assistance, or joint ventures can bear fruit if these are not coupled and carefully synchronized with effective human resource development. Without humanware, technoware is useless because technology is a system of knowledge and experience.

In the metal engineering industry, there is inadequate assurance of output quality. The lack of trained personnel with research and development skills hampers the modification of products and processes for higher value addition. There is currently a critical shortage of skilled and knowledgeable workers to run modern equipment with a larger scale of output. Moreover, there is very little local expertise available for the maintenance and repair of sophisticated facilities.

The third element is the record-embodied documented knowledge called infoware, which refers to facts and formulated design parameters, specifications, manuals, theories, etc. An illustrative example of infoware sophistication, from lower to higher levels, includes documented knowledge that provides awareness, regarding technology components, manuals for operation and maintenance of physical facilities, availability of up-to-date facts and figures for acquisition and optimal performance, access to latest theories, and state-of-the-art knowledge for innovation. In this aspect, there is also a lack of relevant

knowledge, thereby creating another bottleneck for local innovation.

The fourth element is the institution-embodied organizational framework called orgaware, as exemplified by methods, techniques, organizational networks, and management techniques. It is also in this very important productive component of technology where there is a prominent deficiency, in terms of linkages to the source of technology and information regarding the global market. These problems have compounded and have been the basic reasons for the poor technological state of the metal engineering industry.

To summarize, the metals industry, particularly the small- and medium-scale enterprises (SMES), does not have the capacity to improve its technological capacities as firms and as clusters. There is a need not only to modernize firms' production capabilities, but also to upgrade their personnel. This is because of the job-shop nature of firms, due to being service contractors for OELS, their client-driven technology, and lack of orientation to become independent suppliers.

There is also the lack of technology-based organization and cooperation, among related companies, as well as a lack of leadership in upgrading technology. The industry puts its attention on output quality, without even picturing a higher value added in the market. In other words, the firms do not see the potential of market differentiation.

The lack of government support facilities has further compounded the situation. It is, however, worth noting that programs and projects have been implemented to address the industry's technology-related problems. Technology business incubators and science parks have achieved some success.

In this regard, the Metal Industries Research and Development Center (MIRDC) of the DOST is directly mandated to promote the metal engineering industry. It has also adopted a system of equipment complementation and established common service facilities.

The Center will also be establishing *regional service centers* (RSCS). The establishment of RSCS is parallel to the national

government's policy of regional dispersal of industries to promote countryside development. Derivatives of the regional service centers are the *regional metal testing centers (*RMTCS*)*, which were established all over the Philippines.

As far as the technoware problem is concerned, the MIRDC could serve as a venue for new and advanced technologies, which can be diffused, transferred and, more importantly, applied to SMES through common service facilities.

As to humanware, the MIRDC is continuously conducting training programs. Some 2,000 individuals have already been trained in the last three years. The shortage of skilled manpower, particularly in the design and making of tools and dye, will be addressed by the establishment of a *Tool and Dye Center,* which will be funded by the Japan International Cooperation Agency (JICA) in the amount of US$4 million. The UNDP has also allotted US$560,000 to subsidize the Center's training cost.

For infoware, the MIRDC will establish a database for the metal engineering sector, with the provision of US$400,000 from the UNDP. This project will give the industry access to data that will catalyze the formation of business alliances among manufacturers, suppliers, and buyers in the domestic and international markets.

Whether or not we will succeed in capturing a respectable market share locally, or carve a niche in the international market, remains to be seen. This prospect is highly dependent on our continuing commitment to advance our metal engineering technologies. We hope to do this as our modest contribution to the national drive to achieve, if not surpass, the vision and goals of Philippines 2000. I am confident that we all know where we want to go, and that we will be able to get there.

Managing Technology in the Pharmaceutical Industry

JOSE O. JULIANO

Chapter 18

Industry Background

The Pharmaceutical and Healthcare Association of the Philippines (PHAP) is composed of 87 Filipino and multinational pharmaceutical companies which, on the aggregate, provide over 90 percent of the medicines in the Philippine market.

The PHAP therefore represents the bulk of the pharmaceutical industry in the Philippines and, in particular, the research-based industry, which is the source of new drug therapies. PHAP members have 25 pharmaceutical manufacturing plants in the Philippines. Approximately 85 percent of the country's finished pharmaceuticals are locally manufactured, with most of the output coming from plants of PHAP member companies.

Composition of the Industry

The following are key facts about the pharmaceutical industry:

- The local industry, as reflected by the PHAP membership, includes companies in the manufacture, distribution, and wholesale and retail sales of finished pharmaceuticals and related specialties;

- These companies fall under two primary classifications: namely, pharmaceutical establishments and drug outlets;
- Pharmaceutical establishments are companies involved in the manufacture, importation, repackaging, and distribution of drug and medicines;
- Drug outlets are drugstores, pharmacies, and other establishments that sell pharmaceuticals at retail level, or dispense them for the direct use of consumers, as in the case of industrial clinics;
- There are more than 800 licensed pharmaceutical establishments;
- There are some 9,000 drug outlets; and
- Most pharmaceutical dealings are coursed through retail drugstores, at 75 percent; and hospital pharmacies, at 14 percent. Approximately 11 percent of business is from sales to the Department of Health and local governments, dispensing physicians, other institutions, and exports.

Classification of Pharmaceuticals

Pharmaceutical products can be classified according to therapeutic action, method of dispensing, dosage form and strength, and nature of basic raw material.

Pharmaceutical products can vary in their action, even when they share similar properties in terms of therapeutic activity, tolerability, side effects, and others. These variations enable treatment to be tailored to individual patients' needs, taking into account their physical condition, possible allergies, and potential interactions with other drugs.

Manufacturing

Pharmaceutical manufacturers in the Philippines do not produce active substances locally, with the exception of a government-controlled company that imports an intermediate substance and produces semisynthetic antibiotics. Local manufacture of pharma-

ceuticals is undertaken either by the manufacturer's own plant or by a contract manufacturer, such as Interphil Laboratories.

Basic manufacturing is distinct from pharmaceutical manufacturing. The former is the production of active substances—fine chemicals—requiring the operation of various plants (e.g. for synthesis or fermentation). The latter is the manufacture of finished pharmaceuticals, which is well-developed in the Philippines and is, in fact, already a saturated sector with underutilized capacity.

In order to be viable, basic manufacturers must generate and sell large volumes of active substances. Thus, there are relatively few basic manufacturing plants for different active substances, worldwide. Most of these plants are located in countries where innovative pharmaceutical research and development is conducted. Basic manufacturing plants are also located in countries, such as China and India, whose indigenous markets number several hundred million people.

In Indonesia, the UNIDO study shows discouraging results of the plan to require basic chemical manufacturing. It failed because it was not market driven. Their cost of production was higher than in other countries.

Imports

As in most countries, pharmaceutical companies in the Philippines import active substances. However, pharmaceutical imports constitute only a little more than one percent of total imports. Unless economies of scale are obtained, the importation of active substances costs less than local production.

The pattern of imports directly reflects the pharmaceutical industry's output. In terms of rank, antibiotics come first; followed by vitamins, bacteriological products, serums, and vaccines.

Size and Composition of the Market

The pharmaceutical market was valued at P34.35 billion in 1995. In the first semester of 1996, market growth was 20 percent by value,

and 25 percent by units, compared to the same period in 1995.

Given continued political stability, increased employment and purchasing power, resulting from sustained GNP growth at six to seven percent, and with population growth at slightly more than two percent, the medium-term growth of the market is expected to exceed its average compounded growth rate of 15 percent, from 1991 to 1995.

A 1995 breakdown of drugstore sales by region shows that Metro Manila accounted for 46.7 percent; Luzon, 27.4 percent; Visayas, 13.4 percent; and Mindanao, 12.4 percent.

Metro Manila, which has only 13 percent of the country's population, takes the lion's share of pharmaceutical sales for a number of reasons: the capital is the main location of pharmaceutical manufacturing and trading; bulk purchases for the provinces are made in Metro Manila; per capita income in the area is comparatively higher; the metropolitan population is better informed about available pharmaceuticals and healthcare; and, there is greater access to healthcare facilities and professionals.

Competition

An outstanding feature of the pharmaceutical industry is its high level of market competition. Few modern industries have witnessed so much product innovation and replacement of vital discoveries in so short a time.

The competition arises, in part, from not having a single market. The industry is actually composed of several therapeutic segments. Within each of these segments, there is vigorous competition because physicians and consumers have a wide latitude for substituting one product for another.

However, the products of one therapeutic segment are not usually replaceable by products of another. For example, cardiovascular drugs are not effective for treating infections. Therefore, a pharmaceutical company competes with other companies in different therapeutic categories.

Having more than 3,600 brands, competition in the market is

intense and continuous. The list of leading pharmaceutical companies and top-selling products is dynamic, and changes substantially every few years. There are approximately 300 corporate groups, representing more than 400 pharmaceutical companies in the market. Not one manufacturer or product dominates.

Local pharmaceutical manufacturing is an industry in which Filipino-owned companies have shown strength. The United Laboratories group, a Filipino multinational company, accounts for about 22 percent of market share.

While non-Filipino multinational companies have an aggregate market share of 74.5 percent on drugstore sales, their individual shares range from less than one percent to under 10 percent.

Pharmaceutical distribution and retailing are controlled by Filipino-owned companies.

The Role of Research and Development

The pharmaceutical industry is driven by R&D, the sustained effort to discover, and eventually bring to the market, drug innovations, known as new chemical or molecular entities.

The chronology of drug innovation has progressed from serendipitous observation, at the turn of the century, to tissue biochemistry in the 1940s and 1950s, cell biochemistry from the 1960s to the 1980s, and the 1960s focus on molecular structure, which will extend into the new century.

The introduction of the first sulfa drug in 1935, which generated interest in drug research, was followed by the successful development of penicillin, the most significant anti-infective developed during World War II. The 15 years between 1938 and 1953 became known as "The Golden Age of Antibiotics," owing to the unprecedented number of new anti-infectives introduced during the period.

Antibiotics and vaccines played a major role in the control of six major diseases of the 1920s: influenza/pneumonia, tuberculosis, syphilis, diphtheria, whooping cough, and measles.

Despite a recent resurgence of tuberculosis, antibiotics had re-

duced the number of TB deaths, since the 1960s. Today, most patients can recover in six to 12 months, given the full and proper course of antibiotics.

Progress Against Disease

Since the 1950s, pharmaceutical discoveries have revolutionized therapy for chronic, as well as acute, conditions. From 1965 to 1994, cardiovascular drugs, such as antihypertensives, diuretics, beta blockers, and ACE inhibitors, have offered effective treatments for hypertension and heart disease. Similarly, H-2 antagonists, proton pump inhibitors, and combination therapies have reduced deaths and disability from ulcers. Anti-inflammatory agents and bronchodilators have cut deaths from emphysema, and have provided relief from asthma.

Since the 1960s, vaccines have greatly reduced the incidence of childhood diseases.

From the discovery of aspirin at the turn of the century, advances in both scientific understanding and technology have enabled pharmaceutical researchers to target more complex diseases successively.

Research on tissue biochemistry has provided insights that led to the successful development of antibiotics. As antibiotics enabled people to live longer, researchers focus on cell biochemistry. In the future, new knowledge of the human genome will enable drug researchers to target the causes of diseases, rooted in the human molecular structure.

The Promise of Biotechnology

Scientists now have a varied array of biotechnology tools to work with in the fight against disease. For example, monoclonal antibodies act as "magic bullets," selectively binding with foreign organisms or specific cells. They can be used to diagnose and treat diseases, or as homing devices that carry treatments to the disease site.

Gene therapy began as a method of replacing normal genes that

were missing in people with diseases, such as cancer and AIDS. The drug may be a genetically altered virus that can carry genes into the patient's cells via a laboratory procedure. Or it may be DNA itself, encapsulated in a fatty envelope and injected directly into cancer cells to make them susceptible to antiviral drugs. Or in an AIDS treatment, genes may be inserted into infected blood cells to make them produce HIV-like particles.

Today, pharmaceutical research and development can be characterized by the following:

- It is a process requiring the methodical investigation of substances and diseases, at the molecular level;
- The participation of teams of experts from various scientific and technical fields is necessary;
- It involves researchers, whose advanced equipment is worth millions of dollars, including mainframe computers;
- Innovative pharmaceutical R&D is found in perhaps no more than a dozen countries worldwide, where highly developed scientific, technical, and financial resources are available;
- More than 90 percent of pharmaceutical discoveries worldwide is made and funded by private companies, not governments;
- In the 1990s, the average length of time it takes to develop a drug has increased to nearly 15 years;
- Government economists have estimated that the pretax capitalized cost of bringing a new drug to the market averaged US$359 million, for drugs that entered clinical trials in the late 1970s. A precise estimate of the current cost of drug development, starting with the research process, is difficult to arrive at;
- R&D spending of research-based pharmaceutical companies in the United States is projected to reach US$15.8 billion in 1996, representing a 9.6 percent increase since 1995; and
- Pharmaceutical industry expenditures for R&D in the

United States make up 19 percent of sales, the highest among the manufacturing sector.

The state of R&D and the scarcity of resources are challenges that the industry accepts as reality. Pharmaceutical R&D is a high-risk business. There is no assurance of success.

Hundreds of millions of dollars worth of R&D investments can go down the drain. This happens when, for example, a drug that is already in an advanced stage of development is shelved due to safety problems. But such risks are routinely accepted by research-based pharmaceutical companies as part of the business.

Nearly 85 percent of pharmaceutical R&D is geared toward new products. Most R&D efforts aim for a new drug, with significant therapeutic advantages, such as a cure for AIDS. But there is no guarantee that this aim will be achieved. Indeed breakthrough drugs have been few and far between. Nevertheless, drug R&D must be financed in spite of attendant risks.

When a new drug does get to the market, there is no assurance that it will earn commensurate returns. In fact, only three out of every 10 drugs in the market generate returns higher than their average after-tax R&D costs. Given the high cost and risk of drug research, companies must rely on relatively few highly successful products to finance R&D.

Therefore, the profits of research-based pharmaceutical companies need to be commensurate to the risk they take in drug innovation. No one would buy stock in a company that invested huge sums for a modest profit, 10 or 15 years later, because the returns would not be attractive.

Given these conditions, it is therefore understandable that innovative pharmaceutical companies operate in different markets in order to achieve economies of scale and maximize profitability.

The Mission of Research-based Industry

The research-based pharmaceutical industry defines its mission as one of promoting cost-effective health care, by discovering and

bringing to the market innovative and life-saving drugs, which are more effective and safe, and offer maximum value.

Modern medicines save lives; improve the quality of life by eliminating or reducing suffering and pain; make hospitalization unnecessary, or of shorter duration; prevent or reduce lost productivity or incapacitation; and promote the well-being of people.

New and better drugs promote cost-effective health care insofar as they present advances in therapy. Medicines that can cure stomach ulcers effectively, without hospitalization and surgery, represent a good example of such advances. So do new anti-infectives which can cure infections faster and with fewer dosages and drugs that lower cholesterol levels. The most impressive new drugs include thrombolytics, which bring about dramatic and quick recovery from heart attack.

Industry Contributions to Health Care

Modern medicines have no doubt played a major role in significantly improving the country's overall state of health in past decades, along with the progress in medical science, sanitation, nutrition, and public health services.

- Today, the average Filipino lives 11.5 years longer than he would have 30 years ago. Average life expectancy, which was 53.1 years in 1960, increased to 64.6 years, in 1990.
- Crude death rate, the mortality rate among infants less than a year old, and maternal and communicable death rates are decreasing.
- Fifty years ago, there were no cures for acute respiratory infections, particularly pneumonia. While such infections remain leading causes of death in the Philippines, these can now be treated effectively with antibiotics.
- In providing therapies for previously untreatable diseases and reducing disability, the industry has helped reduce the cost and duration of illnesses. Today, new medicines make

it possible to treat people with various conditions while they go about their daily lives, without hospitalization or surgery.

Immunization against deadly diseases, like Hepatitis B, is now available. Research on AIDS vaccines and therapies is making headway. Children are now routinely immunized against BCG, measles, polio, tetanus, and other once-fatal diseases.

Nevertheless, despite much progress in pharmaceutical discovery and health sciences, great challenges remain, including the search for cures for AIDS, cancer, and other life-threatening or debilitating diseases.

Technology in the Pharmaceutical Industry

Acquisition and Development

Technology is the sum of machinery, knowledge, people, and production processes, as well as other practices applied by a firm to achieve given objectives. Technological capability is the combination of skills and organizational structures required to maximize the use of existing technology and improve on the said technology.

Pharmaceutical technology is not always easy to understand and transfer. Much of technology is intangible, existing in the minds of people. Technology transfer is, in essence, the transfer of knowledge. This process requires people with such knowledge to share it; and qualified people, to understand, absorb, and successfully utilize it.

Therefore, an industrializing country's investment in education plays a very real role in establishing the place and quality of technology transfer, especially in science-based and high-technology sectors, including pharmaceuticals. For example, Glaxo R&D facilities for plant-based substances have been built in

Singapore because of Singapore's investment in science education.

Experiences in various countries and industries show that it is generally advisable to gain access to existing technology, rather than develop it indigenously, since the former strategy costs less. Self-reliance is not desirable if the required foundations are not available and if it turns out to be more costly than importation.

The acquisition of technology and the development of technological capability are central to the success or failure of firms in the pharmaceutical sector.

As centrally planned economies collapsed, the current and future global trade environment is and will be defined by free markets and competition. Whereas previously, industrialization by import-substitution was an option, this is no longer true in a world governed by the ASEAN Free Trade Agreement (AFTA), the Asia-Pacific Economic Cooperation Forum (APEC), and the post-Uruguay Round of the GATT.

The pharmaceutical industry is technologically at par with the worldwide state of the art, as far as PHAP members, consisting of MNCs and established national companies, are concerned. In fact, United Laboratories has plants in Thailand, Indonesia, and other countries, which are at par with those of other countries. In pharmaceutical distribution, a Filipino company, Zuellig Pharma Corporation, has established operations comparable to or better than those of other multinational companies.

Local pharmaceutical firms can no longer hope for trade barriers to protect them and, therefore, they must restructure to be competitive, or perish. The decisions they make on acquiring technology and developing technological capability will become increasingly crucial in determining their competitiveness.

Building technological competence must be a sustained and continuing effort at the firm level. Future capability is determined by what it is today and what it was yesterday. Therefore, long-term strategic decisions are indispensable, and investments must be made in human resources. A competitive environment must be welcomed, rather than feared.

Technology Leaders and Technology Followers

Countries are classified either as technology leaders or technology followers. Most countries, including the Philippines, fall under the latter category. The advanced countries are classified as technology leaders, since they spearhead innovation and define the limits of technology. In reality, technology followers need the capacity to learn more than the capability to innovate. The capability to learn can increase over time, until a technology follower actually starts to generate new technology and becomes a technology leader.

Quality as an Imperative

Bioavailability is the rate and extent to which an active substance is absorbed in the human body. Every pharmaceutical product has an intended bioavailability profile. Too little of an active substance, and the product will be ineffective. Too much of an active substance, and the too-rapid absorption or the presence of impurities will result in toxicity or other ill effects.

Given the bioavailability requirement, quality control and quality assurance are major, if not the most important concerns in pharmaceutical manufacturing. This holds true, whether a product is a new innovation or an older generic.

Quality may be defined as measurable compliance with a set of well-established product specifications. Quality control is the utilization of prescribed techniques and processes, to ensure that standards are met and maintained. Quality assurances involve all efforts to ensure quality control.

For pharmaceuticals, the stringent requirements of quality control and quality assurance require advanced technology and considerable investments.

To illustrate, Interphil Laboratories Inc., a pharmaceutical manufacturing facility in Canlubang, Cabuyao, Laguna, was built at a cost of P900 million. Most multinational auditors have asked Interphil to apply for US FDA approval, so that they can source their Interphil pharmaceutical dosage forms in the United States.

Pharmaceutical quality and regulatory standards are agreed upon and observed worldwide. These standards include those defined under Current Good Manufacturing Practice (CGMP). These standards are regularly reviewed and updated, and strictly enforced by drug regulatory agencies in each country. It is no accident that the PHAP cooperates closely with the Bureau of Food and Drug (BFAD), to assure that recognized standards of drug quality, safety, and efficacy are observed in the Philippines. Such cooperation which benefits public health and safety protects the integrity of the industry.

Drug regulations require that each pharmaceutical product perform according to a set of exact criteria. Therefore, pharmaceuticals manufactured by Interphil, under contract for multinational firms, must have the same quality, safety features, and efficacy as those manufactured abroad.

The pharmaceutical industry is a sector in which technology is heavily science-based and investment-intensive. There are no short cuts to successful participation in this already saturated sector, where technological capability and investment requirements are concerned.

Pharmaceutical technology costs less to acquire than to reinvent, and it is useless if it is not current. At present, the Philippines does not have the scientific and financial resource base to develop competitive pharmaceutical technology. Although the technology is available at a certain cost, it can be negotiated to the satisfaction of the parties concerned.

DISCUSSION

Quintin L. Kintanar

The pharmaceutical industry is competitive and good in manufacturing dosage forms of the pharmaceuticals. Our country is unable to produce in a large and significant way because the industry is increasingly becoming globalized.

There is now a move to facilitate the trading and registration of pharmaceuticals in order to harmonize all the technical requirements and come out with a dossier on products based on scientific studies (including preclinical studies) acceptable to all the countries. This paints a picture of a fast-growing global industry.

The world market is valued at about US$ 260 billion, and the major players are limited to three regions: North America, Europe, and Japan, which jointly account for 82 percent. Latin America contributes seven percent, while the tiger economies together contribute seven percent. The contribution of some of the small players in Asia in terms of sales is as follows: South Korea, $3.6 billion; India, $2 billion; Taiwan, $1.3 billion; and Pakistan, $1 billion. Indonesia, Thailand and the Philippines have smaller shares of the market. In terms of drugstore sales in 1995, the United States ranked first, followed by Japan and Germany.

At this point, let me discuss the National Drug Policy, which has been receiving notice worldwide. The policy areas are covered through the Generics Law. Although the market is very competitive and fragmented into smaller therapeutic categories because of the practice of the medical profession, it is further segmented at the level of the same active ingredient.

For example, if you are dealing with amoxicillin, which is a semisynthetic penicillin, the market is further narrowed down because of brand loyalty. When a doctor graduates from medical

school, he learns about the way a brand is being traded, promoted, and advertised. One brand eventually becomes his favorite which he invariably prescribes. Thus, insofar as the doctor is concerned, there is no competition.

The purpose of the Generics Law is to try to break this artificial monopoly brought about by brand loyalty. The law states that, if there is more than one brand or preparation available in the market, and they are proven to be equivalent in terms of the active ingredient, dosage form, delivery system, and bioavailability, the consumer should be given the benefit of the best price. This law is controversial because it touches on the prerogative of doctors to choose their favored brands or products.

It is good for the consumer when we allow more competition. The Generics Law is designed not to lower prices, but to promote competition, and allow the production of cheaper alternatives and inform consumers about it. For example, there are more than 300 different brands of amoxicillin. For this particular antibiotic, there are few problems on absorption and bioavailability.

However, others products have problems with availability. For this, guidelines say that there should be no substitution. To address this, a bioavailability study program, funded by the Australian government, has been undertaken at the UST Hospital to test generic products and determine whether these are equivalent and bioavailable compared to innovator or pioneer brands.

Intellectual property protection is another important issue because it greatly affects us, and there is a need for the patent protection of new discoveries and breakthrough drugs. As Dr. Juliano explained, R&D and product development processes (which include clinical trials) are really very expensive, as much as US$300 million to $600 million per product.

We therefore need some kind of monopoly that is provided by the Patent Law in order to recover this enormous investment. Although we may lose in many products, we may still have a winning product that can pay off all the other failures, as the sales of one product alone can reach up to US$500 million a year.

Finally, there are many other aspects in the use of drugs that should be looked into, and these do not only involve technol-

ogy. The purpose of having a National Drug Policy is to look at all of these aspects. These include the production of more affordable drugs, and making them accessible to more people, through the freer competitive environment provided by the Generics Law. It involves ensuring *quality*.

Congress has passed a law that imposes heavy penalties for counterfeiting essential drugs. Mere possession of a fake drug is now punishable by fines and imprisonment. If a fake drug results in death, the offender can be imprisoned for life.

Other aspects being looked into are the rational use of drugs, as a lot of money can be saved through the Generics Law. For instance, although there are cheaper alternatives, a World Bank study stated that the proper choice and rational use of any drug can save as much as 80 percent of the cost of treatment. This is through the proper use of the best drug, given at a sufficient dosage, at the right frequency and length of time.

Because of the improper use of drugs, many of them are becoming less useful and are losing their potency. For example, most antibiotics should be taken for a week. But many cannot afford a one-week course. So they stop in the midst of a treatment once they feel well. But the ailment usually recurs. Unfortunately, the same drug will lose its potency and antimicrobial efficacy in some patients.

Another policy area covered by the National Drug Policy is *self-reliance,* and this is where technology and basic pharmaceutical manufacturing become important. We have to choose very carefully where we put our money and support by finding a product that is useful in the Philippines. There had been an attempt to try penicillin G and its derivatives, but it was cheaper to import the drug than to manufacture it. To be sure, though, there are many advantages in developing our own technology. We will improve our R&D capability, and perhaps be able to compete better.

The last policy that might save the government a lot of money is one that limits the procurement of medicines to the *real essential drugs*. Three hundred forty-five products are considered essential as they match the needs and kinds of diseases

in the country. Government funds cannot be used to produce any drug outside the essential-drug list. This way, we minimize waste. In the long run, these are very cost-effective because they shorten hospitalization, and decrease morbidity and mortality.

In ending, I would just like to share an insight: *I always wonder when reports that this or that drug will "decrease" mortality because I think that the "number of mortality" is always the same anyway -- one per person (a human being dies only once). It is only a matter of age. We will all die sooner or later.*

Managing Technology in the Telecommunications Industry

MARILYN ELEANOR P. SANTIAGO

Chapter 19

As far as telecommunications is concerned, the most advanced commercial technologies are available for use today. The industry is ready to survive and thrive in the promised cornucopia of a multimedia future. With operators having established fiber optic, fully digital, Internet cable networks, the industry is set to be the Philippines' portal to a yet unwritten and unmonopolized bright future. Simply put, given the current state of technology, the ability to communicate with and be an informed part of the advancing local and global community will soon be available to an increasingly large number of people. Due to competitive offerings, it will be available in ways not yet offered in some highly industrialized nations. But even more spectacular is that the presence of advanced telecommunications platform surfaced over an obscenely short period of time—three to four years since the entrance of new industry competition.

The secret of our industry's initial transformation is the fostering of a local atmosphere that could readily tap international trends and ride the current wave of worldwide telecommunications growth. We have modernized quickly as a result of the global proliferation of technology channeled through foreign collaborations and partnerships. These collaborations are the results of a favor-

able regulatory framework—open to privatization, foreign participation, and competitive growth. Because of an open regulatory framework and changing global trends, our industry has easily shortened the technology infrastructure development process.

But even with these lucky advances and opportunities, the harder work of employing and sustaining the momentum of our now highly advanced technical industry and delivering its potential for quality service remains fraught with unforeseen perils. The next challenge in managing telecommunications technology is to bring it to a large unserved populace, in an attractive, affordable, and distinct way, while also sustainably and profitably driving the sector toward existing global standards. Divining the vision and direction that meet this challege will be the key to mastering our telecommunications technology.

As an industry, our emergence has fortunately coincided with radical changes in the worldwide telecommunications landscape. The effects of the information age have filled the telecommunications industry with seemingly inexhaustible marketing opportunities, innovative ideas, and continually advancing technology. The consensus, as one writer puts it, has been that "the industry....is virtually unrecognizable from that of 1984," and that this transformation has turned the inclination of the industry, from a "natural monopoly, to a multiservice, multisupplier, multimedia market." These drastic and almost total changes, such as digitalization, wireless telecommunication, media convergence, and lowered manufacturing costs, have favored unencumbered and adaptable new entrants to the industry. Benjamin Scott, President of PrimeCo Personal Communications Inc., describes the advantage: "When the game changes, it is very hard for incumbents to learn the new game, whereas, a start-up company...quickly learns.... Fundamental discontinuity...should be a real advantage to new players."

This has been especially true for new entrants in the emerging, free market of the Philippines where, in fact, a whole national industry has entered the telecommunications arena at a fundamental discontinuity in global telecommunications development. Confirming Scott's assumption, our underdeveloped and established local in-

dustry has been able to quickly adapt to new technologies. Several International Gateway Facility/Local Exchange Carrier operators now employ digital switching systems; two of five cellular operators employ digital networks; and fiber optic lines will constitute several new local exchange infrastructures. In some cases, particularly in our recent employment of alpha numeric paging technology, we have not only adapted, but even leapfrogged certain global telecommunication development standards. Pocketbell's Expressline 122+2 automated alphanumeric paging line is the first of its kind worldwide.

Adding to the advantageous situation of fast and early adaptation of new technologies is increasing globalization, and trend toward openness and competition locally. Globalization, seen by some as a growing network of alliances and mergers across national boundaries, and through greater international trade in telecommunications equipment and services, has brought foreign financing, advanced technological supplies, and strong partnerships into the local telecommunications industry. In addition, the industry has recently opened its regulatory borders through RA 7925, which welcomed new entrants with foreign partners in the local service area.

With the proliferation of new technology and funds, the industry has emerged from a formerly backward infrastructure into what could potentially be among the world's most technologically advanced. In the case of PT&T, a long-time national voice and data carrier, its emergence as a modern basic telephony provider in 1995 has been expedited through a successful collaboration with a foreign partner, Korea Telecom (KT). With the technical and financial assistance of KT, PT&T has been able to train its personnel, and adapt to advanced local exchange deployment and operation. Additionally, KT has allowed the financing of new digital switching systems and a fiber optic fixed-line intelligent network to serve Region 4a. And with growing competitive foreign supplier interest in serving the industry, PT&T has had and will continue to have a wide variety of technological choices at relatively affordable prices. This means improved service quality, greater affordability, and modern uncom-

promising choice in the level of service with access to all the bells and whistles of the information age.

Yet, even though we have managed to take a short cut to the industry's technological development, much remains to be done with regard to the sustainability of such development. The technology will only be as sustainable and beneficial as the ability to master, foster, and use it. Even as new tools provide new opportunities, their local enforcement poses challenges. Managing telecommunications technology into a future of virgin markets, uncontrollable global changes in product and pricing, demanding regulatory conditions and competition, and shortages in operational expertise, will require a directed, driving, yet pragmatic and fresh vision.

Illustrating one of the basic operational challenges of managing new telecommunications technology are two recent advertisements. On a billboard in San Francisco, a foreign digital CDMA network ad endorsed its technology as follows: "*Hey Honey*, listen, *I'm leaving* the office now and it *won't be* long before I'm *back*. - With other cellular networks you never know how you're going to come across." The ad implies that, on an analog network, only certain portions of the message would have been received. A similar local ad I vaguely recall from a radio spot goes, "Hey man, my phone, it's got text messaging, caller ID, voice mail, international roaming...whaa I've got no signal! With [alternative brand] you get connections in the most locations...." Paradoxically, digital technology is portrayed as unreliable. The lesson is that technology, as complex as that of telecommunications, has no easy answers and, for a young industry as ours, is often equal only to the competence of its operators.

As industry participants deploy new systems, we will have to overcome our own inexperience in order to manage quality services. Experience and appropriate expertise in this infant field are rare while demand remains high. Outlining the problem in a 1994 article, PETEF notes the need for 160,000 additional technically skilled personnel to ensure the proper operation of new telecommunications infrastructure. To date, the shortage continues to affect the efficiency and growth of new services, as key company positions re-

main vacant and competitors occasionally pirate each other's experienced personnel, upsetting continuity.

However, there are solutions that should be considered in addressing these difficulties. In the short run, a solution that has proved successful, although costlier, for some operators is the turn-key outsourcing approach with regard to telecommunication aspects in which a company is not confident or interested in exploiting. Basically a collaboration between two separate firms, turn-key allows an operator to focus its resources into a core competence by relying on the other firm's expertise in peripheral fields. Such a system has been used in the rollout of some of the local exchange networks in order to hasten compliance with the mandated local line requirements. Though costly, speed and the sharing of limited personnel have been the main benefits of turn-key solutions.

To truly ensure industry competence and continuity, and reduce the cost of acquiring expertise, we will need to take a more active part in the training and education of skilled personnel. Opportunities include the technical assistance and training requirements of foreign partners. The promotion of skills and interest in telecommunications through local schools is another method. Finding a way to acquire a good level of industry competence will be a key part in the management of telecommunications technology.

But beyond acquiring adequate expertise, more challenges remain. In particular, we must provide for the sustainability, renewal, customization, and advancement of technology, as our industry matures and takes shape. Where will we obtain future technology requirements? Will we be able to afford the acquisition of future technologies? Will future technology be sensitive to local or company directions and needs? We will have to ensure that the industry's level of technology and services is not continually, and completely, determined by foreign requirements and the availability of foreign technological supplies. As in the paging industry, the continued high cost of the alphanumeric pager unit has been a function of a greater paging-supplier sensitivity to the competition in the larger numeric markets, than in smaller alphanumeric markets such as ours. As industry operators begin to differentiate their services from those in

the international telecommunications community, it will be increasingly important to prepare for the acquisition of new, more germane, and affordable technology.

Some opportunities for ensuring the sustainability, renewal, and advancement of technology include stronger partnerships with foreign suppliers, the encouragement of local telecommunications technology manufacturers, and increased regulatory participation in the industry's technology management. As the industry grows and more suppliers become interested, it may be prudent to partner with and exact more from them, with regard to technological requirements. With more competition, foreign suppliers will be more amenable to specific technological and cost requirements. Likewise, as demand for new technology grows, there will be an opportunity and need for young local manufacturers to establish themselves. While these events may happen naturally over time, fostering the growth of a more robust and locally sensitive supplier environment can be facilitated more expediently by a favorable regulatory environment.

Another challenge is how to make technology understandable and available to the customer. Unless we can find customers and serve their needs, technology's promise will be nothing more than smoke and magic tricks. Adequate delivery remains a problem as we stumble in the darkness of an untried market.

We must not be misled into employing impractical, hard-to-deploy expensive equipment, at the wrong time and place, simply because we feel it is right. To properly manage technology, we must not forget the end-user's participation. Can customers use this new product conveniently, and will they prefer this new product over others? Is there enough interest in the product? Is this investment justified, based on our understanding of the customer? For every new technology that revolutionized the industry, there are hundreds that withered due to poor market understanding. We should first understand the nuances of the customers if we are to serve them adequately and determine which technologies to pursue. To bring value, we must lead technology closer to their current needs, while also attempting to bring possibilities to their attention, in anticipation of serving their future needs. Simply inundating them with new things will

only confuse and drive them away. And in our competitive environment, this means driving them toward a competitor's more customer-friendly technology. Fulfilling the truest potential of technology can be done only by considering it as people enablers, and not as mere devices; and the ability to meet this challenge will ultimately determine long-term success or failure. Managing technology-based customer benefits remains as important as managing technological expertise and the sustainability of technological development.

Even if the industry is full of technological success and opportunity, it is also fraught with difficult challenges in the area of technology management. In the past three years, it has been bold in the acquisition of new technology, and we have benefited from the lessons and technologies of a transforming international community. But the next steps will require a creative yet prudent vision.

In shaping our vision, we have to consider ways to address the major challenges in making the industry technologically superior, its technological advances sustainable, and its technology-based service offerings attractive and attainable, amidst competitive and discriminating markets. To the challenge of increasing industry technical expertise and technological sustainability, the answer may be a more pronounced collaboration within the local industry, and between the local industry and international community, guided perhaps by prudent regulatory measures. To the challenge of advancing technology and making it more attractive to local needs amidst competition, the answer may be to take a more mature customer-oriented and -focused approach. In the end, a coherent vision for the management of telecommunications technology should be thoughtfully and creatively crafted from the potential solutions to these challenges; the expertise and assistance afforded by foreign counterparts; the empowerment offered by our own experiences and local industry resources; and an understanding of the end-users. Such a developed vision, gainfully employed, will safely see the industry through the challenges of managing technology.

DISCUSSION

Alfredo P. Macapinlac

The driving force that has reached our shores is the advent of the global community or globalization trends. Globalization has introduced technology into our country. Essentially, the technology we are getting now was developed outside. There is a big difference in the use of such technology in our country. For one thing, such technology was developed to meet the demand in its country of origin, whereas its use in the recipient country is driven by its providers. Thus, in our case, are we ready for such technology?

The technology we have greatly depends on the success of its providers. If they are not successful enough, or profitable enough, what will happen? If they decide to go away, what will happen to us? It is therefore important to realize that market demand is a very big factor.

Uniwell Technologies is a provider of technology, and this has been our problem. The technology available to us is at a level that may not be suitable to local conditions. The sad part is that what is truly suitable may not even be available, as it has already been made obsolete by newer technology. Where does that leave us? Do we become manufacturers of obsolete technology?

In any case, there is a need for collaboration, particularly with academe. The question is how long it will take before we can produce graduates that match our technology requirements.

Enlisting the government in enforcing more technological transfer is a step in the right direction. Meanwhile, we can still catch up because the transfer of technology will help academe produce the required manpower.

The telecommunications technology we are now using used to be part of a study in the transmission of information to outer space. The question then was how to transmit a graphic

picture millions of miles away, using only a 10-watt transmitter. The question now is, is the Filipino capable of thinking that way? In the end, the technology transferred to us is "far ahead" of us. We are drawn into globalization, we are caught in the tides, and we are forced to use it.

To cite another observation, take a look at the majority of our PC users today. With all their advanced Pentium microprocessors with many other state-of-the-art features, what do we actually see? How are they used? We see that seven out of 10 personal computers are just glorified calculators or typewriters, which is a gross underutilization of their true capabilities.

That is the state of "true" technology users in the Philippines today. There just aren't enough of them. We have to look for them. This is the real challenge. We have to support our technology providers, in order for them to remain with us. In time, when we finally "technologically update" ourselves in order to become more productive, we will reap the full benefits of technology.

What we have now is good. But are we ready to use it? Managing technology would be the first step; and, in the end, the benefits will flow in, as we continue to be assimilated into the inevitable tide of globalization and the global community.

Managing Technology in the Iron and Steel Industry

WILLIAM E. ROPER

Chapter 20

In 1995, South Africa produced 6.7 million tons of finished carbon steel, of which 39 percent was exported. In the same year, 22.8 million tons of iron ore were exported from Saldanha Bay. This country is not a major global player since its production is only about one percent of the world's output. However, South Africa is a significant exporter of iron ore.

There are two carbon steelmakers in South Africa that produce steel from liquid iron; namely, ISCOR and Highveld Steel. There are three other carbon steelmakers that use scrap-based electric arc furnaces (EAFs); namely, Scaw Metals, Davsteel, and Cisco. In addition to making steel from liquid iron, ISCOR also operates EAFs to make flat products at its Vanderbijlpark Works; steel, at its Vereeniging Works; and stainless steel, at its Pretoria Works. In 1995, South Africa produced some 5.3 million tons of crude steel through the liquid iron areas, and 3.1 million tons through the EAF.

Circumstances Peculiar to South Africa

When South Africa started integrated steelmaking on an industrial scale, the coke oven-blast furnace-open hearth-ingot casting route formed the backbone of the steelmaking process.

By the early 1980s, open-hearth furnaces were phased out, and basic oxygen steelmaking took over completely. This, together with the shift by both EAF and BOF producers to 100 percent continuous casting, reduced the amount of internally generated scrap available for EAFs. More and more pressure was put on local scrap sources to provide EAF feedstock. At the same time, since South Africa had no natural oil resources, the oil crisis was inhibiting its economic growth. As a result, South African producers had to export up to 45 percent of their finished product capacity in order to maintain production volumes at their steel plants. This meant that more scrap-generating capacity from downstream steel manufacturing processes was being lost to offshore markets, and it rapidly became a scarce raw material for the South African steel industry.

Growth in the international scrap market transformed the product into an excellent export commodity. In addition, the local currency was steadily weakening against the US dollar. Inevitably, South African scrap merchants were quick to exploit this marketing opportunity, resulting in the increased export of scrap from 94,000 tons in 1991, to 299,400 tons in 1995. The efflux further reduced the local availability of obsolete scrap.

As scrap supplies continued to dwindle and hence became increasingly expensive, local EAF steelmakers were forced to seek economical subtitutes. Scaw Metals, Davsteel, and ISCOR all turned to the development of direct reduction (DR) processes. Since both steam coal and iron ore were abundantly available, and South Africa did not have any significant natural gas resources, steam coal was logically targeted as both an energy source and a solid reductant for iron production.

Early Alternatives for Scrap Substitutes

In 1973, a South African EAF steel producer, Dunswart Iron and Steel, took the lead in utilizing scrap substitutes by installing a 120,000-ton per annum Frupp Codir kiln. Scaw Metals followed suit 10 years later with a 75,000 ton per annum DRC kiln, and shortly thereafter, a second kiln. In 1984, Davsteel converted a cement kiln

to produce some 40,000-ton per annum of DRI. Meanwhile, in 1982, the world's largest solid reductant direct reduction plant was commissioned. This plant (SL/RN) consisted of four Lurgi rotary kilns, with a combined output of 750,000 tons per annum. Future developments included another DRC kiln for Scaw Metals, a Midrex shaft for the Saldanha Steel project, and an unannounced process by a South African consortium.

Table 1 indicates the growth of DR capacity in South Africa over the last 10 years, and projected growth for the year 2000.

In South Africa, the use of scrap substitutes for EAF production is as follows: Scaw Metals supplements their scrap input with 40 percent DRI; Davsteel, 10 percent DRI; ISCOR Vanderbijlpark, 25 percent DRI and 35 percent liquid iron; and ISCOR Pretoria, 10 percent DRI and 25 percent liquid iron. The remaining steel producers using EAFs only utilize scrap.

Table 1
Growth of DR Capacity in South Africa
(last 10 years) **and Projected Growth to the Year 2000**

Year	Steel works	Add. Cap x 10^3t	Total S. Africa* x 10^3t
1973	Dunswart	120	120
1982	ISCOR (VDB)	750	870
1983	Scaw Metals	75	945
1984	Davsteel	40	985
1985	Scaw Metals	75	1060
1996	Scaw Metals	150	1210
1998	Saldanha	800	2010
1998 (proposed)	Not Disclosed	4000	6010

*Tons per year installed capacity.

In 1983, ISCOR took over the majority shareholding in Dunswart Iron and Steel and after four years closed the Works as part of a ra-

tionalization program. However, the DR kiln was kept in operation to supply DRI to ISCOR's EAFs, at the Pretoria and Vanderbijlpark Works. Despite getting DRI from this source, it soon became evident that EAFs at the Pretoria Works required an additional supply of iron. The coke oven-blast furnace route ceased to be a viable source because coke ovens were becoming a major source of pollution. The quality of their coke was also steadily deteriorating due to the poor condition of the batteries and the inferior quality of their coking coal.

When DRI became available from Dunswart, the Pretoria Works had already developed and perfected a procedure for charging liquid iron from blast furnaces, into their EAFs together with scrap. The DRI was simply batch loaded, as a third component to the charge. With the potential demise of the blast furnaces, a viable alternative source of liquid iron for the EAFs had to be found. In addition, fuel gas for soaking pits and reheating furnaces was required to replace the coke oven and blast furnace gas. This led to the development of the Corex C 1000 unit, which was commissioned at the Pretoria Works in 1988.

Coal-based DRI and the Corex process were suited to the South African situation, which was characterized by rapidly dwindling supplies of coking coal and scrap, coupled with an abundant supply of steam coal.

The coal required for the Corex process should have an adequate fixed carbon content (56 to 62 percent), reasonably low ash content (13 to 16 percent), and a volatile content of approximately 25 percent. Most important, it should not decrepitate excessively as a result of thermal shock when entering the hot melter gasifier, since decrepitation leads to inadequate char formation for the fluidized bed. This leads to the following typical composition for Corex coal:

- Carbon (fixed) 56 - 62 percent
- Volatiles ~ 25 percent
- Ash 13 - 16 percent
- Moisture 3 - 5 percent
- Sulfur 0.4 - 0.6 percent
- Grain size 5 - 40 mm

Besides not requiring a coking-quality coal, the Corex process produces emissions that contain insignificant amounts of NOx_1 SO_2, dust, phenols, sulphides, ammonium, and free cyanides. SO_2 emissions from the Corex are estimated at 53 g/t liquid iron; NO_2 at 114 g/t, and 130 g/t (figure 5). Total CO_2 emissions from the Corex are 1450 kg/t.

The following chemicals, represented in g/ton of liquid iron, are found in Corex waste water:

· Phenols	0.04
· Sulphides	0.01
· Cyanides	1.00
· Ammonia	60.00

The DR process, utilizing a rotary kiln and solid reductant, can be operated successfully with a wide range of fuels and reductants. The best results are obtained with coal that contains a significant percentage of volatiles. Ideally, a noncoking coal, with a high reactivity, low free-swelling index, and high ash-fusion temperature, is needed. These criteria are met by certain coals, which are in good supply within 100 kms of all existing rotary kiln plants.

The composition of the coal used in direct reduction is as follows:

Carbon (fixed)	55 - 58 percent
Volatiles	27 - 30 percent
Ash	12 - 16 percent
Sulphur	0.5 - 0.9 percent
$K_2O + Na_2O$	< 1 percent

New Developments

It is not surprising that South African steelmakers, widely experienced in the use of steam coal as an energy source and reductant, are developing this route further. Scaw Metals is currently

installing a third DRI kiln, and Davsteel is investigating the feasibility of doubling its DRI capacity.

Meanwhile, ISCOR, with its Corex and DR expertise, has reinvestigated its project, aimed at adding value to the Sishen iron ore it has been exporting from Saldanha Bay since 1976. The success of the Corex process at ISCOR's Pretoria Works has led to a revival of interest in establishing full-blown steel works (as against producing DRI or pig iron only) at Saldanha Bay. Although the local market for steel in the Saldanha area is very small, a good international market for high quality hot-rolled coil has been known to exist.

This, coupled with the promising performance of thin slab casting in pilot plants of Germany, has led to the decision to examine the feasibility of producing hot-rolled coil (HRC) through the Corex and the thin slab casting route, at Saldanha Bay, and exporting the total output. The feasibility study has culminated in the approval of the project. The new steel works (Saldanha Steel) is currently under construction. Final commissioning is expected late in 1998. The projected annual capacity is 1.2 million tons of HRC in the thickness range of 1.2-8mm. A thinner gauge of 1.0 mm is planned for the future.

Ironmaking for Saldanha Steel

The main reason for initiating the Saldanha Steel project was to add value to Sishen iron ore, which was being exported from Saldanha. It was decided, from the outset, that liquid steel would be produced from DRI, liquid iron, or both. This decision was based largely on the insufficiency of available scrap in South Africa, for scrap-based steel production.

The Corex ironmaking process was compared to other well-proven technologies, including the conventional blast-furnace route and the solid reductant DRI route. At the level of production envisaged for Saldanha Steel, it appeared that the Corex process offered cost advantages, provided that the export gas was fully utilized. The gas had to be utilized in either of the two process routes; Corex/BOF,

and Corex/EAF. In the Corex/BOF route, the Corex export gas was used to generate power. Likewise, the gas was used to produce DRI. A comparative study indicated that the Corex/EAF route offered better returns on investment.

It was decided that the ironmaking facility would consist of a Corex C2000 and Midrex vertical shaft furnace, with an annual production of 650,000 tons of liquid iron, and 804,000 tons of DRI.

Steelmaking for the Saldanha project

The steelmaking option for Saldanha Steel was the subject of a thorough study. An autothermic process was initially ruled out because of the large quantity of DRI that needed to be melted. The allothermic processes considered were:

- EAF
- KMS (Klockner - Maxhutte Stahlerzeungsverfahren)
- EOF (Energy Optimising Furnace)

The latter two processes relied on carbon injection to achieve the required endpoint temperatures. The prospect of using coal as an energy source initially seemed attractive, but investigation showed that substantial quantities were required. It also resulted in unacceptable phosphorus, sulphur, and nitrogen values in the bath.

It was consequently decided to carry out tests at the Vanderbijlpark Works to establish if the assumed parameters would be met with an EAF. These trials were done in collaboration with personnel from VAI (Voest-Alpine Industrieanlagenbau), and using one of the 150-ton EAFs at the Vanderbijlpark Works. It was decided that DRI would be imported for the 10 trial heats, and that the quality selected should conform closely to the quality anticipated for the Saldanha project.

The trials confirmed that cycle times planned for Saldanha Steel were achievable. It was decided that a 170-ton twin-shell EAF would be installed.

New Challenges for South African Steelmakers

The Thabazimbi iron ore mine, which supplies ore to the Corex plant at Pretoria Works and the blast furnaces of the Newcastle and Vanderbijlpark Works of ISCOR will reach the end of its economic life within the next 10 years.

This high-grade (low alkali and low phosphorous) hematite could be replaced by an increased production of high-grade ore at Sishen, but railage costs from the Sishen mine to the Works are very high. There are plans to replace the Thabazimbi ore by exploiting vast reserves of low-grade ore close to the steelworks.

Known reserves of low-grade magnetite ore at Zandrivierspoort, Kromdraai, Moonlight, and Cascades are thus now receiving serious attention (figure 12). These reserves will render fines of high-grade concentrate, which will require agglomeration for utilization in blast furnaces, the Corex plant, and direct reduction plants.

Local coking coal is also of poor quality and expensive to mine. For ISCOR to continue operating its blast furnaces efficiently after the turn of the century, it will be necessary to import limited quantities of good coking coal and coke despite the high transport cost.

In view of these particular circumstances in South Africa, it is not surprising that emerging technologies utilizing fine iron ore (unagglomerated) and noncoking coal are especially interesting to steel producers, particularly ISCOR. The progress made with the Romelt, Finmet, Hismelt, Iron Carbide, Fastmelt, and other processes is being constantly monitored. At the same time, ISCOR has achieved promising results from a direct steelmaking process conceived in-house. The process, known as IFCON, utilizes steam coal and fine ore to produce low-carbon liquid steel. Induction heating is applied.

Conclusion

Since major South African steel producers are far from the coast, it becomes very costly to import high-grade iron ore, coking coal and scrap. However, lower-grade ores and steam coal are abundantly close to the steel plants and transport costs, in this case, are low.

This, together with the rapidly diminishing availability and increasing cost of scrap, has encouraged steelmakers to study the long-term cost advantages of using fine ore, as well as steam coal, to produce iron and steel. This has led South Africa to become a world leader in developing DRI processes, using a solid reductant, and in smelting reduction. Meanwhile, intensive research is being directed at the utilization of fine iron ore in the unagglomerated state.

While ISCOR does not necessarily believe that the days of the blast furnace are numbered, the South African situation—of rapidly dwindling coking coal supplies, environmental pressure on coke-oven operation, and increasing transportation costs of good-quality lump ore—limits the potential of liquid iron production. The relative shortage of scrap and the associated cost increase are also putting pressure to steelmakers to find alternatives. To survive competitively into the future, South Africa has to find new options for steel production from available raw materials. We are sure international steelmakers will watch our progress with more than a passing interest.

Managing Technology in the Banking Industry

JOHNNY NOE E. RAVALO

Chapter 21

1. Introduction

The concept of "computerization" is an omnipotent phenomenon today. To many, it is an abstract development, whose flexible structure is molded only in the minds of those who understand what it could mean. While it is clear that those who understand are fewer than those who use technology, the idea has taken a momentum of its own in recent years. In discussing how we can make our workforce "globally competitive," for example, the proposal to instill computer literacy and its unquantifiable benefits will inevitably be forwarded. In analyzing the strengths of the local domestic market, those who are able to keep pace with competition-beyond-borders are frequently described as making early investments in technology, and thus are subsequently better positioned to reap its rewards. And what was only a decade ago considered a frivolous expense, the personal computer is now well entrenched in many households, the workplace, and core institutions of learning.

Amidst all these changes, there is the natural temptation to claim that one's industry is at the forefront of technological developments. Inasmuch as technology is a differentiable input, that may well be true for many industries, each innovating in its own

way. As an avid observer of the banking industry, I could also say that technology has had a profound impact on the banking industry as well. Was it not been only in the last decade that all transactions were done within banking premises and within banking hours that seemed incredibly short? Today the automated teller machines (ATMs) conveniently provide most of these services off-site, and beyond normal banking hours. In bank operations, active daily participation in the local and international markets is possible only by a slew of technological gadgets and on-line services.

Beyond mainstream banking operations, technology has already affected banking-affiliated activities. Economic analysis and banking-related policy research are now better delivered to the intended audience. The visualization of technical principles has also made imparting the same expertise more effective by way of bank training programs. Computerized simulation programs are now regular materials in training. Technical discussions of possible policy consequences are now handled interactively with the aid of "just" a notebook (the electronic and full-palette SVGA type, of course). All these are possible today precisely because of the present technology.

In forming an appreciation of "what is" and "what could be" in the banking sector, this article takes the present state of technology as a given and does not attempt to evaluate the merits of available technology per se. Instead, it presents the comments of an economist (who is an active participant in the industry and more than a casual user of the technology in the practice of the profession) about various aspects of the commercial banking industry, where we stand with regards to technology, and the issues that we face and will likely have to address in the future. In Section 2, a few of the more prominent technology-related endeavors in the banking industry are discussed. Section 3 outlines issues specifically related to technology in banking operations. Section 4 provides a short complementary discussion of issues that relate to economic analysis and research in banking. Both of these sections are discussed again, largely within economic confines, rather than from purely technical perspectives. Some concluding comments are contained in Section 5.

2. Technology in the Commercial Banking Industry: A Brief Appraisal

To get a good sense of how the commercial banking industry has used available technology, it will help to go over a selective list of technology-related developments in the 1990s, most of these within the decade's first three to four years. This will give a clear idea of the seemingly unlimited potential of technology, in exhibiting scale and scope economies, particularly in banking and finance.

Philippine Dealing System (PDS)

The PDS is the off-floor foreign exchange trading system that has been in place since August 1992, in line with the foreign exchange (FX) deregulation initiated by the government. Currency trades, between the Philippine peso and the US dollar in a spot market (i.e., fix transactions occurring "on-the-spot" that must be settled within two business days), are now carried out on an on-line real time screen-based system. Handled through the Dow Jones Telerate information services, the PDS is an electronic trading system that allows banks to participate using computer terminals. Transactions are instantaneously mapped out on an electronic page, providing participating institutions up-to-date information on a weighted peso-dollar average rate, the volume of finished interbank transactions, and other various market indicators.

The PDS replaced the previous "open outcry on-floor" system, where traders literally verbalized their prices at the trading floor, searching for a counterparty who would agree to the quoted prices. Under the old system, the trading floor was live only for *30 minutes* a day. Prices quoted under this system were strictly *one-way;* that is, a price to either buy *or* sell US dollars for pesos, fixed until the trading day.

In contrast, the PDS technology provides for a *24-hour trading day*, requiring traders to give *two-way* (i.e., bid and offer) quotes. Quotes under the PDS are valid at the time they are provided, and

until a new indicative quote is given. These quotes can be changed as often as desired by the quoting party. Two rates are involved, indicating the willingness to buy (bid rate) and sell (offer rate) US dollars for pesos. A quoting bank is therefore not sure whether a counterparty would "call" the bid rate (obligating the bank to buy US dollars), or the offer rate (which obligates the bank to sell US dollars).

The effect of technology in this case is that it made the peso-dollar interbank rate very transparent. Like all other professional markets, two-way quotes instill a deep sense of professionalism and market-based competition. Note that, unlike the open-outcry method, banks cannot dictate their trading position (buy or sell) to counterparties in the PDS. All participants must be open to movements in the market, even if it means being forced to buy (sell) when the desired move is to sell (buy) US dollars. This level of professional competition is possible because the technology guarantees on-line real-time information.

The net effect is that the movements of the Philippine peso are just as transparent to the world market as they are in the domestic market. Similarly, technology elsewhere allows the local market to keep abreast with the movements of other trading currencies. From our end, this is a positive development because it continually keeps the peso competitive and freely convertible. (While this is not the place to discuss it in detail, it is sufficient to note that this was not the route taken by Mexico, leading up to the *tequila dilemma*.

Philippine Domestic Dollar Transfer System (PDDTS)

As part of the infrastructure that would complement the PDS, it is ideal for trading banks to be kept up-to-date with their dollar balances as it pertains to the PDS. This points to the need to establish the Philippines' first clearinghouse for US dollar transactions without amount limitations. This effectively provides the banking industry with the vehicle and electronic facility to transfer US dollar funds, from one Philippine bank to another, (a) on the same day and (b) without the need to go through correspondent banks in the

United States. This is an essential requirement of the interbank Philippine peso-US dollar trading market because claims on US dollar holdings are altered in the process. While the PDS provides the end-user vehicle that creates and manages the trading market, it is the PDDTS that handles and monitors the bookkeeping claims to the US dollars being traded and transferred among participating banks.

The primary benefit of this electronic system is the expediency of fund transfer. The alternative requires that dollar funds be transferred through correspondent banks in the United States. This creates a delay between the settlement of previous trades and the information required on current trading transactions. Thus, the PDDTS (bid out in 1993, and subsequently began live run in April 1994) is easily seen as a necessary complement to the PDS. In this sense, the PDDTS establishes the PDS as a "hometown" development that does not depend on external support systems, such as US-based correspondent banks. It allows the Philippine financial system an important electronic vehicle that can be used to structure a globally-competitive financial system. The PDDTS is only the fifth, worldwide, to offer on-line real-time transfer of funds. This is the implicit benefit that is simply immeasurable in resource terms.

Automation Projects with BSP

A group of technology-driven endeavors, actively pursued by the BSP and BAP since the advent of the 1990s, falls under "automation." Unlike other projects, they deal directly with reportorial/information obligations of banks to the BSP. Of course, the various reports are kept from the consumers, but nonetheless pose a significant cost to the performance of the basic intermediation process.

In lieu of these voluminous reports, the Data Delivery Faculty (DDF) has been initiated several years ago. A conventional diskette, containing all the relevant information used to be presented in paper-based reports, is provided to the BSP. In particular, the Consolidated Daily Report of Condition (CDRC), for purposes of required/

available reserves, capital-to-risk asset positions, among others, has been replaced in late February 1992 by the diskette version, which was eventually called the Consolidated Statement of Condition (CSOC). This step alone has provided tremendous savings, not only in the resources needed for these reports, but also because the reports were originally submitted to *both* the BSP and the Philippine Deposit Insurance Corporation (PDIC), in *separate copies*. Under the diskette system, the diskette submitted to the BSP is also accessed by the PDIC, thereby increasing efficiency and savings. Other reports have since been included in the diskette, providing even greater efficiency.

There are other automation endeavors that have been pursued by the BSP and the BAP, much in the same light as the DDF. These cover, among others, funds transfer system, the interbank call loan settlement system, and the electronic delivery of demand deposit account (DDA) balances. Undertaking these automation projects reflects the basic incremental cost advantages that electronic media provide once the general hardware/software system is put in place. For member banks, the ease is evident because computers (with the aid of the proprietarily designed software package) now generate reports by electronically selecting relevant data from, for example, the general ledgers that are now handled electronically as well. What used to be done by several people through the usual maze of bureaucracy is essentially replaced by available technology. For the BSP, it also translates to enormous savings because it is now able to update the data files without encoding, therefore creating internal reports much faster.

Project Abstract Secure (PAS)

The Project Abstract Secure (PAS) is a functional collaboration between the Bureau of Customs (BOC) and the BAP, where an electronic system has been put in place to verify the proper payment of customs duties/taxes, and remit payments electronically through the banks. Under the previous system, the payment and verification processes were done exclusively through writ-

ten documents, which required an array of signatures for confirmation. Such paper trail often led to the fraudulent use of canceled BOC receipts and invited abuse. As a result, the processing of documents required additional resources, further delaying the release of importations.

Phase 1 has been enforced beginning March 1995, with relevant information encrypted into diskettes and delivered through couriers. Phase 2 takes the process into a purely electronic-feed basis, eliminating the need for diskettes and couriers. This guarantees at least the same level of security as phase 1, but will inherently increase efficiency by avoiding delays due to manual interventions.

Again, the cost efficiency of such an endeavor is obvious. This is most evident in the fact that PDDTS communication lines are being used for this purpose. There has been no need to create a separate telecommunications infrastructure to achieve the objectives, and this exemplifies the possibilities for economies of scale and scope with technology.

Philippine Central Depository, Inc. (PCD)

In response to the Book Entry System (BES), which the Central Bank began to adhere to at the onset of the 1990s, a government securities (GS) clearing system was envisioned by the BAP in 1991. The idea was to convert the accounting, clearing, and settlement operations of the GS market into electric mode in order to eliminate settlement risk. This risk included those that were inherent with the physical handling and delivery of GS, counterparty risks, and the possibilities of fraud.

The idea behind the project was to attain the ideal of "delivery versus payment" (DVP). Since this required continuously updated information, it was only possible with technology. Thus, the plan for a Government Securities Clearing and Settlement System (GSCS) to transmit the Confirmation of Sale (COS) and the Confirmation of Purchase (COP) of GS transactions between financial institutions was developed. Information was to be transmitted to the Phil-

ippine Clearing House Corporation (PCHC), which automatically matched, authenticated, and verified the availability of cash and security balances. The PCHC determined if selling parties had securities to sell, and if buying parties had the cash balances to pay for their new purchases. Any discrepancy required an "unwinding" process on a "last-in-first-out" basis, until the correct balances were attained. Properly matched results were subsequently transmitted to the BSP for immediate clearing and upgrading.

Visionary as the project may have been at the time, the GSCS was unfortunately still in the developmental stage when the Bancap scam occured. The scam succeeded in publicly demonstrating the weaknesses of the system, and the corresponding financial consequences of settlement risk. Thus, there was a renewed vigor to hasten the design and enforcement of the GSCS in order to avoid an occurrence of another Bancap-type scam.

The Philippine Central Depository Inc. (PCD) was to be the entity officially tasked to handle the GS clearing operations. However, the PCD still had to be formed, as a joint undertaking between the BAP, the Philippine Stock Exchange, Financial Executives Association of the Philippines, Investment Houses Association of the Philippines, and Citibank N.A. As such, PCHC handled the operations in the interim. The PCD announced its ability to operate ahead of schedule, paving the way for GSCS to be fully absorbed by the PCD.

There is no need to emphasize the benefits of such a clearing system. In a nutshell, everything that went wrong under the Bancap scam could have been easily avoided in an electronic clearing and settlement system.

BAP Policy Research Group (BAP-PRG)

One of the developments pursued by the BAP is the formation of the BAP Policy Research Group. The BAP-PRG performs the duties of an in-house economics unit, specifically on policy issues that relate to banking, the financial sector, macroeconomy, and other allied fields.

While this may seem like a routine expansion, it is interesting to note that the BAP-PRG is heavily driven by technological innovations in the performance of its mandate. What was a team that had machines with dilapidated 80286 processors (and 30 MB hard drives) only two years ago is now a staff equipped with a Pentium-based workstation (with drives measured in gigabytes). To complement these, facilities such as multimedia notebooks, a portable LCD, a colored flatbed scanner, and telecommunications peripherals have also been acquired.

All these "toys" have been assembled not merely to keep pace with the latest gadgets in the market. Instead, they provide the technology for the BAP-PRG to deliver its message to various audiences. The insights offered by an economic unit are inherently technical and, without the aid of these tools, likely to be very confusing and/or boring, even to the most avid listener. With the tools in place, we can produce results faster, and provide a highly visual and portable presentation. Communication lines have been tremendously improved because economic ideas are visually understood, without having to worry about translating tables and equations. Technology provides a vehicle for imparting ideas to audiences, eliminating miscommunication from the process.

3. Issues in Managing Technology Related to Banking Operations

The list of industry initiatives appears to indicate a healthy appreciation of the potentials of technology applied at the industry level. Although these projects could only have been pursued with some general consensus, there is no illusion that the consensus is unanimous. As these projects continue to unfold, divergent views are expected from differing institutions. Nonetheless, these views must be integrated if endeavors are to attain full completion. Among the many issues, the following immediately come to mind:

Selling The Concept and Economies of Scale and Scope

To forward technological innovations, there should be a basic recognition that these types of projects are inherently of a "lumpy" system, as all their benefits (to both the bank and its customers) would entail a prohibitive cost—set-up, maintenance, and infrastructure—making them not viable for individual institutions. Taken at the industry level, however, there are a few opportunities to avail of scale and scope economies.

The PDS and PDDTS are classic examples of projects that are viable, even under the condition of investment indivisibility. And, as we have witnessed, the technology behind these projects can be easily used for instruments/purposes other than the PDS and PDDTS. The activities in the call loan market, for example, are mapped on the same Telerate page as the Philippine peso-US dollar interbank trade, without significant additional programming cost.

Behind the fancy economic jargon of scale and scope economies is nothing more than "consensus." In a very real sense, the attainment of a consensus provides a necessary and sufficient condition to pursue the endeavor. Arriving at this consensus is actually more difficult than perceived. It is not about professing the technical benefits that could be attained with the project. Instead, it is about marketing a concept that would entail substantial cost up front, in exchange for unquantifiable efficiency gains in the future. This is further complicated by the fact that, in most cases, these industry-level projects directly affect plans, decisions, and undertakings already begun by individual banks on the assumption that no industry project is forthcoming.

Therefore, the effort in selling an industry-level concept to market participants should not be underestimated. In the banking industry today, an innovation requires a technical person with sufficient business skills. Marketing the proposal is functionally not different from an underwriter's efforts to market a particular instrument. This is the only way a technical solution can be effectively advocated. The

cost of hardware, peripherals, and software packages is as important as the implicit costs inherent in change and adjustments among market participants.

Standardization

Unfortunately, the consensus that the industry musters is not a blanket authority given to project proponents. The consensus is, in effect, an authority to pursue, not a mandate to accomplish independently. While working on pushing forward the PAS, for example, it would be difficult to explain how much time is repeatedly consumed by discussions on the number and length of the included database fields. An individual designing his/her own database structure would decide on these variables nonchalantly. Raised to an industry project, such modest detail easily becomes a bone of contention.

This points to an issue of standardizing specifications. The difficulty here is not that there is dearth of possibilities. The real problem is that individual participants do not share the same existing specifications. Consequently, any chosen set specifications will be a "gain" for some and a "loss" for others. The issue boils down to adjustment cost, while others benefit from a startup advantage.

The divergence in existing standards is the direct result of alternative products in the market. Technology often does not come in a homogeneous medium. The need to compete and innovate indicates that competing standards are being simultaneously marketed. While differentiated software packages allow some degree of convertibility, competing hardware standards often result in strict incompatibilities.

The choice made by end-users on standards to pursue is often not purely a question of technical specification, but also features that suit one's recurrent use. In this situation, the need to standardize does not only imply changing hardware/software combinations, but also asks users to modify the manner by which they have gotten used to doing a particular transaction. This learning curve phenomenon is again one of the implicit costs that constrain a dictatorial approach to any innovation.

Telecommunications Infrastructure

Just as there are detailed specifications to address, the design and maintenance of a specific telecommunications infrastructure become relevant. Much of the current projects for completion—and surely those which will be pursued in the future—involve a facet of telecommunications. Subsequently, having a clear idea of the needs and its possible expansion is a major consideration.

Part of the issue here is obsolescence that is forced by the industry's initiatives. What may be good for many in the long run does not have to be good for all today. This dichotomy is further exaggerated by the fact that telecommunications infrastructure used to be strictly premises-related. With the current developments, and in anticipation of future changes, telecommunications infrastructure is now part and parcel of database maintenance. In this case, the concerns governing standardization equally apply.

Front-end Design and Controls

With all necessary technical specifications predetermined, the next concern is the front-end design of the relevant software package. This has as much to do with computerizing tasks efficiently, as with the computer literacy of the end-user. The term "user friendly" is the same as "minimizing user error," one that often proved very costly for banks.

However, a successful front-end design is much more than just user-friendly. There must be sufficient control of the checks and balances involved, to be certain that the correct information is processed. At the operational level, the inclusion or deletion of a zero is often a major source of error. If it were just a matter of pesos and centavos, it would be of little consequence (except perhaps for the auditors). But for an industry used to moving large amounts of currencies, the difference between P10,000,000.00 and P100,000,000.00 may be difficult to correct, if transactions get through.

The use of passwords is another example. The natural neigh-

borly inclination of Filipinos often renders passwords useless. In most cases, passwords or pass codes are well-known among colleagues. In some cases, the choice of passwords is often taken lightly. Choosing a birth date, telephone number, easy-to-guess numbers, such as "12345," or "7777777," or the word "password" as password makes it very easy for controls to break down. At the other extreme, there are those who keep codes to themselves, but are often not around to validate transactions. This creates a backlog.

The main issue is literacy, not only in basic computer use, but also in accepting its attendant responsibilities. Innovations must always consider the end-user, not only for his/her proficiency, but also with regard to controls. *Technology as a medium is for users,* and not the other way around.

Managing Technology

With technical obsolescence increasing, the management of technical developments has become a full-time profession. All banks today have a full-time staff in charge of information technology (IT). Efforts to streamline bank operations are handled with the active participation of the bank's IT department. Product innovations and developments are conceptualized and carried out within "technology shells," i.e., the framework that handles and monitors transactions vis-à-vis other transactions in the bank.

The strategic decision that must be made has to do with the sophistication that defines the IT department. On the one hand, technology could be developed for its own sake. That is a decision to invest heavily in technology development as it pertains to bank operations. In the terminology of the computer industry, this involves what is initially a proprietary development which could very well become a standard. While this takes an aggressive position, the main drawback is that it requires a large operation. There is the developmental phase and there is the training of bank personnel. Both take up resources, funding, personnel, and great patience.

The alternative is a modest unit, tasked with managing technological applications, rather than defining its course. This more pas-

sive approach entails acquiring off-the-shelf packages for banks. This cuts the development cost to practically nil. In exchange, the bank is forced to tailor-fit its operations to the features of the commercial packages. Often, this lack of flexibility is a tremendous limitation and an ultimate source of frustration. Depending on how standard the packages are and the extent of the training involved, teaching personnel how to use them can either be handled internally or through computer training institutions.

For standard software use, such as word processing, spreadsheets, and basic database, the passive approach offers the most cost-effective solution. But with industry-wide initiatives, there is every incentive to develop internally, from the ground up. The developmental phase has a long gestation period and this is the only way industry practices could be accounted for.

Technology and Regulatory Requirements

These technological innovations do not exist in a regulatory vacuum. Often, these innovations address an issue of regulatory compliance, modifying either its form or method of delivery. This suggests that a healthy amount of consultation with regulatory and legal bodies must also be done. The intent is not to sell the technology per se but, rather, to determine the extent that the technology can be harnessed, such that it can be accommodated by existing regulations and laws.

One example is the automation project currently under way between the Bangko Sentral and the BAP member banks. The idea is to repackage the voluminous amount of reports, which are routinely—some as frequent as everyday—submitted to the BSP. Instead of paper-based reports, there are scale economies achieved by submitting diskettes containing the same information, but could be accessed and reformatted electronically by the relevant departments of the BSP. Effectively, all that has been altered is the physical form of compliance, with the added feature that diskette-based reports are easier to generate, and more quickly delivered, once the proper system is in place.

A more complicated situation arises with the advent of "scriptless" trading. Since the PCD will electronically validate the existence and provide settlement services, this creates a trading market in which a physical transfer of instruments is redundant and unnecessary. From an operations point of view, this provides security, and expedites trading activity by avoiding the normal bureaucracy of paper-based trading.

From a legal and regulatory standpoint, the PCD has to secure appropriate licenses—a euphemism for being accorded a healthy dose of professional trust by regulatory bodies to operate as a depository. Furthermore, the ideal flexibility of technology has to be contained within the stricter confines of regulatory considerations. This means that contingencies have been thought out for various situations, ranging from computer errors and downtimes, to possible legal complications. The technology at the PCD, under the Book Entry System (BES), has been specifically designed to address all these contingencies, with the appropriate approval of the regulatory bodies.

4. Technology in Banking-Affiliated Economic Services

Innovations are occurring not only in operations-related areas of banking. In the same way, bank-affiliated economic services, like economic analysis, its concomitant policy component, and subsequent training modules, have also witnessed a number of developments, as a result of technological improvements. This development is critical because technological advances have altered the way the profession is practiced and how the academic discipline is taught.

Over the last few years, a specialized field of economics that looks particularly at finance and banking issues—Financial Economics—has gained tremendous foothold, largely because the tools for analyzing and *visualizing* intertemporal problems have become readily available. Without doubt, many of the analytical concepts needed for intertemporal analysis (i.e., dynamic optimization, optimal control theory, Kuhn-Tucker theorem, etc.) have been in place. How-

ever, these have been restricted, either to the classroom or in the minds of those who regularly deal with them. These have had to "wait" for technological improvements in computer power and portability before being appreciated visually.

Today, in more advanced economic units of various financial institutions, "academic research" is performed with strict regularity, and its function has much of its original "nerdy" connotation. As a result of the refocused attention to financial problems and the emergence of "visual technology," banking has been looking at *risk management* concerns from a *technical perspective*. Thus we can now talk about Value-At-Risk (VAR) to bankers without worrying that it would put them to sleep.

The emerging role of derivatives (i.e. swaps, options, forwards, and futures) assumes that the practitioner has some understanding of *intertemporal marginal pricing*, even though this is not the terminology used in banking circles. *Interest rate dynamics* need to be appreciated beyond the static representation of the traditional yield curve because future prices or, more accurately, expectations of future prices affect the way instruments are priced today. Sooner or later, guess estimates will not suffice and the need to generate robust technical forecasts will become increasingly imperative. All these and many more are being analysed with rediscovered technical expertise and without the usual apologetic caveats. And clearly, the key to all these is that technical details can be appreciated using the computer gadgets at the disposal of bankers, gadgets that translate these details into their visual equivalent.

The same visuals and computer gadgets are at the disposal of the economist who must translate economic movements to interested parties. At the BAP Policy Research Group (the economic consulting unit of the BAP), all the analyses are translated into animated pictures that can be better understood. Although there is great care in taking a chartist's perspective, clients respond to graphs infinitely better than technical equations or even data tables. And just as there is a difference between a picture and the equation it represents, there is also a big difference between rigid transparencies and a portable slide show that provides animation and sporadic

sound facilities. While we can claim that the interface between rigorous economics and portable technology, or what we normally refer to as multimedia capability, as one of our strong points, it is clear to the BAP- PRG that this could not have been possible several years ago.

The experience is no different for those who conduct various banking-related training modules. Several years ago, bank training programs meant individuals go through neatly packaged training manuals populated with words, numbers, and questions. Today, we are able to impart more information in less time and for less cost.

The Ateneo-BAP Banking Institute has built a simulated trading room that offers hands-on education to 15 prospective dealing teams, the first of its kind in Asia. Fully equipped with 34 telephone lines and a realistic simulation package, banking recruits experience the highs (mostly in blood pressure) and lows (morale) of trying out the trading profession, usually with very little success. But it is precisely this difficulty that allows them, first, to imbibe the five-day technical seminar and, second, to appreciate the many pitfalls in the practice of trading. This experience is unquantifiable. And if we remember our most successful and embarrassing experiences, this approach is bound to achieve its objectives.

It goes without saying that this trading simulation is not for everyone, however technology-friendly it may be. This bourse game, for example, has been conducted for the Economic Journalists Association of the Philippines (EJAP), and the response has been one of professional appreciation and intellectual confusion. A differentiated seminar on foreign exchange markets (from the basics in swaps and forwards) has been conducted by the BAP-PRG for EJAP. The seminar is run using visuals and slide shows, resulting in the same professional appreciation and excitement.

This suggests an important element: that despite the visual impact of current technology, the *same technology will not necessarily be suited for different people*. This reaffirms the viewpoint that technology should be harnessed in a specific way, for specific end-users—so that end-users may adjust to technology en toto.

5. Some Concluding Comments

The preceding discussion reasserts that there is seemingly unlimited potential to technology once it is properly harnessed. There are a number of initial stumbling blocks to be hurdled as preconditions, but the upside can easily offset any downside. This raises an important question: if technology is as good as it is being packaged and is a basic work-environment complement, then why is there no centralized and recurring effort in the Philippines to tap its benefits on a national scale? Are our ASEAN neighbors more involved with technology because they are more capable in raising lumpy investments, both at the personal and the industry levels needed to finance the startup costs? Is local expertise not competitive enough to undertake possible initiatives?

These are valid and timely questions. However, the larger reason for our apparent passivity toward technology has less to do with funding constraints than with defining a larger-scale program. Those of us who have attempted to mold basic technology into a functional end-user tool know that the key element to its viability is a vision of how the raw power of technology could be harnessed and later streamlined for optimal and continuous use. Here, the operational phrase is not the dichotomy between today and tomorrow, but rather the element of optimality and continuity. For individual users, benefits are achieved *ipso facto* by the facilities of computerization.

In the long run, viability is defined by the continuity of support and access to technical evolution. But if we move the national frontier further, if we tap technology beyond being just an expensive typewriter or a fancy calculator, the necessary condition is to integrate these individual requirements to form an integrated perspective of what is needed, and a definite plan on how it can be best achieved. Larger-scale aggrupations, from industries to economic sectors to trading partners, have the opportunity to best reap the upside to technology if a consistent and common vision is defined.

The experience of the commercial banking industry provides examples of how technology can be "packaged" to benefit each par-

ticipant, from service providers to service consumers. The rewards are not quantified only in shorter waiting-time and faster processing, but in the better generation of deliveries to consumers, whose needs are quickly evolving. It is increased operational efficiency, i.e., a better system of checks and balances, improved interaction among regional peers, less dependence on external support structures, and streamlined processes. This will not be quantifiable in pesos and centavos immediately. And in some cases, this may not be quantifiable at all, allowing contentment only with being able to do better transactions.

This brings back the issue of *marketing* technological improvements. The potential of technology, by itself, will not sell. Technology professionals would have to transcend their expertise, and acquire sufficient *business skills*, if they expect to realize the projects they envision. This is more than just getting a consensus and a mandate to explore further. It involves the realization that, in the short run, the application of a technological innovation is *not likely* to be an encompassing *pareto-superior move*. There will be those who are definitely worse off, initially, because of the need to adjust existing firm-level structures and processes. As such, it is in presenting the longer-term benefits, quantifiable or not, that will be critical. This, as we say, is the forest beyond the trees.

The caveat of this perspective is that the banking industry is unique because of the frequent interaction among financial institutions. Competing institutions often collaborate across syndicated deals and/or transact with each other as counterparties, building very strong intraindustry linkages in the process. Thus what is often misconstrued as colluding economic behavior is a characteristic especially ripe for technological improvements. These intraindustry linkages provide the basis for industry-level infrastructure projects because it is the very essence of *scale and scope economies*. What will not work as an individual initiative may nonetheless be a tremendous innovation at the industry level. The concept of an industry infrastructure becomes increasingly relevant, as more industry players maintain intraindustry linkages.

Evaluating the state of technology in the industrial sector is made

difficult by the fact that the basis of comparison is uneven. The degree to which industry agents are "linked" differs across industries, suggesting that the potential maximum benefits of technology will not be the same across industries. Industry infrastructure, viable for one industry, may not even be attractive to another. This implies that economic activity need not be subjected to technology.

There is also the tendency to associate the inclination to pursue technological innovations to exposure to foreign competition. The basic tenet appears to be that industries shielded from foreign competition have had little incentive to improve technologically, while those that accept the imminence of competition hasten their technological development. It is difficult to speak for all industries, but this has been the case in the commercial banking industry.

Many automation projects and industry infrastructure were conceived even before "liberalization" and "global competitiveness" became buzzwords. Some of these projects were not yet developed in time to avert otherwise avoidable crises (e.g., Bancap scam), while other projects only exemplify future benefits. But all these innovations have been in place, or at least all initial stumbling blocks have been addressed, when RA 7721 (Bank Liberalization Act) allowed foreign banks to operate in the Philippines.

Technology investment is not a once-and-for-all static process. Instead, initial investments in infrastructure and proprietary software design will be subjected to a continuous stream of redevelopment and upgrading. This is technology's natural growth process that allows the redefinition of investments to adjust to changing market conditions and evolving needs. The developments in the economic environment, as characterized by "liberalization" and "global competitiveness," enforce a natural check and balance system on technology. Technological improvements are not pursued solely on the basis of what will be essential to market participants. Rather, the pace of economic integration requires developments to have a keen eye for eventual technical integration, across local industries, and then later, across economies.

The Philippines still has a long way to go before it catches up with international technology. Technology management is a pro-

cess of change, a process that has a clear entry point and a perpetual end point. The process starts with self-need among industry players. There is no better incentive than for direct participants to agree to the need to improve, and to decide that technology will address this need. Across industries, this self-need will vary considerably, depending on a multitude of factors.

The key is to develop a common and consistent vision of what needs to be done, how to get it done, and the commitment to pursue changes and further developments. Technology must be molded according to what market participants need. At this stage, the difficulties with detail become evident. Infrastructure specifications and software design could take an enormous amount of resources, with no guarantee of completion. The only guiding rule is consistency with the vision. Once the industry gets through these, then the initial deliverables materialize. Beyond this point, it becomes a matter of use, development, upgrading, and continuous evolution. Thus the cycle is maintained with perpetuity, bound only by the strength of the commitment to make the best out of technology.

It is easy to suggest that the Philippines, as a country, should harness technology today if it is to preserve and build its competitiveness. How to do that, particularly across varying industries, is the task ahead.

DISCUSSION

Cayetano W. Paderanga Jr.

The presentation recapped all the technological changes introduced in recent years. I will make three general comments in the hope of adding insights, and also present some considerations from the central banker's point of view, which may not exactly coincide with that of a commercial private banker.

First, the article concentrates on the changes in the hardware. While banking is profoundly influenced by available hardware, the main commodities in this commerce are financial instruments and services that are of use to the public. I would have wanted the author to describe in greater detail how changes in available technology have extended the range and depth of financial services available in the Philippines. What financial instruments are now available, or have improved since, say, five years ago because of the available hardware changes?

In fact, the discussion on the PDS and other systems was a good start. Such information sometimes come as a surprise, even to those operating in the sector. It allowed us to visualize how financial services evolved within a short time. For example, the increasing use of super computers in head offices and main branches of banks has allowed the design of complex instruments such as exotic financial derivatives. On the other hand, the proliferation of more powerful desktops and workstations among users has made them more receptive to rapid innovations. As a result, more financial instruments that directly address individual needs and preferences have been cropping up in the market. Similar ruminations in other areas of banking would have been extremely useful.

While Dr. Ravalo's paper is rich on the present applications of technology in the Philippine commercial banking system, I would have wanted it to focus a bit more on impending techno-

logical changes. A discussion of technological applications already being applied in the more developed financial markets but have yet to reach us would have been very useful, as well as the implications of the more intense use of current technology. For example, what forms can we see in the use of the Internet in the Philippine commercial banking system? What changes can we look forward to? With the directions of the changes in the computer and similar machine, how would things be in the Philippine commercial banking system, say, in the next five years? Finally, I would have wanted the author to also address the question on whether commercial banking would be effective, in some fundamental or structural way, by present or forthcoming technology.

Let me frame some questions that could have been posed in this direction. Would the extension of financial services and credit access to more remote areas be enhanced by the bank's increased ability to process credit information almost instantaneously in more centralized databanks? For example, the processing of credit application in the regions is often delayed because forms are first brought to the central office to be approved by officers of a certain rank, and then brought back to the region. The possibility of doing this in a very short time will soon become reality. Would this change the personal aspects of banking? Would the regional distribution of credits be enhanced or reduced? Similar questions can be raised on all the other dimensions of banking. What seems clear is that technological changes are increasing our ability to facilitate savings by making more instruments adapted to individual needs and preferences available. This increased capability is also raising the financial system's ability to discriminate among investments projects, making the allocation of resources more efficient.

From the Central Bank's point of view, while technological advances offer tremendous opportunities, they also present some danger. The speed of transactions leads to large volumes and faster turnover. It is such that what used to take several days or weeks can now ensue within a few minutes or seconds. Computer programs now link transactions almost instantaneously.

An initial glimpse, or a primitive example of what could happen, is the meltdown of the US stock market, which was caused or worsened by the presence of computerized trading algorithms used by stock brokerage houses. Markets and market regulators need new standards and techniques, just to keep up with the nimbler and sometimes more aggressive market participants. Perhaps new technology would also promote these with fewer and better tools. For example, the article has alluded to how increased computer capabilities have allowed the use of book intersystems for tremendous volumes of traded instruments, and how credit and settlement risks can be reduced with the use of these databanks.

Increased system capability may additionally be provided by impending innovations. Neural network programs from artificial-intelligence research and complex statistical algorithms now enable us to discern patterns in seemingly chaotic data, almost at real time. These new techniques may help in catching up with new trends, even at their onset. But we still have to increase research and data development in order to keep abreast with the changes made possible by evolving technology. New technology has allowed rapid and almost instantaneous global financial integration of flows. Markets now move around the world 24 hours a day.

These financial integrations and continuous movements imply that extended events could swamp a country's financial system overnight. The dangers of contamination by outside events have already appeared over the past several months. These trends are expected to intensify in the near future, hence, the *Bangko Sentral* has been coordinating very closely with all concerned sectors.

We have insisted that the BSP be the settlement bank because of the dangers of default, which could hold up the liquidity of the whole financial system. We also have a very broad program for computerization, in which all of the commercial, thrift, and rural banks in the country have expressed their eagerness to participate.

Managing Technology in the Packaging Industry

GUIDO BAMBAGIONI

Chapter 22

After several years of protection from foreign competition, the market is now gradually opening its doors to international packaging material manufacturers. In most of these cases, the latest technologies are available for specific industrial segments given the economies of scale brought about by the size of international markets, the high quality of locally produced raw materials, and the number of available skilled personnel.

The packaging industry is not yet used to a climate of tough competition. For so many years, protective import duties have shouldered the costs of inefficiencies in the industry, such as the use of old technologies for converting lines and poor quality control in processing operations.

Benchmarking exercises done by end-users generally show that the cost of packaging material in the Philippine market is higher than the price of the same item in European countries, and even in the Asian region. This can be explained by import duties that allow local suppliers to quote high prices for their products, or by the nonavailability of certain raw materials, as

well as other factors that contribute to high production costs.

The present reduction in import tariffs for most raw materials and finished packaging materials is changing the local environment into an open market, where foreign companies have an opportunity to compete with local suppliers under conditions of parity.

The availability of modern technology, the possibility of sourcing raw materials at competitive prices, the availability of qualified personnel, and the capability of managing these technologies at a level comparable to the international market will be the greatest challenge to the Philippine packaging industry for the next 10 years.

State of the Industry

The packaging industry is composed of a few large and medium-sized companies, and several small ones. A few large companies dominate the local market, and their market share enables them to maintain immense production capacities and manufacture high-quality packaging products.

Over the years, most of the major end users consist of multinational companies whose continuous demand for high-quality packaging contribute to the improvement of standards for local packaging products. The high demand for quality and volume has allowed local converters to invest in new technologies in order to upgrade their productivity and line efficiency.

In terms of industry type, the food and beverage industry is the leading end user of packaging products, with requirements that correspond to roughly 60 percent of the total production of the local packaging industry. The other end-user industries are those in cosmetics, health-care products, footwear, pharmaceuticals, cigarettes, cement, soap, and detergents.

In 1996, the estimated revenue for the packaging industry totalled P39.3 billion: of which 34 percent was earned by paper- and paperboard-based packaging; 23 percent, by metal packaging; 17 percent, by flexible packaging; 14 percent, by glass packaging; and 12 percent, by rigid plastic packaging.

Trends in Packaging

With the continuing evolution of society, and the changes in habits and lifestyles, consumers are becoming more discriminating of packaging features.

The market is highly price-driven. Nevertheless, consumers are discovering the convenience of certain modern packaging features for a number of products that are not necessarily price-directed. Among these are:

- tamper-evidence systems;
- easy-opening features, especially for single-serve food packs; and
- reclosable features, especially for family or economy-size food packs.

Quality consciousness among consumers is growing. For instance, the demand for *barrier properties* of packaging, especially for food products, has to be addressed in order to preserve the original quality of the products. The attention given to *environmental protection* is also continuously growing, particularly when used packaging products are seen as a major contributor to environmental contamination. Suppliers and end-users are thus focusing on this issue in order to minimize all possible negative environmental impacts of packaging and continuously develop new more "environment-friendly" features.

Although volume continues to grow especially for big companies, *flexibility* is still a key factor to achieving better competitiveness. This requires a reduction in lead-times for new developments, as well as shorter runs for suppliers, in order to launch new varieties of the same product, even if the volume is still small.

Just-in-time delivery is already a normal practice in several countries, where packaging materials are delivered one to two hours before production, thereby minimizing warehouse considerations for the end-user. But the greater benefit of this system is that it introduces a unique *partnership* between the supplier and the end-user.

The relationship is based purely on reciprocal trust, and certain crucial production activities are not only performed by the end-user, but also by the supplier as part of the overall quality system.

Packaging does not only involve the technology of manufacturing and converting packaging materials. It also involves the technological development of *packaging machinery* at the end-user side, an important activity in the determination of the specifications of packaging-material requirements.

Some of the latest and more significant developments in packaging machinery are:

- High-speed Continuous Vertical Form Fill Seal Machines;
- High-speed Cartoning Machines;
- The Wrap-around Case Packer; and
- The Robot Palletizer.

Transfer/Acquisition of Technology

The transfer of technology is not an overnight process. The first consideration is if new technology can produce a volume that is sufficient for a good return on investment. Technical aspects also have to be considered. It might be easy to purchase and install new equipment, but at what level of productivity and efficiency will this equipment operate? Are there local personnel capable of operating and maintaining the equipment? Will the output meet the expected level of quality? Will the technology meet the requirements of the customer? The transfer of new technology involves several factors that have to be considered before it can be effectively managed.

Forging *joint ventures*, or the right choice of technical partners, is a well-known and widely-practiced system, ensuring a smooth transition into a new technology. The San Miguel Packaging Products Corp. (SMPP) is a leader in venturing into new packaging technologies through technical tie-ups, partnerships, or joint ventures with foreign partners who have mastered these technologies, including the SMPP-Yamamura glass manufacture joint venture; SMPP-Yamamura-Ball Corp. joint venture for manufacturing two-piece ALU

cans; Rengo of Japan tie-up for manufacturing corrugated shipping cases; Fuso Machine Molds of Japan tie-up for manufacturing glass molds; technical cooperation with Toppan of Japan; National Plastic of Korea tie-up for manufacturing plastic pallets; and the Schoeller tie-up for plastic crate technology.

In technology transfer and assistance, it is important to deal with partners who operate according to international standards. This provides an invaluable form of benchmarking, in order to further develop local standards.

Sharing R&D projects and activities is also an important learning process, and it will eventually enable local companies to implement their own R&D. Thus a technical partnership serves as a vehicle for introducing new packaging technologies into the local market. And in view of the need for global competitiveness, a technical partnership can facilitate local companies' introduction into the international market by:

- upgrading their standards;
- benchmarking their performance against those of international companies;
- gradually developing their R&D capabilities; and
- training their personnel through an exchange program with the technical partner.

Another important mechanism for technology transfer is the establishment of *alliances with end-users*. End-users (customers) can play a decisive role in the introduction of new technologies. Since meeting the needs of the end-users is the first important requirement in manufacturing packaging materials, the development of end-user packaging equipment will have to be closely monitored; thereby, also providing opportunities to develop new packaging products, and eventually introduce new technologies.

A good example of this synergy between the end user and supplier is the automation of the end-line stage of the packaging process, where *automatic case packers* are introduced for the packing of finished goods. At the same time, the transport unit is changed from

the *regular slotted container (RSC)* into the *wrap-around (w.a.) shipping case*. This change requires an investment in a high- or medium-precision die-cutting machine needed to produce the w.a. shipping cases. The production volume, as required by the end-user, will enable the supplier to invest in this new technology. In turn, the end-user will derive a cost-saving benefit in the shift toward w.a. because it covers a smaller board area for shipping storage.

In all cases where the end-user shifts to a new technology for cost-saving purposes, the packaging supplier also benefits, particularly if the end-user's market share, volume demand, and competitiveness increase.

Licensing can also be considered another strategy to facilitate the introduction of new technology. Here, the local supplier receives the exclusive use of a new technology (including the necessary technical assistance) for a fixed period of time.

It is also important that whenever a new technology is introduced technical personnel should undergo an educational process supported by the government.

Industry Issues and Problems for Government Attention

1. Cost of raw materials - it has been observed that the price of local packaging materials is higher locally than in international markets.
2. Standardization - there are no established packaging standards. It is therefore recommended that:
   a) There be a National Packaging Center, complete with laboratories, testing equipment, and technical seminars for private companies.
   b) Standards are set up, tested, enforced, and disseminated to the companies.
   c) Quality control is improved through the assistance of the Bureau of Product Standards.
3. Cost of money - it is very expensive and vulnerable to foreign-exchange fluctuations.

4. Power cost - it is too expensive, as compared to other Asian countries.
5. Training - government incentives should be given to companies that send their technical personnel abroad for training and technology transfer, to facilitate the introduction of new technologies.
6. Investment support - tax holidays should be given to investors in new technologies whose outputs are directed toward the local market.
7. Unfair competition - smuggling and undervaluation should be prevented. The 1995 Antidumping Law should also be strictly enforced.
8. "De-urbanization" - decongestion of highly urban areas, strict enforcement of zoning laws, and relocating factories outside highly-populated areas should be a government concern.

Role of Industry Associations

There are several packaging associations, but most of these were formed under an umbrella organization called the Packaging Institute of the Philipines (PIP). The PIP has more than 160 member companies, categorized as packaging-material converters, printers, importers, and end-users. Member associations under the PIP encompass various industry sectors, such as flexible packaging, corrugated board manufacturing, and tin can manufacturing.

These associations still do not play a major role in developing the packaging industry, and most initiatives have so far been undertaken only by the goodwill of a few individuals, or the interest of a handful of major private companies.

One major but unfinished PIP project in collaboration with the government was initiated way back in 1978—the establishment of a National Packaging Center. This project was motivated by the industry's need for a public center to test packaging materials. At present, these tests are still done abroad, or by large companies that can afford expensive testing equipments. Such situation hardly oc-

curs in other countries where national packaging centers exist.

Another project packaging associations should initiate is the establishment of proper packaging standards. We should learn from the experiences of countries like Japan where printing companies defined a *voluntary* regulation for the use of printing ink in packaging materials.

A complete database on the local packaging industry should also be made available. This could be used by the government to support the industry, and assist foreign investors for possible ventures. As of today, data are only approximations or incomplete. Thus it is the primary task of packaging associations to gather reliable data yearly from their member companies.

The opening of local markets to international players and the need to be globally competitive should encourage local suppliers to work together. Packaging associations should find it necessary to set up standards for the packaging industry and create alliances and synergies in order to face this new global challenge.

Conclusion

In the new scenario of global competitiveness, the management of technology will become a must for the packaging industry, as the need grows for high-quality and cost-effective packaging, comparable to the packaging of imported finished goods, and the direct importation of packaging materials.

To compete globally, it is necessary to think global. The packaging industry cannot just focus on the local market while competing with foreign companies. The size of the Philippine market will not provide the sufficient volume demand and economies of scale.

What does the packaging industry need in order to be able to compete on an international level? These pertain mostly to quality standards and quality controls; the availability of modern technologies; the achievement of good line efficiencies in order to bring down production costs; and the training of personnel.

It is *necessary to upgrade our local quality standards* to an international level, in order to meet global customer requirements. Improving

the quality of locally produced packaging is a must. A key factor in achieving this objective is the *definition of a detailed packaging specification*. This has to be properly discussed and studied, and requires a good level of technical expertise and advanced testing methods for quality control. In addition, the process of establishing packaging material specifications, a requirement in purchasing packaging materials and a tool in consistent quality performances, also involves the proper training for technical personnel, and the proper technology to test quality.

Partnerships with end-users will serve as a strong incentive for suppliers to set up quality monitoring systems, Certificates of Analysis of delivered times, and just-in-time deliveries.

A National Packaging Center must be operational as soon as possible in order to provide local companies with instruments to test quality.

There is definitely a need to upgrade the *average* technological level of the packaging industry. While a few major players avail of the latest technologies, the industry average is still wanting in technological growth. Automation will lead to increased productivity and lower production costs. Investment in modern equipment, with government incentives, will support technological growth. Volume demand in the Philippine market is relatively small. To justify major investments, it is necessary to consider exports to Asian markets.

New technologies will have to meet customer requirements. Their development should be complementary, and not conflicting to end-user long-term plans. The transfer or acquisition of a new technology will also require the proper training of personnel.

ISO certification should be considered as a base standard for the industry. At present, only a few companies are duly certified. In European countries, most companies source their raw materials only from ISO-certified suppliers.

These are the major requirements which the packaging industry must fulfill in order to achieve global competitiveness. The management of technology, standardization, and quality will be the key elements to achieve this goal.

DISCUSSION

Mariano S. Lagman

Mr. Guido Bambagioni has given a very thorough exposition of the status of the packaging industry in the Philippines, as well as its future if we manage and harness technology as it exists in the more advanced countries of North America, Europe and Asia. He has dealt with significant items which I would like to address.

Mr. Bambagioni has stressed the integration of the activities of the packaging material manufacturer and the end user. These two entities hardly discuss common problems and possible solutions. The presentation further elaborated on the partnership that should exist so that concepts, like JIT and single-sourcing, could be practiced, saving money on, for instance, inventory cost and materials handling by minimizing double handling in the factory.

We especially look at the integration of packaging materials for the consumer, since this is vital in saving money. For instance, if we take a pallet of a beverage and look at the boxes stacked on the pallet, and inside the boxes are bottles, we are actually looking at three packaging materials. We have the paper board, bottles, and the pallet. It is conceivable to take all three, and look at these as a unit, with possible savings from any of the three materials. In addition, there are trade-offs within the units and, as such, we also have to look at the total cost of the whole unit. We can no longer look at just one.

Education is important even for a system like this. If, for example, you look at the top of one package, you will find that the stacking pattern is a certain way, the next pattern is different, and then back to the first pattern again. The educational aspect here is that a lot of small- and medium-scale companies are not aware of this. If you do this type of stacking pattern,

you tend to interlock and don't get the blossoming of the packages where the protection is almost inherent. You can always rick-wrap or stretch-wrap, as well as use other new technologies. Nowadays, these are no longer new. Ten years ago, I remember seeing glue put on top of packages that were being stacked in order to prevent them from shifting; they could even be lifted without much fiber turn. With boxes, you always have to look at it through a two-by-three relationship, as a perfect pattern. These processes, even though they are simple technologies, are not well communicated down the line. Things like these form the educational aspect.

Mr. Bambagioni's presentation made me recall some personal experiences when I was in a brewery in North America. As early as the 1980s, we were working with glass suppliers and looking for a seven-ounce glass that was seven inches high and capable of holding 12 ounces of beer. When we found this, we realized that we shipped 15 percent more beer to, say, Clark Field than what we were shipping to the United States. Somehow, lightweighting had to come in because it saved on freight, as well as glass or the raw materials used to make glass.

Mention was also made of the role of the government and private industry groups in fostering standardization, as well as forming test labs and other possible synergies, to undermine the packaging industry to modernize. The role of the government in giving incentives for new and modern equipment is equally important. The same holds true in the establishment of testing labs, for small manufacturers to assure their customers of product integrity, in terms of packaging and rigid specifications.

The time frame for incentives should be reduced at some point, because we cannot subsidize private industry forever. We have to let market forces operate, and if some firms are not competitive, then that's just too bad.

Mr. Bambagioni also raised a significant point about what it takes to be able to compete in the international market, both now and in the future. The thrust should be to bring down production cost by investing in state-of-the-art equipment, such

as high-speed lines, or investing in waste-reduction activities, with emphasis on quality. Furthermore, the presentation strongly advocates ISO 9000 certification, as it makes product acceptance much easier especially in Europe.

However, all these efforts do not come cheap or easy, since they also require highly skilled people, engineers, and other technical personnel. This is where formal or informal training programs come in.

As a developing country, the Philippines should be watchful of whether these technologies are environment-friendly, and if the systems for recycling packaging material are in place. At this point, we hardly have any organized recycling centers, especially for scrap aluminum, and yet we are starting to consume a lot of beverages and food that use aluminum packaging. Take these instant, ready-to-cook noodles—how many materials are in there? There is styrofoam, aluminum over paper, a plastic foil for some of the contents, another aluminum foil for other ingredients, and sometimes even a plastic spoon—there are four or five things that we need to dispose of.

The question now is: should the beverage and food industry take the lead in opening these centers? In some advanced countries like the United States, some brewers have taken the lead in opening recycling centers. The same is true for glass, plastic, and other containers. We should take care that we do not adopt all the convenient packaging of more advanced countries. This is probably why I am often gratified when I see people, especially young children, walking with a plastic bag filled with softdrinks and consuming it through a straw—you have only one packaging, one material, perhaps two different kinds of plastic. How simple can it get?

The use of advanced technologies in packaging carries with it the obligation to look at its entirety as it affects our lives both in the short- and long-run.

Managing Technology in the Maritime Industry

REYNALDO B. VEA

Chapter 23

In this article, *maritime industry* shall refer to the fields of ship design, construction, and operation.

Ship Design

Ship design is the determination of: a hull which will, under anticipated cargo loading, float at the desired level and that will be seaworthy and seakindly; a structure which will withstand the loads imposed by cargo and other weights and by the sea; engines and propellers which will give the right speed, and economy of operation; and auxilliary machineries which will ensure habitability of living spaces, and operability of systems, most especially those involved with cargo operations. Ship design is based on the engineering knowledge of structures, hydromechanics and machineries, and associated systems. It also relies heavily on numerical methods.

Ship design is carried out by shipyards, or by independent naval architects. Government is normally involved in the regulatory aspects. Ship designs are checked for compliance with the requirements of the Philippine Merchant Marine Rules and Regulations (PMMRR). The design rules refer principally to aspects related to ship safety, and the protection of the environment. The Phil-

ippine Navy has its own limited capability to design and build ships.

For commercial ships, ship designs are normally submitted to so-called classification societies for evaluation, in terms of structural adequacy and, in recent years, for stability. Classification is normally sought by the ship owners for insurance purposes. These classification societies, like the Lloyd's Register of Ships and the American Bureau of Shipping, maintain their own research, enabling them to continually update classification rules.

Ship Construction

Ship construction is the principal responsibility of shipyards. However, these yards rely heavily on so-called ancillary industries which supply the components of a ship. Most yards may only have the independent capability to construct the hull. They have to get their portholes, doors, and other appurtenances; winches; air-conditioning; propellers; thermal insulation; electrical conduits; electronic equipment, and others from outside. As in the automotive and the building construction industry, the array of technologies needed to put together a ship is vast. It includes new materials, metallurgy, electronics, microelectronics, controls, communications, radar, paint technologies, etc. Shipyards themselves need joining, casting, machining, operations research, and information technologies.

Ship Operation

Ship operation involves taking a ship from point A to point B as safely and economically as possible; and doing cargo operations, in the most efficient manner, to minimize time spent in port. It also involves operating all machineries for propulsion, maneuvering, cargo handling; and the maintenance of satisfactory conditions in the living quarters. The former is the responsibility of deck officers; the latter, of engine officers.

Ship operation requires people who understand and are able to properly use ship equipment and machineries. It needs people versed in electronic navigation and communication aids, such as satellite,

position-fixing, and radar technologies. It needs people who are knowledgeable in control technologies for engines, electrotechnologies, new materials, joining technologies, and industrial chemistry. It needs people who are familiar with inert-gas systems (IGS) and Crude Oil Washing Systems (COW), as well as other environmental technologies.

Ship operation also involves landside operations, such as stowage preplanning, container tracking, and weather routing.

Recent Developments

There are four developments that have caused radical changes in the technologies of ship design, construction, and operation: 1) the rapid development of information technology; 2) the growing use of seas, as a source of minerals and energy; 3) environmental concerns; and 4) globalization.

Information Technology

Information technology loosely refers to computer and communications technologies that enable ultrafast storage, retrieval and processing, and transfer of information. This is the most obvious development of recent years, and has affected all sectors.

In ship design, computer technology has raised the expectation of naval architects. Whereas they were expected to come up with a ship given the required cargo payload and speed, these days they are now expected to also carry out the technoeconomic study that will yield cargo payload and speed requirements. This involves parametric studies of a wide range of possibilities that heretofore would have been intractable. In general, the intractability of calculations due to sheer volume is no longer valid just as in other engineering and scientific fields.

The finite element method (FEM) is now routinely used for structural and hydrodynamic analysis. The design of propellers need no longer be confined to the use of charts based on empirical data. Lifting surface models has been successfully employed in design.

Numerical hydrodynamics enables the better prediction of wave resistance. Reliability-based structural design has now become possible.

In ship construction, information technology has enabled the use of powerful tools for process analysis; data storage, management, retrieval, and tracking; quality assessment; online search; modeling and simulation; software toolkits and libraries; benchmarking; management and organizational design; and planning. Information technology has also enabled the use of certain services, such as electronic mail; forums and bulletin boards; directories; parts catalogues; referral services; best practices databases; teleconferencing services; electronic bidding networks and services; online training and outreach; access to government services; and access to government procurement information. Computer technologies have also enabled the use of CAD/CAM, which has essentially fused design and construction. Computer aids for lofting and fabrication are now de rigueur in advanced countries.

In ship operation, computer and control technologies have enabled unmanned engine rooms. Positioning technologies have become very accurate. Weather routing has become possible. The least-time path need not necessarily be the shortest path between A and B. The determination of this path needs tremendous number-crunching by a computer, in a land-based facility. Loading of containers is optimized with preplanning software. Design and operation are also fused by computer technologies. Design data are easily accessible through computer programs, which are used in ship operations to keep tab of stability, trim, and structural safety.

Oceans for Minerals and Energy

The search for new sources of minerals and energy has led to the oceans. Departments of naval architecture have been transformed into departments of ocean engineering, or offshore engineering, to address these new possibilities. The technologies for these new activities are extensions of naval architecture and marine engineering. Platform technologies—structures, mooring, dynamic positioning,

etc.—have dramatically improved in recent years. Energy alternatives from the sea, such as wave energy and thermal energy, have been prototyped. Mining of manganese nodules from the sea bottom is now a reality.

Environmental Concerns

Media coverage of recent oil spills has stressed the importance and urgency of marine pollution as an issue. There are a host of prevention measures. The techniques of COW, segregated ballast, and IGS are covered by international rules under the International Maritime Organization (IMO). Prevention technologies appear to be more within grasp than clean-up technologies, such as the use of absorptive feathers, oil-eating bacteria, etc. For instance, one rule has recently been mandated—the use of double skin—which is not high technology at all. What had prevented its use in the past is economic cost and ease of construction and operation.

On another level, the desire to conserve resources has led to the design of computer-controlled rigid sails and Flettner rotors. It has led to the design of fuel-efficient engines.

Globalization

Besides the environment, there are other global concerns. The vigorous recruitment of seamen has necessitated international training standards. International standards of ship safety have also been promulgated. Today, the naval architect has to be familiar not only with national, but also with international requirements. The dissemination of technologies has been encouraged by globalization.

Issues

Awareness and Capability of Managing Technology

The first thing one has to realize about the management of technology in the maritime industry is that nobody seems to be thinking

about managing technology—at least, at the sectoral level. The author is aware of only two conferences related to the United Nations Convention on the Law of the Sea (UNCLOS), in which science and technology needs and policies were discussed. There appears to be no technology assessment going on and, as such, no real technology planning at the sectoral level. Such an exercise is by no means trivial since the range of technologies is vast. An example is the technologies used by the ancillary industries associated with ship construction.

The first step for technological development is building the awareness of technology management at the sector level, as well as at the firm level. The next step is to do the actual management.

Level of Technologies

The use of advanced tools in ship design is just starting to gain headway. The high cost of software and the discomfort with the new method are factors that have hindered the proliferation of design software. In schools, the mathematics and computer-science knowledge necessary to fully appreciate these new tools has not been built into the curriculum.

While it is an acceptable and sometimes recommended practice, there seems to be a very strong tendency to rehash existing designs. The capability to accomplish innovative designs has been hampered by the inability to use new technologies and tools. One wonders, for example, why there has been no attempt to find a more elegant solution to the problems addressed by ships designed to be like the World War II-vintage Landing Craft Transports (LCTs). These vessels, as it were, are the jeepneys of the seas.

The access to knowledge is very limited. School libraries do not have books or access to the Internet. There are no international linkages with professional societies. Even among naval architects, there is very little exchange of technical information.

Given this situation, the question of whether R&D capability exists need not even be asked.

In all, the level of technology employed by local ship designers

is very low, and there is no capability to produce new knowledge.

Those in ship construction have it better. The entry of foreign investments into our shipyards has exposed them to high levels of technology. The question, in this case, is whether technology is being transferred properly or not. The usual method employed is to go for the series production of ships in which the local content progressively increases.

In ship operation, our seamen are initially trained in generally poorly equipped maritime schools. Those who work aboard ocean-going vessels get exposed to high technologies and eventually become very good at it. Those who work on domestic ships still make do with outdated technologies, with a few notable exceptions.

Another area of concern in technology management in the maritime industry is the raising of technological levels. With the crumbling of national borders, competitiveness in the maritime sector will rely to a great extent on the level of technologies it employs. In this case, we can say that spending on technology cannot hurt the business.

Opportunities and Requirements under the UNCLOS

The provisions in UNCLOS on the continental shelf and the exclusive economic zone (EEZ) define expansive areas that fall under the national jurisdiction of coastal states. The inventory, exploitation, processing, conservation, and protection of resources, within the said area, require the extensive use of ocean platforms and vehicles, and oceanographic equipment. Research vessels and submersibles are needed for gathering data, and taking stock of living and nonliving resources. Fishing vessels of greater capacity and longer range are required to fully exploit the riches of the EEZ. Specialized platforms and vessels and appropriate equipment are needed to mine the seabed and subsoil. Platforms are also needed to generate energy from the sea. To secure the EEZ against violators, a sizable fleet of state-of-the-art seacrafts for patrol and interdiction is a must.

Provisions on the nationality of ships require the continuous

updating of national rules and regulations to govern the design, construction, operation, and inspection of ships. These rules and regulations must incorporate international conventions. The formulation of and compliance with these rules and conventions imply the need to be up-to-date on ship technologies, notably, those pertaining to ship structures and seaworthiness. For example, the IMO has shifted to a probabilistic criteria for damage stability. Designing to comply with these criteria requires more sophisticated and computerized calculations. Designs for simple empirical rules are not acceptable.

In view of the UNCLOS, a basic government issue is how technological development, in the fields of naval architecture and offshore engineering, is to be prioritized against the competing needs of other sectors. A long-term plan for maritime technological development cannot be divorced from an overall plan for the EEZ and other UNCLOS-related concerns. Ideally, all these must be in the context of the overall national economic development plan.

UNCLOS-related concerns have to be prioritized. In technological development, the most urgent needs are technologies necessary for the security and protection of the resources under national economic jurisdiction. Upgrading design and construction capability should be given immediate attention. This fortifies the security of relevant sea areas, and facilitates surveys and large-scale fishing. The development of technology in offshore oil rig design, construction, and operation is already a current need. For the moment, Offshore Thermal Energy Conversion (OTEC) and seabed mining technologies may be put on hold.

The need for managing technology development in the maritime sector is vital to economic development. The UNCLOS only heightens this need.

Closure

The development of maritime technologies is a complex process, subject to both market forces and government intervention. The creation of an environment, conducive to the evolution of a system which can generate, develop, acquire, adopt, adapt, absorb,

protect, organize, store, diffuse, and apply scientific and technological knowledge, is a difficult undertaking.

Various organizations, public and private, exist in the maritime sector. These organizations could serve as the network for technology-related activities. But, before this, there should be a heightened awareness of the role of technology.

DISCUSSION

Elenita C. Delgado

We are at the crossroads of making policies that we hope will stimulate the development of technology in the maritime sector. It is my sincere hope that all concerned will strive to take stock of the realities, and endeavor to explore alternative solutions, and to reduce, if not remove, the barriers that impede the growth and development of technology. We have hardly begun to think seriously about where we want to go.

Suffice it to say, however, the government, through the MARINA, envisions to develop the shipbuilding and shipping sector in order to meet the modernization program of the Philippine Merchant Fleet.

As an implementing strategy, we have been soliciting foreign technical and financial assistance. For example, we lined up the *Shipbuilding Technology Training and Safety Project* for the Japanese government to consider. This project is geared toward meeting the immediate medium- and long-term needs of the industry; to cope with the construction standards of class societies, and comply with conventions, codes, and regulations of the International Maritime Organization, as well as national legislations involving *maritime safety and protection of the marine environment*.

Sadly, however, our request was scaled down to a degree that will not warrant the conduct of research and development by the industry, government, and academe. The repackaged project will entail the support of the University of the Philippines—the *institutionalization of courses on naval architecture and marine engineering* at the U.P. College of Engineering, under the Mechanical Engineering and Civil Engineering Departments.

The creation of a pool of qualified and trained manpower,

for the construction and inspection of ships, is expected to become one of the outputs of the undertaking. Again, there has not been much headway in pursuing the R &D program for the shipbuilding and ship repair sector. However, our cooperative stance with the DOST, through the Philippine Council for Industry and Energy Research and Development (PCIERD), has somehow resulted in joint activities that promote the use of indigenous materials, as in the *Ferrous Cement Application Project.*

Two other projects, with similar funding assistance from DOST, are: 1) the design and prototyping of a detachable minicontainer for Asian utility vehicles that will provide a low-cost cargo handling module for the rural areas, particularly for perishable goods and farm produce; and 2) the P3-million project, involving the design, development, and prototyping of a landing craft transport for minicontainers, in order to develop a more efficient transport system for the rural areas which is adaptable to AUV carriage.

It is just a matter of time before the transport of farm products to their destination, using this modularized system, will be realized. A total of 100 minicontainers are already being manufactured by the Sun Valley Manufacturing Development Corporation.

There appear to be several concrete moves aimed at managing technology in the maritime industry. These can be judged from past records and developments—whether involving assessments of the gaps in technology requirements, given the challenges posed by the revolution in information and communications; or the obligations to secure and protect our national territory, as defined by the UNCLOS; the removal of economic boundaries through the formation of regional blocks; or, above all, global competition. Without focus and sectoral technology planning, we may lose whatever competitive advantage we enjoy, and end up self-destructing in the midst of global opportunities and problems.

It has been mentioned that there is a need to continuously update national rules and regulations, governing the design, construction, operation, and inspection of ships. Having recog-

nized the anachronistic feature of the RPMMMR, MARINA is committed to come up with revised regulations soon. In particular, with the advent of fast ferries being deployed in domestic shipping, we are now trying to fast-track the formulation of appropriate rules and regulations governing their operation, notably those on structural soundness and seaworthiness.

The effect of the introduction of unmanned ships should not escape the attention of both the public and private sectors. With fast technological advancements taking place in maritime transport, this could cause jitters within the seafaring industry, which is a recognized revenue source for the economy. This could also mean the displacement of crews, and major adjustments in organizational structures. In quantitative terms, this could mean a reduction of manning to unimaginable levels, particularly in automated and highly sophisticated vessels.

Given this scenario, we would not choose automated vessel operations, until after displaced seafarers have a place in the labor arena. The industry should take the initiative to upgrade present training standards to meet the requirements of the revised training standards. Certification and watchkeeping conventions should be encouraged, with the government always ready to extend available support and assistance.

These recommendations are made in the light of a mission report submitted by Dr. Asis, an IMO consultant on maritime training. Dr. Asis took note of a growing lack of confidence in the quality and competence of Filipino seafarers because of inadequate training facilities and poor instructional capability.

Dr. Asis has often said that "global competitiveness starts with quality competitiveness, and ends with technology competitiveness." We should thus become quality-competitive, before we strive to be technologically competitive, or even cost-competitive, especially in the global environment.

We should not wait and tarry. The industry, government, and academe should join forces in the spirit of mutual cooperation, and focus on a common technological vision. With the DOST at the forefront of a critical mass of 3,000 highly trained scientists with graduate degrees to spearhead the country's bid

for global competitiveness, we in the maritime sector hope to get our share of that pool.

Then we can face technology planning in terms of opportunities which have become problems because we had failed to learn the new rules of the game, and reckon with the need to change and improve—both of which spell the difference between getting by and getting ahead.

Managing Technology in the Automotive Industry

FLORENCIO B. JURADO

Chapter 24

According to the 1995 World Competitive Report, the Philippines ranked 35th in overall *competitiveness* among Asian countries. Within the ASEAN, this ranking was the lowest, compared to Indonesia (33rd), Thailand (28th), Malaysia (21st), and Singapore (2nd). The Philippines' biggest liabilities were *poor infrastructure*, *low telephone ratio per capita*, *inadequate transport systems*, and *inefficiency of income distribution*. Its biggest strength was *internationalization*. Fortunately, the country placed first in the openness of its people, second in managers' interest in overseas postings, and fourth for growth in export goods and services.

Before discussing how this picture reflects on the present status of the automotive industry, an overview of global automotive technology development is necessary, since this also affects the growth of the local industry.

Trends in Automotive Technology

Automotive technology has developed rapidly since the mid-1970s, fueled by two oil shocks, increased motorization, and the resulting need for safer and more environment-friendly technol-

ogy. Rising oil prices have increased consumer demand for energy-saving, small-sized models. A growing awareness of the need for alternative energy sources and greater fuel economy has forced governments to adopt stringent environment regulations. An example is the establishment of the Corporate Average Fuel Economy standard by the United States.

During the 1980s, automotive technology development focused heavily on electronic devices, with remarkable results. The need for engine control system with low-emission devices and improved fuel efficiency led to the development of the electronic injection system, which is now widely applied to shock absorbers, antilock brake systems (ABS), airbags, and electronic automatic transmissions.

Vehicle Weight Reduction

The growing number of electronic parts and safety devices installed in vehicles has led to a steady increase in their weight. Research is under way not only to reduce weight, but also to ensure that stricter standards for emission and fuel consumption are observed. Moreover, since current technologies, devised to improve engine performance with lower fuel consumption and reduce air resistance, have their limits, attempts are being made to develop technologies to produce lighter cars.

Accordingly, the use of steel is diminishing, and research on developing parts made of aluminium and plastic are under way. The high price of aluminum restricts its use in luxury cars. New alloys are being developed for cheaper cars, specifically for the lower and upper arms of shock absorbers, and compressors for air-conditioning units. Plastics are also more widely used for bodies, drive shafts, double plate springs, and bumpers. The use of plastics is increasing because their use makes it easier to adapt to changes in design.

Since cylinder blocks made from aluminum will reduce weight substantially, research toward this end is under way in Japan, the United States, and several countries in Europe; and it is expected that, by the year 2000, such blocks will be installed in more than 30

percent of all motor vehicles worldwide. Metals and materials used for other parts include titanium for engine valve systems, and metal matrix composites for engines and parts supporting loads. Magnesium will be used for the oil pan and cylinder head covers. Plastic, which is currently used only for the interior and exterior, will be used for the air-intake manifold, as well.

Safety Technology

Two types of safety technology have been developed: *active*, to prevent accidents; and, *passive*, to minimize damage in case of accidents. Active safety technology includes the ABS, traction control system, and four-wheel drive. Passive safety technology includes air-bag, door impact bars, and seat belts. A rapid increase in demand for vehicles with such safety devices is expected, and governments are currently reviewing regulations to tighten them further.

Environmental Considerations

In order to minimize environmental pollution caused by vehicles, the US government has regulated the volume of motor vehicle emission by law since 1968. The California Air Resources Board has introduced regulations, requiring a certain percentage of total vehicle production to be transitional, low-emission vehicles by 1994; low-emission vehicles and ultralow-emission vehicles by 1997; and zero-emission vehicles by 1998.

The Big Three in the United States, together with other major manufacturers and research centers around the world, are striving to develop new engine systems and alternative fuels to comply with increasingly stringent emission standards. The automotive industry is also focusing its attention on recycling wastes generated during production.

Studies on alternative fuels for motor vehicles have been ongoing for some time. Electricity, methanol, natural gas, and hydrogen gas are considered important alternative fuels for the future.

The Toyota Perspective on Productivity and Globalization

The distinction of Toyota's production system rests on two pillars:

- *Just-in-time system,* which eliminates all activities that do not generate value for customers, and focuses on the production of what is needed, when it is needed, and in the amount needed; and
- *Jidoka* - "Intelligent Automation"

The uniqueness of the Toyota production system is based on a *management philosophy with a production point of view*. It is centered on a *man-machine system,* which is driven by the belief that "a conveyor does not operate man, but rather, it is the man who must operate the conveyor."

The very foundation of the production system rests on the respect and dignity of team members. Here, team members are allowed to use their ingenuity, participate in the design of their jobs, and develop communication channels to keep team members informed of what is going on in the company. Thus the four corners of this foundation are:

- *Muda* - Two of the most fundamental principles of the Toyota production system are the elimination of wastage by plant and office team members, and the achievement of the highest productivity and quality. Combining these principles with Toyota's firm belief that a person's time is very precious, the company fulfills its obligation to eliminate useless movements, and effectively utilize the person's time at work. Under this system, every movement should contribute to the production process, and help increase overall productivity.

- *Andon* - Team work is an essential component of the total system. Hence, problems are resolved through team effort. Communication is fundamental to the success of the

Toyota production system. One of its principles is "visual control," which is demonstrated in many areas of its operation, such as the Andon Board. Problems in the production line are solved immediately through the use of the Andon system, in which color-coded lights are employed to signal the foreman responsible.

- *Kanban* - This refers to the production and conveyance of what is needed, when it is needed, and in the exact amount needed, resulting in high productivity, lean inventories, and tremendous savings. This synchronized manufacturing process shortens production lead time, and makes the total system as efficient as it is flexible.

- *Kaizen* - Kaizen simply means "search for a better way." Team members have the opportunity to suggest improvements in the system, from work-flow ideas to working conditions, through the "suggestion system." The Quality Control (QC) Circle, on the other hand, is more of a detailed and long-term team effort, which guides management in their planning and decision making. Also, the team concept allows the company to reassign tasks quickly in order to cope with unexpected changes in the production sequence, as well as with the introduction of new models. To further improve Kaizen, quarterly competitions are held, which involves all team members not only from the production line, but also from the support offices and front-line divisions.

Industry Analysis

Exports

The export performance of the local automotive industry is due mainly to the following:

- Foreign exchange requirement for the importation of Completely Knocked-Down (CKD) parts, under the Vehicle Program;
- Full-scale implementation of the Brand-to-Brand Complementation (BBC) scheme; and
- New investors in Export Processing Zones.

In addition, the industry can look forward to the benefits that can be gained from the enforcement of the ASEAN Industrial Cooperation Scheme (AICO).

Export Performance and Targets of the Automotive Industry

Year	Total (in billion $)	Auto Parts/Components (in million $)
1993	11.4	444
1994	13.5	689
1995	17.4	751
1996	21.0	—
1997	25.6	—
1998	32.0	—
1999	40.0	—
2000	50.0	2,000

Expansion

Among the various industry players undergoing expansion activities are:

· Toyota	P3.0-billion manufacturing complex in Santa Rosa, Laguna
· Nissan Motors	P1.9-billion plant in Santa Rosa, Laguna
· Scandinavian Motors	P800-million multibrand assembly plant (Volvo) and a joint venture

	with Universal Motors
· Honda	Expansion of capacity to 24,000 units per year (from 10,000)
· Toyota Auto Parts	P1.3-billion plant for new products and transmission expansion
· Asian Transmission	P350-million expansion project

Under the liberalized program, the industry is also introducing new Completely-Built Unit (CBU) models, like the Toyota *Camry* and *RAV4*, the Volkswagen *Polo*, the *Audi Quattro*, the new *Land Rover*, and the *Jaguar* with Universal Motors.

Opportunities

At present, the main opportunities for growth available to the automotive industry are:

- Liberalization - imports of CBU models
- Expansion program of major players
- Current road infrastructure projects - C5, Skyway, etc.
- Growing market for vehicles
- Available financing, at competitive rates
- ASEAN Industrial Cooperation Scheme (AICO)
- Special attention given to support industries and small- and medium-scale enterprises
- Reactivation of the ASEAN Automotive Federation, in coordination with the ASEAN Chamber of Commerce and Industry and the ASEAN Secretariat

Threats

On the other hand, the threats to the future growth of the industry are:

- Liberalization - so many models
- Lack of economies-of-scale for support industries

- Lack of firm commitments from some industry players
- Trading perspective versus manufacturing perspective
- Policy conflicts, in terms of:
  - Proposed new taxes, even in the course of liberalization
  - Transportation program versus emission/pollution control program (used vehicle imports)
- Traffic problem, attributed to the growing vehicle production and sales
- Road infrastructure unable to cope with growing vehicle population (160,000 km since 1992)

Finally, the Philippines lost to Thailand, in the widely publicized bidding war for General Motors to locate its $750-million plant, mainly because of the following advantages of Thailand:

- Proven infrastructure
- Strong domestic market base
- Developed automotive support industry

Technology Needs and Concerns of the Industry

The automotive industry still cannot be involved with the global trends in automotive technology. The local industry has to attend to more crucial concerns affecting its growth and development, among which are:

- Need for an integrated steel industry - our steel industry, to date, is not yet in a position to produce and supply deep raw materials for automotive stamping (press) operations.
- Low-tech tool and die industry - we are well behind Thailand, Indonesia, and Malaysia in tool and die-making technology, as the market volume of these countries allows production of full-pressed body components (i.e., for

Thailand's pick-ups, Indonesia's AUVs, and Malaysia's Proton cars).

- Limited Casting and Forging Operations - confined only to specialized production, like aluminum castings and metal forgings for transmissions.
- Limited Machining and Heat Treatment Technology - confined to specialized production only.
- Limited Manpower Training/Vocational Education - linkages with vocational schools are limited to certain members of the industry, while training programs through the Technical Education and Skills Development Authority (TESDA) and the Automotive Industry Board Foundations (AIBFI) still need the support and cooperation of participants in the Motor Vehicle Development Program (MVDP). DOST programs are also limited to specific projects, like electric vehicle projects, technology for transport planning and management, drive cycle pattern for Metro Manila, and component parts for public utility jeepneys.

Adding to these concerns are the weaknesses and strengths of the local automotive industry:

Strengths

A. Assembly
- Unutilized capacity
- Competitive position as area production platform
- Growing economy

B. Parts Manufacturing
- Local content requirement in the Motor Vehicle Development Program (MVDP)
- Foreign exchange requirement in the MVDP
- ASEAN Industrial Cooperation Scheme (AICO)
- Competitive labor force
- Many manufacturing technologies are in place

Weaknesses

A. Assembly
   1. For foreign-owned companies/joint ventures
      - Smaller domestic market
      - Liberalized imports of new vehicles
      - Competition from used vehicles
      - Motor Vehicle Inspection System (MVIS) is still in the process of being established
   2. For local companies
      - Less support from brand owners

B. Parts Manufacturing
   1. For foreign-owned companies/joint ventures
      - Smaller domestic market
      - Most components are unique to certain models only
      - Underdeveloped support industries
      - Perceived less favorable investment climate
   2. For local companies
      - Uncertain local market foothold
      - Poor foreign marketing networks
      - Joint-venture projects are nil
      - Only lower-grade technology is available
      - Shops and manufacturing equipments are outdated
      - Lack of capital
      - Lack of public and private support to improve productivity, quality, and acquired technology (R&D)
      - A tool and dye center is not yet operational
      - Low tariffs for Completely Knocked-Down (CKD) imported units
      - High tariffs on raw materials
      - Testing laboratories are not yet available

Figure 1

Salient Features of the New Motor Vehicle Development Program (MVDP)

(as per MO 346)

Items	*Car Development Program (CDP)*	*Commercial Vehicle Development Program (CVDP)*
Objectives	· Development of the parts manufacturing industry · Technology transfer and development · Employment generation · Foreign exchange savings and earnings	- same as CDP -
Coverage	· Category I - with engine displacement of 1,200 cc and below and with a reasonable price ceiling - a larger engine displacement may be allowed provided its selling price shall be in accordance with the price ceiling · Category II - above 1,200 cc but below 2,190 cc · Category III - 2,190 cc and above Note: equivalent diesel engine displacement will be allowed	· Category I - all AUVs up to 3,000 kgs GVW · Category II - all LCVs up to 3,000 kgs GVW · Category III - all vehicles from 3,001 kgs GVW to 6,000 kgs GVW · Category IV - all vehicles from 6,001 kgs to 18,000 kgs GVW · Category V - Trucks above 18,000 kgs GVW and SPVs

Items	*Car Development Program (CDP)*				*Commercial Vehicle Development Program (CVDP)*		
Local Content	· Categories I and II - 40% minimum - 50% forex award if LC weighted average is 50 % · Category III - none				· Categories I and II - 45% minimum - 50% forex award if LC weighted average is 55% · Category III - 21.90% · Category IV - 21.44% to 13.77% · Category V - 13.77%		
Foreign Exchange Requirements (%)	*Category*	*I*	*II*	*III*	*Category*	*I&II*	*III&IV*
	1996	5.0	45	75	1996	5.0	5.0
	1997	7.5	45	75	1997	7.5	5.0
	1998	7.5	50	75	1998	7.5	5.0
	1999	15.0	50	75	1999	15.0	5.0
	2000	15.0	55	75	2000	15.0	2.0
Investment Requirement for New Participants	$10-million worth of investment in parts and components manufacturing facilities				$8-million worth of investments in parts and components manufacturing facilities		

Action Plans for the Industry

Strategies

To help counter its inherent weaknesses, the following strategies are recommended:

A. For Existing Companies
   1. Those already exporting
      - Continued competitiveness program
      - Expansion
      - AICO promotion
      - Higher value-added program
   2. Those not yet exporting
      - Quality enhancement and other export development schemes, like capital equipment financing
      - Joint ventures and/or technical collaboration
      - Manpower development
      - Other infrastructure development schemes

B. For New Investors
   - A revitalized marketing program
   - Intensified promotion of support industries

Interventions and Assistance

The government should also assist in the development of the automotive industry through the following interventions:

- Promote technical tie-ups
- Promote joint ventures
- Intensify export development activities
- Intensify the promotion of support industries
- Work for a special financing window
- Promote the AICO
- Work for tariff adjustments
- Pursue intensified activities for export competitiveness
- Pursue exports with increased value-added

Immediate Activities and Plans

Finally, the industry must prioritize and undertake the following immediate activities, as a first step toward concretizing industry growth:

- Create an industry directory listing of the following industry players, together with applicable data on capitalization, number of employees, models/parts being produced, capacities, group sales, etc.:
  - Assemblers
  - Franchise dealers
  - Component manufacturers
  - Industry associations
  - Phil. Export Processing Zone (PEZA)-registered automotive parts makers
- Create a directory of automotive exports and exporters, in terms of:
  - Forex earnings reported by the assemblers
  - Exports per product category
- Encourage buying/joint venture missions from Japan, Korea, and Taiwan to visit the Philippines.
- Pursue support industry promotion activities.
- Network with the Development Bank of the Philippines (DBP) for a special window for autoparts producers.
- Work for tariff adjustments within the Tariff Regulatory Mission (TRM).
- Pursue manpower training activities through the TESDA and AIBFI.
- Campaign for shop modernization.
- Campaign for higher value-added automotive exports.

Recommendations

In a developed country, the status of its automotive industry is considered a key indicator of its overall economy and national development. In view of the Philippines' handicap, as compared with

other ASEAN countries, and in line with the action plans presented, the following are the recommendations for the further development of the automotive industry:

- Additional road infrastructure, funded by revenues generated by the automotive industry. In 1995, major players in the industry generated almost P15 billion in revenues for the government. If a portion of this amount is devoted to road infrastructure, like the ad valorem tax (P4.5-billion), then the industry's potential for growth would be enhanced. Additional vehicle sales would translate to additional revenues for the government.
- Enforcement of a more realistic pace for the liberalization program - The current pace of tariff reduction is even faster than Thailand; thereby resulting in reduced government revenues, and a drain in foreign exchange due to an increase in exports.
- Maintenance of the current local content and foreign exchange requirement, even after the year 2000 - While we are developing industries to become globally competitive, these industries should also enjoy the benefits of the domestic market. Similarly, export growth should be promoted.
- Government support for vehicles used in the transport of goods, and as a means of mass transportation - In the absence of national car projects, the government should at least help develop the production and sale of these vehicles because they contribute to economic growth and development.
- New vehicle emission regulations should be consulted with the industry - A proactive approach is needed so that it will not stall the growth of the industry.
- Continued ban on used vehicle imports, especially passenger cars, Asian Utility Vehicles (AUVs), and Light Commercial Vehicles (LCVs) - The second-hand market for vehicles should be a by-product of the operations of

the existing automotive industry, and not the result of the importation of surplus vehicles and parts.

- No excise tax should be levied on utility vehicles, particularly the AUVs - Imposing such would be antipoor in perspective.

DISCUSSION

Gino T. Bautista

Mr. Jurado presented a very comprehensive picture of the state of the automotive industry today. This industry, together with its numerous support industries, has many opportunities for technological growth and development. Most of these support industries are fledgling companies with a great potential for growth, and a great need for technological development at the same time.

It is difficult to progress if we do not even know what we are doing wrong. We should therefore pay particular attention to the weaknesses of the automotive industry, most of which can be remedied.

The presentation discussed the *BPR or Business Process Design*, a method that achieves radical improvement over a short period of time, which is just what we need. Mr. Jurado also mentioned the Toyota production system, particularly the *Just-in-Time System*, the *Jidoka* or "intelligent automation," and others, such as *Muda, Andon, Kanban,* and *Kaizen*.

These systems may be the buzzwords of the future, yet Toyota's performance through the years shows that these methods work. The problem is how to disseminate these technology management techniques among our young and promising companies. There is no denying that the automotive industry is booming, and this is good. It is healthy for our economy, although terrible for our traffic. Nevertheless all this may be considered part of the growing pains of a future tiger economy.

Part VI
STRATEGIC OPTIONS FOR GLOBAL COMPETITIVENESS

Perspective from Government

SERAFIN D. TALISAYON

Chapter 25

How can entrepreneurs and producers be globally competitive? What are some of the strategic interventions that could help the Filipino entrepreneur become globally competitive? The assumptions behind this formulation are:

- Competitiveness is primarily a characteristic of those who produce and trade in goods and services, namely, the private sector, and not the government. Competitiveness hinges on the quality of decision-making of Filipino entrepreneurs, more than the government's, because entrepreneurs make the most crucial decisions affecting production and trade.
- Government can play a secondary role that is facilitative or obstructive, by setting priorities in public investments and establishing the policy and regulatory environments, affecting private sector operations.
- Some government interventions are strategic, as they affect private-sector competitiveness in a quantitatively and qualitatively dramatic way.

We want to identify these strategic interventions given the present conditions.

A New Frame of Mind

Global competitiveness is a frame of mind that many entrepreneurs still do not have. A clear indication is the pressure exerted by many leading businesses against the lowering of tariff rates, despite the handwriting on the wall represented by the Asean Free Trade Area (AFTA), Common Effective Preferential Tariff (CEPT) schedules, Asia-Pacific Economic Cooperation (APEC) agreements, and General Agreement on Tariffs and Trade (GATT).

Shifts are needed in the prevailing culture among our compatriot businessmen:

- from the predilection to influence-seeking and occasional manipulation of government rules in their favor, to the willingness to stand proudly on their own two feet, and take on competitors here and abroad;
- a redefinition of markets -- from the domestic to the bigger AFTA and global markets; and
- in the manner of creating wealth, away from using unhealthy and unethical relationships with politicians and officials in government regulatory agencies, toward the virtues of industry, creativity, and technical efficiency.

One of the socially destructive behaviors of some big businesses is the tendency to operate monopolies or cartels aiming at zero or little competition and erecting barriers in the entry of new players or investors. This has resulted in products of poor quality, high prices, and foregone investment and employment. These can be socially destructive, especially in the banking industry. Abnormal and scandalously high spreads between lending and borrowing rates set by commercial banks discourage savings, as well as depress business activities across the entire economy. These behaviors result in uncompetitiveness through poor quality products, and indirectly, through raising the cost of inputs for exported goods. No wonder that for many decades we have had uncompetitive exports and negative balance of trade.

- How can Filipino software companies compete if high telecommunications costs eat up 40 percent of their total expenditure? Cheap and reliable telecommunication is necessary for survival and competition in emerging knowledge-based industries and services.
- How can exporters expand production capacities if cost of money is high? Despite the liberalization of the industry, bank spreads in the Philippines are still higher than in many other countries.
- How can Davao fruits compete with imported fruits in the Metro Manila market, if domestic shipping costs more than international shipping?

It is the duty of government to ensure that the economy serves the common good, and this often means the consumers, greatly outnumbering the few producers who use government rules and regulations to create their wealth. Some of these firms resort to appeals to "economic nationalism" and "buy Filipino" to continue to prey on consumers, while refusing to grow up and compete with their counterparts abroad.

These, and similar observations, have largely characterized many industries, until President Ramos and Congress—for the sake of the common good and despite opposition from big business, many of them "big infants" still seeking protectionism—started liberalizing some industries: telecommunications, shipping, banking, air transport, and maybe retail trade.

The first strategic intervention is to set up and sustain policies that will encourage a new frame of mind among businessmen.

Creating New Products

To paraphrase Peter Drucker, competitiveness is not so much producing more efficiently or cheaply the same products everybody else is producing, but producing new useful products nobody has yet imagined. Both entrepreneurs and ecologists know that growth is fastest when an organism is colonizing a new environment or a frontier,

than when it is competing with others in an old, stable environment. In other words, the real name of the game of competitiveness is not efficiency, but innovation. This means R&D and creativity. This means experimentation to come up with both technological and social innovations. And finally, this means an open political and economic system, which is the best system to encourage a national culture of excellence and innovation.

Social experimentation or social innovation is a broader, more exciting field, although the focus of this presentation is technological innovation. Several steps must be taken to ensure that technological R&D will contribute to the entrepreneur's global competitiveness.

1. Product identification must be more market-driven.

In applied research, identifying a topic based on a researcher's own notion or valuation which in many cases results in a limited research scope is a mortal sin. If you ask a chemist for research priorities, you will get chemistry topics; if you ask an agriculturist for the same, you will get agriculture topics, etc.

A few Filipino inventors have succeeded because they developed devices first and clearly saw a market. Some inventors have become rich because they are good not in problem-solving, but in "problem-finding." We need less of those new solutions to old problems, like the perennial cooking stove or *kalan* seen in yearly inventors' fairs, but more of good solutions to new problems. Of course, the immediate "problem" is not a scientific or technological problem, but rather a problem from the perspective of consumers.

My guess is that the millionaire Scandinavian who invented the now common paper clip did not start with the elastic properties of steel alloys. He started from a need to keep together sheafs of paper in a convenient and simple way.

In various technical degree courses in universities and vocational schools, 95 percent of the effort is devoted to problem-solving. There is no course in problem-finding.

2. Financing of R&D should shift toward the private sector.

First, government is structurally incompetent in making business decisions. For example, the reward system, embedded in the government bureaucracy, is detached from market forces. Second, our government does not have enough resources (partly because of large-scale tax evasion), particularly for expenditure items, whose social impacts are not readily obvious. Third, industry will pay for R&D only if it is market-driven.

A possible measure is to enable businessmen and professionals to directly donate, in lieu of tax, to S&T education and R&D support. DOST is currently studying a draft bill for this purpose.

An entrepreneur can be viewed as a "technology consumer." He is the crucial decision maker, selecting the technology when new production capacity is being contemplated. Basically, an entrepreneur can buy proven, but expensive, technology from abroad. Or he can risk having it developed locally. It might be simpler for him to pick up a US or Japanese catalog than to ask a local team of scientists and engineers to develop the technology he needs. The first option promises more predictable results—attractive for traditional and conventional businessmen. But if he decides on the second option, his first problem is to find out who among the local R&D, academic, inventor or fabricator communities can meet his specific requirements.

Therefore, one way to shift greater R&D burden to the private sector is to create information mechanisms that make it easier for local entrepreneurs to identify the right "technology producers." The little-known friendship and working relationship between Thomas Alva Edison and Henry Ford is worth noting. This symbiotic relationship between a technology producer and a technology consumer was mutually reinforcing and beneficial.

What we need is an institutionalized manner to facilitate Filipino Edisons and Filipino Fords meeting each other. We need a technology exchange-clearinghouse, where local technology consumers and local technology producers can meet and find their match. We need to invent and develop a "technology market." DOST can start

by simply putting out newspaper ads. It can later graduate to a database that can be accessed via the Internet, similar to the one planned for the APEC Center for Technology Exchange and Training for SMEs.

3. *We should link with "frontier companies."*

Learning how to "smell new opportunities" and then designing "front-edge solutions" are skills not normally learned in graduate schools, conferences, and technology journals. They are best learned while working in "frontier companies" with track records in applying these skills.

If the Philippines is to leapfrog ahead of others, rather than just play catch-up, we must bring these skills into the country. For example, we can attract Filipino expatriates who are working in these frontier companies to either relocate or set up subsidiaries in the Philippines. Remember how Stanley Shih set up Acer, over a decade ago, in Taiwan? We can also send Filipino experts for training in selected frontier R&D institutions, or enter into research subcontracting arrangements with those institutions.

An example of a mechanism to reverse the former brain drain and transform it into a "brain gain" is an IT business incubation and trade facilitation facility. An R&D, or technology park, eonsisting of support infrastructure and incentive packages, would be another example.

Improving the Quality of Decision Making

Competition requires strategic information. Making sense of the bewildering mass of information on the global market; anticipating new ideas, technologies, and products; and keeping track of competitors for the benefit of decision makers are special skills. They constitute a service industry—the "think-tank" industry.

We need to encourage the growth of a "think-tank" industry, in order to improve the quality of decision making in the private and public sectors.

A "social brain" must be developed—a network of think-tanks

and R&D institutions—which will generate new knowledge and chart optimum national strategies, coupled with a new culture and work ethic on innovation, high-quality decision making, and product excellence.

We need the skills of specialists in making important decisions at the firm and national levels. What R&D is being done elsewhere which pose threats to local products? What new niches are emerging for the Philippines?

Developing Our Competitive Edges and Niches

The last question is crucial.

Information is the essential element in four "sunrise" industries of the 21st century: computers (processing of information); telecommunications (transmission of information); robotics (using information for control and automatic action); biotechnology (genetic information); and their combinations. This is the starting point of arguments on the failure of countries to recognize the importance of information resources and information technologies (IT), and why they would most likely be unable to successfully compete in the next century.

A crucial view is that we must design our industrialization differently from the Western models, based on emerging global IT realities and on our mix of human, natural, and institutional strengths. There are some reasons to believe that the Philippine competitive edge lies in, among others, knowledge- and IT-based services.

First, the type of industrialization seen in Europe and in the United States in the mid-20th century was made possible by three conditions that do not occur today and may never occur again: (a) cheap energy; (b) large captive colonial markets; and (c) higher absorptive capacities of relatively unpolluted environments. This means that industrial approaches, more appropriate in the 21st century, would have to possess different characteristics. They would tend to be: (a)less energy-intensive and use renewable energy resources; and (b) environment-friendly and less material-intensive, such as recycling or miniaturization.

Second, in the same fashion that industry can be structured to reinforce and increase efficiencies in agriculture, information technologies can also be made to reinforce and increase efficiencies in industry and agriculture. Information technologies have become essential to any type of industrialization, including agroindustrialization.

Third, the industrial or secondary sector is the most energy-intensive, while the services or tertiary sector is the most human resources-intensive. The Philippines, a net energy importer and services exporter, must seek its competitiveness in the tertiary sector, and less in the secondary sector. In fact, during the past 10 years, our tertiary sector has been the biggest employer, and has accounted for the biggest component of GDP. Furthermore, our export mix has been shifting toward service trade. These trends have not been planned by the government; they are the workings of market forces.

Therefore, we must identify human resources and knowledge-intensive subsectors in the tertiary sector, and develop global niches in identified areas. It should include: (a) IT services, such as computer software production, data banking, and Internet services; (b) medical, health, helping, and allied services; (c) other high value-added professional services; (d) computer-based education and entertainment, or "edutainment;" and (e) selected areas in biotechnology, related to food processing, drug production, and marine products.

In general, the Philippines can consider a strategy of excellence in international service trade. But it is important to make the issues of competitive edge and global niches a continuing focus of analysis and debate in academe, as well as of practical search among those in industry.

DISCUSSION

Filemon T. Berba Jr.

Dr. Talisayon identified key points that we must consider as we aspire to gain global competitiveness. First and foremost, we must be market-driven. We must know which is our market, where it is, and how to satisfy it. That market can be overseas, or it can be local. But we must know how that market behaves, and how to best serve it.

The market may be existing, or it can be new. Take the progress on information technology, in which the convergence of telecommunications and computers has shrunk the world in terms of time and distance. Our technological development must therefore be market-oriented and market-driven.

Second, we must analyze total cost to get products or services into the market. Some of us, who are very obsessed with technology, merely fall in love with it while forgetting that we must make some money.

We cannot just look at production cost or the cost. What matters is the total cost, that is, until it reaches our market. After all, the customer is only concerned with what he pays for, and not what it costs to produce the product.

Inherent in this analysis is the fact that we must be quality-driven to a level that is comparable with our competitors. Right now and with the present competitive environment, quality is a given—this is the mark of a market-driven global economy.

Third, we must analyze our resource balance sheet—where we are abundant in and where we are short of resources. As such, for example, pushing the service industry toward global competitiveness draws on our abundant manpower and brainpower which, when harnessed in the right direction, can give us both a quality and productivity edge.

Fourth, we have to redefine the role of government. We must,

of course, depend less on government protection. The government should stop putting very old commercial and industrial "babies" in the incentive-protective cribs. The government, instead, must provide key infrastructure that drive economic activities. What are these *infrastructure drivers*?

The first is *power*. The government must see to it that there is enough power. We all remember those power failures in 1991 and 1992, when brownouts lasted four to eight hours, until President Ramos eased the problem.

Another infrastructure driver of economic activity is *transportation*, such as airports, seaports, roads, and bridges. At least airports are being improved. But when you go abroad, say, to Malaysia, Indonesia, Thailand, Singapore, or Taiwan, you feel that there is still much to be done with our airports.

The third, of course, is *telecommunications*. In doing business, you must have power. You must be able to move around; and you must be able to communicate. The government must provide the framework, so that these infrastructure can be made available.

The Philippines must be competitive. About three or four years ago, I used to run a manufacturing company called Integrated Microelectronics. At one time, we were losing a lot of money, and we had to turn it around. When we went to Japan, the Philippines was not listed among possible areas for subcontracting. We had to invite them to come over. After seeing our modern plant, they also wanted to look at the infrastructure. When they saw that things were beginning to happen, they thought that the Philippines was something they should look into. They eventually invested about $250 million, and consigned equipment with us.

Fifth is the mindset of our technology and R&D people. They must be outward-looking, and they should not be obsessed with technology for technology's sake. At this stage, we can probably do more with applied research than with basic research. We must be cognizant of the relationship between market size, production cost, customer needs, and competition.

Sixth, as we enter the 21st century, the convergence of com-

puters and telecommunications makes time and distance almost irrelevant in the global market. This therefore presents an opportunity. The availability of Filipino brainpower in the software and related industries will allow us to address the global market.

We don't have to export our people. We can export brainpower through telecommunications facilities in this country.

The government and the private sector can cooperate to set up R&D centers with universities and the necessary infrastructure, particularly telecommunications. There are a number of Japanese and foreign companies that want to set up R&D centers here, but you have to create a critical mass in order to have a community within a university, with population centers, and to facilitate an environment of intellectual exchange.

For the last four years, an annual survey of a Hong Kong-based consultancy firm has been placing the Philippines on top of its manpower survey list, in terms of cost-quality availability for both skilled and unskilled manpower. This is a very important advantage.

Finally, the key determinant for success is our ability to recognize that change is a continuing phenomenon, occurring at a rapidly accelerating pace, and that technology is a tool that will enable us to respond to and manage change.

All our efforts for global competitiveness should focus on an understanding of market forces, both inside and outside the Philippines. We should be effective by doing the right things, not just by being efficient. Sometimes we can be so efficient in doing the wrong things—and that can be disastrous.

Perspective from Industry

AUGUSTO L. DE LEON

Chapter 26

Threats activate action. This brings us together to find courses of action that will adequately respond to the threats posed by the changing economic order due to globalization.

As we go into the next century, the players in the economy will no longer be able to measure themselves in relation to their domestic competitors, but will have to be pitted against the best in the world. In competition, there will be winners and losers. Winners will survive, losers will perish.

The assumption that I am sure we are all talking about is that we should have economic growth as our immediate, general objective. The general formula for economic growth is cheap and ample capital, which we don't have; a high level of private investment, as against public investment, to increase productivity; and a high level of education and advanced technology, which can be within our reach. If we fail to achieve economic growth, we will become a sick nation. We can expect unemployment, decline in productivity, low income, and social unrest. Our only option for survival will be to produce more goods and services, increase employment and value-creation activities, and increase wages and the wealth of the people.

Wealth is generated by harnessing enterprise management, and driving and orchestrating the progressive application of sci-

ence and technology in machines, equipment, and processes driven by fossil energy. This peaked with the successful organization of a global oil cartel. Finance and services took over, driving the growth of most economies in the aftermath of the oil crisis.

The Changing Society

In terms of the effects of how people make a living, the percentage of people working in agriculture in most developed countries went down from more than 50 percent to less than 10 percent of the population. The manufacturing sector absorbed majority of the workforce during the industrial era, while the finance and service sector dominated employment growth in the subsequent period of development. These same sectors will continue to gain in the age of information and knowledge economy, except that the nature of work will have been upgraded from that of menial servants and skilled workers to that requiring knowledge in addition to skills.

It is generally accepted that we have entered the era of information and knowledge economy. Brian Quinn, of the Amos Tuck School of Business at Dartmouth College in New Hampshire, states that even among the "boring manufacturing companies, three quarters of value-added comes from knowledge." He cites, as an example, Rubbermaid, which manufactures a wide variety of household gadgets, but does so in an intelligent way, as to enable the company to grow in sales and profits, in spite of a very competitive environment.

Not too long ago, *Fortune* and *Business Week* featured articles on the major shift in the creation of wealth, "Your Company's Most Valuable Asset— Intellectual Capital, New Ways to Build and Measure It," and "The Global Economy Is Changing, Jobs Are Changing, The Workforce Is Changing, Are You Ready? Rethinking Work," respectively.

In essence, the articles point out that the ratio of value-added has shifted from the mass use of materials and manpower to a greater contribution of knowledge and use of information. Other articles cite the competitive success of Honda over Chevrolet. Honda is said

to have been utilizing more knowledge input and less volume of materials, as compared to Chevrolet.

Recent articles on the competition between Boeing and the European Airbus highlight the improving edge of Boeing over Airbus, in terms of, for example, having the ability to design a plane completely with the use of computers. Boeing has also been able to produce a new model at a shorter span of time, and is able to market more planes by having a more intimate knowledge of customer needs. An example is a design that enables the reconfiguration of a plane's interior in 72 hours, instead of the usual three weeks.

The Boeing article also provides a good example of what managers of technology call the merging of "islands of knowledge" to create greater value. To manufacture a plane, Boeing has more than 800 different computer systems. It aims to convert these into a single computer platform that will enable each system to interface with other systems. Thus information technology will provide the company with the additional competitive advantage. One of the best examples of the value of information is the success of Michael Bloomberg, who became a billionaire many times over just by providing financial information.

The change in the nature of work is the shift of value creation, from manual work based on experiential skills, to knowledge work, which is basically learning-based.

In summary, the knowledge and information era will be when design, utility, craft, durability, and knowledge add to mass. Quality and intelligence make products more useful, functional, longer lasting and easy to use or repair, and less costly.

The sum of improvements increases product desirability which, in turn, improves its chances of success over products with less intellectual content. Consumers will have more choices and communications will make it possible for consumers to know and source out these choices.

Information will have an intrinsic value, just like any physical commodity. As a perishable commodity, time becomes an essential element of its value. Information that comes late is not worth any-

thing. Similarly, valuable knowledge today may be useless in a few years. Diplomas and degrees will not last if they are not learned. It is the capacity to learn that has lasting value.

The impact of this new era is that, while society was divided between the land-holding and the working classes during the agrarian era, the movement into the industrial society, and later into the finance and service-oriented societies has narrowed the gap, cutting a dominant middle class. However, less developed countries continue to have a marked stratification between the "haves" and "have-nots".

The intelligence and knowledge society will create two new divisions: the knowledgeable, and the ignorant. This is observable in egalitarian societies, like the United States, where those with higher education are earning 130 percent more than high school graduates, by 1994. By 1996, the gap had increased to 149 percent. The middle class is no longer being separated in terms of material wealth, but in terms of the capability to create wealth through knowledge.

The Present Situation

Today, more than 50 percent of our population are still dependent on agriculture. Our primary farming system is still dominated by the use of human and animal energy applied to the land, indicating an agrarian society.

Our manufacturing and service sector is growing, with organizations on top of the industry matching the sophistication of those in more developed economies. The modern segments of society are aware and quick to absorb new knowledge. In the information era, computers and the Internet have become widely accepted at an even faster rate than in some European countries. We are proud to have a pool of educated manpower produced by educational institutions locally and abroad.

However, there is great room for improvement in the use and practice of knowledge and technology. In 1991, Mr. Chung, Chairman of Korea's Hyundai Conglomerate, visited the Manila Light Rail depot in Pasay, and was surprised at what he saw. The Philippines

had on hand all the machinery to manufacture the rail car right in the depot. It even had a place for fabrication and assembly. The equipment was purchased from the Belgians when the first LRT was installed. According to Mr. Chung, the only parts that we lacked in order to produce were the steel-rail wheel assembly and electric motors. But we could still manufacture with everything else if we could prepare the design and engineering calculations to construct a durable rail-car body frame.

Theoretically, we could have started producing rail cars as soon as there was additional demand. Today we know that the rail cars are no longer adequate, that some of the original cars are nonoperational even before they could be fully depreciated. But instead of considering the option to build our own rail cars, we were only concerned about how and where we can borrow money to buy new ones.

Mr. Chung was also interested in how we made our passenger-bus bodies, so we visited a bus-body building plant in Laguna. He was very confident that, if we could build large air-conditioned passenger buses, there was no reason why we could not build a rail car.

A visit to the Manila Railroad in Caloocan showed that we have machines that could manufacture railroad cars. These had been supplied by the Japanese, but remained virtually unused. Thus while we already have two idle rail car manufacturing facilities, we are considering the importation of rail cars to rehabilitate the PNR North lines, and buying another rail system for Mindanao. We are buying more, yet we have not learned how to maintain the existing ones.

I could not help but think of the Indonesian project to build airplanes, a more technically complex venture, yet we shy away from undertaking the manufacture of rail cars, which is much less technologically demanding. In fact, Indonesians have formed a joint venture with a foreign company and all the bidders for the various light rail systems will have to order their rail cars from this local joint venture manufacturer. In the process, Indonesia has gained experience, skills, and technology. In contrast, the Philippines has committed to three different suppliers for three systems: Belgian, Japanese, and Spanish. Each will eventually require different main-

tenance systems and spare parts. The volume needed, however, will hardly make the supply of parts to these investments worthwhile. Thus, even without liberalization, we are positioning ourselves to be dependent on imports for years to come.

Recently, a former Science government official observed that in the installation of a pilot ceramic plant by the Department of Science and Technology, they had to import even the steel plates and walk-ways, which were actually no more than welded metal sheets and bars.

These two examples demonstrate a cultural inclination "to buy" rather than "make." This culture of buying instead of making slows down and reduces opportunities for people to apply science and gain technological experience. A scientist has aptly observed that a science that is useful usually involves the recording, analysis, and systematic arrangement of knowledge resulting from practice. When practice is at a low level or scientists become detached from it, scientific output moves further away from becoming immediately useful.

In agriculture, farmers are still not in a position to receive adequate information on weather conditions in order to reduce risks. Weather information has not been analyzed to determine patterns of the typhoon path. Data on amounts of rainfall per area are not available as guide for depth requirements of plowing. Satellite information on the El Niño phenomenon are compiled and filed instead of being interpreted and disseminated to farmers.

Strategic Options

Adopt a Leapfrog strategy

Some thinkers propose the strategy of leapfrogging, from the agrarian situation into the service, information, and knowledge economy. We can bypass capital-intensive industries, and make use of manpower resources in providing services that range from low to high scales of sophistication.

To some extent this strategy has merits. The opening of China,

Eastern Europe, and Russia to the world economy has made the output of basic industries, like steel and basic chemical industries, available in the world market. Having recovered capital-investment cost, these manufacturers are exporting their products at prices based on direct cost.

When demand starts to exceed worldwide capacities, new capacities will be required. By that time, new technologies will also become additional options in economic calculations.

Move on All Fronts

We have been left behind in almost all fields, hence, there are opportunities everywhere just by catching up on all fronts: from the modernization of agriculture, manufacturing, and services, to the application and entry into the knowledge and information technology business.

This has merits, considering the large population, and the diverse stages of training and capability of the people. We can improve and do better in all the areas of endeavor.

Back to Basics

Before we are able to succeed in any strategy option, it is essential to review some of the basics needed to be globally competitive. In military parlance, the best strategy will fail if soldiers do not know how to be soldiers.

Efficient Institutions and Government

The first area we should look into is the elimination of systemic inefficiencies in the economy. We have to develop and operate a system in which productive activities of the private sector can operate freely from self-imposed handicaps. This is the only way to make more local producers on a par with global competitors. This has to do with the cost of doing business with the government, cost of time it takes for government to decide and move at snail's pace, interest

cost of money that adds to capital and production cost, high cost of moving goods and communicate information, and cost/reliability of power. The sum of all these costs takes away competitiveness, but are not within the capacity of producers to rectify.

Technology managers and knowledge workers must make a dramatic shift in management philosophy. Instead of improving discipline, they need to release energies. Before, management systems were created to minimize the idiosyncrasies of human behavior; today, the best managers are those who encourage and harness those idiosyncrasies to attain organizational objectives. (Those interested to learn more about this management philosophy may wish to study the case of Science Application International Corporation, a $2.1 billion high-technology research and engineering organization led by Dr. Robert Beyster, a physicist.)

Education

The knowledge and information society requires the proper education of our manpower. The requisite formal education cannot be bypassed. Private companies are showing great willingness to provide training. Some industries, like the telecommmunications industry, even have specialized schools to train manpower for their specific requirements. However, they need graduates to train. Private business cannot replicate what should have been learned over a period of 14 years, even within a one-year training period. At best, companies will allocate three to six months for training, and then provide intermittent opportunities to gain more knowledge. Companies are also consciously turning themselves into learning organizations.

In a study by the Personnel Management Association of the Philippines, businessmen ranked poor English and communication as the field in which our graduates were most deficient. This was true of all types of work. In technical and supervisory jobs, general weakness in math and science and the poor ability to analyze and synthesize information was ranked highest, together with English. Attitude toward work and the ability to work productively with other

people—values that make possible the subordination of diverse personal goals for organizational goals, honesty, and beliefs—are the most difficult to remedy.

Institutions of higher learning, particularly those in science and technology, will have to realize that it is not just how much is learned, but how much understanding is gained, or how knowledge can be used which is important. Knowledge is power only if it is used properly.

Cultural Dimension

As a people, we are very visual to the point of being highly superficial. We see a well-known science laboratory and conclude that we will also succeed by having all the equipment necessary in a successful laboratory. We fail to see that we also need the know-how to use and maintain the equipment. Moreover, we have to know what the equipment is for. Without these two elements, we duplicate and waste our investments in research facilities without realizing any useful output.

We are also quick to think that we are not able to do things because we lack money. In visits to colleges and universities in the provinces, administrators are quick to point out that lack of funds caused their sloppy performance. On the other hand, casual observation shows that their resources are not properly used. We have challenged these schools to demonstrate that if they are to succeed in teaching management, they should be able to apply good management in their schools. If they are to teach computer science, then their computers must be used for various applications in their operations.

Institutions and Organization

If we are to believe *Fortune*'s article stating that intellectual capital is the most valuable asset of our time, the faculty of our universities must have the most valuable assets in the Philippines. Yet other than

the students these universities turn out, we do not see the conversion of these assets into wealth. It is about time these intellectual assets were mobilized and organized into teams that will merge specialized and segmented information and knowledge with economic value.

Scientists will need to have a better appreciation of the value of their knowledge in realistic economic terms. A scientific invention is only a part of a potential product. There has to be other technologies to convert inventions into applicable, affordable, and useful products. There is a need to develop ways to replicate and create market demand to complete a commercial product. The cost of these activities is often greater than that incurred in inventing the product. Investments in all the stages from invention to marketing will somehow have to be recovered. The value of intellectual contribution will most often depend on the volume of products that can be sold rather than its percentage share in the per-unit value of the product.

Focus and Priorities

We have a tendency to spread ourselves very thinly in the attempt to accomplish many things. Lack of focus and prioritization of objectives eventually work against getting anything done within a reasonable period of time. It is a small wonder how the first lesson in making a thesis—identifying a specific problem and concentrating research on that singular problem—is so quickly forgotten in practice.

There was once a food scientist who wanted to formulate low-cost nutritious food. The problem was, in itself, very complex because in addition to the cost parameter, it had to be in a form, shape, and flavor that consumers will accept. The scientist insisted on making the research more complicated by specifying that the ingredients had to be indigenous and produced in rural areas where there may be no electricity and facilities to control temperature during processing.

Summary and Conclusion

The best among our industries will be able to rise to the challenge of global competition. These companies will source technology and knowledge from wherever they may be available. Note that in the major constructions in the city, foreign architects and consultants are already being brought in to create new value to the development. In fact, joint ventures with companies that have ongoing research and available technologies are increasingly becoming a popular form of business organizations.

There is also a perceptible realignment in companies-- they are identifying the lines they will keep and those they will give up in order to gain a better position in global competition.

Organized corporations are keeping their ears close to the ground by being in constant dialogue with other organizations that have the latest technology. For example, there are already 80 or so Philippine firms connected to Bloomberg's information terminals, paying $75,000 to hook up and $10,000 monthly to keep information flowing. The number of subscribers is expected to double and grow at a rate that will justify the inauguration of a new branch here.

Our greater concern will be the organizations that are rigid and closed to the idea of changing and absorbing new technology. Companies will have to realize that it makes sense to hire and train qualified manpower instead of saving on cost. Cost and expenses will increasingly have to be viewed relative to returns rather than absolute cash outflows. Industry also needs a healthy domestic consumer market.

How we can pull the rest of the economic players to a level of global competitiveness should therefore be a major concern. Businessmen are increasingly getting involved with education. The technical panel for business and management education of the Commission on Higher Education (CHED) is trying to bring schools and the business community together. Educators will be included on the agenda of the Business Conference in some regions. Moving away from the process and performance measure of degrees and diplomas toward the capacity and relevance of what is learned to match the requirements of employers is a policy direction that is being encour-

aged. Schools and businesses are asked to put together four- to five-year projections of manpower requirements. Academic and business organizations are urged to become active in securing resources and policies that will prepare more people for the era of the knowledge economy.

If we are to adopt the current practice of management in the information and knowledge era, managers of industry have to move away from a single-corporation strategy, and define organizational purposes so that human resources can adopt microstrategies of their own, thereby achieving organizational goals. The recent trends in the actions of industry players indicate that the first step is to pay attention to the basics, while applying the first and second strategy options in their business.

DISCUSSION

Emmanuel S. de Dios

I was provoked by all the three papers on Strategic Options and I want to give a synthesis that touches on all of these papers and comment on competitiveness. From the viewpoint of the firm, competitiveness means getting an increased market share and increasing profitability. This is achieved through cost reduction, innovation, the introduction of new products, better quality, and so on.

It is not clear, however, what competitiveness means with regard to the country. Some economists say that the word is meaningless when applied to nations. I think, however, that it is premature to dismiss the issue of the competitiveness of a country, and what I would like to propose, therefore, is that competitiveness at the level of a nation is really *locational competition*.

This is the era of factor mobility where capital, labor (and to a certain extent, skilled labor), and technology are mobile across borders. Countries strive to attract these factors of production, in order to create national wealth and combine it with factors of production (which are not mobile) that are found in their own countries.

The implication is that complementary assets for these mobile factors of production have to be developed. I therefore slightly disagree with Dr. Talisayon's point that the government's role is merely supportive of the private sector. In fact, the government's role is crucial because the atmosphere for investment and its subsequent growth generates the adoption of new technology. Scale justifies investments, including investments in R&D, and new technology is embodied in new capital goods.

What then are these complementary assets, which the government must provide? 1) Physical infrastructure, taxes, and

tariff systems which must be comparable to those in other countries; 2) the institutions of governance which include peace and order, safety, or law and order; and 3) the macroeconomic environment, such as exchange rate policy, fiscal and monetary policy, price stability, environmental protection, amenities in the urban areas, and education and the pool of skilled manpower. These are all complementary assets to the factors of production that are internationally mobile.

Failure to provide these assets will prevent us from attracting the required factors of production, to the extent that even our own factors of production will start to migrate abroad. After all, the economy is heterogenous where first-, second-, and third-wave technologies coexist. It is actually the duty of government (the duty of public policy) to ensure that, whether or not one or the other technology is involved, the entire country should share in the generation of wealth.

Second, it does not really matter what strategy the government advocates because it is the private sector that chooses the technology. It has already been pointed out that it is the technology, not the sector, which is important. You can have first-, second-, and third-wave technologies regardless of whether you are in the agriculture, manufacturing, or services sector.

This brings me to some particular comments on the matter of services. I do not agree that we should concentrate on services because services are not directly tradeable, except perhaps in information technology development. More important, however, services are embodied in people, and people themselves are mobile. The manufacturing industry is important just as agriculture is important. Knowledge must be embodied in goods if the complementary factors for people are to work and thus enable the use of their skills. If not, then these people will simply move out of the country—a phenomenon we are witnessing now.

I fail to see leapfrogging, as in the reverse engineering proposed by Dr. Posadas, as a matter of national policy. Whether to make or buy a technology, or whether to do reverse engineering is a business decision. In fact, whether it is cheaper to learn

how to make a product or to continuously source it from abroad is a part of long-run cost considerations.

The same goes for third-wave technologies. My guess is that these technologies will not be funded by the private sector, but by government. I don't think it will be a top priority of the business sector to finance basic research into third-wave technologies. The more likely development is that when the proper atmosphere for business decisions is provided, and when businesses in the Philippines feel that they have to compete on a global level, with the need to adopt globally competitive industries, they will see the motivation to adopt third-wave technologies.

This brings me to the paper of Mr. de Leon, whose suggestions I strongly agree with, although I do not think these strategies are really mutually exclusive. They refer to actions by different segments of society, and government as the provider of the *hard* and *soft* infrastructure required for a good business environment. When government provides the basics, which Mr. de Leon himself advocates, such as physical infrastructure, education, governance, and environmental protection, then the private sector will move on all fronts in order to *leapfrog*, if warranted by long-run cost calculations.

When it comes to *university-government-private sector* collaboration, as I have said, government must provide the basics. There is a basic distinction and a divergence of interests among these sectors. The university likes to do basic research, but with as little outside interference as possible. Business, on the other hand, is interested in immediate commercializable outputs. What is the role of the government in this equation? It is really to marry the two purposes.

The government should use its resources so that university research can at least be partly directed toward commercializable outputs. At the same time, it should also catalyze businesses toward the provision of support for long-run basic research. A possible compromise is to look at what kinds of research need to be done, and determine which ones are interesting to the government, academe, and the private sector.

My guess it that many of these things have to do with R&D. The general aim for R&D is to shift more of R&D spending to the private sector. They cannot, however, do this unless there is a ready pool of R&D scientists who are willing to take on the job. Building up this initial pool is really a big problem, and this is what the university is experiencing right now.

Once this pool of scientists and technicians is produced, then these people can be put to work toward more commercializable outputs. In a sense, the government can initiate this pool-building process. By doing so, large multitiered projects between the university and government, or between the university and the business sector, become feasible. These are the kinds of collaboration that form the basic infrastructure needed to attract capital from abroad and to keep labor at home.

Perspective from Academe: Technological Leapfrogging as a Strategic Option

ROGER POSADAS

Chapter 27

The strategy of technological leapfrogging was first proposed by me years ago in September 1985 as an alternative national strategy for catching up and gaining mastery in science and technology. It involves bypassing the mastery of second-wave technologies and undertaking reverse engineering of imported key third-wave technologies as a means of diminishing the Philippines' S&T gap, and enhancing our economy's competitiveness.

In November 1993, Dr. Serafin Talisayon presented a paper titled "Towards a Leapfrogging Strategy for the Philippines," which proposed two types of leapfrogging: first, bypassing second-wave technologies and leapfrogging into selected high technologies; and second, leapfrogging from the agricultural stage to a postindustrial stage, which suggests the feasibility of bypassing or sidestepping the manufacturing sector and focusing on the tertiary or service sector.

Based on various forecasts and studies over the past 10 years, there seems to be a growing concensus that the 21st century will be marked by the following:

> The emergence of a borderless world economy, through the globalization of business, production, research and

development, financial services, lifestyles, consumerism, travel, and tourism.

- The realization of a seamless, wireless, global communications network that enables communication with anyone in any language, anytime, anywhere in the world.
- The convergence of computing communications and content (information technology), leading to new modes of learning, work, recreation, organization, governance, and business.
- The emergence of cybernetic, robot-operated, superautomated factories that will make manufacturing superproductive, superefficient, and flexible.
- The realization of biotechnological breakthroughs that will revolutionize medicine, agriculture, and manufacturing.
- The critical importance of speed and time-saving technologies in product development, production, marketing, and business transactions for global competitiveness.
- The strategic importance of molecular science and engineering knowledge, such that new technologies, like protein engineering, new materials, integrated optics and optical computers, micromachines, and new pharmaceuticals become accessible.
- The exploration, colonization, and industrialization of space, resulting in new ways of manufacturing, construction, travel, and new sources of minerals.
- The increasing importance of environmental protection and strategic energy management for sustainable development.
- The shift in the principal sources of wealth and competitive advantages; from capital, natural resources, and labor to information, knowledge, and intelligence.
- And the shift in the world's economic center, from the United States to the Asia-Pacific Region, leading to Asia's cultural and technological renaissance.

Will the expansion of a borderless global economy diminish the importance of nation-states and national cultures? Some say yes,

while others say no. John Naisbitt, for instance, stresses that "although people want to come together to trade much more freely, they want to be independent politically and culturally." Michael Porter also points out that "globalization makes nations more, not less, important."

Is the proposal to leapfrog the agricultural stage to the postindustrial stage, and bypass the industrialization stage a viable option for the Philippines and other less developed countries? The categorical answer is no. While the service sector can support the growth of the manufacturing and the agricultural sectors, or the goods-producing sectors, it cannot act as an engine of growth simply because while goods can be traded to generate growth, services are trainable only to a limited extent. Besides, the hype about a postindustrial society or information-based economy is turning out to be a myth. As Lester Thurow, in *Head to Head,* points out, "the end of the postindustrial era is probably already at hand." In fact, in the United States, the service sector is said to be pulling down the productivity of the entire American economy.

In choosing technological development strategies, we should first address two basic issues in selection and acquisition. First, what classes of technology should we select? Second, how should we acquire the technology?

The answers to the first question can be any or a combination of the following: first-wave technologies, like Schumacher's labor-intensive, small-scale, decentralized, rural-based intermediate technologies; second-wave technologies, such as the coal-fired car assembly factories, and other capital-intensive technologies; and third-wave technologies, the technologies that have reached maturity and are being transferred to less developed countries such as genetic engineering, advance materials, robotics, photonics, and other high technologies.

The answers to the second question could be any of the following: first, make all the technologies on your own, which leads to "technological autocracy," or try to be self-sufficient and self-reliant in technology development; second, buy or rent all the technologies, resulting in the technology development approach, or

"technological dependence;" third, make some technologies and then buy or rent the others needed, which is basically "technological liberalism;" and, fourth, buy a needed technology, analyze it, and try to make an improved version of it—"technological mastery" through reverse engineering.

There are various national development perspectives that can influence or determine the technological approaches and trajectories of a country. The three major ones are: *structuralism*, the variants of which are the *dependency theory* or *Marxism*, which essentially holds that the poor become poorer because they do not have political power, therefore there is a need to gain political power and delink the economy from the world economy; *economic liberalism, laissez faire*, or *individualistic capitalism*, which states that less-developed countries are poor because they are inefficient, therefore one has to remove the inefficiencies, liberalize the economy, and open up the market, which is what the Philippines is following right now; and third, *neomercantilism, economic nationalism*, or what Lester Thurow calls *communitarian capitalism*, which is the kind of development perspective adopted by Japan and followed by the NICs, like Korea and Taiwan, where the State plays an important role in economic growth, through its industrial policy, targeting of industries, providing subsidies and incentives, etc.

If our development goal is to catch up technologically, as fast as we can, to achieve competitiveness in the global economy, the strategy of mastering technology through the reverse engineering of key third-wave technologies is advocated. This would involve the buying or renting of high technologies from abroad, in order to analyze and learn, and eventually improve on them, thereby gaining replicative and innovative capabilities. This is the strategy of "technological leapfrogging."

The choice of third-wave technologies is based on the following considerations. First, third-wave technologies can narrow technological lag, and provide industries with a cutting edge for global competitiveness. Second, third-wave technologies can be used to improve the productivity and efficiency of the agricultural, manufacturing, and service sectors. Third-wave technologies can be en-

vironment-friendly and compatible with sustainable development. Fourth, third-wave technologies, being science-based, will strengthen the linkages between academe and industry, and between our local industries and industrialists.

The adoption of reverse engineering, as the key to the mastery of high technologies, is based on many factors. One, reverse engineering is the fastest and least risky way of acquiring and mastering a technology, as the experiences of Japan, South Korea, and Taiwan have shown. This is in contrast to trying to invent everything, or "reinvent the wheel," and carrying out indigenous technological innovations that could be very risky.

Two, reverse engineering, coupled with new manufacturing and process technologies, can make industries produce better models of products that were invented and developed in other countries. As many observers have pointed out—and this has been the experience of Japan and Korea—it is not important that a product is invented in a particular country. What is important is if one can produce that product cheaper, faster, and with better quality. The experience of Sony in compact discs and the VTR is an example of this.

Three, competence in reverse engineering can compensate for the Philippines' poor track record in invention, R&D commercialization, and product development.

Economic nationalism, based on the experiences of Japan, Korea, and Taiwan, will require a very strong State or, what they call, a *hard State*. Unfortunately, the Philippines has always been one of the *soft States*, which makes the leapfrogging strategy very difficult.

The strategy of technological leapfrogging can be successfully carried out only under certain conditions:

- a very close cooperation among the private industry, government, and academe in the selection of high technologies, as well as the organization of R&D programs to support reverse engineering efforts;
- the establishment of specialized innovation centers for each industrial cluster or subsector, that would undertake reverse engineering in the development of generic models

of core technologies for the cluster or subsector. These could be centers that are supported by industry associations or cluster associations, assisted by the government, and linked to academe;

- the organization and enforcement of strong R&D programs for each key high technology, to facilitate reverse engineering and keep abreast with emerging technologies;
- the enforcement of a crash program to develop a critical mass of R&D scientists and engineers in key areas of high technologies;
- the development of local science engineering colleges into world-class institutions, in terms of facilities and faculty;
- the overhaul of the educational system, such that it can produce large numbers of high-quality engineers, scientists, and technicians; and,
- the establishment of a national network for technology forecasting, monitoring, intelligence, and assessment.

Let me conclude with the following aphorisms. The first one comes from Lester Thurow who said in his *Head to Head*, "Technological leaders remain economic leaders, technological laggards become losers." The next quotation is an invention of mine. I am thinking of it as an appropriate title for a book that has yet to be written and published: The development of technology equals the technology of development.

DISCUSSION

Elmer C. Hernandez

We should first look at the industrialization of the country, or of the world, for that matter, in relation to global competitiveness. The first level of industrialization in Asia, except Japan, occurred with the advent of the newly industrialized countries (NICs) in the 1970s and 1980s.

Now we are experiencing the second level of industrialization which is characterized by industrial assemblies, and which is where the Philippines rightfully belongs. However, the Philippines is facing the problem of industrial integration which makes NIC-hood even more difficult to achieve.

As far as the BOI and the DTI are concerned, the government is still bent on the establishment of basic industries, such as the petrochemical and iron and steel industries. The petrochemical industry has many products that we depend on. In Thailand, the growth of its petrochemical industry is a measure of its overall growth. The iron and steel industry is also a very basic industry that we cannot do without. Its growth is indispensable to industrialization.

For industries such as these, a combination of second- and third-wave technologies (as Dr. Posadas put it) should be used, focusing on adaptive and innovative ones. The objective is to develop industries with a strong domestic value-added. The *upstream* portion of the iron-steel industry is currently being developed. The problem is in the *downstream* portion, where technology is already in a state of obsolescence. The normal process in the development of an industry starts from the downstream. When the market for the downstream is developed, it will then justify the establishment of upstream industries.

The downstream is already present in the iron and steel industry, but the problem lies in its use of inefficient technologies.

We are also trying to develop the upstream industries for this industry, together with modernizing existing downstream industries.

We have also developed the downstream for the petrochemical industry, and this justifies the establishment of upstream facilities. There are many issues involved here, and one issue that is most dear to private sector businessmen is *tariff reduction*. Some business sectors say that the government's tariff reduction is fast, in comparison to neighboring ASEAN countries. How can basic industries compete with imported raw materials available to downstream industries, when the products of upstream industries cannot be protected?

The basic issue is that we have had bad and inefficient industries. They have been protected for so long that they have not done anything to improve or upgrade their facilities. These industries need what we could call a *shock treatment,* in order to get them out of their deep slumber. It is either they do something as a fully liberalized economy approaches, or they end up experiencing slow death.

This, in effect, is the measure being adopted by the government: to allow the entry of new players who will use state-of-the-art technology, or a combination of second- and third-wave technologies with world-class capacities, so that industries can survive without tariff protection.

I basically agree with the observations of Dr. Posadas that a combination of the three technology waves, including reverse engineering, is very important. Academe and government should coordinate with the private sector so that government does not finance the country's R&D efforts entirely. Likewise, any combination of technologies should be used to improve the global competitiveness of industries. Once this happens, then the other strategies described by Dr. Posadas for technological leapfrogging will follow.

List of authors and their affiliations*

MA. JOY V. ABRENICA
Asst. Professor, UP School of Economics

ALFONSO A. ALIGA JR.
Principal, SGV Consulting

GUIDO BAMBAGIONI
Vice-President, Nestle (Philippines) Inc.

EMMANUEL S. DE DIOS
Professor, UP School of Economics

AUGUSTO L. DE LEON
President, De Leon Consultancy

FORTUNATO T. DE LA PEÑA
Vice-President for Planning and Development, UP System

PACIFICADOR C. DIRECTO
Trustee, Metalworking Industries Association of the Philippines

MA. ROWENA R. GONZALES
Law Research Specialist, UP Law Center

JOSE O. JULIANO
Secretary, National Academy of Science and Technology

FLORENCIO B. JURADO
Senior Vice-President, Toyota Motor Philippines Inc.

FRANK LITTLE
Visiting Research Associate, UP School of Economics

CLARO T. LLAGUNO
Chancellor, UP Diliman

JOSE A. MAGPANTAY
Professor, National Institute of Physics

IGNACIO S. PABLO
Trustee, Philippine Chamber of Food Manufacturers Inc.

WILLIAM G. PADOLINA
Secretary, Department of Science and Technology

EPICTETUS E. PATALINGHUG
Professor, UP College of Business Administration

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*as of 1998

ROGER POSADAS
Professor, UP College of Science
NESTOR O. RANESES
Associate Professor, UP College of Engineering
JOHNNY NOE E. RAVALO
Chief Economist, Bankers Association of the Philippines
WILLIAM E. ROPER
Consultant, Iscor Inc (South Africa)
MARILYN ELEANOR P. SANTIAGO
President, Philippine Wireless Inc (Pocketbell)
RICHARD K. SMITH
Associate Director, CPRST, Simon Fraser University
JOSE P. TABBADA
Associate Professor, UP College of Public Administration
SERAFIN D. TALISAYON
Asst. Director-General, National Security Council
GWENDOLYN R. TECSON
Professor, UP School of Economics
DOUGLAS WILLIAMS
Partner, ARA Consulting Group (Canada)
REYNALDO B. VEA
Professor, College of Engineering
ELVIRA A. ZAMORA
Professor, College of Business Administration

List of discussants and their affiliations*

AMELIA C. ANCOG
Undersecretary, Department of Science and Technology
ESTRELLA F. ALABASTRO
Undersecretary, Department of Science and Technology
ERNESTO D. BAUTISTA
Asst. Resident Representative, United Nations Development Programme (UNDP)
GINO T. BAUTISTA
Professor, UP College of Engineering

FILEMON T. BERBA JR.
President, Manila Water Company
FRANCISCO P. BERNARDO
Professor, Asian Institute of Management
ELENITA C. DELGADO
Director, Maritime Industry Authority
EMMA C. FRANCISCO
Director, Bureau of Patents, Trademarks and Technology Transfer
MANUEL S. GASPAY
Director, Environmental Management Bureau
ELMER C. HERNANDEZ
Director, Board of Investments
QUINTIN L. KINTANAR
Director, Bureau of Food and Drugs
MARIANO S. LAGMAN
Professor, Asian Institute of Management
ALFREDO P. MACAPINLAC
General Manager, Uniwell Technologies Corp.
EDUARDO R. MAGTOTO
President, Agro-Industrial Management Consultants Inc.
PABLO F. MANGARAN JR.
Program Director, De La Salle University
NIMAI M. MEHTA
Associate Professor, UP School of Economics
NAPOLEON Y. NAVARRO
Program Manager, UNDP
CAYETANO W. PADERANGA JR.
Member, Monetary Board
CARLOS I. SUMERA
Division Chief, Bureau of Product Standards
EMMA TEODORO
Trustee, Philippine Exporters Confederation
ROLANDO C. VILORIA
Executive Director, Metal Industries Research and Development Center

This volume responds to a timely and urgent concern – understanding and highlighting the need for technology management if the Philippines is to meet greater challenges ahead. It is a compilation of papers presented by experts during the First National Conference on Technology Management, organized by the Technology Management Center of the University of the Philippines, held in October 1996. Commentaries given by specialists and leaders from industry, government, and academe accompany the papers.

It brings together policy and empirical studies regarding the role of science and technology in the country's development. Part I gives an overview of the state of science and technology in the country. Policy issues and institutional challenges are discussed in Part II. The papers in Part III look at technology, competitiveness, and growth. Some methodological and legal aspects of technology management are tackled in Part IV. The papers in Part V analyze the relevance of technology in specific industries. Part VI enumerates the strategic options for global competitiveness.

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Inquiries may be sent to:

The Director, Technology Management Center
Unit 2, ASTI Bldg., Technopark, CP Garcia Avenue
University of the Philippines, Diliman, Quezon City 1101
Tel Nos (632) 435-6203, 426-2767, 9205301-09 ext 7646, 7795
Telefax (632) 4262765; e-mail: tmcjep@info.com.ph

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