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SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES AND ECONOMIC CATCH-UP*

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This paper seeks to explain why the Philippines has remained technologically and economically underdeveloped up to now and what it will take for the country to catch up scientifically, technologically, and economically. The paper first reviews the extent to which the Philippines has been left behind in S&T and economic development. Next it discusses and confutes two approaches to the problem of economic and S&T under- development that have been pushed in the past: (1) the "science-push" approach advocated by basic scientists starting with Vannevar Bush and (2) the "market-pull" approach favored by mainstream (neoclassical, neoliberal) economists and traditional businessmen and based on the neoclassical economic theory of comparative advantage. The paper then presents an alternative approach ─ a "catch-up oriented", "capability-based", technonationalist approach ─ which draws from the successful catch-up experiences of East Asian NICs. The approach entails the abandonment of the precepts of neoliberalism and the Washington Consensus, seeks to achieve rapid national economic and S&T catch-up, and calls for the integrated upgrading of the supply, demand, and linkage parts of the national S&T system to world-class standards.

Keywords: Technological and economic catch-up, technological capabilities, technonationalism, technoliberalism

I. INTRODUCTION

It has become a consensus that the Philippines was second only to Japan in East Asia in industrial, technological, and economic development in the 1950s. Since then, however, the Philippines has been overtaken by its neighbors in East Asia with the exception of Vietnam, Myanmar, Laos, and Cambodia.

So why has the Philippines been left behind by its East Asian neighbors? Why has the country remained underdeveloped scientifically, technologically, and economically? Why has it failed to become a newly industrialized country up to now? Is it because the country neglected to develop its science and technology or S&T? Or is it because the Philippines adopted protectionist, nationalist policies for too long and failed to adopt open, liberal policies soon enough?

This paper tries to explain why the Philippines has remained a scientific, technological, and economic laggard up to now and what needs to be done to enable the country to catch up scientifically, technologically, and economically. Section II first gives a brief overview of the extent to

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which the Philippines has been left behind in terms of per capita GDP from 1950 to 2008. Then Section III presents an updated review of the poor and laggardly state of Philippine S&T. Next, Section IV discusses the "science-push" approach, advocated by the S&T community as a solution to the country's S&T and economic underdevelopment. Section V then discusses the "Market-pull" approach, advocated by mainstream economists and most businessmen as the route to the country's economic growth and development. In Section VI, the central problem of Philippine S&T is identified as its entrapment in a vicious circle of S&T laggardness and dependence. Section VII then proposes an alternative approach – a "catch-up oriented", "capability-based", technonationalist approach that draws from the successful national catch-up experiences of East Asian newly industrialized countries. The approach entails abandonment of the Philippine government's neoliberal economic policies, and seeks to achieve rapid national economic and S&T catch-up. Finally, Section VIII presents a Technonationalist agenda for the country that calls for the integrated upgrading of the supply, demand, and linkage parts of the national S&T system to world-class standards and the transformation of the vicious circle of S&T laggardness and dependence to a virtuous circle of global S&T excellence, competitiveness, and innovativeness. Section IX concludes the paper.

II. OVERVIEW OF THE EXTENT TO WHICH THE PHILIPPINES HAS BEEN LEFT BEHIND

Based on GDP per capita (PPP dollars), the Philippines was actually No. 4 in 1950 among East Asian countries, ranking below Singapore, Japan, and Malaysia as shown in Table 1. Nevertheless, in 1950 the per capita GDP of the Philippines was slightly higher than those of South Korea and Taiwan, about 1.5 times those of Thailand and Indonesia, and more than 2.5 times that of China.

Table 1
The Growth in GDP per Capita by PPP$
of the Philippines and of its Neighbors

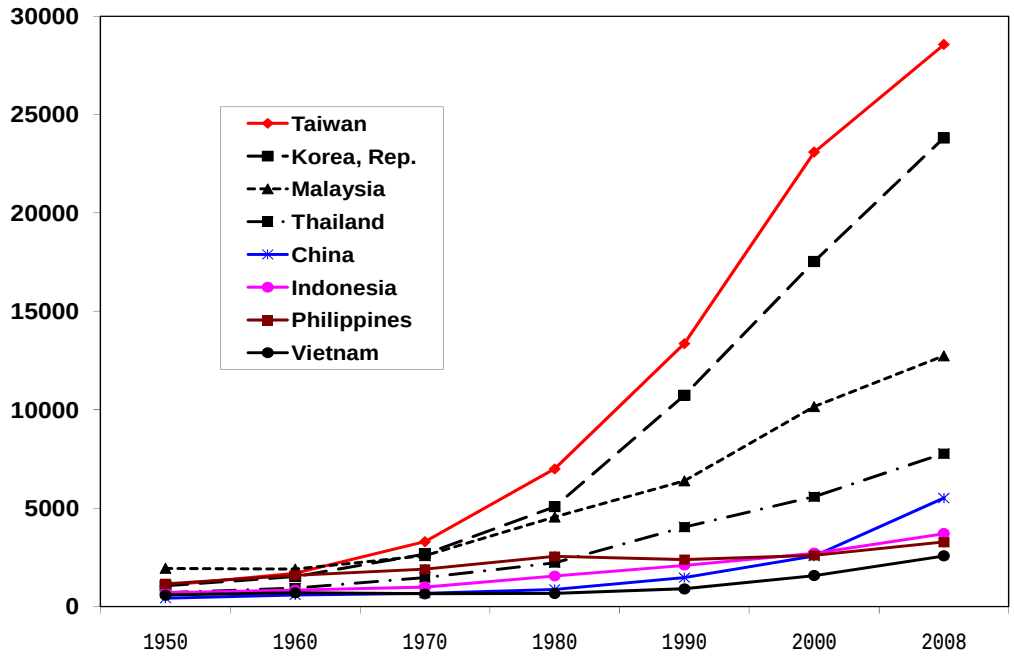
Country	1950	1960	1970	1980	1990	2000	2008
Singapore	3,533	3,426	6,994	14,104	23,143	36,835	45,295
Japan	2,645	5,489	13,375	18,488	25,870	28,559	31,823
Taiwan	1,064	1,679	3,300	6,995	13,361	23,094	28,560
Korea, Rep.	1,054	1,513	2,674	5,076	10,739	17,543	23,824
Malaysia	1,940	1,904	2,587	4,550	6,386	10,161	12,794
Thailand	712	940	1,477	2,227	4,039	5,578	7,776
China	418	592	665	868	1,465	2,564	5,520
Indonesia	704	834	986	1,549	2,097	2,715	3,708
Philippines	1,149	1,584	1,893	2,549	2,386	2,598	3,279
Vietnam	579	696	641	660	894	1,577	2,576

Source: Gapminder (2010).

The Philippines, however, was overtaken by Taiwan in 1960, by South Korea in late 1960s, by Thailand in the early 1980s, by Indonesia in the late 1990s, and by China in 2000, and it is about to be overtaken in the next five years by Vietnam as indicated in Table 1 and shown dramatically in Figure 1.

These facts and figures cannot be disputed; they imply very clearly that there is something drastically wrong with the development strategies and economic policies of the Philippine government. Since there is now a consensus that economic development is a catch-up process and that catching up requires building up capabilities, it follows that the Philippine economy has been left behind because it has failed to upgrade its capabilities to globally competitive standards. So we now examine the S&T capabilities of the Philippines.

Figure 1
Graph of the Growth in GDP Per Capita by PPP$
of the Philippines and of its Neighbors



III. THE CURRENT STATE OF PHILIPPINE S&T CAPABILITIES

To assess the current levels of Philippine S&T capabilities, we examine the supply, linkage, and demand parts of the Philippine S&T System, using the integrated framework for analyzing a National S&T System[1] depicted in Figure 2.

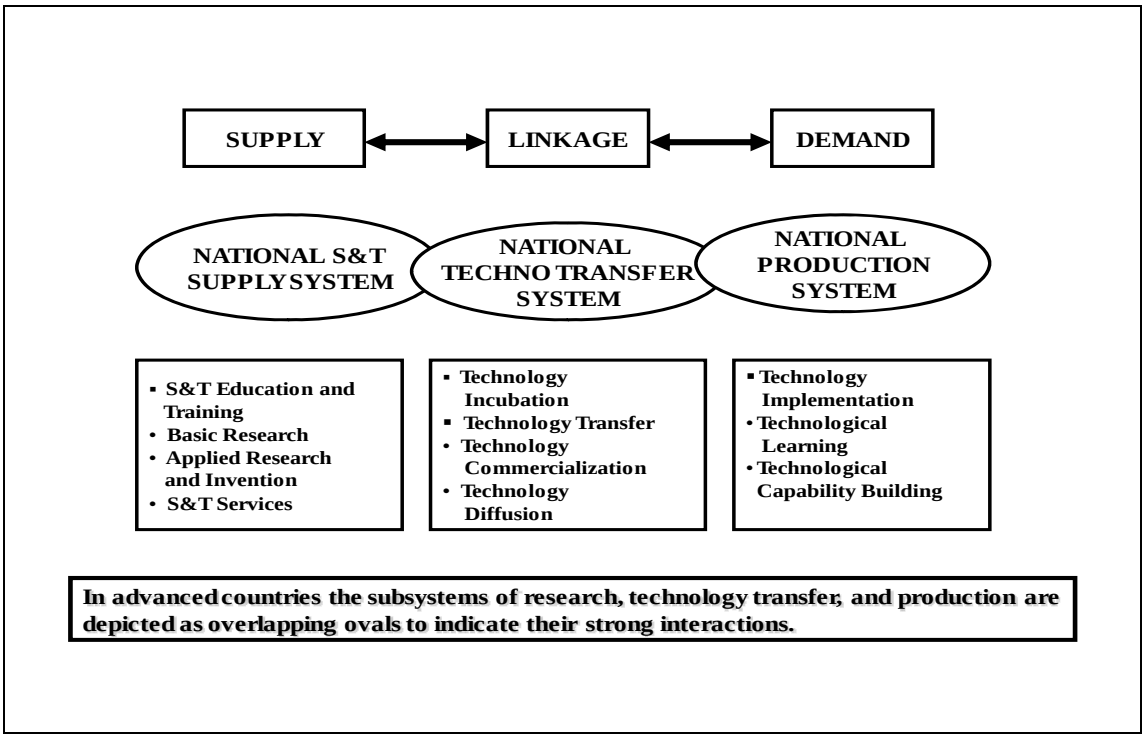
Assessment of the Philippine S&T Supply Subsystem

The most important international measures and indicators of S&T Supply are the following:

1. The country's number of full-time (FTE) researchers per million population;
2. The country's gross expenditures on R&D (GERD) as a percentage of GDP;
3. The country's per capita gross expenditures on R&D by PPP dollars;
4. The country's world share of internationally recognized or ISI publications; and
5. The country's world share of patents granted by the U.S.

The first three are input indicators of a country's S&T Supply, while the last two are its output indicators.

Figure 2
An Integrated Framework for Analyzing a National S&T System



According to UNESCO (2010), the Philippines has very few researchers in proportion to its population – only 81 FTE researchers per million of its population in 2005 – which is way, way below the 1980 UN target of 380 for developing Asian countries[2] and which is the lowest among the original ASEAN-5 plus Vietnam, as shown in Table 2. In absolute numbers, the Philippines had only 6,896 FTE researchers and a headcount of 10,690 researchers. The country's number of FTE researchers per million actually dropped from 155 in the 1990s[3] to 81 in 2005, which means that its pool of researchers hardly increased even as its population increased rapidly.

Table 2
The Number of Researchers in the Philippines as Compared to those of its Neighbors

Country	No. of FTE Researchers per Million Population	Total No. of FTE Researchers	Total Head Count of Researchers
Singapore	6,088[a]	27,301[a]	31,657[a]
Japan	5,573[a]	709,974[a]	883,386[a]
U.S.A.	4,663[b]	1,425,550[b]	-
Korea, Rep.	4,627[a]	221,928[a]	289,098[a]
China	1,071[a]	1,423,380[a]	-
Malaysia	372[b]	9,694[b]	19,021[b]
Thailand	311[c]	20,506[c]	34,084[c]
Indonesia	205[e]	42,722[e]	-
Vietnam	115[d]	9,328[d]	41,117[d]
Philippines	81[c]	6,896[c]	10,690[c]

a= 2007; b= 2006; c= 2005; d= 2002; e=2001
Source: UNESCO Institute for Statistics (2010).

The UNESCO Institute for Statistics (2010) also reports that the Philippines had a GERD/GDP of only 0.12 percent in 2005, which is a big drop from its value of 0.2 percent in the 1990s, which is again way below the UN benchmark of 0.5 percent for GERD/GDP that had been set as a 1980 target for developing countries,[4] and which is second to the lowest among the original ASEAN-5 as shown in Table 3.

Table 3 also shows that the Philippines had a per capita GERD of only $3.40 PPP in 2005, which is next to the lowest among the ASEAN-5 and way below the per capita GERD of $500-$1000 PPP of developed countries. Table 4 then shows the decline in relative Philippine expenditure on R&D under the Arroyo Administration.

Table 3
The Philippine Expenditures on R&D as Compared to those of its Neighbors

Country	GERD as % of GDP	GERD Per Capita (PPP$)
Japan	3.45 [a]	1,158.50 [a]
Korea, Rep.	3.47 [a]	868.50 [a]
U.S.A.	2.67 [a]	1,194.80 [a]
Singapore	2.61 [a]	1,341.80 [a]
China	1.49 [a]	78.90 [a]
Malaysia	0.64 [b]	79.90 [b]
Thailand	0.25 [b]	18.10 [b]
Vietnam	0.19 [d]	3.10 [d]
Philippines	0.12 [c]	3.40 [c]
Indonesia	0.05 [c]	1.60 [c]

a= 2007; b= 2006; c= 2005; d= 2002
Source: UNESCO Institute for Statistics (2010).

Table 4
Philippine Expenditures on R&D under the GMA Administration

	2002	2003	2005
GERD as % GDP	0.15	0.14	0.12
GERD Per Capita PPP$	3.60	3.50	3.40

Going now to the output indicators of the country's S&T Supply, we find from the Citation Databases of the Institute for Scientific Information – Web of Science (ISI-WOS) that the Philippines in 2005 had only 520 ISI publications which constituted only a tiny share ─ 0.04 percent─ of all world-wide ISI publications that year and gave the country a world ranking of 72nd.

In comparison, as shown in Table 5, Indonesia had 586 publications, Vietnam 590, Malaysia 1,596, Thailand 2,615, Singapore 6,528, Taiwan 16,147, South Korea 26,434, and China 70,962, Japan 77,263, all in 2005.[5] Table 6 then shows the growth in ISI publications of some ASEAN countries during the period 1999-2005, showing that the cumulative total of ISI publications from the Philippines was the lowest among the ASEAN-5.

Table 5
Comparative Statistics on World Share of ISI-WOS Publications and Number of ISI-WOS Publications per FTE Researcher

Rank	Country	No. of Publications	% Share	No. of FTE Researchers	No. of Publications per FTE Researcher
1	U.S.A	304,670	25.60	1,393,520[a]	0.22
2	Japan	77,263	6.40	677,206[a]	0.11
5	China	70,962	5.96	926,252[a]	0.08
11	South Korea	26,434	2.22	156,220[a]	0.17
18	Taiwan	16,147	1.36	-	-
30	Singapore	6,528	0.55	21,359[a]	0.30
43	Thailand	2,615	0.22	18,114[b]	0.14
50	Malaysia	1,596	0.13	12,670[a]	0.12
66	Vietnam	590	0.05	9,328[c]	0.06
68	Indonesia	586	0.05	42,722[d]	0.01
72	Philippines	520	0.04	5,860[b]	0.09

a = 2004; b = 2003; c = 2002; d = 2001
Sources: ISI-WOS Citation Database and UNESCO Institute for Statistics (2010).

Table 6
Annual Number of ISI-WOS Publications from the Philippines and Its Asian Neighbors During the Period 1999-2005

Country	1999	2000	2001	2002	2003	2004	2005	Total 1999-2005
Singapore	3,129	3,732	4,249	4,620	5,218	5,955	6,528	33,431
Thailand	1,076	1,272	1,466	1,766	2,100	2,299	2,615	12,604
Malaysia	889	860	997	1,039	1,213	1,412	1,596	8,006
Indonesia	389	457	506	481	497	540	586	3,456
Philippines	343	387	366	451	467	475	520	3,009
Vietnam	271	328	377	376	510	464	590	2,916

Source: ISI-WOS Citation Database.

The other output indicator of the country's S&T Supply is the world share of the patents granted to Philippine-based inventions by the US Patent and Trademark Office or USPTO out of the total number of USPTO patents granted. As shown in Table 7, Philippine-based inventions were awarded only 355 patents by the USPTO during the period 1988-2008, which was more than Indonesia's 178 and Thailand's 303 but less

than half of Malaysia's 947 and much less than tiny Singapore's 4,097, China's 8,975, South Korea's 57,968, Taiwan's 70,643, and Japan's 725,866.

The 355 patents credited to the Philippines in 1988-2008 correspond to a world share of 0.008 percent and a world rank of 42. These are embarrassingly low in comparison with those of its neighbors, but what makes the country's patent profile worse is that most of these seemingly Filipino inventions turn out to be inventions made by Philippine subsidiaries of foreign multinational corporations.[6]

Table 7
The World Share and Rank of the Philippines in Terms of USPTO Patents Granted in 1963-1987 and 1988-2008 as Compared to those of its Neighbors

Country	1963-1987			1988-2008		
	No.	% Share	Rank	No.	% Share	Rank
U.S.A	1,091,416	66.46	1	2,538,250	57.94	1
Japan	148,024	9.01	2	725,866	16.57	2
Taiwan	1,306	0.08	22	70,643	1.61	7
South Korea	343	0.02	34	57,968	1.32	8
China	519	0.03	28	8,975	0.20	19
Singapore	76	0.005	46	4,097	0.09	23
Malaysia	34	0.002	59	947	0.02	34
Philippines	132	0.008	39	355	0.008	42
Thailand	19	0.001	70	303	0.007	45
Indonesia	75	0.004	47	178	0.004	55

Source: USPTO

Assessment of the Philippine S&T Linkage Subsystem

The National Technology Transfer Subsystem of the Philippines is still in the embryonic stage as indicated by the following:

- Universities and government agencies are still in the process of setting up their technology transfer offices and systems.
- The counterpart of the 1980 Bayh-Dole Act of the U.S. has not yet been signed into law.[7]
- Technology-business incubators and technology parks are still in the development stages.
- The Philippine venture capital industry is still in its infant stage.
- Activities involving technology entrepreneurship or university spin-outs have not yet taken off.
- A Triple Helix of innovative collaborations among government, academia, and business has not yet been developed.
- Technology commercialization activities leading to new or improved technology-based products, processes, or services are scarce among domestic firms

Assessment of the Philippine National Production Subsystem

The nature and direction of technology demand in the Philippine production system can be gauged from what it exports and imports:

- The Philippines exports mostly low value added products such as garments; assembled integrated circuits or ICs; fashion accessories; gifts, toys, and houseware; fresh and processed fruits; tuna, shrimp, and seaweed; furniture; and low-end software.
- The country imports high-tech products such as power-generating machineries, specialized machineries, transport equipment, telecommunications equipment, computing equipment, heavy equipment, machine tools, chemicals, bulk pharmaceuticals, IC wafers, etc.

The most important gauge of a firm's, industry's, or country's level of technological competitiveness is its level of technological capability. Depending on what it is capable of doing with products and processes, a firm's technological capability can be identified with one of the rungs in the following ladder of technological capabilities:[8]

- *Acquisitional capability* – the ability to assess, select, and acquire appropriate technologies from external sources.
- *Operative capability* – the ability to implement, operationalize, and repair an externally acquired technology.
- *Adaptive capability* – the ability to adapt an external technology to local conditions through the modification of its scale, capacity, inputs, and peripheral components.
- *Integrative or investment capability* – the ability to assemble a complex technological system or commission a production facility on a self-reliant basis.
- *Duplicative capability* – the ability to reverse engineer and make a duplicate of an externally acquired product or process technology.
- *Improved-design capability* – the ability to improve the design of an existing product in terms of performance, architecture, or aesthetics without changing the existing technology.
- *Reproductive capability* – the ability to reproduce the core component(s) of an externally acquired product technology.
- *Innovative capability* – the ability to design and commercialize an incremental but significant improvement of the core or basic technology of an existing product or process.
- *Creative capability* – the ability to create a radically novel, breakthrough technology through endogenous research and development and to commercialize it into a new-to-the-world product or process.

Almost all Filipino-owned firms have technological capabilities that do not go beyond the operative level, while some have reached the adaptive level of technological capability. In general, domestic firms acquire the technologies they need through licensing, joint ventures, turn-key projects, and other modes of international technology transfer and simply implement these foreign technologies without attempting to learn these technologies and to improve them.

As a consequence, the Philippine economy has remained a mere importer and consumer of industrial and high technologies and has not yet learned to become a producer and exporter of advanced technologies. Philippine technological capabilities are still largely backward and dependent, being mostly adaptive relative to industrial 20th century technologies, and merely theoretical or at most operative relative to 21st century high technologies.

An egregious yet typical example of the weak and dependent technological

capabilities found in almost all Filipino-owned firms is the National Power Corporation (NPC or NAPOCOR), which has remained at the operative level in electric power generating capabilities since 1972 due to this company's continuing dependence on foreign firms for the design and construction of power plants. In stark contrast, its South Korean counterpart, KEPCO, has successfully attained innovative capabilities and global competitiveness in electric power generation technologies, including nuclear power technology.[9]

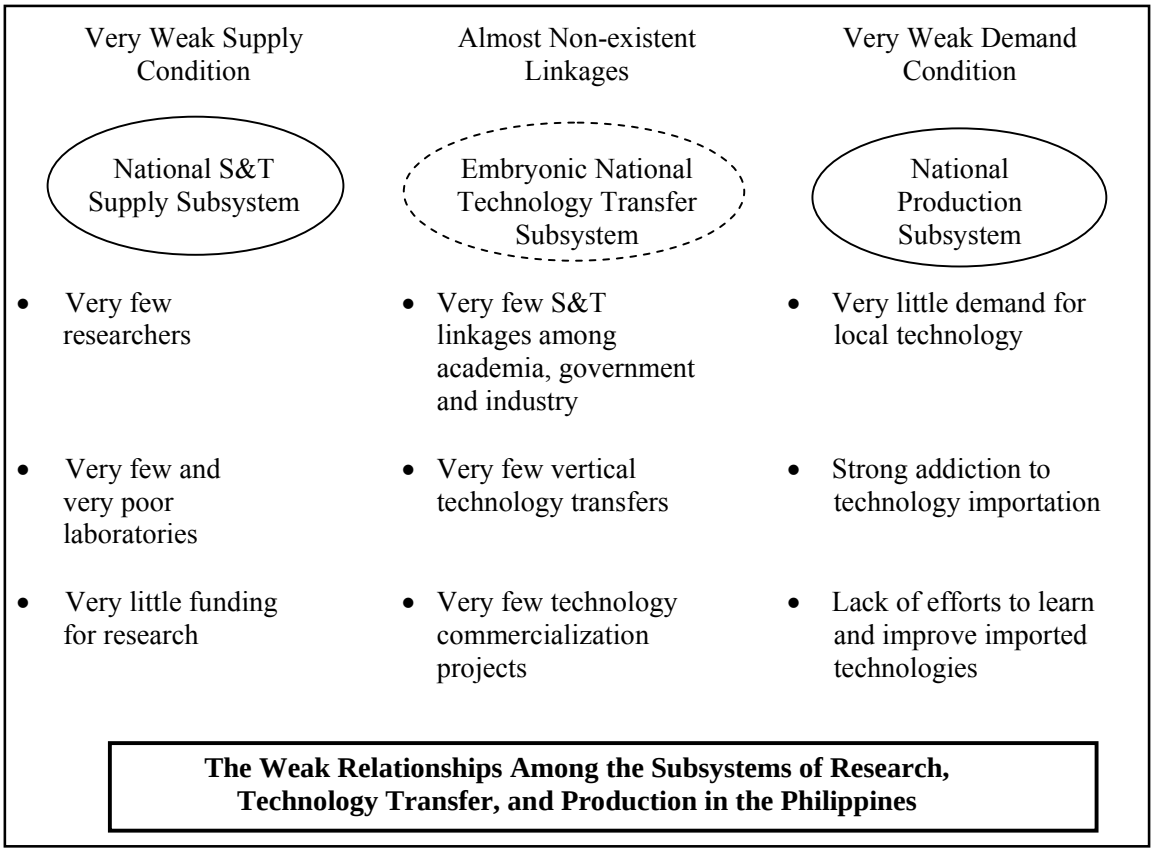
Thus, the Philippine production system can be characterized as:

- having low levels of technological capabilities;
- being highly dependent on the importation of technologies through various modes of international technology transfer from technology purchase, licensing, subcontracting, turn-key projects, joint ventures, and foreign direct investments;
- having no motive or effort to learn and master the imported technologies or to move up the ladder of technological capabilities;
- being averse to local technology sourcing or technology transfers from domestic R&D laboratories;
- lacking competence in technology management and making do with poor product and process technologies; and
- lacking technology-based global competitiveness.

The overall conditions of the Philippine S&T system is summarized in Figure 3 where the subsystems of research, technology transfer, and production are depicted as disjointed ovals to reflect the almost non-existent linkage between domestic S&T supply and S&T demand in the Philippines.[10]

To address the underdevelopment of the Philippine economy and S&T system, two approaches have been advocated and pursued: the Science-push approach and the Market-pull approach. Each of these two approaches will be examined in the next two sections.

Figure 3
Overall Condition of the Philippine S&T System



IV. THE SCIENCE-PUSH APPROACH

The "science-push" approach holds that the solution to the underdevelopment of the country's S&T and economy is to pour more resources (human, financial, etc.) into the national S&T supply subsystem.

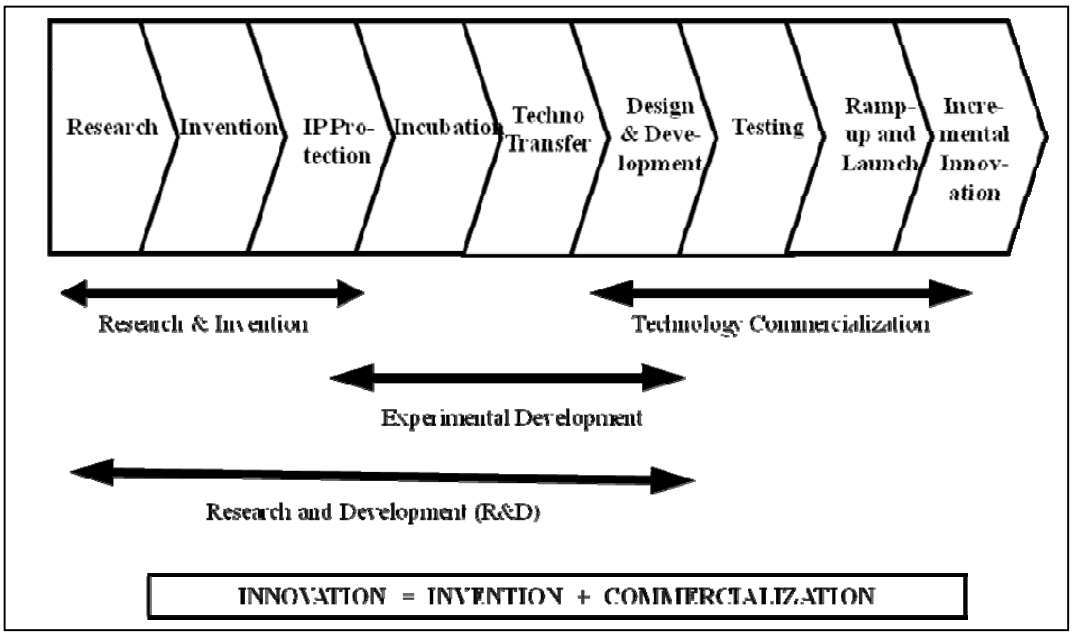
First expounded by Vannevar Bush (1945) in his Report to President Truman, *Science The Endless Frontier,* this is the approach advocated by most foreign and local scientists. A strong local exponent of this science-push approach is Dr. Flor Lacanilao (2007), retired professor of the U.P. Marine Science Institute, who seems to believe that S&T development is just a matter of getting local scientists to undertake research properly and to publish their research results in ISI journals. To quote him: "We have spent too much time and resources addressing problem symptoms instead of attending to their causes. The direct cause of under-development is poor S&T, brought about by failure to do research properly."

Dr. Camar Umpa (1997), former president of the Mindanao State University, has also advocated this approach by arguing that since GERD/GDP is correlated with per capita GDP then the Philippine government

should increase its GERD/GDP to levels of at least 1.0 percent in order to attain per capita GDP levels of advanced countries.

This science-push approach is, of course, based on the naive, simplistic view of the technological innovation process as a linear, pipeline model as depicted in Figure 4.[11]

Figure 4
The Linear Model of Technological Innovation



This linear model of the innovation process has two main pillars:

- The belief by Bush (1945) that "basic research is the pacemaker of technological progress".
- The assumption by Bush that "those who invest in basic science will capture its return in technology as the advances in science are converted into technological innovation."[12]

These seem to imply that all basic research results will sooner or later find a commercial application and become a product or process innovation.

These beliefs, however, either ignore, or are ignorant of, the non-linear models of technological innovation as well as the realities, difficulties, and frustrations of the technological innovation process that students of Technology Management are very familiar with.

The reality is that only around 10 percent of inventions pass the tests of technical and commercial feasibility to be considered as possible product ideas, only about 10 percent of product ideas are successfully commercialized into product innovations, and only about 10 percent of commercially launched products become successful in the market.[13]

In the Philippines, the Department of Science and Technology (DOST) is the principal government agency that has been pursuing the "science-push" approach for the past 51 years through its focus on the development of the National S&T Supply

Subsystem. Of course, the DOST has also been striving to address the problems and needs of the National Technology Transfer Subsystem and the National Production Subsystem (as demonstrated, for example, by its Technology Incubation for Commercialization Program or TECHNICOM), but it has not made much headway in transforming the other parts of the national S&T system because its mandate does not empower it to influence the demand side of the Philippine S&T System.

In early 2007, a joint Congressional Commission on Science and Technology and Engineering (COMSTE) was created, through the initiative of Senator Edgardo Angara, for the purpose of creating or repealing laws so as to make the country competitive in S&T.[14] COMSTE, however, has also been focusing on ways of improving the National S&T Supply Subsystem and the National Technology Transfer Subsystem without any apparent intention of changing the economic ideology and policies of the National Production Subsystem. Hence, as a government entity that is carrying out projects which the DOST can very competently undertake, COMSTE can be easily predicted to be another superfluous exercise in "science-push" futility.

Studies of Brazil and Mexico by Eduardo Viotti (2003) show that a country can have a high world share of ISI publications and a small share of USPTO patents, contrary to what would be expected from the "science-push" approach. The best counterexample to the "science-push" approach, however, is the late industrialization experience of South Korea for, according to Linsu Kim (1993): "R&D in the formal sense of the term was not important for Korea during this stage of imitating mature technologies. Industries in fact reversed the sequence of R&D&E: it started with engineering (E) for products and processes imported from abroad, and then progressively evolved into the position of undertaking a substantial development (D). But research (R) was not relevant to Korea's industrialization through the 1970s."

The "science-push" approach can at most be wasteful of resources but it is not as pernicious as the market-pull approach that will be discussed next.

V. THE "MARKET-PULL" APPROACH

The "market-pull" approach holds that the solution to the underdevelopment of our country's economy and S&T is to make all economic, business, and technology decisions conform to market needs, problems, and opportunities and to the "principle of comparative advantage."

This is the approach advocated by mainstream (neoclassical, neoliberal) economists and favored by most businessmen. It is also the basic approach that has been adopted by successive Philippine governments for the past 24 years since 1986.

The "market-pull" approach is based on two pillars of neoclassical economics:

- The "Principle of Comparative Advantage", which holds that a firm, industry, or country should specialize on production technologies and systems that can make maximum use of its current endowments or its comparative advantage.
- Neoliberalism or the Washington Consensus,[15] which calls for free trade, free enterprise, free markets, FDI liberalization, deregulation, privatization, and minimal government intervention in the market.

The application of these two pillars of neoclassical economics to the selection, acquisition, and exploitation of technology is what I term "technoliberalism."

Technoliberalism holds that a firm should not design and produce its own technology if it does not have the comparative advantage to do so or, in other words, if it is easier and more cost-effective to buy or lease the technology.

Thus, technoliberalism is the reason behind the NPC's unwillingness to design and produce its own power plants and core power equipment and its continuing addiction to the importation of power plants through turn-key projects. Technoliberalism is the reason why most Filipino-owned firms have remained technologically backward and dependent, have continued to be mere users and importers of foreign technology, and have not attained technology-based global competitiveness.

It is technoliberalism that has been preventing our economy from industrializing, making our economy stagnant and dependent on OFW remittances, allowing our neighbors overtake us in terms of GDP per capita, and letting them leave us behind as the economic basket case of Asia .

But Dr. Bernardo Villegas (2009), one of the chief proponents of neoliberalism in the Philippines, has recently blamed our country's continuing underdevelopment on the anti-market, protectionist, import-substituting policies adopted by the government for 30 years since 1945. Yet he ignores the fact that neoliberalism has held sway in our country for the past 24 years since 1986 which was also the period when we were overtaken by Thailand, Indonesia, and China.

Technoliberalism is confuted by the fact that its adoption by successive Philippine governments since 1986 has kept our economy and S&T underdeveloped while its rejection by Japan, South Korea, Taiwan, China, and Malaysia enabled these countries to achieve rapid industrial, technological, and economic catch-up. In fact, these late industrializing countries deliberately defied the principles of comparative advantage to create globally competitive industries in steel-making, shipbuilding, transport vehicles, IC fabrication, mobile communications, machine tools, heavy equipment, power generation, etc.[16]

In the past five years, the ideological hegemony of neoliberalism itself has been undermined by the consensus, among critics and proponents alike [such as J. Stiglitz (2004), D. Rodrik (2006), and S. Radosevic (2009)], that the Washington Consensus is a failed recipe for economic development. In fact, development economists are now working out a post-Washington Consensus that appears to be more open to the emerging alternative economic paradigm known as "innovation economics."[17]

VI. THE VICIOUS CIRCLE OF S&T UNDERDEVELOPMENT AND DEPENDENCE

The local proponents of the "science-push" approach see the very high levels of research funding, research staffing, and research productivity in developed countries and conclude that the Philippines must attain the same levels of research inputs and outputs in order to become a developed country. On the other hand, the local advocates of the "market-pull" approach see the open, free, and unregulated market economies of developed countries and conclude that the Philippines must adopt a similar kind of economy in order to become a developed country. Both of these two approaches, however, fail to see the Philippines as a developing country that is

trapped in a vicious circle of S&T and economic laggardness and dependence.[18]

The adoption of technoliberalism has made our national production subsystem dependent on the import of foreign technologies and eliminated demand for domestically created technologies. This almost zero demand in turn has reduced pressure on the government and industry to make substantial investments in S&T development. The underinvestment in S&T in turn has rendered local S&T underdeveloped and incapable of meeting the technological needs of local industry. And this local technological incapability in turn has reinforced the dependence on technology importation, resulting in a vicious circle of S&T and economic under- development and dependence, as depicted in Figure 5 and Figure 6.[19]

Figure 5
Macro View of the Vicious Circle of Philippine S&T and Economic Underdevelopment and Dependence

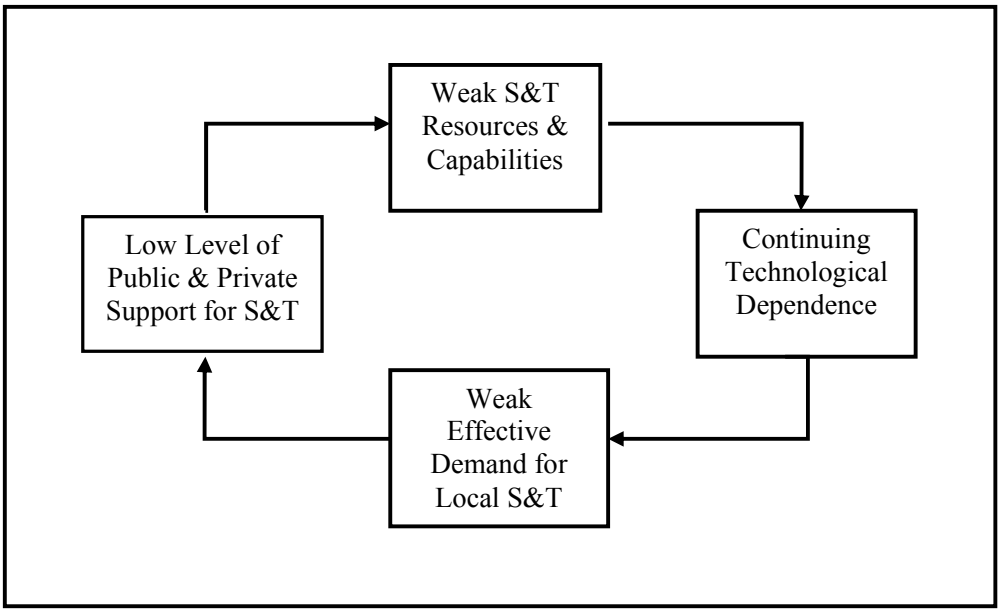
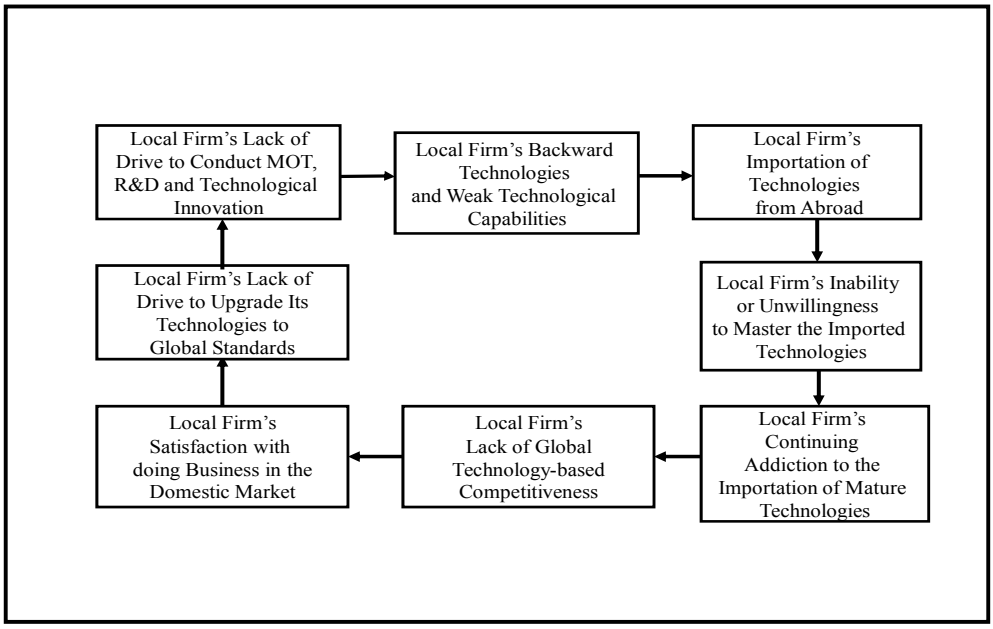


Figure 6
Micro View of the Vicious Circle of Philippine S&T and Economic Underdevelopment and Dependence



This vicious circle is the basic central problem of the Philippines that has perpetuated the underdevelopment and dependence of our country's economy and S&T system. It explains why Filipino-owned firms like NAPOCOR have remained dependent on technology importation up to now, why the Philippines has failed to industrialize and catch up, and why our neighboring countries have overtaken us.

This vicious-circle framework also explains why the DOST's thrusts, policies, and programs have turned out to be seemingly feckless and futile up to now. For the past 51 years the DOST has been mainly and vainly trying to develop the National S&T Supply Subsystem but it has been stymied from effecting needed changes in the S&T Demand Subsystem because the DOST lacks the intellectual and political clout to challenge the national government's economic ideology of neoliberalism.

With the identification of our country's basic central problem, its solution becomes obvious. What needs to be done is to cut the vicious circle of S&T and economic laggardness and dependence and to replace it with a virtuous circle of S&T and economic innovativeness and competitiveness geared towards rapid national economic and S&T catch-up and even leapfrog in certain sectors. To achieve this, the government will have to do the following:

1. discard the failed and discredited economic ideology of neoliberalism
2. use the principles of technonationalism and the techniques of technology management to transform the vicious circle into a virtuous circle
3. adopt the catch-up-oriented, capability-based precepts of the "East Asian Consensus", which is explained in the next Section.

VII. THE CATCH-UP ORIENTED, CAPABILITY-BASED, TECHNONATIONALIST APPROACH

What the author has been advocating for the past twenty-five years as an alternative to the "science-push" and the "market-pull" approaches is the catch-up-oriented, capability-based technonationalist approach.[20]

It is based on what the author calls "technonationalism" which holds that long-term strategic national interests should take precedence over short-term comparative advantages on matters involving technology selection, acquisition, and exploitation and that building up a country's scientific and technological capabilities to the highest world-class levels is a matter of paramount national interest and national security.

It is "catch-up-oriented" because it aims to achieve rapid economic and S&T catch-up, if not leapfrogging in certain sectors. It is "capability-based"[21] because it is based on the rapid development of the technological capabilities of Filipino-owned firms to global competitiveness and the build up of the country's scientific capabilities to world-class levels of excellence.

Moreover, it follows more or less the "East Asian Consensus" or what Lee and Mathews (2009) prefer to call the "BeST Consensus", after Beijing, Seoul, and Tokyo ─ the set of industrial catch-up precepts that has enabled East Asian countries to achieve rapid industrialization, technological catch-up, and economic progress or what has been called "The East Asian Miracle".

As expounded by Lee and Mathews (2009), the basic components of the "East Asian Consensus" are:

Creating the two principal agents of economic growth

- Creating firms and building their capabilities (e.g., family-owned conglomerates or *chaebols* like Samsung in South Korea or government spin-out companies like Lenovo of China and Taiwan Semiconductor Manufacturing Company of Taiwan).
- Creating and relying upon the "pilot" or coordinating State agencies to guide industrialization (e.g., MITI in Japan, Economic Planning Board in South Korea, Central Economic Planning Board in Taiwan, and National Development and Reform Commission in China).

Setting into motion the process of capability enhancement

- Arranging firms to access and leverage advanced knowledge through various modes of international technology transfer.
- Promoting export-based engagement with the global economy to discipline firms and expand markets.
- Targeting industries/technologies for (initially import-substituting) development.[22]
- Sequential upgrading of the leading sectors and activities to secure dynamic comparative advantages.

Creating an economic environment in which capability development will proceed

- Building broad-based education, from primary education to tertiary education.
- Creating a financial system that is catch-up friendly but cautious about external financial liberalization.
- Establishing stable macroeconomic settings.
- Gradual phasing out of non-market interventions.

VIII. THE TECHNONATIONALIST AGENDA

To carry out the technonationalist approach, there is a need to put together and implement a Technonationalist Agenda that seeks to tackle the weaknesses and disjointedness of the demand, supply, and linkage parts of the national S&T system in an integrated and holistic way by:

1. Creating a strong demand for local S&T within the National Production Subsystem;
2. Building up the National S&T Supply Subsystem to world-class levels in terms of human, financial, institutional, and infrastructural resources; and
3. Developing a dynamic and effective National Technology Transfer Subsystem

The following programs comprise the main elements of the Technonationalist agenda:[23]

Programs to Create a Strong Demand for Domestic S&T:

- Formulate and implement a National Technology Strategy and a National Technology Roadmap geared towards rapid technological catch-up and institutionalize the practice of technology management at national, industry, and firm levels.
- Establish and develop industrial clusters in every district and province of the country and link these clusters to global value chains for technology acquisition and market access.
- Establish cluster-based and cluster-dedicated training centers, R&D institutes, and technology management centers.
- Use the State's procurement and regulatory powers to promote international standards of quality for domestic products, processes, and services.
- Adopt a system of incentives to stimulate the conduct of R&D and innovation in large firms and to induce the continuous upgrading of the technologies of SMEs to global standards.

Programs to Upgrade the Domestic S&T Supply Subsystem:

- Formulate and implement a National R&D Plan that is integrated with the National Technology Roadmap and that is oriented towards world-class R&D productivity in terms of publications and inventions.
- Implement a massive crash program to increase the quantity and quality of Philippine R&D scientists, engineers and technicians to minimum international standards.
- Provide massive public and private investments in R&D to meet the 1980 U.N. GERD/GDP minimum target of 0.5 percent.
- Develop the University of the Philippines into a world-class research university, create at least one world-class university department in every major discipline of science and engineering, and insure that the country's R&D support facilities are adequate and world-class.
- Implement a national crash program to upgrade to global standards all Philippine educational institutions and curricula at all levels, especially in science and technology.

Programs to Strengthen the Domestic S&T Linkages:

- Formulate and implement a National Technology Transfer Policy that will provide the laws, policies, institutions, and incentives needed to stimulate the transfer and commercialization of research outputs from academic and government laboratories.
- Establish university-linked technology business incubators and high-tech parks or technopolises similar to Taiwan's Hsinchu Science-Based Industrial Park or South Korea's Daeduk Science Town.
- Create government endowed contract R&D corporations (similar to Germany's Fraunhofer Society) and grant corporate powers to some of the existing government R&D institutes.
- Establish courses and incentives to encourage technology entrepreneurship among high school and college students.
- Establish an extensive national network of institutions for technology diffusion, technical extension services, and online S&T information services.
- Create and nurture a Triple Helix of S&T collaborations among government, academia, and business.

IX. SUMMARY AND CONCLUSION

This paper presented some facts and figures to indicate the extent to which the Philippines has been left behind in economic and S&T development. It also discussed two traditional approaches to the problem of economic and S&T underdevelopment: 1) the "science-push" approach advocated by scientists, and 2) the "market-pull" approach favored by mainstream economists and most businessmen. The "market-pull" approach is based on the neoclassical economic theory of comparative advantage.

The paper also explained that these two approaches are unable to solve the problem of Philippine economic and S&T underdevelopment because they fail to tackle the country's basic central problem: the vicious circle of S&T underdevelopment and dependence. We then presented an alternative approach ─ a "catch-up oriented", "capability-based", technonationalist approach that intends to transform the country's vicious circle of S&T laggardness and dependence into a virtuous circle of world-class S&T excellence, innovativeness, and competitiveness geared towards rapid national economic and S&T catch-up and even leapfrog in certain sectors like genetic engineering, materials engineering, electric cars, stem cells, renewable energies, etc. This technonationalist approach entails the abandonment of the failed and discredited ideology of neoliberalism and the Washington Consensus and the adaptation of the successful catch-up precepts of the "East Asian Consensus."

Finally, a Technonationalist Agenda was presented which consists of programs designed to upgrade the supply, demand, and linkage parts of the national S&T system to standards of world-class quality and competitiveness in an integrated and holistic manner.

NOTES

* The preliminary powerpoint version of this paper was delivered at the Science and Technology Session of *A UP Academic's Congress to Challenge our Next Leaders* held at the Malcolm Theater, College of Law, University of the Philippines - Diliman, February 3, 2010.

[1] This framework was originally presented by the author in his paper, *An assessment of the state of science and technology in the Philippines*, which he delivered during the First National Conference on Technology Management held in Manila on October 25-26, 1996 and published as Posadas (2000).

[2] This 1980 U.N. target for the no. of FTE researchers was first brought out by the author in Posadas (1982), citing the U.N. publication, United Nations (1971).

[3] This figure of 155 FTE researchers per million population was used in Posadas (1999b), citing the DOST report of Padolina (1996).

[4] This 1980 U.N. target of 0.5 percent for the GERD/GDP was also first brought out by the author in Posadas (1982). The oft quoted figure of 1.0 percent is actually the U.N. target for (GERD + GESTS)/GDP, where GESTS stands for gross expenditures on "science and technology services" such as metrological, analytical, and computing services.

[5] These data on a country's no. of ISI publications per FTE researcher, which the author derived by dividing the country's no. of ISI publications by its no. of FTE researchers, do not seem to have been used before as indicators of a country's research productivity.

[6] This little known fact about patents granted to Philippine-based inventions was first pointed out by the author in Posadas (2006).

[7] The U.S. Bayh-Dole Act of 1980, which gave U.S. universities entitlement to patents obtained from federally funded research grants, is credited for strongly stimulating technology transfers from U.S. universities. A local counterpart bill, called "Technology Transfer Act of 2009" and principally authored by Rep. Joseph Abaya of Cavite and Sen. Edgardo Angara, was passed by the Congress of the Philippines on December 15, 2009 but has not yet been signed into law.

[8] The original version of this ladder of technological capabilities was first presented by the author in a paper presented during the *Second Nation-in-Crisis Colloquia* held at the College of Law, U.P. Diliman, in October 1985 and published as Posadas (1986).

[9] It was recently announced by CNN online last December 28, 2009 that a South Korean consortium led by KEPCO was awarded a US$ 20.4 Billion contract by the United Arab Emirates to construct four 1,400-megawatt nuclear power plants by 2020.

[10] This framework was originally presented by the author in his paper, *An assessment of the state of science and technology in the Philippines*, which he delivered during the First National Conference on Technology Management held in Manila on October 25-26, 1996 and published as Posadas (2000).

[11] This diagram of the linear model of technological innovation was devised by the author.

[12] Quoted in Viotti (2003), citing Stokes, D. E. (1997).

[13] See, for example, Schilling (2005) in the References for this "innovation funnel".

[14] Details about the organization and activities of COMSTE can be found in its website www.comste.com.ph

[15] The "Washington consensus" was the set of interrelated policies for macroeconomic stabilization and trade liberalization that was first formulated by John Williamson (as cited in Radosevic, 2009) on the basis of the policies being practiced by the International Monetary Fund (IMF), the World Bank, and the U.S. Treasury.

[16] See, for example, Kim (1997) and Amsden (1989) in the References for details on how South Korea defied the precepts of comparative advantage to create globally competitive industries. See also Lin and Chang (2009) for a debate on whether industrial policy in developing countries should conform to comparative advantage or defy it.

[17]See, for example, Gjerding (1997) and Atkinson & Audretsch (2008) in the references for an introduction to innovation economics.

[18]This vicious circle was first pointed out by the author in his lecture delivered in 1985 and published as Posadas (1986).

[19]These macro and micro views of the vicious circle were devised by the author and first presented in Posadas (2004).

[20]This technonationalist approach was first presented under a different name in Posadas (1986) and explicitly propounded as such in Posadas (1999a).

[21]See, for example, Lee (2009) in the references for an elaboration of the capability-based view of development.

[22]See, for example, Amsden (1989) in the references for South Korea's experiences in industrial and technology targeting.

[23]The original version of this Technonationalist Agenda was first presented in Posadas (1999a).

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