Technological Development and Technology Policy in East Asia: Prospects for Technological Leap-Frogging

Koh Ai Tee*

This paper profiles some important factors which underly successful technological catch up in East Asian economies within a relatively short space of time in defiance of glaring obstacles to development. The study shows that while there are many different approaches and strategies for technological success, the mix and effectiveness of these ingredients are constantly changing in response to new dynamic challenges emanating from both within and outside East Asia. This in turn demands a new level of creativeness and agility on the part of technology policy and technolgy policymakers in meeting the challenge to transition to the next technological frontier. (*JEL* Classification O32)

I. Introduction

The success and dynamism of East Asian economic growth is well recognized. A recent World Bank Study entitled 'The East Asian Miracle' (World Bank 1993) documents the following characteristics of East Asia: From 1965 to 1990, the twenty-three economies of East Asia grew faster than all other regions of the world (World Bank 1993). Most of this growth is concentrated in eight economies: Japan; the 'Four Tigers' —Hong Kong, S. Korea, Singapore, and Taiwan; and the three newly

*Senior Lecturer, National University of Singapore, Department of Economics and Statistics, 10 Kent Ridge Crescent, Singapore 0511. The author wishes to thank participants at the October 1994 Second Seoul Journal Economics Conference for their very useful comments and feedback. She is particularly indebted to the paper discussant, Dr. Somi Seong, for her sharp and insightful comments which have helped tremendously in the course of revising this paper.
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industrializing economies of Southeast Asia, Indonesia, Malaysia, and Thailand. Since 1960, these eight high-performing Asian economies (HPAEs) have grown twice as fast as the rest of East Asia, roughly three times as fast as Latin America and South Asia, and twenty-five times faster than Sub-Saharan Africa. They also significantly outperformed the industrial economies and the oil-rich Middle East-North Africa region. Between 1960 and 1985, real income per capita increased more than four times in Japan and the Four Tigers and more than doubled in the Southeast Asian NIEs.

Furthermore, growth in efficiency has not been at the sacrifice of equity. "The HPAEs enjoyed much higher per capita income growth at the same time that income distribution improved by as much or more than in other developing economies, with the exceptions of Korea and Taiwan which began with highly equal income distributions. The HPAEs are the only economies that have high growth and declining inequality. Moreover, the fastest growing East Asian economies, Japan and the Four Tigers, are the most equal" (p.2,4).

The East Asian countries covered in this paper include all the eight HPAEs mentioned above plus the Philippines. The Philippines economy has shown significant signs of having turned around in the recent one year, and appears to be firmly back on the road to recovery. Like the other Southeast Asian NIEs though on a smaller scale, it is also experiencing a foreign investment boom and shows great potential for technological and economic advancement in the near future, barring any unforeseen circumstances.

Within the context of this paper, the following terminology will be adopted. Besides Japan, the other eight countries under study shall be referred to as the first-tier East Asian Newly Industrializing Economies (EANIEs) covering South Korea, Taiwan, Hong Kong, and Singapore, and the second tier EANIEs embracing Indonesia, Malaysia, the Philippines, and Thailand.

No single model can capture and explain the diversity of East Asian experience. A popular view has been to contrast the approaches adopted by Latin American NIEs with those followed by Japan and Asian NIEs and attribute the latter's success to outward-oriented growth strategies as opposed to the former's inward-oriented growth stance. The story goes that Asian NIEs outperformed their Latin American counterparts by 'getting prices right' by giving greater freedom to the operation of market forces (Bradford 1986 and Hirschman 1986 cited in OECD 1992a). Empirical evidence however shows that the govern-

ments of Japan and the first-tier EANIEs were highly interventionist, although in different ways (World Bank 1993). The Korean government, for example, used subsidized credit and highly selective rationing of credit to favoured sectors and firms as a way of directing investment into strategic industries. The Taiwanese government relied more heavily on fiscal incentives, also administered in a highly selective way to promote certain priority industries. Moreover, public enterprises in Taiwan have played a much larger role than in Korea in fixed capital formation

Another variant of the 'getting prices right' argument is the 'stages theory of comparative advantage.' The latter views the shifting industrial structures of the NIEs as merely the reflection of shifting comparative advantages enjoyed by relatively open economies, i.e. those with few price distortions (Balassa 1977). Countries are deemed to move from producing mostly primary commodities to light manufactured goods to more skill and capital-intensive manufactures as their factor endowments changed in the course of development. By this reasoning, unskilled labor scarcity in the first-tier Asian NIEs is now forcing the transition to skilled labor-intensive and capital-intensive activities. While this argument is plausible, it tends to ignore the significant role played by explicit policy interventions in creating comparative advantages that would have developed far more slowly in response to market forces alone (Amsden 1989, cited in OECD 1992a). In the context of this paper, it will be argued that the above is no less true in the development of East Asian technological capability which has been speeded up in no small way by far-sighted, highly pragmatic, and highly interventionist technology policies.

A. Definition of Technological Capability

Technology here is conceptualized in a broad way and technological capability defined as follows:

> "The notion of technological capabilities attempts to capture the great variety of knowledge and skills needed to acquire, assimilate, use, adapt, change and create technology. It goes well beyond engineering and technical know-how to include knowledge of organizational structures and procedures as much as knowledge of behavioural patterns, e.g. of workers and customers. Firms need certain complementary assets and capabilities in order to create, mobilize and improve their technological capabilities, among which may be noted organizational flexibility, finance, quality of human resources, sophistication of the

support services and of the information management and co-ordination capabilities". (OECD 1992a, p.262)

At a practical level, broad technological competence should include capabilities both on the supply (i.e. production) as well as demand side. Producers' capability may be grouped into four broad categories which include:

(i) the knowledge and skills required for the process of production, where shop-floor experience and 'learning-by-doing' plays and important role;

(ii) the knowledge and skills required for investment, i.e. the establishment of new production facilities and the expansion and/or modernization of existing ones;

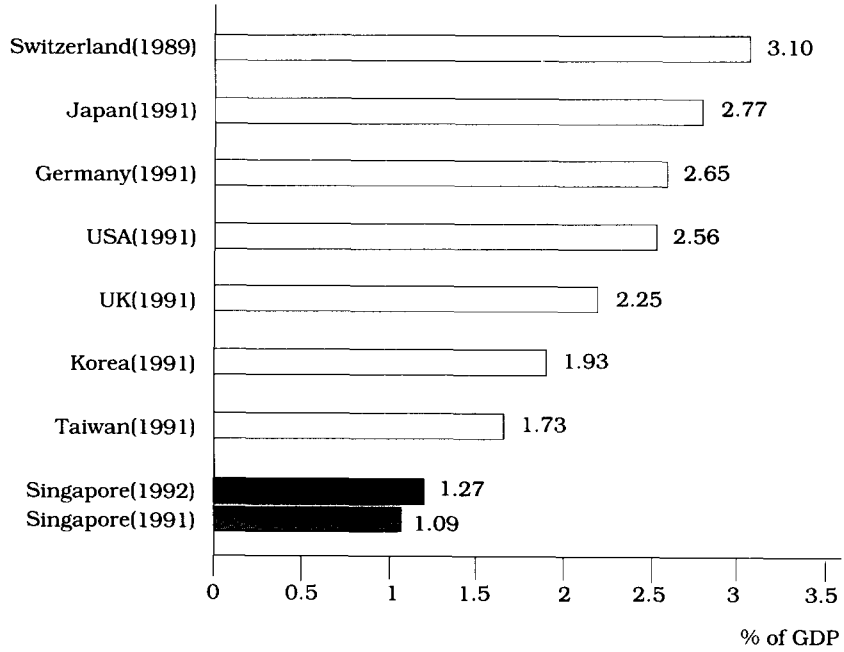
(iii) the vast area of adaptive engineering and organizational adaptations required for the continuous and incremental upgrading of product design and performance features of process technology;

(iv) the knowledge required for the creation of new technology, i.e. major changes in the design and core features of products and production processes.(OECD 1992a, p.262)

In short, producers' capability should reflect abilities of a progressively more difficult and demanding order, namely, production capability, investment capability, adaptive capability, and finally creative capability.

On the demand side, knowledge about user needs has become quite as important. Increasingly, innovation and successful learning require knowledge about user needs as much as the knowledge about the process of production. This is because knowledge of how a particular technology can be utilized requires significant 'learning-by-using' experience. Having sophisticated users who can conceptualize a need and translate it into a requirement for products and services will help put pressure on producers to improve their technological capabilities (OECD 1992a).

The rest of the paper is organized as follows. The next section (Section II) provides recent macro data that aims to reflect the current technological capability profile of East Asian countries in a comparative setting with other world technology leaders. The second-tier EANIEs are discussed separately due to paucity of actual R&D data. Section III outlines some of the key success factors behind the impressive ability in technological catch-up within Japan and the first-tier EANIEs (particularly S. Korea and Taiwan), and identifies lessons that may be relevant for other industrializing nations that hope to similarly leap-frog to



Source: National Science and Technology Board, Singapore, 1992 National Survey of R&D in Singapore.

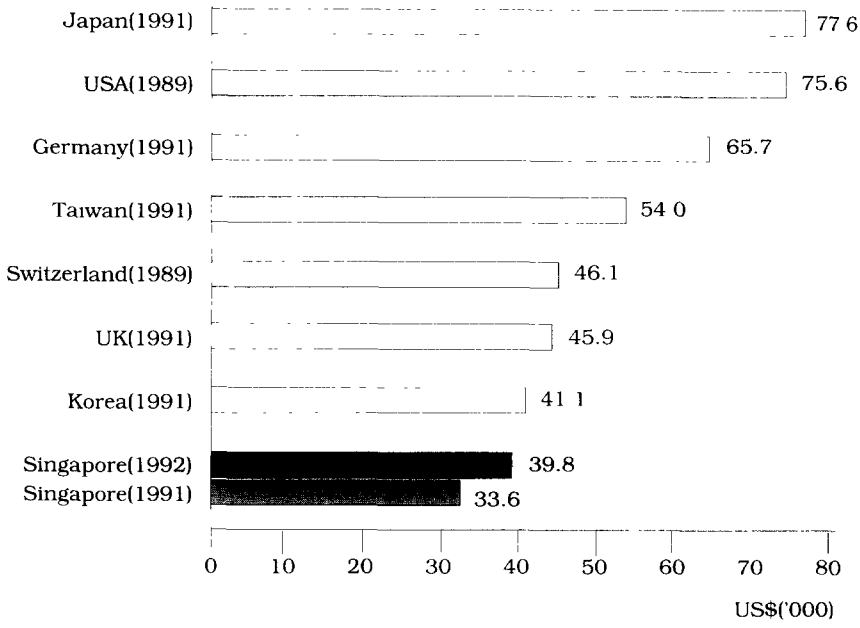
FIGURE 1
INTERNATIONAL COMPARISON ON GROSS EXPENDITURE ON R&D

a higher technological level. Section IV attempts to identify potential areas of challenges and obstacles to technological leapfrogging within East Asia in the light of current world economic and technology trends. Section V summarizes and concludes the paper.

II. Technological Profile of East Asia

A. Japan and First-tier EANIEs

Technological effort is only partially captured by national expenditures on research and development (R&D). Nonetheless on this score, Japan ranks rather favourably among the developed OECD nations in terms of its R&D spending which at 2.77 percent of GDP in 1991, surpasses those of the United States, Germany, and the United Kingdom (Figure 1). S. Korea's 1.93 figure is not substantially behind the United



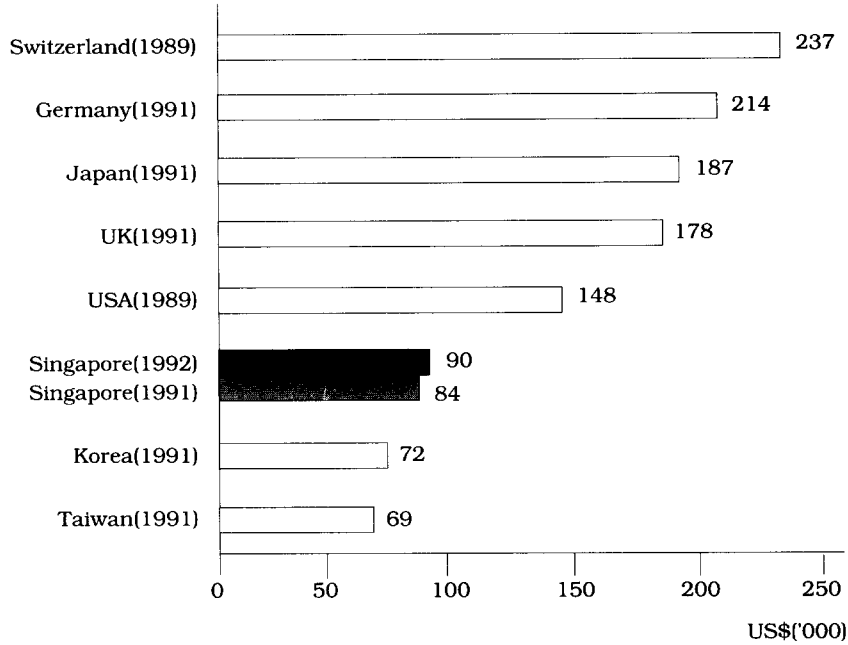
Source: As in Figure 1

FIGURE 2
INTERNATIONAL COMPARISONS - RSE PER 10,000 LABOUR FORCE

Kingdom's. Taiwan is next in line with 1.73 percent of its GDP spent on R&D. Figures for Hong Kong are not available. Among the first-tier EANIEs, Singapore spends the least.

Apart from commitment of finance, commitment of human resources into R&D is another indicator of commitment to technological development. Based on this criterion, Japan has largest stock of research scientists and engineers(RSEs) per 10,000 labour force among the leading technological leaders. Japan's 1991 figure of 77.6 is considerably higher than similar figures for the United Kingdom, Switzerland, Germany, and the United States (Figure 2). Singapore again lags behind the EANIEs technological leader, S. Korea.

On the other hand, based on another measure which tries to capture financial support given to each research scientist and engineer, Japan ranks below Switzerland and Germany, though still ahead of the United States and the United Kingdom (Figure 3). Rather surprisingly, Singapore's figure runs ahead of those for Korea and Taiwan.



Source: As in Figure 1.

FIGURE 3
INTERNATIONAL COMPARISON ON R&D EXPENDITURE PER RSE

Based on the above macro data, it is obvious that Japan ranks among the top technological leaders of the world. The first-tier Asian NIEs' technological capabilities are still considerably below these world leaders. Within the Asian NIEs, S. Korea ranks top, followed by Taiwan and Singapore. It is not possible to comment on Hong Kong due to non-availability of data.

The above macro data however provides only a rough picture of a country's technological standing among nations, and hides important microeconomic and sectoral details. Despite their smaller size and their being industrial latecomers, the East Asian NIEs have managed to carve out for themselves certain areas of excellence. S. Korea for instance, is the third largest producer in the world of consumer electronic products and components, and Korean electronics have become the world's third largest industry. It is also the third largest exporter of consumer electronics, though ranking fifth with the inclusion of components and re-exports. Korea now accounts for 40 percent market

share of the global microwave market (Hong 1993). The Taiwanese information technology industry ranks fifth in the world with exports of US$4.8 billion in 1989 (OECD 1992b). Furthermore, local enterprises such as Acer, Tatung, and Mitac, have successfully diversified into the manufacture of microcomputers and peripherals. Taiwan's petrochemical industry ranks 12th in the world with a capacity equal to Spain's. Singapore's relatively longer history of dependence on foreign direct investment and the experience gained in consumer electronics and micro-mechanics has allowed her to become the number one manufacturer of disk storage equipment (OECD 1992b). She accounts for 40 percent of the world market share in disk drives.

B. Second-tier EANIEs

Science and technology indicators for the four second-tier EANIEs (Table 1) are highly fragmented and not strictly comparable in terms of time frame. For example, 1984 data are the most recent ones available for the Philippines while those for Malaysia are for 1989. Despite this, some rough pattern may still be discerned. Among the four nations, Malaysia shows the highest commitment in terms of R&D spending as well as commitment of scientific and technological personnel. The Philippines spends the least on R&D, yet registers the highest patent counts among all four EANIEs. Indonesia's commitment to R&D spending is the second highest among the four countries but performs rather poorly on patent counts.

As far as science and technology (S&T) institutions are concerned, each country has at least one key organization charged with promotion of S&T activities (Table 2). Each country also has their own technology transfer board, except for Indonesia where monitoring and control of technology transfer falls within the purview of its Investment Coordinating Board (BKPM). The demands placed on science and technology are also recorded in each country's 5-year or in some cases 10-year development plans. Malaysia, Philippines and Thailand also have their own S&T targets which are not strictly comparable due to the different time frame of their development plans. (Table 3). Malaysia's S&T plans appear to be the most well developed and also the most ambitious. In addition to its second 10-year Outline Perspective Plan (OPP2) (1991-2000), there is also Vision 2020 (1991-2020) which lays out strategies to help Malaysia attain developed country status by the year 2020. Industries targeted for promotion and special attention are highly similar. Information technology, biotechnology, electronics or microelec-

TABLE 1

FACTS AND INDICATORS ON SCIENCE AND TECHNOLOGY IN ASEAN

	Indonesia		Malaysia		Philippines		Singapore[1]		Thailand[2]	
	1982[3]	1990[4]	1982[5]	1989[6]	1980[7]	1984[8]	1982	1992	1987	1991
R&D Expenditure(GERD) in million of US$[9]	408.7 (270.3)	417.5 (769.4)	126.1 (295.0)	282.3 (765.0)	91.9 (690.42)	36.9[10] (616.41)	37.9 (81.0)	558.5 (949.5)	103.6 (2,664.4)	153.9 (3,928.1)
GERD as a percentage of GDP	0.45(GNP)	0.55(GNP)	0.5	0.8	0.26	0.12	0.26	1.27	0.21	0.16
GERD contribution from the private sector	2.7%	~30.0%	7.2%	6.0%	18.6%	19.4%[11]	54.6%	60.8%	8.9%	12.3%
GERD contribution from the public sector	97.3%	~70.0%	92.8%	94.0%	81.4%	80.6%	45.4%	39.2%	91.1%	87.7%
Total RSE	18,533	33,650	3,332[12]	5,537	5,403	10,185	1,193	6,454	5,539	9,752[13]
R&D Manpower	26,256	n.a.	9,639	13,605	11,053	n.a.	2,741	10,611	14,947	15,721
RSE per 10,000 labor force	2.92	4.29	6.1	8.1	3.15	4.9	10	39.8	1.96	3.07
R&D manpower per million population	167.1	n.a.	682.2	784.1	228.7	n.a.	1,158.6	3,765.2	277.34	279.99
Other Indicators:										
Total Patents granted[14]	2(34)		58(61)		4(71)		58(167)		6(35)	
Science graduates (as a % of total graduates)[15] 1986-1988	12		31		40		31		13	

TABLE 1
CONTINUED

	Indonesia		Malaysia		Philippines		Singapore[1]		Thailand[2]	
	1982[3]	1990[4]	1982[5]	1989[6]	1980[7]	1984[8]	1982	1992	1987	1991
Literacy rate(for 1985 & 1990)[16]	74	77	73	79	86	90	86	87	91	93

Note: 1. Source. NSTB(1993) *1992 National Survey of R&D in Singapore.*
2. Source: Ministry of Science, Technology and Environment
3. Source: APCTT(1986) *Technology Policies and Planning: Indonesia*
4. Source. PAPITEK & LIPI(Dec 1993) *Science and Technology Management Information System* vol. II.
5 Source: APCTT(1986) *Technology Policies and Planning: Malaysia* (p 177).
6. Source: Ali(1992) *Malaysia's Industrialization: The Quest for Technology*, and Jabatan Percetakan begara(1991) *6th Malaysia* Plan(1991-95).
7 Source: APCTT(1986) *Technology Policies and Planning.*
8. Source Correspondence with the Information Officer from the National Academy of Science and Technology dated 1st Sept 1994.
9. Figures in parenthesis are in million of local currency For Indonesia, figure is in billion of local currency.
10 Figures for 1990 and 1991 are US$45 25 million (or P1 1 billion) and US$44.76 million (or P1.23 billion) respectively
11 Source: (1994) *Pacific Science and Technology Profile 1994.*
12. Consist of Scientific Manpower in Institution of R&D and Universities.
13 Source: Theerakoonlert(Apr. 1993) *A Study on Expenditure and Manpower in Research and Development of Thailand in 1991*
14 Figures in Parenthesis are Patents granted by the US Patent Office from 1980 to 1993 June Figures for British Patent are for the period from 1985 to 1991 (not in brackets). Source. Muslimin (1993/94)
15. UNDP(1992) *Human Development Report 1992.*
16. Source: UN(1992) *Statistical Yearbook for Asia and the Pacific 1991*

TABLE 2

S&T AGENTS AND DEVELOPMENT PLANS

	Indonesia	Malaysia	Philippines	Thailand	Singapore
Technology First Mentioned	1978(in Repelita III, FY 1979/79-1983/84)	1973(by the set up of MTRLG[1])	1974(in FY 1974-77 Plan-NSDP[2])	1982(in 5th Plan)	1967(by the set up of SSC[3])
Subsequent S&T Plans	Repelita IV(1984) & Repelita V(1991)	IMP[4] & 5th Plan(1986), APITD[5](1990), 6th Plan (1990), OPP2[6](1991), & Vision 2020(1991)	STMP[7](1990)	6th Plan(1987) & 7th Plan (1992)	INTECH[8](1984), Economic Committee's Report (1986), & NTP[9] (1991)
Latest Plans	Repelita V(FY 1989/90-FY 1993/94)	6th Plan(1991-95) OPP2 (1991-2000) & Vision 2020 (1991-2020)	Updated Development Plan (1990-92)	NSTDA Strategic Technology Plan; 4th National Research Policy Framework & Plan; & 7th Plan (all for the period from 1992-96)	NTP(1991-95)
Key Ministry/ Organization	Ministry of Research and Technology(MRT)	National Council for Scientific Research & Development(NCSRD)	Science and Technology Coordinating Council(STCC)	Ministry of Science, Technology and Energy (MOSTE)	National Science and Technology Board (NSTB)
Related Ministry/ Organization	Puspiptek[10], Indonesia Science Academy, LIPI[11] & DSN[12]	MOSTE[13], SIRIM[14], MTDC[15] & MIGHT[16]	DOST[17], CTTC[18], DECFI[19], ITDI[20] & EDUFI[21]	NSTDA[22], STDB[23] & TISTR[24]	SISIR[25], MTI[26] & EDB[27]

TABLE 2
CONTINUED

	Indonesia	Malaysia	Philippines	Thailand	Singapore
Technology Transfer Agency or Proxy	Investment Coordinating Board [BKPM] (1983) Agency of Application and Implementation Technology [BPPT][under Ministry of Research and Technology](1983)	Technology Transfer Unit [under MTI] (1976) & Technology Transfer Center [under SIRIM] (1986)	Technology Transfer Board [under MTI] (1978)	Technology Transfer Center (1982)	Economic Development Bard [EDB] (1961) Technology Transfer Division [under SISIR] (1990)

Note. 1. Ministry of Technology, Research and Local Government, renamed in 1974 as Ministry of Technology, Research and coordination of New Villages.
2. National Science Development Program(1973), of which the National Science Development Board (NSDB) is the chief implementing agency, is geared towards the development of the country's scientific resources for economic, social and cultural progress and the strengthening of the national efforts in agricultural production, industry, resources utilization, public health, housing, technical manpower training, industrial plant development and infrastructure.
3. Singapore Science Council (1967)
4. Industrial Master Plan (1986-95)
5. Action Plan for Industrial Technology Development (1990).
6. Second Outline Perspective Plan (1991).
7. Science and Technology Master Plan (1990)
8. Initiatives in New Technologies (1984).
9. National Technology Plan (1991)
10. Research Center for Science and Technology
11. Indonesia Institute of Science.

12. Denan Standardisani National (National Standardization Council)
13. Ministry of Science, Technology and Environment (1976).
14. Standards and Industrial Research Institute of Malaysia (1975).
15. Malaysia Technology Development Center (1992).
16. Malaysia Industry-Government Group of High Technology (1993).
17. Department of Science and Technology.
18. Comprehensive Technology Transfer & Commercialization.
19. Design & Engineering Center Foundation, Inc.
20. Industrial Technology & Development Institute.
21. Energy Development & Utilization Foundation, Inc.
22. National Science and Technology Development Agency (late 1991).
23. Science and Technology Development Board.
24. Thailand Institute of Science and Technology Reserves.
25. Singapore Institute of Standards and Industrial Research (1969).
26. Ministry of Trade and Industry (1979).
27. Economics Development Board (1961).

TABLE 3
S&T TARGETS AND TARGETED INDUSTRIES

	Indonesia	Malaysia	Philippines	Thailand	Singapore
Latest Plans	Repelita V (1990-94)	OPP2 (1991-2000) & Vision 2020 (1991-92)	Updated Development Plan(1990-92)	7th Plan (1992-96)	NTP (1991-95)
S&T targets in latest plans[1]:					
(a) R&D/GDP;	(a) n a.;	(a) 1 0% & 2.5%;	(a) 0.32%-by 1992; and	(a) 0.75%;	(a) 2.0%;
(b) R&D personnel/ million population;	(b) n a., and	(b) 800 & 4,200; and	(b) 380	(b) 250; and	(b) 1970, or 40/ 10,000 labour force; and
(c) others	(c) Develop Indonesia Institute of Science -by 1994	(c) n.a -by the year 2000 & 2020 respectively	(c) n.a	(c) min. 1/3 private share in total R&D expenditure -by 1996	(c) min. 50% private share in total R&D expenditure- by 1995
Targeted Industries[2].	telecommunications;	information technology,	information technology;	information technology-based,	information technology;
	electronics;	micro-electronics,	electronics,	electronics,	microelectronic system,
		biotechnology;	biotechnology,	biotechnology,	biotechnology,
	assembling;	automated manufacturing technology;	process industry;		manufacturing technology;
	energy;	nuclear technology; and	energy,		energy, water, environment & resources,

TABLE 3
CONTINUED

	Indonesia	Malaysia	Philippines	Thailand	Singapore
Latest Plans	Repelita V (1990-94)	OPP2 (1991-2000) & Vision 2020 (1991-92)	Updated Development Plan(1990-92)	7th Plan (1992-96)	NTP (1991-95)
Targeted Industries:		material science.	material science;	material technology-based;	materials technology;
	agricultural implements;		agricultural, aquaculture & marine fisheries, forestry & natural resources;		agrotechnology;
	machinery;		metal & engineering; instrumentation & control	machinery, machine tools & electrical equipment.	
	aviation; maritime and shipping; land transport; defence; and software.		food & feed; pharmaceuticals; construction; mining & minerals; laser technology; and transportation.	integrated circuit; PABX; computer; and software.	food; and medical science.

Note: 1. Sources: Indonesia-Repelita V (1991); Malaysia-Sulaiman(1993); Philippines-Nat'l Economic & Development Authority (1990b); Thailand-Nat'l Economic & Social Development Board (7th Plan 1991); & Singapore-Nat'l Science & Technology Board (1991)

2. Sources: Indonesia-Repelita V (1991); Malaysia-6th Plan (1991); Philippines-Philippine Development Report (1990); Thailand-TDRI report (1991); Singapore-NTP (1991).

TABLE 4
TECHNOLOGY ACQUISITION ACTIVITIES IN SINGAPORE, 1992

Technology Acquisition Activity	Private Sector	Higher Education Sector	Government Sector	Public Research Institutes	Total
Patents	19	-	-	-	19
Licenses	44	1	-	2	47
Technical Assistance Agreements	31	1	2	1	35
Consulting Services	48	2	7	3	60
Capital Equipment Containing New Technology	63	4	6	4	77
Information System Containing New Technology	42	2	6	3	53
Companies Owning Technology	14	1	-	-	15
Others	1	-	-	-	1
Total					307

Source: As in Figure 1

tronics and materials technology are cases in point.

At this stage of their development, the bulk of the technology within second-tier EANIEs are imported. The prime vehicle of transmission since the mid-1980s is FDI emanating mainly from Japan and the first-tier EANIEs. The influx of FDI into second-tier EANIEs since the mid-1980s reflected economic restructuring efforts within Japan and first-tier EANIEs on account of the appreciation of their currencies as well as dynamic changes in the structure of their comparative advantage. Apart from these 'push' factors which forced Japanese and first-tier EANIEs firms to move offshore, there were also 'pull' factors which made ASEAN attractive to the former. Following a sever economic recession in 1985-86, many second-tier EANIEs became more open and embarked on a path of economic liberalization and reform on an unprecedented scale. Liberalization occurred on a broad front covering financial, fiscal, and the investment arenas. Highlights of deregulation measures include permission for foreign investors to engage in joint-venture participation in previously closed sectors, retention of majority ownership and control for fairly generous periods of time, and such like.

TABLE 5
TYPES OF AGREEMENTS APPROVED IN MALAYSIA, 1975-(MAY) 1994

Types of Agreements[1]	1975-88	1989	1990	1991	1992	1993	1994[2]	Total
Joint Venture	162	15	15	11	7	7	1	218
Technical Assistance	688	64	72	93	80	85	19	1101
Licensing & Patent	142	35	17	28	14	44	13	293
Know-how	14	13	12	10	21	23	7	100
Trade Mark	26	18	19	9	12	14	2	100
Management	130	12	5	6	2	2	-	157
Turnkey & Engineering	26	0	1	1	0	1	-	29
Services	67	12	6	4	4	9	5	107
Sales, Marketing/ Distribution	31	6	5	0	0	0	-	42
Supply & Purchase	2	6	2	0	0	0	-	10
Others	93	17	1	3	0	0	-	114
Total	1,381	198	155	165	140	185	47	2,271

Note: 1. Source: Ministry of International Trade and Industry
2. From January to May 1994.

First-tier EANIEs accounted for between one-fifth to well over one-third of total FDI in ASEAN—26% in Indonesia, 29% in the Philippines, 35% in Malaysia, and 36% in Thailand (Chang 1994/95). The Asian orientation of FDI within ASEAN is quite striking. First-tier EANIEs and Japan together account for well over half of FDI in ASEAN, ranging from 54% in Philippines to 70% in Thailand. Most of the investments are being committed in the manufacturing sector and are mainly channeled into (i) the electrical and electronic products and components, and (ii) the chemical industry (Chang 1994/95). FDI also brings along with it 'embodied' technology in the form of imports of machinery, equipment, and other capital goods. Machinery imports have been highly correlated with FDI inflows, and account for between 30 to 40 percent of total imports in the three countries with the highest investment boom, Malaysia, Thailand, and Indonesia.

Apart from FDI and imported machinery and equipment, reliance was also placed on other modes of transfer, although the pattern tends to differ across the three countries for which data is available, namely Singapore, Malaysia, and the Philippines. Singapore appears to place a heavy reliance on technology that is embodied in machines and infor-

TABLE 6
AGREEMENTS IN PHILIPPINES, 1979-1992
(by Types of Assets Transferred against Country of Origin)

Types of Assets	USA	Japan	UK	Swiss	Germany	Others	Total
Know-how, Patent, Trademarks, Management	6	5	1	1	-	-	13
Know-how, Patents, Trademarks	162	66	16	26	24	49	343
Know-how, Management, Trademarks	9	3	1	1	1	5	20
Know-how, Management, Patents	2	1	-	-	-	-	3
Know-how, Management	11	5	1	2	-	8	27
Patents, Trademarks	6	3	1	1	2	1	14
Patents, Know-how	36	27	1	7	2	19	92
Trademarks, Know-how	160	47	44	11	18	41	321
Trademarks, Management	2	-	-	-	-	-	2
Patents	4	1	-	-	-	2	7
Trademarks	64	15	6	8	8	21	122
Know-how	59	48	12	10	8	82	219
Consultancy	30	15	6	9	6	48	114
Software	20	4	2	2	1	36	65
Management	1	2	2	-	-	18	23
Distributorship	2	1	-	-	-	3	6
Franchise	6	1	1	-	-	3	11
Total	580	244	94	78	70	336	1,402

Source: Department of Trade and Industry, Bureau of Patent, Trademarks and Technology Transfer

mation systems. Thus capital equipment and information systems containing new technology alone account for 42% of Singapore's total acquisition activities in 1992 (Table 4). Malaysia on the other hand, relies most heavily on technical assistance (Table 5), while the Philippines reflects a preference for patents, trademarks, and know-how (Table 6).

III. Success Factors in Technological Catch Up

Almost without exception, firms in Japan and first-tier EANIEs have acquired their technological capabilities by making judicious use of foreign technology sourcing to gain quick access to the needed knowledge. They relied on customer firms to provide specifications and concentrat-

ed on refining productive capacity to produce to specification at low cost. Firms in Korea and Taiwan deployed Original Equipment Manufacturer (OEM) agreements while Singapore and second-tier EANIEs relied largely on FDI as their means of entry into world markets. A key element for success is the effectiveness with which a firm combines foreign technology elements with its own experience and knowledge in order to strengthen its internal capabilities. It is principally this ability to learn how to utilize technology to strengthen competitiveness which distinguishes the successful NIE firms from the less successful ones. More specifically, countries like Japan, Korea and Taiwan have been particularly successful at exploiting foreign technology to their own advantage because of judicious efforts taken at developing and enhancing their own indigenous technology base. Other factors such as governmental financial support, injection of competition, supplier/subcontractor networks, development of scientific and technological manpower, etc. are also instrumental. A close examination of the experience of the Korean consumer electronics industry is particularly instructive in illuminating some of the factors behind successful technological catch up. Subsequent discussion of the Korean consumer electronics industry draws heavily on Hong (1993).

A. Buildup of Institutional R&D Infrastructure

More than any other Korean industry, the consumer electronics industry has relied quite substantially on foreign investment throughout its short history. In the early stages, many of the OEM agreements signed with foreign companies did not provide much opportunity for the transfer of electronics technology to Korea. Most of the operations were wholly foreign owned and were primarily involved in production of electronic components. A limited amount of technical know-how was diffused through the presence of foreign engineers and production managers. While outside assistance provided an important base, it was a precarious foundation for a state-of-the-art type of industry such as consumer electronics. A much more advanced level of indigenous technological capability was required if Korea were to become a world leader in this area.

In recognition of this, the Korean government proceeded in the mid-sixties to lay a strong foundation for developing indigenous technological know-how and 'in constructing a research edifice for the future' (Hong 1993, p.6). Thus the Korean Institute for Science and Technology (KIST) was founded in 1966 to promote R&D and to attract more for-

eign technology and foreign-trained Korean RSEs back to Korea. In 1973, the National Council for Science and Technology, chaired by the Prime Minister of Korea, was formed and given the mandate to design and implement plans to spur growth in indigenous technology. The same year also saw the enactment of the landmark Law of the Promotion of Industrial Technology Development which places strong requirements on Korean industries to carry out research activities aimed at commercializing technology for the purpose of penetrating foreign markets. More specialized policies emerged in the mid-1970s to promote research in key industrial sectors. Thus in 1976, for example, the Korean Institute of Electronics Technology (KIET) was formed to direct important research projects in the realm of semi-conductor development, IC design and wafer production. Two years later in 1978, the Applied Optics Laboratory of KIST commenced research into fiber optics technology, such as multi-mode and signle-mode fibers.

Public R&D institutions play an instrumental role in assimilating and diffusing foreign technology particularly during the early stage in the development of a country's technological capabilities when reliance on foreign technology is still pervasive. As such capabilities are strengthened within private firms, and as those firms face increasing barriers to acquiring foreign technology, public R&D institutions then shift focus to more basic research to support the increased applied R&D efforts of the private sector. This appears to be roughly the pattern followed by certain public R&D institutions in the EANIEs in general and in Korea in particular. In Korea, the KIET started out as a 'demonstration laboratory' to show the feasibility of efficient operation of complex imported production processes (e.g. integrated circuit wafer fabrication). Now that the *chaebol* have invested large sums in their own wafer fabrication operations and are nearing the frontier in a few specific markets, they are forced to undertake large investments in their own R&D. As a result, the Electronics and Telecommunications Research Institute (ETRI) which evolved from KIET, has been redefined to focus on research into the basic technologies on which the success of the *chaebol*'s applied R&D efforts depends (OECD 1992a).

B. Injection of Competition to Enhance Standards

Apart from the important role played by public research institutions, another important element for success has been the imposition of the discipline of the international marketplace on Korean firms. The numerous government agencies and institutes which sprouted up in the

1960s, 1970s, and 1980s had one common goal, and that is, to enhance indigenous technological capability by promoting research within Korean industry itself. Furthermore, research goals had one very clear objective, namely, *to develop products for export.* This latter requirement imposed tremendous discipline on firms to aim to produce high-quality goods at competitive prices in order to secure a niche in the international marketplace.

C. Effectiveness of the State as an Agent of Industrial Transformation

Related to the above is the effectiveness of the State as an agent of industrial transformation. This clearly sets Japan and first-tier EANIEs apart from the Latin American NIEs. OECD observes that:

> "In the latter, the state has generally been beholden to powerful vested interests, whose privileged economic positions it has helped to preserve and even reinforce without extracting any quid pro quo. Indeed, in Latin America the State has generally exacerbated 'rent-seeking' activities of firms, first by creating conditions which have made such activities profitable and then by demanding a share of the rents... With a heavily protected domestic market serving as their principal source of profits, firms faced little external competitive pressure to improve their efficiency. Yet those economies were not entirely devoid of technological effort. What was lacking was an institutional structure and policy regime which systematically encouraged and rewarded such efforts". (OECD 1992a, p.266)

D. State Finance and Tax Incentives

Provision of research infrastructure and close government-industry research linkages were accompanied also by state finance and tax incentives for R&D. This is particularly so during the 1980s. Hong (1993) reports that by 1987, almost 95% of all corporate R&D in Korea was financed through preferential loans from the state. The basic thrust of these incentives helped to create an economic climate in which the private sector was actively encouraged to establish its own technological infrastructure, with the goal of progressively reducing its dependence on foreign technology. State finance also had a futuristic dimension. A program called the Technology Development Reserve Fund allows corporations to reduce their taxes even further by setting aside 20-30 percent of all pre-tax profits each year for future R&D. The results had been three-fold: first, government policy helped transform

Korea's technological workforce from one involved in mainly low-skilled, equipment maintenance—and operation-based tasks, to one involved in cutting edge development and research. This in turn allowed Korean electronic companies to branch out and secure more profitable contracts. Second, there has been a significant reduction—though not total independence—in Korean reliance on foreign technology. The Korean consumer electronics industry has gone beyond production, investment, and adaptive capability to attainment of creative capability in terms of producing independent innovations. Thirdly, and most interestingly, Hong notes that Korea's newly-created technological infrastructure has expedited the transfer of technology from foreign countries to Korea in arrangements which are much more favorable to Korea than were previous arrangements. Enhancement of indigenous technological capability has considerably led to enhancement of Korea's bargaining power in technology negotiations. The result has been to allow Korean corporations to procure numerous joint research and development projects, cross-licensing and other agreements with foreign companies which transfer technology more quickly and cheaply compared to the primarily production-oriented arrangements of the fifties and sixties.

E. Buildup of a Strong Core of Science and Technology Personnel

A major comparative country study on the informatics industry (defined hereto include semi-conductors, integrated circuits, and computers, including mainframes, minis, and micros, and word processors) highlighted new success factors behind technological advancement, while also emphasizing some of the factors already listed above (Brown and Rushing 1986). This study covers the national informatics industry in eight countries namely, Brazil, France, India, Japan, Korea, Mexico, Taiwan, and the United States. What were the 'correct' policies that laid the foundation for success stories such as Japan and Taiwan? An important new finding that emerge is the need for governments to develop a strong core of scientific and technological personnel.

The study found that government policies have played a critical role in the development of national informatics industries both in success stories (Japan and Taiwan), and in the less successful case of France, which failed to establish a strong national industry. In all the cases examined, promotion of the industry by the government was by design and supported with resources. Although policies and institutions used to advance the development of hitech industries were extremely diverse,

there was strong agreement that a *strong national informatics industry*, whether developed strictly indigenously or with foreign technology, *requires a cadre of science and engineering manpower.*

It needs emphasizing however, that having a large stock of scientific and engineering personnel is a necessary but not sufficient condition for ensuring industrial success. Both India and China have large stocks of RSEs and have a long-standing tradition of basic and applied research which, at least in certain military-related fields, is close to the frontier. Yet despite their scientific expertise, they have been slow to acquire proficiency in commercial application of new technologies. In these countries, there would appear to be sizable barriers to diffusion of scientific knowledge into the industrial economy. Such diffusion is by no means an automatic process but involves a number of intermediate links or 'bridging institutions' which may be only imperfectly formed in those economies. Japan, Korea, and Taiwan, in contrast have been very successful in bridging institutions such as government R&D institutes which are built primarily to assist industry. Furthermore, another shortcoming of the science and technology infrastructure in China and Latin American NIEs such as Brazil has been the high degree of concentration of R&D activities in government laboratories and state enterprises and a relatively narrow focus of such R&D on defence-related applications. This may partially explain the relatively advanced state of aeronautics, space-related as well as nuclear-related research in China, India, and brazil, and the relatively infant state of industrial research in these same countries. In contrast, the emphasis in Japan, Korea and Taiwan has been on industrial research for commercial applications.

F. Educational Profile of Population

The educational level of the population also matters. Japan and first-tier EANIEs in general have very highly educated populations and educational access is fairly evenly distributed, at least at primary and secondary levels compared to Latin American NIEs and countries like India. In the World Bank 1993 study, data on school enrollment rates and educational expenditures per pupil reflect dramatic growth and transformation of systems of education and training during the past three decades. In a comparison of 90 developing economies between 1965 and 1987, although enrollment rates are higher at higher levels of per capita income, the HPAE's enrollment rates have tended to be higher than predicted for their level of income. This was most obvious in

primary education in 1965, when Hong Kong, Korea, and Singapore had already achieved universal primary education, well ahead of other developing countries. Even Indonesia with its vast population had a primary enrollment rate above 70 percent. By 1987, East Asia's superior education systems were evident at the secondary level. Indonesia had a secondary enrollment rate of 46 per cent, well above other economies with roughly the same level of income. Korea on the other hand, had moved from 35 to 88 percent, maintaining its large lead in relative performance. Data on expenditures per pupil tell the same story. Between 1970 and 1989, real expenditures per pupil at the primary level rose by 355 percent in Korea. In Mexico and Kenya, expenditures rose by 64 and 38 percent, respectively, during the same period, and in Pakistan expenditures rose by only 13 percent between 1970 and 1985. In standardized, performance tests on cognitive skills, East Asian children tend to perform better than children from other developing regions—and even recently, better than children from high income economies (World Bank 1993, p.45). Educational institutions in EANIES have also been quite flexible in adapting to the demands generated by the restructuring of the economy and the changing skill composition of the workforce compared, for instance, to their Latin American counterparts. Furthermore, in many developing nations in Latin America, fiscal constraints have caused the quality standards of educational institutions to deteriorate.

Kim (1990, p.156) argues quite forcefully that "what distinguishes Korea from other developing countries is the way it invested in human resources prior to launching a drive to develop the economy... investment for human resource development should precede industrialization efforts, as human resources cannot be trained overnight when needed".

G. The Role of Supplier/Subcontractor Networks

The development of supplier/subcontractor network—as an alternative to vertical integration—is a crucial factor in enhancing technology diffusion through interaction between component producers and their industrial customers (OECD 1992a). Supplier/subcontractor networks are common in Japan, Korea, and Taiwan. The main form of technology transfer from principal to subcontractor has been in the area of training in inspection standards and tight quality control, the organization of just-in-time inventory management systems, and close co-operation. Transfer of personnel provides an important source of improved man-

agerial methods and technical expertise, while pressures exerted by the principal serves to force subcontractors to improve efficiency and quality. In contrast, Brazilian conglomerates have tended to opt for the internalization of component production and have thereby forfeited significant economies of scale.

Some Caveats*

The above cited 'common factors' underlying technological catch-up in East Asia are by no means exhaustive, and should be interpreted as suggesting necessary but not sufficient conditions for success. It in no way downplays the significance of other considerations such as diversity in culture, history, 'initial conditions' and differences in industrial structures, which are clearly important for a completed understanding of technology development within East Asia. Apart from constraints of space, their exclusion is justified partly on the grounds that many of these factors are clearly non-replicable, particularly if they are based on historical, cultural and chance events, and hence would offer little scope for emulation by other developing countries. Interpreting these factors as necessary but not sufficient conditions does not rule out situations in which two countries have attained success despite differences in the 'non-common' factors. The case of Korea and Taiwan serves a good illustrative purpose. The fairly successful development of Korea and Taiwan's electronics industry for example, have been arrived at through quite different strategies associated with the non-common factors. Korea's technological prowess has been achieved through a small number of large conglomerates (namely, the *chaebols*) while the Taiwanese model has tended to rely on highly dynamic, small- and medium-sized firms, with government assistance assuming quite different forms as a result. For example, public enterprises in Taiwan have played a much larger role than in Korea in fixed capital formation. On another front, Korea's policies concerning FDI and foreign licensing were also relatively more restrictive than Taiwan's in the early years of industrialization. The proportion of FDI to total external borrowing in 1983 was only 6.1 percent in Korea compared with 45 percent in Taiwan, in partial reflection of Korea's explicit policy of promoting its 'independence' from multinationals in management control (Kim 1993).

*This section entitled 'Some Caveats' has been inserted following useful comments by Dr. Somi Seong.

Secondly, there is also considerable diversity even within the so-called common factors. For instance, under 'State finance and tax incentives', differences among success countries may still be discerned. As mentioned previously, the Korean government, for example, used subsidized credit and highly selective rationing of credit to favoured sectors and firms, while the Taiwanese government relied more heavily on fiscal incentives, also administered in a highly selective way to promote certain priority industries.

What seems clear from the above discussion is that there is clearly more than one path to successful technological catch up. However, within these paths to success lie certain common underlying thrusts which tend to surface quite frequently. These so-called 'common factors' are but an attempt to highlight, even if imperfectly, what these general thrusts should be. Developing countries wishing to engage in successful technological catch up need to sift these factors through their own cultural, historical, and economic settings, and come up with their own unique strategies and instruments to do the job.

IV. Challenges Facing East Asia

Can East Asia maintain its economic dynamism into the next century? In particular, can the first-tier EANIEs leap-frog smoothly and speedily into developed country status, while the second-tier EANIEs move into the position presently occupied by their first-tier counterparts or even further? Can Japan, Korea and Taiwan transit easily from being technology users to being technology creators? The answer to these questions depend to a large extent on how East Asian nations are able to respond to challenges posed by new international trends particularly in the area of new technology, as well as challenges arising from within their own nations.

On the international front, two important forms of technological change hold important implications for the economic future of East Asia. The first relates to the microelectronics revolution which has helped to accelerate the transition away from the so-called 'Fordist' models of production towards a production paradigm based on the concept of 'flexible specialization'. The Fordist model of mass production involves manufacturing standardized products in high volumes using special purpose machinery and predominantly unskilled labor. The 'flexible specialization' paradigm involves, on the other hand, the production of a wide and changing array of customized goods using

flexible, general purpose machinery and skilled, adaptable workers.

The microelectronics revolution allows new types of re-programmability to be introduced into the manufacturing process. An important outcome of this has been a reduction in the minimum efficient size of production lots as well as production units, thus providing greater room for customization of output. The costs usually associated with customized production have been greatly diminished as a result of greater emphasis on economies of scope. Consequently, flexible specialization has meant less emphasis on costs and more emphasis on quality. Because of the global integration of factor as well as capital markets, firms must now place greater emphasis on product differentiation and customer-responsiveness. Labor costs account for a smaller percentage of overall costs and non-price competition take on greater significance than price-related factors.

In view of the above, it is not surprising that microelectronics will increasingly, and in fact have begun to, alter the foreign investment behavior of multinationals. Successful multinational firms of the future will be those that can manage a broad-range of value-added activities across a diverse set of geographical boundaries, capitalizing on the distinctive advantages offered in each of the respective domain. The choice of location for overseas investment will be increasingly geared to accessing higher value-added resources than simply availability of cheap labor or taking advantage of traditional types of tax holidays.

The second international trend is the information technology revolution which puts at the MNCs' disposal the tools to orchestrate an entirely new production architecture that places more weight on coordination than control. Control through ownership becomes less important since transactions costs can now be substantially reduced. This gives multinational firms greater discretion over the choice of relationship it wishes to develop with a particular supplier, assembler, distributor, etc. This also allows MNCs to be more foot loose and less entrapped by the consequences of an equity investment.

The implication of the above for second-tier EANIEs is quite unmistakable. Given that FDI will continue to be an important vehicle for technology transfer in the near future, and given that MNCs will in the near future give preference to locations with higher value-added resources than simply cheap labor, the task of enhancing the quality of its workforce takes on greater urgency and assumes new strategic importance if second-tier EANIEs wish to attract high quality FDI to their shores. The task of educating and training high quality human

resources should be pursued diligently, intensively, and earnestly since this process takes time and is not achievable overnight. Furthermore, an important precondition for successful technology transfer from FDI is a strong base of indigenous technological capability. Without this, FDI merely transfers production capability (i.e. capability to operate and maintain a production system) but hardly investment capability (ability to set up or expand new production systems) or innovation capability (ability to generate new products and processes) (Kim 1990). Second-tier EANIEs therefore need to follow in the footsteps of Korea and Taiwan to build up a sufficiently high level of indigenous capability in order to capture the full benefits of technology transfer from FDI.

Over time, reliance on foreign technology will progressively decline in the first-tier EANIEs. Many will shift into the innovation phase of their industrialization. Given the increasingly demand-driven nature of the new competition, an important challenge facing first-tier EANIEs is whether they are able to firm up a hitherto weak area, namely, the area of product design and market development capabilities. This problem is more serious for Korean and Taiwanese, than for Japanese firms. The recent shift by Korea and Taiwan from OEM to Own Brand Name (OBN) reflects not simply a desire to realize higher profit margins. It is a necessary adjustment to the shifting OEM sourcing patterns of major Japanese and US firms toward lower-cost countries, especially in South-east Asia. In transiting to OBN, Korean and Taiwanese electronics firms must contend with the image problem that their products are of lower quality and reliability compared to products made by say, Japanese firms. Moreover, they also face the threat of erosion of their comparative cost advantage stemming from the renewed competitiveness of Japanese products as a result of the transfer of Japanese production to lower-cost localities, rising productivity within Japan, and appreciation of their currencies against the yen. Taiwanese firms, being on average much smaller than their Korean counterparts, face a more difficult time making the adjustment. Few can afford the large advertising and promotion budgets of the Korean *chaebol*. Among the Taiwanese firms, Acer, appears to be the most successful in establishing international brand name recognition. Even then, its NT$30 million expenditures on advertising and trademark registration are small by comparison with the $100 million the five or six leading Korean companies spend each year on promotion (Kok 1995).

A third international (albeit longer term) trend is that within the OECD area, a risk of shortages of research scientists and engineers in

future years exists while demand for such personnel is likely to increase (OECD 1992a). Possible contributory factors include, among others, diminishing student interest in science and technology and increasing availability and attractiveness of other professions to science and technology degree recipients. It is expected that due to the ageing population phenomenon in many OECD countries, massive retirement of science and technology personnel is expected to lead to intensified recruitment needs from about 1995. Possible candidates for recruitment would inevitably include scientists and engineers from East Asia (particularly Japan, Korea, and Taiwan), among others. The policy challenge within East Asia would include, among others, a consideration of how to provide a sufficiently attractive home environment to retain such precious human assets within East Asian shores.

At the level of 'domestic' issues, an important challenge confronting the more technologically advanced nations of Japan, Korea and Taiwan is that as these economies approach the frontier, it is going to be increasingly difficult to define the type of technology to be developed in any given project. Reliance on foreign technology will be almost nil, since by definition, the economy is already at the frontier. There will be a need for more basic research which is likely to be inadequate if left to the private sector. The challenge at least in the case of Japan where the issue is of increasing significance, is whether government policy is able to change with the times and reorient its focus from organizing R&D projects involving private firms, to providing R&D funds to private firms and research institutes to do basic research (Tamura and Urata 1990). On this score, provision of funds may not pose too much of a problem. Private firms and research institutes may even be willing to do basic research if sufficient funds were made available for this purpose. A more fundamental question has to do with the ability to engage in breakthroughs research—research that can come up with whole new products and processes. Associated with this is the issue of whether the cultural and educational orientation of East Asian society with its emphasis on team work and conformity, is compatible with the increasing demands for originality, creativity, and a spirit of inquiry which appear to be important ingredients for innovation and breakthroughs research. In short, can East Asian nations who have been so adapt at imitation and adaptation move from being technology users to being technology creators?

V. Summary and Conclusions

Despite being industrial latecomers, Japan, and particularly first-tier EANIEs have achieved technological competence within a relatively short space of time by combining judicious use of foreign technology with its own experience and knowledge to strengthen internal capability. Japan now ranks among the top world leaders particularly in industrial technology and applied research and is at or close to the frontier in many of the areas in which she has excelled. Similarly, first-tier EANIEs have carved out for themselves particular niche areas of excellence in consumer electronics, disk drives, information technology, automobile and petrochemical. Since the mid-1980s, second-tier EANIEs in varying degrees have been vigorously following in the footsteps of their first-tier counterparts by tapping into foreign technology through FDI, and have designed plans to deploy technology for strategic advantage. Malaysia hopes to attain developed country status by 2020 while the Philippines hopes to become a new 'Tiger' by the turn of the century.

One of the most important factors in technological catch up in the East Asian technological success stories—Japan, Korea, and Taiwan—has been the development of a strong indigenous technology base which has helped speed up the process of selection, assimilation, adaptation, and deployment of foreign technology to strategic advantage. This process was by policy design and supported with resources. However, if this alone was sufficient, other nations like India, China and Brazil who have strong indigenous technology bases would also have been just as successful. Other contributory factors for success include injection of competition to enhance standards, effectiveness of the State as an agent of industrial transformation, strong focus on industry-driven, export-oriented research aimed at commercial application, state finance and incentives, strong core of scientific and technology personnel, role of supplier-subcontractor networks, high savings rate, and so forth.

Despite past successes, East Asia now faces new challenges particularly in the light of new international technology trends. The microelectronics and information technology revolution will increasingly reduce the role of cheap labor as a factor for attracting FDI thus placing a greater burden for upgrading human resources within second-tier EANIEs. The increasingly demand driven nature of the new competition

which emphasizes quality and product differentiation poses new challenges to first-tier EANIEs to strengthen their design and market development capabilities. As she approaches the frontier in many areas, Japan faces the challenge of shifting her focus from developmental/applied research to more basic research and from emphasis on technology adaptation to technology creation.

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Comment

Somi Seong*

Thank you Mr. Chairman. It is my great pleasure and honor to participate in this Symposium. I want to thank the Director Cae-One Kim and the Institute of Economic Research for inviting me. I also extend my special thanks to all my teachers and colleagues at Seoul National University.

And I appreciate professor Koh for her excellent presentation of a very thought provoking paper. As I understand, the questions she tries to answer are as follows:

—What is the key technology factors that caused the rapid economic growth in Japan and the East Asian 'Four Tigers'?

—What is the lesson, if any, for the latecomers? and

—Can these models of successful countries continue to extend their dynamism in technological development into the future, from technology users to technology creators?

These are some of the most popular and relevant questions raised by policymakers, development economists, and other specialists, especially in developing countries.

To answer the first two questions the author tried to find common factors in Japan and the 'Four Tigers' by collecting as many episodes as possible. Even though she accepted the diversity of East Asian countries in p.2 of her paper, the author took a position that common factors in these countries explained the cause of the economic dynamism, and that common factors gave useful lessons for the latecomers. She summarized seven agreeable common factors in Section III:

- institutional R&D infrastructure
- competition both in international markets and in domestic markets
- effectiveness of the State
- finance and tax incentives
- science and technology personnel

*Fellow of the Korea Development Institute.

· education
· the role of supplier/subcontractor networks

The author has well chosen these factors, described each for its relevance to development. As the paper presents them in style, I will leave the details for each one's reading.

However, what seems to be common on the surface may not be so common when examined carefully, considering context as well as temporal aspects of the factors that contribute to the development. To focus on the common factors is certainly important and is one of the mainstream approaches of the development case studies. However, in another point of view, it can be said that it is surprising to find so many relevant common factors, even as many as seven, among the countries so diverse and different in their culture, history, and the time path of economic development, etc. It is the opinion of this commentator to say to look at the differences in these high performing countries, differences even in the what seems to be the common factors, and how they integrated into the establishment of each and respective countries.

During last five years working at KDI(Korea Development Institute), I often came across similar questions when interviewed by or giving lectures to government officials from developing countries. The group of representatives from developing countries, some from socialist countries, have asked such questions from their heart: what was *the secret* of the Korean Miracle? What should we do to make our people live in better condition? And whenever I was asked these sincere questions, I was at a loss of words, not only because of my limited knowledge but also the very complex nature of the development process.

First of all, the secret of the Economic Miracle, if any, must be described as a system solution not as a sum of partial solutions. Even though we made our development efforts in a piecemeal fashion, the outcome of the development efforts came from the complete set of the national economic system, and the structure of the system kept changing over last 30 years. Therefore, it is virtually impossible to summarize the whole system of the development and its dynamics in a few sentences. At the best, one can point out the distinctive characteristics of Korea's development process in comparison with that of other developing countries, and make a quest on the key success factors. However, there is no feasible way to separate out the extent of each distinctive factor's contribution to the performance of the whole economic system.

Second, "initial conditions" of each developing country varies. With

the initial conditions different from those of Korea, a country's optimal development path or structural adjustment process could be quite different from that of Korea. In addition, successful strategy working in one industry would not necessarily work in other industries. Moreover, because of the rapidly changing economic environment these days, there may not be so many lessons that the other developing countries can learn from the past experience of Korea.

Now, let us move onto the author's third question

The author points out well that technological innovation in micro electronics and information industry will provide challenges and opportunities to the East Asian countries in the future. The foreign direct investment will play an important role, and it would be vital for each country to provide attractive business environment for multinational corporations, whom in turn will create opportunities for education and training of high quality human resources.

However, we can hardly expect that activities of multinational corporations by themselves will provide a systematic solution for each developing country's future prosperity. The remaining most critical task for the developing countries in East Asia would be to design their own unique strategy and comprehensive system which will continuously create the growth potential and the improvement of standard of living for the people of each respective country.