V A PERSPECTIVE ON ENTREPRENEURSHIP, INTELLECTUAL PROPERTY CREATION, ENTERPRISE DEVELOPMENT AND COMPETITIVENESS IN ASEAN[1]

Overview of issues

Intellectual property creation has become even more important under the new economy and new global competition

Research and development (R&D) and the accelerating progress in science and technology have been the backbone of the global information revolution, dated as beginning in 1969 with the commercial production of a computer on a silicon chip. All these have, in turn, greatly facilitated the emergence of knowledge-based economies (KBEs), inventive entrepreneurs and technology-driven SMEs. In the process, radical ways and means have also been devised and applied to industrial organization and value creation with significant success both within and across geographical, cultural and political divides.

R&D and the associated development of IP assets are a critical weakness in ASEAN, however

Yet the creation of intellectual property (IP) and the generation of intellectual property rights (IPRs) have long been the Achilles' heel of virtually all economies in ASEAN. This weakness has been a serious drag on higher levels of local value addition in production and service activities. It has made it more difficult as well to foster, attract and internalize activities of high value added in the region. A clear symptom of this weakness is the so-called "race to the bottom": it is the cheaper prices of physical and human resources and of infrastructure and environmental inputs that have, by and large, been the main determinant of gained external markets and inward flows of FDI among many industries and economies, most of those within ASEAN included.[2]

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[2] As observed by Daly (2000), this is a process in which developing economies with a comparative advantage in attracting trade-driven FDI projects often have a poorer record of internalizing all social and environmental costs of production and trade into the prices of their products and services and into the generous incentive packages made available to external investors. There is currently little evidence in support of Daly's hypothesis (Frankel, 2003, p. 21) but there are, nevertheless, scattered examples of competitive offers which lead to a lower domestic living standard while doing nothing to improve local productivity (UNIDO, 2002, p. 111). At the same time, however, the precautionary principle as applied selectively in some developed countries can well lead to a race to the top (Otsuki, Wilson and Sewadeh, 2001).

ASEAN must break through the vicious circle of accumulation-led growth to a virtuous development circle driven by knowledge formation and life-long learning

It is well known globally that the patterns of accumulation-led growth have contributed powerfully to rapid and broad-based income generation, social progress and poverty reduction in ASEAN over the last 40 years. But the same growth model of the past decades will not be adequate or sustainable in meeting the changing aspirations and multiplying needs of future generations. This is not just because of the inevitable decreases in social and economic returns to capital in the long run. There are also absolute limits to the accumulation and utilization of tangible resources – economic, social, demographic and environmental. Moreover, quality matters greatly at more advanced stages of development.

The technological and inventive capabilities of ASEAN entrepreneurs, industries and economies have to be shifted to a higher orbit. This qualitative transformation is needed to bring about the virtuous circle of productivity growth pulled in the main by knowledge formation, ongoing innovation and life-long learning and competence-building in the region. But such a transformation can also be regarded as a sequential, albeit overdue, progression in development strategy and policy in this part of the world. For these reasons, this imperative in transformed development deserves to be at the forefront of national and regional policy attention given a variety of difficult challenges, many with transboundary impact and implications, to be managed in the complex, massive and time-consuming undertakings ahead.

Knowledge-based advantages

The information revolution has spawned new and innovative ways for industrial organization and value creation across geographical, political and cultural divides

The rapid and cumulative advances in science and technology have led to an astounding and continuous decline in the prices of ICT.[3] In turn, cheaper ICT goods have permitted "intelligence" to be built progressively and innovatively into an ever larger number of products, production methods and services in most human endeavours. But new and innovative modalities in industrial organization and sources of value creation have also arisen along with the truncated frontier, distance and time brought about by the information revolution and related advances in transport technologies and logistics.

It has been reinforced by far-reaching liberalization and deregulation …

Meanwhile, a complementary global trend is embodied in the multi-dimensional liberalization and deregulation of a variety of cross-border transactions in goods and selected services, finance and investment. In addition, there are parallel measures in the liberalization and deregulation of domestic product and factor markets in virtually all economies regardless of their former shades of ideology. All these have led, on the one hand, to a

[3] The most extreme example is the unmatched drop in the cost of computing power. Microprocessor speed was only 400 kilohertz in November 1971. It reached 2 megahertz in April 1974, over 1 gigahertz in March 2001 and in excess of 3.4 gigahertz in March 2004. In particular, a Pentium processor with 42 million transistors arrived in 2000 and the commercial introduction a year later of the Itanium processor was, in fact, ahead of Moore's prediction as it has 320 million transistors (Gordon Moore is a co-founder of Intel). It has been suggested that such exponential growth can go on for another 20 years so that a processor chip will then have at least 1 trillion transistors, the computing power of the human brain (Jovanovic and Rousseau, 2002).

huge expansion of trade and financial flows and the emergence of vast, new sources of demand for goods and services across the world.[4] On the other hand, the trading environment itself has been characterized by increasingly intensified competition and commercial rivalries and by more sophisticated and frequently changing consumer choices.[5]

… and by the worldwide trend towards broader and stronger protection of IP rights …

The above development trend is then reinforced by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which is administered by WTO (set up in 1995 as the final institution in the Bretton Woods structural troika). For the first time, this global treaty links the protection of IPRs directly to multilateral trade benefits and obligations. Additionally, provisions under the TRIPS Agreement extend IPR protection in developing countries to a level comparable to the generally high levels of IP asset protection in developed countries (Maskus, 2000, pp. 20-22). Furthermore, a large number of bilateral or regional free trade agreements concluded between developed and developing economies since the mid-1990s have embodied both stronger and broader IP protection, the so-called TRIPS-plus regime (Wattanapruttipaisan, 2004).

… and has sharpened and multiplied the comparative advantages of KBEs …

All these interactive trends in development have sharpened significantly the competitive edge of KBEs and multiplied the comparative advantages enjoyed by invention-driven industries and enterprises. At one level, this can be seen as regards the self-reinforcing nature of new and existing knowledge, and the speedy diffusion of new knowledge and technologies through learning and competence-building. Additionally, the proprietary IP assets gained (both knowledge and technologies) can be, and have been, deployed tactically and strategically so as to maximize lead time and other business advantages of inventors and IPR owners. But such deployment has also served to retard or make it more costly and difficult for follow-on or substitute inventions and

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[4] Indeed, a larger proportion of domestic output is now traded; the ratio of global merchandise exports to world GDP being 12 per cent in 1980, 17 per cent in 1995 and 20.5 per cent in 2003. By and large, international trade has also expanded much faster, by 7 per cent during 1995-2000 for example, than the rates of increase in world production, by 4 per cent in the same period. Furthermore, manufactured goods accounted for almost 85 per cent of non-oil export value in the early 2000s, compared with 28 per cent in 1975 and 47 per cent a decade later (WTO, 2003).

[5] Currently, for example, consumer preferences are also determined by such non-price parameters and considerations as the quality and design of products and services, health and safety in consumption, social equity in employment and production, and the ecological compatibility of products and production processes. Pertinent in this connection are two related developments. First, marketing research in developed countries has indicated that consumers are willing to pay a price premium of up to 200 per cent for technology, functionality or social and emotional appeal in products (also known alternatively as the social and ethical responsibility premium). These range from high-tech vacuum cleaners, consumer audio and video equipment and specialty olive oil to "fair trade" and organically grown primary and manufactured produce ("Best of the best", *Newsweek*, 12 April 2004, p. 43). Secondly, there is the concept of "decent work", which implies not only freely chosen employment with adequate working conditions and income sufficient to satisfy economic and family needs. Decent work also encompasses broader aspirations of those employed, including the rights to representation and basic social protection. For further details as regards the interface between decent work and globalization, see World Commission on the Social Dimension of Globalization (2004, pp. 12-23 and 64-66).

innovations (Carr, 2003; Popp, 2003; Shapiro, 2000; and Lanjouw and Schankerman, 1999).

… as well as increased the inherent significance of inventive entrepreneurship and technology-driven SMEs

At another level, the intrinsic importance of entrepreneurship and SMEs has become even more significant along with the proliferation of domestic and transborder production arrangements and services platforms, especially since the mid-1980s. There is, meanwhile, a parallel shift towards more decentralization, greater dispersion (or de-verticalization) and leaner systems in production and services activities, especially in many developed countries. Indeed, a significant share of domestic employment creation and the commercialization of new economic knowledge is currently associated with clusters of hightech manufacturing and service activities populated largely by innovative and entrepreneurial SMEs in cooperative linkages with R&D and science and technology institutions. These trends are evident not just in the United States but in many parts of Western Europe as well (Yusuf and others, 2003; Audretsch, 2002; and Audretsch and Thurik, 2001).

Revealing weaknesses in IP creativity

Productivity growth has been modest among the miracle economies of East and South-East Asia

Most economies in East and South-East Asia have achieved a "miraculous" performance over the last several decades. However, such an impressive achievement appears to have been pushed largely by higher rates of physical accumulation of tangible productive factors (such as labour force participation and capital resources). The contribution of indigenous, R&D-based inventions and innovations has been subdued, albeit not insignificant, in the tiger economies in East and South-East Asia. Total factor productivity (TFP), for example, accounted generally for a third or less of the GDP expansion of the four Asian newly industrializing economies (NIEs), China, Indonesia, Malaysia and Thailand, in various periods from the early 1960s to the mid-1990s (Eichengreen, 2002, pp. 17-22). In comparison, the same stimulus to growth was as much as four fifths in the United States, and about two thirds in France, Germany and the United Kingdom in the post-War years.[6]

By and large, IP creativity and inventions in ASEAN have been limited …

In ASEAN, the critical weakness above is well revealed by the very small amount of IP asset creation, either as innovation patents or grain-sized innovations patented under the utility model (Lam and Wattanapruttipaisan, 2004b and c). Patents provide a good indicator of a country's R&D capabilities and productivity and of the sophistication of its science and technology base, support industries and services, and legal and financing infrastructure and facilities. They are also the cornerstone of discrete gains in efficiency and productivity at the level of firms and industries, and hence of the dynamism and competitiveness displayed by sectors and economies as a

[6] Under the growth accounting methodology, TFP (or the Solow residual) is that part of output gains which cannot be explained by increases in tangible factor inputs. TFP became a controversial matter in East and South-East Asia in the pre-crisis mid-1990s after a provocative article by Klugman, who had based his observations largely on the research results from Young. There are numerous complex conceptual, specification, estimation and data problems in TFP accounting. For a recent discussion on these issues and related estimates, see Bosworth and Collins (2003, pp. 2-5 and 33-34), Lau (1998, pp. 48-63), Pack (2001, pp. 134-135) and Yusuf (2001, pp. 15-21).

whole.[7] Qualitatively, however, a patented asset has limited value until or unless it is successfully commercialized and protected, or its application and diffusion (as public-domain knowledge) lead to a subsequent surge in innovative output and flow-on inventions.

… in both absolute and relative terms, with the exception of Singapore since the mid-1990s

The volume of inventions registered to ASEAN residents (including subsidiaries of transnational corporations or TNCs) at national IP offices in the region totalled less than 1,600 patents during 1993-2002. This number was below 1 per cent of all the ASEAN patents granted by these offices to both resident and non-resident owners (Lam and Wattanapruttipaisan, 2004b). The overwhelming and persistent dominance of developed countries as owners of patented IP assets in the region is thus evident in both absolute and relative terms. Within ASEAN, however, Singapore has become technologically the most dynamic, an achievement underpinned by greatly intensified efforts to foster science and technology and R&D-intensive activities from the 1990s (Wong, 2003, pp. 10-20). This island economy had a relative share of only 25 per cent (or 50 patents) of regional patent grants to ASEAN residents during 1995-1996; the proportion jumped to 59 per cent (or 140 patents) in 2000-2001.

ASEAN-based patents are also negligible in global terms

Globally, data from the United States Patent and Trademark Office (USPTO) also indicate a similar, entrenched divide in knowledge accumulation and applied technology.[8] Developing countries as a whole accounted for only 5 per cent (or 64,363) of the United States patents granted to all countries during 1991-2001. Meanwhile, residents of ASEAN were the owners of only 1,584 (or 0.1 per cent of the total) United States patents issued in the same decade. Notably, most of these proprietary assets cover microelectronics fields in the case of USPTO patents received by residents of Singapore and, to a lesser extent, Malaysia. In addition, TNC subsidiaries operating in the region are the owners of a large proportion of United States patent grants to ASEAN residents, except those in Singapore.

[7] It should be noted that patents do not capture all of the techno-scientific progress so far achieved. First, most fundamental insights and much of the basic research for the creation of "pure" or pre-commercial knowledge are not subject to patent or copyright (Stiglitz, 2003; and Daly, 2000). Secondly, many other discoveries are not patentable because they are intangible or informal in nature, or because they may not rise to the level of novel and non-obviousness inventions, or of original and creative works of authorship that still dominate current thinking and practice as regards IP assets and their registration and protection. Thirdly, the propensity to patent varies considerably across industry; it is itself influenced by a variety of tactical and strategic considerations, as indicated earlier.

[8] Foreign inventors seeking the international commercialization and diffusion of their IP assets tend to take out patents in the United States, given the country's sheer size as a market for goods and services (including IP assets) plus its sustained strength and dynamism in science and technology and R&D (Lall, 2001). Additionally, there are the relatively more stringent standards for patentability, including strict requirements (backed by legal sanctions) regarding the full disclosure of prior-art in patent applications in the United States. European patent law does not have an equivalent provision, however (MacGarvie, 2003; and Trajtenberg, 1999). Moreover, legal standards create a formidable environment for third-party efforts made to invalidate a patent issued in the United States; patent grants enjoy a strong presumption that they are "born valid" (Graham and others, 2002).

Singapore is by far the largest holder of United States patents granted to ASEAN residents

Chartered Semiconductor Manufacturing of Singapore, the world's third-largest dedicated chip foundry, is the most important owner of USPTO patents in ASEAN. During 1997-2001, it accounted for 282 patents (or 32 per cent of the total of 872 registered to Singapore residents), with another 34 patents (or 4 per cent of the total) held by the National University of Singapore. The six highly inventive TNC subsidiaries (with 19 or more United States patents each) were the sources of 163 patents, or just under 19 per cent of the total, in Singapore. All these represent a remarkable achievement; Singapore had less than 50 United States patents to its technological credit during 1991-1992. Malaysia is the second-largest holder of United States patents in ASEAN (151 during 1997-2001) and Motorola is the biggest single owner of these patents (numbering 33 or 22 per cent of the total) in this country.

Sobering undertones

Efficiency gains from mature, readily available and widely shared technologies are limited

Such an unfavourable record in science and technology and R&D achievements casts a large shadow on the otherwise impressive picture of economic growth and social transformation in most parts of ASEAN. This is a matter for significant concern to all stakeholders in the region. On the one hand, the social and economic returns from R&D are far higher than those associated with imitation and reverse engineering activities, or with the formation of tacit skills and knowledge (such as know-how and then know-why).[9] On the other hand, efficiency gains tend to be limited in technologies which are mature, readily available and widely shared (more in footnote 11 below). A compounding difficulty in this context is the rapid technological changes and the resulting fast-paced obsolescence of skills, equipment, processes and products, and hence degradation of current cost advantages.

A good case in point is the microelectronics industry in most parts of ASEAN

A good illustration in the above context is the FDI-driven commoditization of ICT-related production and trade, and the dominance within a short decade by East and South-East Asian economies in those closely networked and interlinked activities. This is another impressive achievement of tiger capitalism in the 1990s. Notably, the share of ICT items exported from developing economies in East and South-East Asia reached almost 65 per cent of intraregional exports (totalling US$ 418 billion) in 2001, compared with less than 19 per cent (or US$ 44 billion) in 1985 (Ng and Yeats, 2003, pp. 14 and 37-39). Exceptionally, the first- and second-generation NIEs generally

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[9] Tacit knowledge and skills are basically gained through learning by doing and shared through social interaction. The concept of tacit knowledge was put forward by Polanyi in 1958, with know-how denoting the attainment of a minimum level of operational capability required in all industrial and, more generally, technological undertakings. This may or may not lead to a deeper understanding (know-why) of the underlying theories or principles concerned. Audretsch and Thurik (2001, pp. 14-16) and Senker (1995, pp. 425-447) provide an extensive review of recent discussions on tacit knowledge (including the heuristic, subjective, sticky and internalized variety) in comparison with the codified, structured and explicit knowledge whose diffusion relies mostly on the use of formal and systematic languages and methods. It should be noted, however, that the distinction between these two kinds of knowledge is a contentious issue in the literature.

enjoyed a faster rate of expansion as well as a higher share in world production of microelectronics products than they did in world trade itself in the last decade; Hong Kong, China, being the only exception.[10]

The ready availability of external technology has reduced the need to build up a solid science and technology and R&D foundation …

Within ASEAN, however, microelectronics production remains mired in labour-intensive, low value added and standard-product segments. This has become a structural problem because external resources and technologies have enabled most ASEAN economies to move up the ladder of production complexity without first building a strong and extensive domestic science and technology and R&D base. Such a foundation is necessary to underpin and diversify a nexus of interwoven support industries, infrastructure and services.[11] The problem is further compounded by the chronic and acute shortage of skilled human resources and IP creation virtually across the whole region (Best and Rasiah, 2003; UNIDO, 2002; Ernst, 2000; and Hobday, 2000). Exceptionally, Singapore has successfully shifted to an integrated base of microelectronics production characterized by high-capital and skilled-labour intensities and increasing value addition locally.

… so that most segments of the industry exhibit low levels of value addition locally

Malaysia has the largest electronics industry in terms of employment (with a workforce of 330,000 in the late 1990s) and a production value of US$ 27.4 billion in 1998 (compared with US$ 37.8 billion in the case of Singapore). As a whole, however, the estimated share of value added is modest – ranging from less than 1 per cent in computers and 7 per cent in consumer electronics to 21 per cent in semiconductors in 2000. What is more, the local addition to value rose only marginally between 1994 and 2000, by 10 per cent or less, except in consumer electronics (Yusuf and others, 2003, p. 272). The overall situation and circumstances are not that dissimilar as regards the electronics industry in Thailand (with output valued at US$ 14.6 billion in 1998), the Philippines (US$ 7.3 billion) and Indonesia (US$ 5.2 billion).[12]

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[10] The relative shares (in order of importance) of Singapore, Malaysia, Thailand, the Philippines and Indonesia in global electronics production combined to reach 1.8 per cent in 1985, 4.2 per cent in 1990 and 8.5 per cent in 1998. The corresponding ratios for the Republic of Korea plus Taiwan Province of China were 2.6 per cent, 5.4 per cent and 6.7 per cent (Wong, 2001, p. 4).

[11] Indeed, the low levels of local value creation in a variety of export-oriented production activities under supply subcontracts or as part of an international production network are relatively well established. However, research based on enterprise-level data on gained TFP and value added is much less extensive and systematic. In the spring of 2001, the World Bank carried out a large-scale survey of 1,500 firms in China and 326 enterprises in six other countries in East and South-East Asia. The results show generally that firms within international production networks experienced more export growth and innovations. These favourable outcomes, however, were not often translated into faster growth in value addition (relative to non-networked firms), or into broad-based, direct employment and income expansion (Yusuf and others, 2003, pp. 295-305).

[12] For a more detailed discussion on these matters, see Tham (2004, pp. 31-33); Tangkivanich, Nikomborirak and Krairiksh (2004, pp. 20-24); Lall (2001, pp. 22-24); UNCTAD (2003, pp. 112-123); Dodgson (2000, pp. 245-248); and Linden (2000, pp. 213-218). Meanwhile, the new electronics-based specialization in production and trade plus related opportunity costs, in terms of defensive and positive restructuring and of the heightened vulnerability to cyclical external demand, in ASEAN during the 1990s are examined at some length in Lam and Wattanapruttipaisan (2004c, pp. 28-31).

Social and economic returns on R&D investment are far larger than those associated with most economic activities and services

In the above context, social and economic returns on investment in R&D activities are far higher than those obtainable from investment in most other activities and services. At the aggregate level, for example, R&D spending produces economic payback rates of 20-40 per cent for OECD countries. In the case of middle-income economies, these rates approach 60 per cent but they are as high as 100 per cent in low-income countries. The overall economic gains average 78 per cent while the rates of social returns are in the range of 70-100 per cent.[13] Another survey of 57 published studies on industrial R&D plus 292 publications on agricultural R&D shows consistently double-digit rates of economic returns (Watson, Crawford and Farley, 2003, p. 10).

In addition, the necessary technologies may not be available on reasonable commercial terms and conditions

Indeed, innovation rents have become a substantial proportion of the increasingly sophisticated flows of goods and services in global production and trade (Lau, 1998, pp. 54-55). The cursory evidence available on the supply side is sufficiently illustrative of the substantial magnitude of such rents although the terms and conditions of licensing contracts are normally a commercial secret. Indeed, it should be remembered in this connection that there is no guarantee that the necessary technologies or the additional licences required can be obtained on reasonable commercial terms or in a timely manner. Even if such technologies are available, there are normally geographical and field-of-use restrictions in technology transfer contracts to ensure that IPR owners can determine the timing, conditions and circumstances of market entry of both business partners and commercial rivals.

In absolute terms, the innovation rents are a substantial share of gross revenue

Illustratively, the royalties and licensing fees paid by China, currently the world's largest supplier of digital versatile disk players, were equivalent to about 25-33 per cent of the unit retail price of US$ 60 in 2003.[14] Such outward payments absorbed up to 30 per cent of the revenue of semiconductor firms in the Republic of Korea in the mid-1990s (Dodgson, 2000, p. 242). In total, they averaged around US$ 100 million a year in the 1970s and, after the liberalization of licensing agreements in 1978, jumped to US$ 1 billion in 1990 and US$ 2 billion five years later (OECD, 2000, p. 58). Meanwhile, the technology fee on genetically modified cotton seeds sold by Monsanto in China is about 44 per cent of the retail price of 42 yuan renminbi (US$ 8) per kilogram; this fee is equivalent to 27 per cent of the value of the estimated harvested crop (Keeley, 2003, pp. 8 and 20-21).

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[13] (Lederman and Maloney, 2003, pp. 3 and 12-14). The study sample covers 99 countries with 1,386 observations of five-year averages for the period 1975-2000. R&D includes expenditure on fundamental as well as applied research and experimental activities; the latter two components are more commercially oriented in nature.

[14] Japanese and United States corporations are the owners of most of the DVD technologies used by manufacturers in China. The high royalty fees coupled with intense competition render manufacturing activities less attractive because of the severely squeezed margins and low value addition locally. These are the main reasons behind concerted efforts in China to develop local video standards and technologies ("China spins a new disk", *Far Eastern Economic Review*, 26 February 2004, pp. 34-35).

Back to the basics

A technological transformation is necessary to sustain high growth and the availability of decent work in ASEAN

Thus, IP creativity and proprietary asset generation are indispensable as differentiators in business competitiveness and dynamic inputs to fuel the race to higher trajectories of productivity and growth. Indeed, the large and widening gap in new knowledge and applied technology is the characteristic, and probably unbridgeable, divide between the industrialized North and the developing South (Stiglitz, 2003, p. 4; and Romer, 1993, pp. 64-66). A strategic response at the policy and firm levels is to foster ongoing inventions, innovations and competence-building processes. Such an approach is considered essential, first, in regaining the dynamism and resilience of the miracle years and, secondly, in ensuring the availability of "decent work" and social safety for all. All these apply especially to middle- and high-income economies as well as to those enterprises which need to leapfrog technologically in global competition (World Commission on the Social Dimension of Globalization, 2004; Yusuf and others, 2003; UNCTAD, 2003; and Yusuf and Evenett, 2002).

Entrepreneurship and SMEs have played an important role in the above regards among developed countries

The critical role of entrepreneurship and SMEs in the KBEs deserves a brief note in the above context. There is solid evidence that SMEs in the United States (defined as those firms with fewer than 500 workers) produce a disproportionate share of breakthrough inventions. For example, SME patents are at least twice as likely (than those of large firms) to be found among the top 1 per cent of the highest-impact patents, technology-wise and commercially. In addition, the citation index (a measure of technological diffusion) associated with SME patents averages 1.53, compared with 1.19 in the case of large firm patents. Furthermore, SME inventions cover a wider spectrum of technologies while the technological influence of SMEs has also been on the rise. The percentage of highly inventive SMEs (those with 15 or more United States patents) constituted two thirds of all firms in 2000 (sample database of 488 companies) and two fifths in 2002 (622-firm sample size).[15]

Most developing economies are trying to replicate this pattern of development …

Indeed, the enhanced importance of technology-driven entrepreneurship and the innovative SMEs in the KBEs has been well appreciated by most developing countries in the world. This is best exemplified by, for example, a re-focus on the removal of long-standing policy and other biases against SMEs together with the additional allocation of resources for SME development in East and South-East Asia, especially in the aftermath of the 1997/98 economic crisis (Wattanapruttipaisan, 2002, pp. 57-58 and 65). Moreover, massive investments have been made across East and South-East Asian economies, among many others, to foster and replicate local versions of California's Silicon Valley, Boston's Route 121 and high-tech corridors

[15] CHI Research Inc. (2003 and 2004). Baumol (2004, p. 15) reproduces a highly interesting list of 68 inventions of enormous commercial and technological significance by American SMEs in the twentieth century. This list ranges from A (air conditioning and aeroplane) to Z (zipper). Other listed items include audio tape recording, catalytic petroleum cracking, computerized and X-ray scanning, DNA fingerprinting, frequency modulation radio, gyrocompass, heat sensor, helicopter, integrated circuit, desktop and portable personal computers, Polaroid camera, computer operating software, soft contact lens and xerography.

of interlinked clusters of dynamic SMEs and inventive entrepreneurships in R&D, manufacturing and services activities (Cook, 2003, pp. 11-21; and Yusuf and others, 2003, pp. 236-245).

… which is likely to have both large firms and SMEs as the key players in IP creation and commercialization

Many large firms are highly inventive as well, although many others tend to focus more on less risky technological breakthroughs. These inventions are essentially derivative, incremental and cumulative in nature as speed and cutting-edge creativity are often not a hallmark of big companies. However, most large corporations have a decided advantage over SMEs in their extensive and established sales and distribution networks as well as in their internal capabilities to undertake costly commercialization projects based on newly developed technologies of their own or purchased and licensed from elsewhere (Baumol, 2004, pp. 13-14). As such, an ideal development scenario contains a mix of large firms, which provide not only a production and export platform for their allied networks of innovative and competitive SME suppliers. Those large enterprises can be both the initiators and the sources of in-house R&D activities and IP generation on a broad front. Meanwhile, many SME start-ups act as vehicles for the incubation and eventual transmission of leading-edge ideas and breakthrough technologies to the industrial mainstream. The transfer process can be mediated through mergers and acquisitions, through the formation of collaborative linkages and alliances (or value networks) between small and large firms or, as circumstances permit, through export-driven transformation of the dynamic SMEs into large enterprises or TNCs themselves.

The technological miracle in East Asia

The Republic of Korea and Taiwan Province of China achieved an outstanding technological transformation in the 1990s

Recognition of the current structural problems to foster IP creation through the adoption of a strategic approach for technological transition is an important step forward. In this connection, there may be useful insights for consideration and good practices for possible replication from the technological transformation achieved largely within a decade by the Republic of Korea and Taiwan Province of China. Such a transformation, in which both SMEs and large corporations are playing a critical role, is perhaps one of the few most outstanding achievements of these two East Asian NIEs in the 1990s.

Globally, they are now leaders in several fields of microelectronics in their own right

The Republic of Korea and Taiwan Province of China were technological followers, copiers and imitators in the 1960s and early 1970s. They graduated into junior partners in R&D linkages with external business partners and technological leaders in the following decade and since the 1990s have become major players and pioneers in R&D of a commercial and, to a much lesser extent, basic nature.[16] In terms of United States invention

[16] It is worth noting that February 2004 witnessed a breakthrough in the creation of the first cloned human embryo (from which a human embryonic stem cell line was generated) in the Republic of Korea. All but 1 of the 15 scientists involved in this pioneering, basic work were local scientists and researchers. Such an achievement will lay the foundation for a variety of follow-through R&D activities, especially those in therapeutic cloning, and this will certainly lead to a large number of patented inventions and commercial applications in a variety of fields. Needless to say, however, there are basic moral issues and legal implications to be resolved in many of these R&D activities and related business spin-offs.

patents, for example, the Republic of Korea was ranked thirtieth (with a total of 34 patents) and Taiwan Province of China twenty-fourth (with 196 patents) during 1977-1980. In 2000-2001, however, the latter economy (with 12,351 United States patents) moved up to fourth position and the Republic of Korea to eighth (with 7,235 patents).[17] Additionally, data on patent citations of prior art show different patterns of knowledge diffusion. Patents from the Republic of Korea tend to cite much more frequently inventions patented by Japan, while those from Taiwan Province of China lean more evenly on both United States and Japanese inventions (Hu and Jaffe, 2001, pp. 21-22).

Most inventors are local entities, either large corporations as in the Republic of Korea or individuals and SMEs as in Taiwan Province of China …

The large bulk of inventions in these two economies relate to micro-electronics fields and are registered mostly to home-grown entities (individuals, institutions and business corporations).[18] Structurally, almost 80 per cent of United States patents belonged to only four business groups (*chaebols*) in the Republic of Korea during 1997-2001; about another 10 per cent went to various research institutions there. The Samsung group, currently with some 26,000 researchers on its payroll, has dominated IP asset creation in the country, having 6,749 United States patents (or 44 per cent of the total) to its credit. Following at a distance are other *chaebols* such as LG Electronics (13.8 per cent), Hyundai (11.9 per cent) and Daewoo (7 per cent). In contrast, individual owners accounted for 42 per cent of United States patents registered to Taiwan Province of China (totalling 18,888) during the same period, reflecting the economic durability and structural importance of SMEs and inventive entrepreneurship. Patents registered to large corporations accrued largely to Taiwan Semiconductor Manufacturing Company (TSM) and United Microelectronics Corporation (UMC), with a combined share of 16.4 per cent or 3,106 patents over 1997-2001 (Lam and Wattanapruttipaisan, 2004b, pp. 21 and 30-31).

The global successes of Samsung Electronics are due, to a considerable extent, to IP creativity …

In particular, Samsung Electronics is one of the very few entities from a developing country to be among the global leaders in nanotechnology, a term coined by K. Eric Drexler in 1986.[19] This corporation (together with, for that

[17] Other principal inventor countries are the United States (with 195,680 USPTO patents), Japan (67,815 patents), Germany (22,717 patents), France (7,860 patents), the United Kingdom (7,632 patents) and Canada (7,025 patents).

[18] One of the main reasons for such R&D specialization relates to the nature of the technologies themselves. It is postulated that microelectronics are more engineering-driven than science-based chemicals and pharmaceuticals. Technological progress in microelectronics is both very fast and characterized by discontinuities, thus offering good entry opportunities and niches for the late comers. By contrast, earlier movers have a decided advantage in chemicals and pharmaceuticals, which require time-consuming learning by doing and painstaking selection through a process of trial and error. All these pose considerable difficulties to countries with a relatively short period of industrial experience and a shallow and narrow science and technology base (Luthria and Maskus, 2003, pp. 147-148).

[19] A nanometre is 1 billionth of a metre in length and generally the term nanotechnology covers R&D in subject matters of less than 1,000 nanos in width (e.g., nanoinstrumentation in microelectronics, ribonucleic acid and deoxyribonucleic acid sequencing, viruses and proteins, atoms and molecules in advanced materials, etc.). However, the most common view of inventions in nanotechnology limits them to products and processes measured at 100 nanos or less. For more details on the coming technological revolution, see Dutfield (2003, pp. 44-49) and Anton, Silberglitt and Schneider (2001, pp. 5-33).

matter, LG Electronics) has taken a pole position technologically and has consequently enjoyed strong pricing power over several major rival corporations in a variety of consumer electronics items. Such a performance is due to astute foresight, substantial market "savvy" and contrarian decisions in making huge investment projects for the commercialization of newly developed technologies in the aftermath of the 1997 financial and economic crisis in East and South-East Asia (Yusuf and others, 2003, p. 148). The widespread popularity of Samsung Electronics' product mixes and the current cyclical upturn in global demand for ICT parts and components are other helpful factors as well.

… and such commercial achievements have overshadowed several other major rivals in consumer electronics

Comparatively, the market capitalization of Sony Corporation (the world's largest consumer electronics firm with 5,475 United States patents during 1997-2001) was more than twice that of Samsung Electronics in 2000 but dropped to 52 per cent (or US$ 38 billion) by February 2004. Global Samsung sales, at US$ 50.2 billion in 2003, were about four fifths of Sony's, but the former recorded a much higher profit margin on sales, 12 per cent, compared with less than 2 per cent in the case of Sony. In May 2004, Samsung Electronics was ranked on a composite index by Forbes magazine forty-fifth among the world's 2000 leading companies.[20] Sony Corporation was ranked eighty-second and Matsushita Electric Industrial Company four hundred and fifteenth. The latter is the world's second-largest consumer electronics firm (with global revenue of US$ 62.6 billion and a net loss of US$ 145 million in 2003) and secured 5,284 United States patents during 1997-2001.

Research institutions have played a crucial role in both economies, although in different ways

Another equally notable feature is that research institutions have played an important role, although in different ways, in both the Republic of Korea and Taiwan Province of China. The institutional research infrastructure in the former economy was particularly important in creating technological diffusion capacity in the copying and imitation stages during the 1960s and 1970s. In particular, researchers in public sector institutions (excluding universities) and government expenditure on R&D were about twice larger than the pertinent number and magnitude in the private sector up to the late 1970s. From then on, however, the situation has been reversed so that private sector researchers and spending on R&D by business conglomerates (noted earlier) were more than three and a half times greater than those of public sector institutions (Lee, 2000, pp. 272-277). During 1997-2001, for example, the four largest institutes (each with more than 100 United States patent grants) accounted for only 5.8 per cent (or 901) of the total of 15,564 patents issued to entities in the Republic of Korea. Another 126 patents (or 0.8 per cent of the total) were shared by 10 other research outfits.

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[20] It is the largest or among the principal global suppliers of colour monitors, advanced plasma flat-screen display panels, various semiconductors (such as memory chips), wireless hand phones and microwave ovens and other household white goods. See "Forbes 2000", *Forbes*, 23 May 2004, pp. 46-76.

ITRI has a major influence on science and technology and R&D in Taiwan Province of China …

The Industrial Technology Research Institute (ITRI), set up in 1973 in the Hinshu-Taipei science corridor in Taiwan Province of China, was the source of 986 United States patents (or 5.2 per cent of the total of 18,888) during 1997-2001. Another 7.8 per cent of the patents were granted to seven other research institutions (123 patents) and the National Science Council (361 patents). Institutional research efforts, especially those by ITRI, have been instrumental in sustaining successful R&D networking and commercialization and hence the continuing importance of SMEs in Taiwan Province of China. In particular, these firms have remained the dominant players in both desktop and notebook computers at the global scale, despite the considerable barriers facing them in terms of technology and economies of scale.[21] This provides a sharp contrast to the failure of the much larger and resource-rich corporations in the Republic of Korea to sustain even a modest presence in these particular segments of the electronics industry (Ernst, 2000, p. 114).

… in terms of the multifaceted spin-offs from its activities …

The spin-offs from wafer-related fabrication technologies and design expertise developed by ITRI have also contributed to the success of the local semiconductor foundries. TSM and UMC, the world's largest and second-largest dedicated fabricators of semiconductors, are highly profitable.[22] ITRI also plays an intermediary role in R&D activities (for example, through the Open Lab Program), provides consultancy and incubation services on technology and management (with a partial subsidy from the Government), fosters and coordinates multiparty technological R&D consortia, and disseminates technological information. ITRI is now the key player in a large nanotechnology project, with government funding from 2003 of some US$ 650 million over a six-year period. In 2002, the Institute had 6,190 employees, of whom 77 per cent were R&D personnel with one half having more than 10 years of research experience (many being returning expatriates) and three fifths with postgraduate qualifications.

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[21] By the mid-1990s, some three fifths of the global supply of desktop personal computers had come from this island economy, which had also become the world's largest producer of notebook personal computers. The electronics industry in Taiwan Province of China had its roots in the local assembly of vacuum-tube radios in 1948, and the first transistor radio factory was set up in 1961. In the production of personal desktop computers and computer peripherals especially, SMEs there have overcome the technological barriers to entry through vertical disintegration and a de-technology arrangement whereby the most advanced and demanding technology functions are outsourced to specialist, independent subcontractors. In addition, economies of scale and scope are realized through the pooling of work orders and other inter-firm linkage and coordination arrangements in the capital-intensive segments of production and manufacturing. Moreover, the flexibility and capacity to adjust to abrupt and often unexpected changes are another decided comparative advantage of SMEs in an industry characterized by high volatility, great uncertainty, and disruptive inventions and technologies (Chen and Ku, 2003, pp. 38-51; Ernst, 2000, pp. 100-140; and Hobday, 2000, pp. 143-154).

[22] The former, established in 1979 as a manufacturer of electronics parts, went into the dedicated semiconductor business in 1987 and had a current payroll of some 15,000 employees worldwide in 2003. It recorded a net profit of US$ 8.1 billion, which was equivalent to a net return of almost 42 per cent on sales revenue of US$ 19.4 billion, during 2000-2003. UMC has been in operation since 1980 but went into the pure-play foundry business in 1995 with about 8,500 workers worldwide at present. Net income totalled US$ 2 billion during the same 4 years (including a net loss of US$ 90.3 million for 2001), or about 23 per cent of sales receipts of US$ 8.8 billion.

… and as a catalyst in the future development of both basic research and commercial technologies

Currently, the R&D program at ITRI is structured and organized with one fifth of the resources going to technologies and inventions which can be commercialized within 1-2 years. Another one fifth is allocated to fundamental research with commercial applications one or two decades down the road. The middle segment of three fifths is channelled to leading-edge inventions and related technologies which can push up the productivity frontier and hence the competitive advantage of enterprises in this island economy. About one half of the ITRI operating budget of just over US$ 430 million a year during 2001-2002 came from the Government (mainly the Department of Industrial Technology, Ministry of Economic Affairs) and the other half from earned revenue. Notably, its net income (after taxes) during 2001-2002 averaged 4.5 per cent of operating revenue, one half of which was earned from fees and other services.[23]

Significant underinvestment in science and technology and R&D

Meanwhile, there has been inadequate allocation of public and private sector resources to science and technology and R&D in ASEAN, except Singapore

All these present another sharp contrast to the situation in ASEAN, one which reflects the cause as well as the consequence of a shorter history in R&D activities, a more shallow and narrow science and technology base at the starting point, and a persistence of significant underinvestment in R&D activities in the region; Singapore being an exception but only from the early 1990s. The regional economies are well known for their manufacturing prowess based on foreign investment and imported technologies, both hard and soft. By and large, however, they have yet to be widely recognized as centres of science and technology excellence and cutting-edge R&D activities of world-class standard.

This underinvestment has resulted in a series of entrenched bottlenecks and constraints …

Public spending on R&D averages in general less than 0.3 per cent of GDP among ASEAN economies, way below the 2.5-2.8 per cent range in, for example, Japan, the Republic of Korea and the United States. Exceptionally, Singapore has been successful in hiking R&D expenditure to 1.8 per cent of GDP from the late 1990s.[24] In turn, this persistent and sizeable underinvestment has created a bottleneck in terms of inadequate job creation in science and technology and R&D. The consequent constraint on employment opportunities contributes to the low enrolment rates in the hard sciences in ASEAN, again with the exception of Singapore. These low rates are one of the reasons behind the grossly inadequate supply of scientists, engineers, computer specialists and research technologists and technicians, knowledge

[23] See Dodgson (2000, pp. 285-288) and the references cited therein for a further discussion on ITRI, and access <www.itri.org> for current information on R&D focus areas and activities, personnel and financial statements.

[24] Wong (2003, pp. 5-22) provides a detailed examination of the strategic policy shift, plus a variety of promotion and facilitation measures, to lift the operational trajectories of industries and enterprises from using to creating technologies in Singapore. Amsden, Tschang and Goto (2001, pp. 5-18) give a conceptual framework and an extensive assessment of the exceptionally large share of general expenditure on R&D (GERD) from the private sector in this island economy (some 63 per cent for most of the 1990s). In particular, R&D outlays by TNCs operating in OECD countries typically average 12 per cent of their total spending but the share of foreign private sector in total private sector GERD is as high as 44 per cent in Singapore.

managers workers in most regional economies (see table below). Meanwhile, returning nationals and expatriate workers have helped to bridge the knowledge gap in Singapore, but this is not an equally feasible solution in other parts of the region at present.

Some indicators of research and development in selected countries, latest years available

	R&D expenditure (percentage of GDP)		*Scientists and engineers per million persons (late 1990s)*	*Knowledge workers (percentage of labour force, 2002)* [a]	*Patents granted in the United States during 1995-2001* [b] *(annual average)*
	Government (late 1990s)	*Business (late 1990s)*			
ASEAN					
Malaysia	0.2	0.1	93	25.2	33
Philippines	0.2	n.a.	157	12.7	14
Singapore	1.8	0.9	2 318	35.8	156
Thailand	0.2	… [c]	103	12.7	23
Other economies					
Australia	1.7	0.8	3 357	36.6	748
China	0.6	0.3	454	n.a.	113
Japan	2.8	2.2	4 909	36.4	29 081
Republic of Korea	2.8	2.2	2 193	18.4	2 721
Taiwan Province of China	1.5	0.8	2 114	n.a.	3 969
United States	2.5	1.9	3 676	47.3	83 475
OECD average	2.1	1.0	2 163	31.4	2 092 [d]

Sources: APEC, "Towards knowledge-based economies in APEC", pp. 195-202; International Labour Office, *Yearbook of Labour Statistics*, various issues; OECD, *Knowledge-based Industries in Asia*, p. 59; and United States Patent and Trademark Office at <http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_all.pdf>.

[a] Knowledge workers are defined as those engaged in professional, technical, managerial, administrative and clerical occupations.

[b] Including both resident and non-resident inventors and owners.

[c] Negligible.

[d] Excluding United States patents granted to resident and non-resident inventors and owners in Japan and the United States.

… including a shallow science and technology base and limited employment opportunities in R&D

Another major bottleneck is reflected in the limited scope and shallowness of R&D activities and the science and technology base in ASEAN. In consequence, this has had an adverse impact on the quality, skills, versatility and experience of the existing, but highly limited, pool of trained and professional workers. There is, indeed, no substitute for professional apprenticeship and incubation, on-the-job learning and practical experience in R&D as well as in business management (Amsden, Tsang and Goto, 2001, pp. 11-12). Furthermore, the lack of a minimum critical mass in technological capabilities in ASEAN has made it more difficult to foster strategic linkages with transborder entities in science and technology and R&D so as to share risks. Meanwhile, the sustainability of such networking also depends on the age-old "Catch 22" situation of mutual trust, reliability, quality and timeliness in the delivery of IP results and outcomes among partners and collaborators (Wagner, and others, 2001; and UNCTAD, 1995).

Closer stakeholder interaction and synergies

Progress in education reform and restructuring has been slower than expected in most parts of ASEAN

And the above problems and bottlenecks cannot be resolved with just money. Higher spending on science and technology and R&D will not be cost-effective and productive without a commensurate supply of the necessary human resources in ASEAN. However, such resources will not be available without a well-endowed, forward-looking and flexible educational and training system – one which is explicitly geared to encouraging and incubating a culture of technological creativity, business entrepreneurship and collaborative networking. Indeed, systemic reform in education and training has been high on the policy agenda in ASEAN. Regrettably, however, the progress so far achieved has been slower than expected virtually across the region. In part, this is because such reform is a long-term issue requiring significant changes in mindsets, long gestation periods and the costly provision of ancillary facilities, resources and expertise (Yusuf and others, 2003, pp. 181-216; and APEC, 2000, pp. 195-198).

Business spending on R&D and technological cooperation remains unsatisfactory …

Another issue of concern is that spending on R&D by the business sector has been virtually negligible in ASEAN. In addition, the record of technology cooperation and linkages between local business enterprises remains generally unsatisfactory. Moreover, there is the persistent and conspicuous absence of established networks of science and technology infrastructure and R&D activities which are in close synergy with, or tightly interwoven into, the domestic industrial fabric in the region. This applies, in particular, to the development and transfer of commercially relevant and viable technologies from science and technology and R&D institutions to the private sector. Singapore is the only notable exception in the above contexts (OECD, 2000, p. 59).

… while there is considerable scope for improvement in IPR systems and instruments in the region

Lastly, there is also much room for improvement and greater user-friendliness in IPR systems and instruments within ASEAN. In particular, front-end outlays in patent filings are quite substantial in absolute value; they also account for about one third of the total cost over the 20-year life typical of an invention patent. Indicatively, the basic expenses for patent agents' fees and related charges by national IP offices (but excluding translation fees) range from US$ 11,000 and US$ 12,000 in Indonesia, Malaysia, the Philippines and Thailand, to US$ 14,000 in Viet Nam. In comparison, the corresponding cost is estimated at US$ 21,000 in Japan, US$ 10,000 in the United States and US$ 16,000 in the United Kingdom (Lam and Wattanapruttipaisan, 2004a, pp. 70-71).

In particular, national IP offices can be a potent force in fostering inventions and entrepreneurship

Currently, there are also long delays of several years in the processing of patent filings in the region. This means in effect a shorter protection time after patent approval and a depreciated lead-time advantage and commercial value to the prospective owners because of the statutory publication of the invention as public-domain information (normally within 18 months of the filing date). The long delays are partly due to the time-consuming nature of prior-art search and examination and partly due to the fact that most IP offices in ASEAN are typically underfunded in terns of resources and facilities. Indeed, a more proactive role for these offices will not only relieve the burdens, delays and other costs of the patenting process. It will also be a great stimulus to IP asset creation and technological upgrading in the region.[25]

The ways ahead

There are difficult tasks ahead in initiating and sustaining a technological transformation in ASEAN …

In sum, physical capital accumulation alone will not be adequate to sustain development under the new economy and the new global competition. ASEAN must attain a higher trajectory of technological capabilities and competitiveness. Such a qualitative transformation has to be based on knowledge formation, driven by innovation, steered by collaborative linkages and sustained by life-long learning. The Achilles' heel in the current patterns of development has been well perceived by many stakeholders for quite some time; and so have the multidimensional changes and adjustments needed in the transition process. However, the road ahead is mostly uncharted. Great faith, enlightened leadership and lasting perseverance are required to engineer an agenda for transformation, to ensure a consensus for action, and to push persistently forward despite the inevitable setbacks and slippages in implementation.

… but the outstanding success in the two East Asian NIEs gives some grounds for cautious optimism

Only time can tell how long it would take to alter fixed mindsets, loosen institutional inertia and sustain a forged coalition for the technological transition required in ASEAN. However, the striking technological transformation in the Republic of Korea and Taiwan Province of China within a short decade gives grounds for cautious optimism as to the prospects for success among the miracle economies in South-East Asia.

[25] A variety of systemic and institutional issues and constraints on patenting on the demand side in ASEAN are discussed in detail in Lam and Wattanapruttipaisan (2004a, pp. 67-75).

REFERENCES

Amsden, Alice H., Ted Tschang and Akira Goto, 2001. "Do foreign companies conduct R&D in developing countries?", Asian Development Bank Institute Working Paper 14 (Tokyo, Asian Development Bank Institute), March.

Anton, Philip S., Richard Silberglitt and James Schneider, 2001. *The Global Technology Revolution: Bio/Nano/Materials Trends and Their Synergies with Information Technology by 2015* (Arlington, Virginia, RAND Corporation).

APEC, 2000. "Towards knowledge-based economies in APEC", report by the APEC Economic Committee to the APEC Ministerial Meeting, Brunei Darussalam, November.

Audretsch, David B., 2002. "Entrepreneurship: a survey of the literature", background paper prepared for the Enterprise Directorate General of the European Commission, Brussels.

Audretsch, David B. and Roy Thurik, 2001. "Linking entrepreneurship to growth", STI Working Papers 2001/2 (Paris, OECD Directorate for Science, Technology and Industry).

Baumol, William J., 2004. "Education for innovation: entrepreneurial breakthroughs vs. corporate incremental improvements", in Adam B. Jaffe, Joshua Lerner and Scott Stern, eds., *Innovation Policy and the Economy*, vol. 5 (Cambridge, Massachusetts, MIT Press).

Best, Michael and Rajah Rasiah, 2003. "Malaysian electronics: at the crossroads", Small and Medium Enterprises Branch Technical Working Paper Series, Working Paper No. 12 (Vienna, UNIDO).

Bosworth, Barry P. and Susan M. Collins, 2003. "The empirics of growth: an update" (Washington, Brookings Institution), unpublished manuscript.

Carr, Nicholas G., 2003. "IT doesn't matter", *Harvard Business Review*, vol. 81, No. 5, May, pp. 41-49.

Chen, Tain-Jy and Ying-Hua Ku, 2003. "The development of Taiwan's personal computer industry", *East Asian Economic Perspectives*, vol. 14, No. 2, August, pp. 38-51.

CHI Research Inc., 2003. "Small serial innovators: the small firm contribution to technical change", report to the United States Small Business Administration Office of Advocacy, Washington, February.

________ , 2004. "Small firms and technology: acquisitions, inventor movement, and technology transfer", report to the United States Small Business Administration Office of Advocacy, Washington, January.

Cook, Philip, 2003. "Strategies for regional innovation systems: learning transfer and applications", UNIDO Policy Papers, Vienna.

Daly, Herman E., 2000. "Globalization and its discontents", paper presented at the Fiftieth Anniversary Conference of the Aspen Institute, Aspen, Colorado, August.

Dodgson, Mark, 2000. "Policies for science, technology, and innovation in Asian newly industrializing economies", in Linsu Kim and Richard R. Nelson, eds., *Technology, Learning, and Innovation: Experiences of Newly Industrializing Economies* (Cambridge, Cambridge University Press).

Dutfield, Graham, 2003. "Literature survey on intellectual property rights and sustainable human development", background paper prepared for the UNCTAD/ICTSD Capacity Building Project on Intellectual Property Rights and Sustainable Development, Geneva, UNCTAD and ICTSD.

Eichengreen, Barry, 2002. "Capitalizing on globalization", *Asian Development Review*, vol. 19, No. 1, pp. 14-66.

Ernst, Dieter, 2000. "What permits David to grow in the shadow of Goliath?: the Taiwanese model in the computer industry", in Michael Borrus, Dieter Ernst and Stephan Haggard, eds., *International Production Networks in Asia: Rivalry or Riches?* (London, Routledge).

Ernst, Dieter and John Ravenhill, 2000. "Convergence and diversity: how globalization reshapes Asian production networks", in Michael Borrus, Dieter Ernst and Stephan Haggard, eds., *International Production Networks in Asia: Rivalry or Riches*? (London, Routledge).

Frankel, Jeffrey A., 2003. "The environment and globalization", Working Paper 10090 (Cambridge, Massachusetts, National Bureau of Economic Research), November.

Graham, Stuart and others, 2002. "Post-issue patent 'quality control': a comparative study of US patent re-examinations and European patent oppositions", Working Paper 8807 (Cambridge, Massachusetts, National Bureau of Economic Research), February.

Hobday, Michael, 2000. "East versus Southeast Asian innovation systems: comparing OEM-and TNC-led growth in electronics", in Linsu Kim and Richard R. Nelson, eds., *Technology, Learning, and Innovation: Experiences of Newly Industrializing Economies* (Cambridge, Cambridge University Press).

Hu, Albert and Adam Jaffe, 2001. "Patent citations and international knowledge flow: the cases of Korea and Taiwan", Working Paper 8528 (Cambridge, Massachusetts, National Bureau of Economic Research), October.

Jovanovic, Boyan and Peter Rousseau, 2002. "Moore's law and learning-by-doing", Working Paper 8762 (Cambridge, Massachusetts, National Bureau of Economic Research), February.

Keeley, James, 2003. "The biotech development State? Investigating the Chinese gene revolution", IDS Working Paper 207 (Brighton, Sussex, Institute of Development Studies), September.

Lall, Sanjaya, 2001. "Indicators of the relative importance of IPRs in developing countries", paper prepared for the UNCTAD/ICTSD Capacity Building Project on Intellectual Property Rights and Sustainable Development, Geneva, UNCTAD and ICTSD.

________ and Manuel Albaladejo, 2003. "Indicators of the relative importance of IPRs in developing countries", Issue Paper No. 3, UNCTAD/ICTSD Capacity Building Project on Intellectual Property Rights and Sustainable Development, Geneva, UNCTAD and ICTSD.

Lam, Ngo V. and Thitapha Wattanapruttipaisan, 2004a. "Intellectual property rights and enterprise development in ASEAN", *The Journal of World Intellectual Property*, vol. 7, No. 1, January, pp. 53-97.

________ , 2004b. "Intellectual property creation as invention patents in ASEAN", unpublished manuscript, April.

________ , 2004c. "From grain-sized innovations to triple-test patents in ASEAN: patterns, issues and implications in development and competitiveness", unpublished manuscript, May.

Lanjouw, Jean O. and Mark Schankerman, 1999. "The quality of ideas: measuring innovation with multiple indicators", Working Paper 7345 (Cambridge, Massachusetts, National Bureau of Economic Research), September.

Lau, Laurence J., 1998. "The sources of East Asian economic growth", in F. Gerard Adams and Shinichi Ichimura, eds., *East Asian Development: Will the East Asian Miracle Survive?* (London, Praeger).

Lee, Won-Young, 2000. "The role of science and technology policy in Korea's industrial development", in Linsu Kim and Richard Nelson, eds., *Technology, Learning, and Innovation* (Cambridge, Cambridge University Press).

Lederman, Daniel and William Maloney, 2003. "R&D and development", World Bank Policy Research Working Paper 3024 (Washington, World Bank), April.

Linden, Greg, 2000. "Japan and the United States in the Malaysian electronics sector", in Michael Borrus, Dieter Ernst and Stephan Haggard, eds., *International Production Networks in Asia: Rivalry or Riches?* (London, Routledge).

Luthria, Manjula and Keith E. Maskus, 2003. "Protecting industrial inventions, authors' rights, and traditional knowledge: relevance, lessons, and unresolved issues", in Kathie Krumm and Homi Kharas, eds., *East Asia Integrates: A Trade Policy Agenda for Shared Growth* (Washington, World Bank).

MacGarvie, Megan, 2003. "Do firms learn from international trade? Evidence from patent citations and micro data", working paper available at < www.cid.harvard.edu/cidtrade/site/new.html > .

Maskus, Keith E., 2000. *Intellectual Property Rights in the Global Economy* (Washington, Institute for International Economics).

Ng, Francis and Alexander Yeats, 2003. "Major trade trends in East Asia: what are their implications for regional cooperation and growth?", World Bank Policy Research Working Paper 3084 (Washington, World Bank), June.

OECD, 2000. *Knowledge-based Industries in Asia* (Paris, OECD).

Otsuki, Tsunehiro, John S. Wilson and Mirvat Sewadeh, 2001. "A race to the top? A case study of food safety standards and African exports", World Bank Policy Research Working Paper 2563 (Washington, World Bank, Development Research Group), February.

Pack, Howard, 2001. "Technological change and growth in East Asia: macro versus micro perspectives", in Joseph E. Stiglitz and Shahid Yusuf, eds., *Rethinking the East Asia Miracle* (New York, Oxford University Press).

Popp, David, 2003. "Lessons from patents: using patents to measure technological change in environmental models", Working Paper 9978 (Cambridge, Massachusetts, National Bureau of Economic Research), September.

Popp, David, Ted Juhl and Daniel Johnson, 2003. "Time in purgatory: determinants of the grant lag for U.S. patent applications", Working Paper 9518 (Cambridge, Massachusetts, National Bureau of Economic Research), February.

Romer, Paul, 1993. "Two strategies for economic development: using ideas and producing ideas", in World Bank, *Proceedings of the World Bank Annual Conference on Development Economics 1992* (Washington, World Bank).

Shapiro, Carl, 2000. "Competition policy and innovation", STI Working Paper 2000/11 (Paris, OECD Directorate for Science, Technology and Industry).

Senker, John, 1995. "Tacit knowledge and models of innovation", *Industrial and Corporate Change*, vol. 4, No. 2, April, pp. 425-447.

Stiglitz, Joseph, E., 2003. "Globalization, technology, and Asian development", *Asian Development Review*, vol. 20, No. 2, pp. 1-18.

Tangkitvanich, Somkiat, Deunden Nikomborirak and Busaba Krairiksh, 2004. "Country studies on foreign direct investment – Thailand", in Douglas H. Brooks and Hal Hill, eds., *Managing FDI in a Globalizing Economy: Asian Experiences* (London, Palgrave Macmillan).

Tham, Siew-Yean, 2004. "Country studies on foreign direct investment – Malaysia", in Douglas H. Brooks and Hal Hill, eds., *Managing FDI in a Globalizing Economy: Asian Experiences* (London, Palgrave Macmillan).

Trajtenberg, Manuel, 1999. "Innovation in Israel 1968-97: a comparative analysis using patent data", Working Paper 7022 (Cambridge, Massachusetts, National Bureau of Economic Research), March.

UNCTAD, 1995. *World Investment Report 1995: Transnational Corporations and Competitiveness* (United Nations publication, Sales No. E.95.II.A.9).

________ , 2003. *Trade and Development Report 2003* (United Nations publication, Sales No. E.03.II.D.7).

UNIDO, 2002. *Industrial Development Report 2002/2003: Competing through Innovation and Learning* (United Nations publication, Sales No. E.02.II.B.13).

Wagner, Caroline S. and others, 2001. *Science and Technology Collaboration: Building Capacity in Developing Countries* (Arlington, Virginia, RAND Corporation).

Walsh, Keith, 2003. "Foreign high-tech R&D in China: risks, rewards, and implications for US-China relations" (Washington, Henry L. Stimson Center), unpublished manuscript.

Watson, Robert, Michael Crawford and Sarah Farley, 2003. "Strategic approaches to science and technology in development", World Bank Policy Research Working Paper 3026 (Washington, World Bank), April.

Wattanapruttipaisan, Thitapha, 2002. "Promoting SME development: some issues and suggestions for policy consideration", *Bulletin on Asia-Pacific Perspectives 2002/03* (United Nations publication, Sales No. E.02.II.F.69).

________ , 2004. "Intellectual property rights and enterprise development: some policy issues and options in ASEAN", *Asia-Pacific Development Journal*, vol. 11, No. 1, June (United Nations publication, Sales No. E.04.II.F.41).

Wong, Poh-Kam, 2001. "ICT production and diffusion in Asia: digital dividends or digital divide?", Discussion Paper No. 2001/8 (Helsinki, United Nations University/World Institute for Development Economic Research).

________ , 2003. "From using to creating technology: the evolution of Singapore's national innovation system and the changing role of public policy", in Sanjaya Lall and Shurijo Urata, eds., *Foreign Direct Investment, Technology Development and Competitiveness in East Asia* (Cheltenham, Edward Elgar).

World Commission on the Social Dimension of Globalization, 2004. *A Fair Globalization: Creating Opportunities for All* (Geneva, IILO).

WTO, 2003. *International Trade Statistics 2003* (Geneva, WTO).

Yusuf, Shahid, 2001. "The East Asian miracle at the millennium", in Joseph E. Stiglitz and Shahid Yusuf, eds., *Rethinking the East Asian Miracle* (New York, Oxford University Press, World Bank).

Yusuf, Shahid and Simon J. Evenett, 2002. *Can East Asia Compete? Innovation for Global Markets* (New York, Oxford University Press, World Bank).

Yusuf, Shahid and others, 2003. *Innovative East Asia: The Future of Growth* (New York, Oxford University Press, World Bank).