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Is this the Asian Century? China, India, South Korea and Taiwan in the Age of Intellectual Capitalism

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ABSTRACT *Because of Asia's remarkable economic performance since the 1980s, some observers have predicted Asia's rise and the coming of a Pacific Century. We doubt this optimistic view. In the knowledge-based economy, ways of amassing wealth have changed, and better criteria for evaluating economic development are needed. This study compares research and development activities of four Asian developing countries – China, India, South Korea and Taiwan – with those of two advanced economies – the USA and Japan – to emphasise a neglected trend. The Asian cases do succeed in the information technology industry, a typical sector in the knowledge-based economy. None the less, Asia may be lagging further behind in relative terms. We show that this may not be the Asian century. In addition, it is possible that the battlefield between multinationals will switch from markets to intellectual property courts.*

KEY WORDS: Asia's rise, intellectual property, knowledge-based economy, KBE, Pacific Century, patents

Talk of the Pacific Century and the rise of East Asia became commonplace from about the mid-1980s (e.g. Borthwick, 1998; Hsiung, 2001; Linder, 1986; Wade, 1990). Book titles referred to the rise of Asia (Tipton, 1998), the rise of "the rest" (Amsden, 2001) and the Pacific Century (Soon and Suryadinata, 1988).[1] Such titles raised the prospect of more years of impressive Asian growth and industrial catch-up. Of late, terms illustrating the remarkable achievements and future prospects of the Chinese and the Indian economies have prevailed; these include "dragon economy" (Anderson, 2007), the "rise of India" (Chu et al., 2007), "Planet India" (Kamdar, 2007) and India as the elephant and China as the dragon (Meredith, 2007). Titles referring to "tiger technology" (Mathews and Cho, 2000) and the "tiger's roar" (Weiss, 2001) reflect a rising confidence in Asian countries' technological advancement. However, we will explore how these heartening terms fail to describe what is really happening.

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These terms imply that latecomers do benefit from industrialisation. But does technology improve the relative positions of developing countries in the international division of labour? In this study, we examine only the four developing economies – China, India, South Korea and Taiwan – that are generally regarded as having achieved success in high-tech industries. In so doing, we ask if collective learning has equipped certain Asian countries to compete in the knowledge-based economy. We do not treat Japan as one of the Asian countries, in spite of its geographical location, as the Asian Century and similar terminology implies that developing Asian countries will follow in Japan's footsteps. Japan is a developed and rich country that controls core technologies. Therefore we locate Japan alongside the USA in the category of developed countries. In this research, we will compare the technological developments of four Asian developing economies with those of the USA and Japan. First, however, we have to describe the features of the current means of accumulation in the global economy as we move into the knowledge-based economy (KBE).

The Organisation for Economic Co-operation and Development's (OECD) definition of the KBE has been generally accepted. The key idea is that the creation and communication of knowledge becomes the major engine for gathering wealth and creating employment opportunities. State officials, analysts and scholars explored fields such as technological innovations, knowledge management, intellectual capital and patent licences in their search for ways to gain momentum in the knowledge-intensive era (Foray, 2004; Juma and Yee-Cheong, 2005). The protection of intellectual property (IP) rights allows companies to rapidly gain an advantage over other producers that cannot afford to gain access to relevant IPs (Chen, 2004). Sophisticated methods to protect IPs promise victory in a highly competitive setting. We may call this specific means of accumulation "intellectual capitalism." Although nuances may exist, in this study we use the terms KBE, "new economy," "intellectual capitalism" and "information society" interchangeably, for these terms all emphasise the critical role that knowledge would play in the new epoch. The implications of this knowledge role include changes in regulations, organisations and institutes that arise with the coming of the "new economy." This is the background against which scholars claim the coming Pacific century. Willingly or not, developing economies in the region will be required to follow the new rules of intellectual capitalism.

We chose the two East Asian tiger economies – South Korea and Taiwan – and the two largest emerging economies – China and India – as cases to analyse for four reasons. First, since the early 1980s, South Korea and Taiwan have been significant players in the global hardware production sphere of the information technology (IT) industry. South Korea specialises in DRAM, handsets and liquid crystal display (LCD) panels; and Taiwan specialises in notebook computers, motherboards, IC foundry and LCDs. Secondly, China has recently surpassed Taiwan in hardware production and, thanks in part to Taiwanese investment, has become the world's second-largest hardware exporter. Thirdly, both India and China have substantial software sectors; India controls the largest share of offshore software production world-wide, and China is becoming a competitor to India. Fourthly, and perhaps most importantly, all four countries are succeeding in their manoeuvring in either the hardware or software sector (or both) of the IT industry, providing us a good opportunity to examine whether the Asian Century is really upon us.

This study aims to disprove the appealing concepts of Asia's rise by demonstrating that there has been a widening knowledge gap between our four Asian developing countries and Western advanced economies such as the USA and, arguably, Japan. We do not deny the impressive performance of some Asian countries. But we believe that a widening knowledge rift between developed economies and industrialising latecomers in Asia needs to be addressed. We intend to demonstrate that Asia's developing countries may lose the tools they need to succeed in the KBE, an economy in which knowledge is transformed into intangible assets of great significance.

The sections of this paper are organised as follows. First, we portray the substantial economic achievements of the four Asian latecomers in their IT undertakings. Secondly, we review the existing literature and criticise the overly optimistic views that imply that latecomers will eventually acquire the positions currently held by advanced countries. Thirdly, to demonstrate the breadth of the gap between China, India, South Korea and Taiwan on the one hand and the core economies of the USA and Japan on the other, we compare R&D expenditures, patent filing statistics and the numbers of patents granted. Fourthly, we raise the possibility that the battlefield between high-tech multinationals has switched from marketplaces to intellectual property courts because patent litigation has become a useful strategy for hampering competitors. The final section summarises our findings and demystifies the rise of Asia and the Pacific Century.

High-tech Growth in Asian Developing Countries

Since the 1990s, Taiwan has become a regional hub for original design manufacturing (specialising in design and production capabilities) in the global hardware market. Recently, Taiwanese companies have dominated design and production in several sectors, making more than 70% of the world's motherboards, notebook computers and LCD monitors (Tzeng, 2006). Achievements in the notebook computer sector are remarkable, with Taiwan occupying market shares from 55% in 2001 to 86% in 2006 (Market Intelligence Centre [hereafter, MIC], 2007d). Other products of Taiwanese IT enterprises – such as cable modems, servers and telecommunications equipment – have also gained significant shares of the world market (Information Technology Industry Services, 2006).

The 1997 Asian financial crisis cause severe damage to South Korea's currency and financial markets, nearly depleting the nation's foreign exchange reserves (Chen and Ku, 2000; Chow, 2000). The subsequent revitalisation of South Korea has indeed garnered much attention. Scholars, such as Foy and O'Connor (1998) and Haggard (2000), argued that many fundamentals of economic growth, including high rates of investment, commitment to education and openness to learning, remained in place. With the rescue package of the International Monetary Fund, Korea's foreign exchange reserves reached US$74 billion by 1999 (Lee and Han, 2006: 306). Thus, the financial crisis can be seen as a short-term problem that made the Korean government and corporations consider a new model for economic development. South Korea's efforts in R&D activities can also be seen in the numbers of patent filings by Korean residents, which almost doubled from 68,000 in 1996 to 124,000 in 2004. Exports of telecommunication hardware tripled from

US$8.3 billion in 1996 to 28 billion in 2006 (MIC, 2007c: 95, 189). South Korea's economic achievement provides an impressive lesson for many.

The Indian software industry has become increasingly important since the 1991 economic reforms. According to India's National Association of Software and Service Companies, around 80% of the world's software outsourcing is done by Indian firms (cited in MIC, 2007b: 62). Currently there are 34 functioning Software Technology Parks (STPs) nationwide. The number of IT workers increased from 133,000 in 2001 to 214,000 in 2005. The numbers of patents granted to Indian residents by the United States Patent and Trademark Office (USPTO) were ranked 25th in the world in 1999 and 19th in 2005 (MIC, 2007b: 64). These data show that India is playing an increasing role in the global software industry, particularly in offshore outsourcing.

China's hardware production has had a 15-20% annual growth rate since 2000. In 2006, the Chinese market for personal computers was about 20 million, of which local companies provided 55% of the desktop computers and 40% of the notebook computers (MIC, 2007a). Software exports grew from US$470 million in 2000 to US$5 billion in 2006. In terms of global software outsourcing, China's production was about 1.8% of the world total, valued at US$5 billion in 2003; this percentage is expected to increase to 9% in 2011 (MIC, 2007a: 139). In general, the growth in amount of electronics exports has been remarkable, increasing from US$26 billion to US$460 billion between 1998 and 2007 (YCII Editorial Board, 2008). These numbers show that China has achieved good results and rapid growth in both the hardware and software sectors in IT industrialisation.

These numbers seem to support Arrighi's (2007: 10) argument that China's extraordinary rise may well exemplify a kind of non-exploitative market economy characterised by "a socially more equitable and ecologically more sustainable developmental path."

Obviously science and technology have been conducive to economic expansion in late industrialising countries. These Asian stories have raised hopes that less developed economies can move forward on the high-tech boulevard if they take positive measures.

Technological Catching-up

The four Asian economies show that developing countries can succeed in high-tech manoeuvrings. But do these successes substantiate the coming of the Asian Century in general and China's rising hegemonic power in particular, as Arrighi suggests? Here, we critically examine the arguments of the scholars who support this idea. These scholars share at least three beliefs: First, that developing countries can succeed in sectors such as biotechnology, semiconductor and nanotechnology; secondly, that the largest economies, notably Brazil, China, India and Russia, own certain advantages, such as an inexhaustible pool of human capital and huge domestic markets; and, thirdly, that states are capable of effectively industrialising in strategic sectors (see, for example, Amsden and Chu, 2003).

For example, Diaz-Balart and Perez Rojas (2002) examine the technological development of India, Brazil and Cuba. Diaz-Balart and Perez Rojas use the term "software revolution" to applaud India's exceptional growth in the global software industry. For India, this has not only generated a substantial amount of wealth and employment, but also created a new cadre of high-tech entrepreneurs (Diaz-Balart and Perez Rojas, 2002: 330-31; see also Panagariya, 2001). They conclude that in order for developing economies to master technologies and gain advantages in the world markets, scientists in these countries should play a more direct role in education and state industrial policies.

Stiglitz (2003) discusses the importance of state support and government management of infrastructure (e.g. Internet and communications) for the new economy. He suggests six basic requirements, including a broad intellectual infrastructure, close links between research and education institutions, and joint ventures between the public and private sectors. Stiglitz (2006: 9-11) maintains that education will play a key role in the KBE, although he suggests that latecomers will have difficulties in improving higher education mainly due to the shortage of resources. At the same time, a substantial labour supply promises a competitive advantage, and huge domestic markets attract foreign capital and make technology transfers possible.

Niosi and Reid (2007) also declare that some conditions, for example a large reservoir of human capital, are propitious for large economies to expedite high-tech industrialisation. They conclude that Brazil, China and India are succeeding in the biotechnology and nanotechnology industries, and that Argentina, Chile, Mexico and Taiwan may achieve success in biotechnology and Mexico and South Korea in nanotechnology. Thus, they claim that less developed countries have already overcome entry barriers and succeeded in their IT attempts. They provide tangible strategies for manoeuvrings in the LCD sector, such as "early patenting in areas with the potential to attract foreign venture capital" and "cluster and alliance strategies" (Niosi and Reid, 2007: 435-6).

The optimism of these authors may sound reasonable, but we are not convinced. For example, Diaz-Balart and Perez Rojas use the fact that Indian engineers generated great wealth for Silicon Valley companies to demonstrate India's success in the global software industry. However, since the 1960s, US immigration policies have encouraged foreign students to stay in the USA and work for American enterprises to keep the latter competitive in the global markets (Sell, 2003). Certainly, some Indian expatriates will bring technologies and skills back to their home country, but the USA will be the country that benefits most from the thousands of outstanding Indian engineers who are educated there or who migrate to the USA.

Secondly, both Stiglitz (2003) and Diaz-Balart and Perez Rojas (2002) highlight the importance of advanced education in intellectual capitalism. In the KBE, maintaining information superiority is essential, and support for higher education becomes a must. Therefore, it could be expected that developing countries that invest more in their education systems will produce more engineers who can promote high-tech industrialisation. However, in 2006, according to one survey, 53 American, 11 British and 6 Japanese universities were ranked among the top 100 universities in the world (Shanghai Jiao Tong University, 2006). None of the world's top 100 universities are located in developing countries.[2] In China and India, the catch-up would likely be delayed by a significant portion of education resources being allocated to other concerns, such as the reduction of illiteracy (World Bank, 2006).

Thirdly, the numbers of patents obtained by Chinese and Indian residents seem insignificant when compared with those in developed countries. Niosi and Reid (2007) provide evidence of the achievements of China, India, South Korea and Taiwan, but they ignore the widening of the gap between developing countries and advanced economies over the past two decades. For example, when they show us that seven large developing countries acquired 105 biotechnology patents from the USPTO in 1976-2004, they forget to tell us that the same table shows 1234 US patents granted to Japanese residents and 627 to German residents during the same period – respectively 12 and six times the number obtained by the seven large developing countries combined (Niosi and Reid, 2007: 430, table 6).

Fourthly, although statistics seem to tell of the notable accomplishments of the four Asian developing countries, some of the numbers may be exaggerated, particularly in the case of the Indian software sector and, to a lesser extent, the Chinese software sector. For example, India's software industry has drawn attention from all directions, but 90% of the world's exports of software are from the USA and Western Europe. India occupies only 3% of the total (McManus et al., 2007). Currently, more than 250 Indian software companies, notably Wipro, Tata and Infosys, have been certified by the capability maturity model integrated system (CMMI), which guarantees the quality of software products and services (Hamm, 2007; Ma, 2007). However, although CMMI allows these Indian firms to compete in the international software markets, this system has little to contribute to software innovation. Moreover, in India, as in other developing countries, most cutting-edge technologies are controlled by foreign multinational corporations (see, for example, D'Costa, 2004).

To summarise, the optimistic perspective regarding Asia's rise is not without its faults. Some points of view need to be considered further. In the following analysis we will prove that the knowledge gap between these countries and the USA and Japan remains exceedingly wide or is even increasing.

Flagging the Asian Century in the KBE?

It is argued that in the information society, "knowledge is raw material to be converted to products, processes, or service" (Slaughter and Rhoades, 2004: 15). Patents – a major form of intellectual property rights – provide evidence of this claim. As Sell (2003: 24) states, IPs are "a subset of one particularly important component of late-twentieth, early-twenty-first-century capitalism and are embedded in the deep structure of global capitalism." A key feature of intellectual capitalism is that knowledge-intensive industries lead other sectors of the economy. Hence, it is helpful to discuss the changing role of universities.

Since the early 1980s, many countries, notably the USA, have changed institutions, laws and organisations to make universities more suitable for the new era. In the USA, legislative frameworks, such as the 1980 Bayh Dole Act, shifted the traditional teaching role of universities to that of research entrepreneur (Etzkowitz, 2005). Another example is the 1984 National Cooperative Research Act, which facilitated collaborative research endeavours by mingling federal and university monies with financial support from private sectors (Rhoades and Slaughter, 2006). Other examples abound. Scholars, such as Wong et al. (2007) and Wu (2007), emphasise the co-operative relationships among state, industry and higher education. Advanced countries are better situated in the KBE because most of the world's top universities are located in those countries. Millions of excellent international graduates from less developed countries have worked in developed countries, mostly because of wide wage differentials. These expatriates constitute an almost inexhaustible pool of human capital, further benefiting the already advanced economies.

To answer our research question posed above, we use three criteria: (a) R&D expenditure; (b) patent filings; and (c) patents granted by the USPTO. The investigation of R&D expenditure reveals the technological advancement efforts of the four selected Asian countries included here. Patent filings reflect the number of innovations developed in a country. Patents granted by the USPTO indicate a country's performance in the largest and highly competitive market – the USA. These comparisons will suggest that the widening gap between our four cases and the two advanced economies is large and may be unbridgeable. We will show that the numbers of patent filings and patents granted are much lower in developing countries than in advanced economies. We also demonstrate that the speed of technological advance in developed economies is much greater than that in developing countries.

R&D Expenditure

R&D expenditure and its proportion of the GDP have been treated as a measure for evaluating a nation's technological level and capabilities. Using this percentage is not without shortcomings, mainly because of differences in the sizes of the economies (Comerford, 2007). Thus, we will also discuss the actual R&D expenditures of our cases later in this article. Table 1 shows R&D spending in all six countries has gradually increased. Since 1998, Japan has spent more than 3% of its total GDP on R&D each year. Anything over 3% is generally regarded as highly conducive to high-tech industrialisation. Meanwhile, Taiwan has shown itself to be a strong contender for the title of "Technology Island," as its R&D percentage has increased steadily. South Korea also shows growth in R&D, increasing from 2.48% of GDP in 1997 to 3.23% in 2006.

Table 1. R&D expenditures of selected countries, 1997-2006 (percentage of GDP)

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
USA	2.58	2.62	2.66	2.74	2.76	2.66	2.66	2.59	2.62	2.62
Japan	2.87.	3.00	3.02	3.04	3.12	3.17	3.20	3.17	3.33	3.39
China	0.64	0.65	0.76	0.90	0.95	1.07	1.13	1.23	1.33	1.43
India[a]	0.77	0.81	0.86	0.93	0.84	0.80	0.74	0.77	0.85	0.89
S. Korea	2.48	2.34	2.25	2.39	2.59	2.53	2.63	2.85	2.98	3.23
Taiwan	1.82	1.91	1.98	1.97	2.08	2.18	2.31	2.38	2.45	2.58

All figures include national defence R&D expenditures.

[a]India's statistics are ratios of R&D expenditures to Gross National Product (GNP).

Source: Department of Science and Technology (2008), Main Science and Technology Indicators, 2008/1, OECD, cited in National Science Council (2008).

The percentage of GDP spent on R&D in the USA increased only slightly during the 1997-2006 period. However, the USA is the largest economy in the world, and its R&D expenditures remained substantial. Although India's total R&D spending remains low, it increased dramatically over prior decades, from 0.16% of the GDP in 1958 to 0.83% in 1986 (Chinainfo.gov.cn, 2004). In 1997-2006, the percentage of R&D expenditure remained at less than 1% (Qiu, 2008). China has doubled its R&D percentages from 0.64% in 1997 to 1.43% in 2006. Thus, it is seen that the four Asian cases have increased their R&D activities, which is critical to competitiveness in the global IT industry.

But when we compare the R&D spending of advanced economies with that of their developing counterparts, we see that the USA and Japan continue to lead. Table 2 shows the differences between Japan and South Korea, the latter regarded as a recent success story in IT sectors such as DRAM, LCD panels and handsets.

Differences exist between Japan and South Korea, not only in terms of amount spent, but also in the growth rates of expenditure. South Korea's R&D expenditure nearly doubled from US$16,637 million to US$35,886 million in the period 1997-2006, but the differences between the two countries' R&D expenditures continued to grow from US$71,148 million in 1997 to US$102,896 million by 2006, with the highest growth rate in the difference being 10% in 2005. The strong scientific base in the advanced countries can generate more R&D expenditure and, arguably, results as well.

A comparison of the Taiwanese case with those of the USA and Japan presents a similar picture. The consequences look similar. The gap between Taiwan and the USA increased from US$205,072 million in 1997 to US$325,887 million in 2006, and growth rates of the difference were usually maintained at 4-9% (the exception being in 2002). In comparing Taiwan and Japan, we find similar outcomes, with the difference increasing from US$76,101 million in 1996 to US$122,229 million in 2006. The growth rates of the difference stayed within the range 1-6% (National Science Council, 2008). When we compare South Korea with Japan and the USA, the results look the same. In short, the gap between the advanced countries on the one hand and Taiwan and Korea on the other is growing.

There also exist substantial differences when we compare the USA and China, as indicated in Table 3.

A few points draw our attention. First, China's R&D spending increased six fold over the ten-year period, from US$24,330 million in 1997 to US$144,037 million in 2006. Secondly, except for a slight decline in 2002, the USA spent increasingly more money on R&D from US$212,709 million in 1997 to US$343,748 million in 2006. Thirdly, there were two declines in the rate of the difference: -5% in 2005 and -4% 2006. For China, this looks like good news, because the knowledge gap is narrowed in 2005-06. Fourthly, the difference between R&D spending in China and the USA was still maintained at around US$200 billion in 2005-06. In short, China is improving in R&D activities, but the difference in R&D expenditure between the USA and China remains large.

When we compare China with Japan, we find similar results – minus growth rates in the difference but a huge gap in the amount of R&D spending. For instance, in 1997 the gap between China and Japan was US$63,455 million. In 1999, the growth rates of the difference between the two countries was negative. In 2004, China lagged

Table 2. Differences in R&D expenditures of Japan and South Korea 1997-2006 (US$ million, current PPP)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Japan (A)	87,785	91,062	92,774	98,783	104,025	108,248	113,259	118,577	130,746	138,782
South Korea (B)	16,637	14,789	15,763	18,387	21,157	22,247	24,344	28,363	31,959	35,886
Difference (A – B)	71,148	76,273	77,011	80,396	82,868	86,001	88,915	90,214	98,787	102,896
Growth rate of difference (%)		7	1	4	3	4	3	1	10	4

Source: Main Science and Technology Indicators, 2008/1, OECD (cited in National Science Council, 2008).

Table 3. Differences in R&D expenditures of the USA and China 1997-2006 (US$ million, current PPP)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
USA (A)	212,709	228,109	245,475	267,768	277,820	276,260	292,437	312,535	324,465	343,748
China (B)	24,330	26,858	33,990	44,894	52,436	65,516	77,899	95,498	117,455	144,037
Difference (A – B)	188,379	201,248	211,485	222,874	225,384	210,744	214,538	217,037	207,010	199,711
Growth rate of difference (%)		7	5	5	1	−6	2	1	−5	−4

Source: Main Science and Technology Indicators, 2008/1, OECD (cited in National Science Council, 2008).

behind Japan by US$23,079 million and the rate of the difference was −35%; in 2005 the gap was US$13,291 million, and the rate of the difference was −42%. China's improvement is undeniable. But keep in mind that China is one of the largest economies in the world. When we look at R&D spending from 1997 to 2006, it does seem that China is on the rise. However, in our later analysis, two criteria – patent filings and patents granted by the USPTO – will tell us a different story.[3]

The data provided above show that three of the four developing countries – China, South Korea and Taiwan – have spent more money on R&D activities. But what is important is that the gaps between South Korea and Japan, between Taiwan and Japan, between the USA and Taiwan, and between the USA and China have remained very wide.

Patent Filings

Patent protection encourages invention by granting rights to those who are willing to spend time and money on unknown fields. Often, inventors can use their monopolistic position to prevent followers from entering the market (Warshofsky, 1994). Although not all patents lead to money making, patents do defend the rights of inventors and allow them to make a fortune in the market. Logically, the more patents a nation holds, the more advantages it will have in the market. This encourages activities of invention and innovation. The substantial scientific base of developed countries makes frontier technology more accessible to those countries. A Schumpeterian view of technological progress provides us with the theoretical underpinnings of this pattern. As Arrighi et al. (2003: 17-18) explain:

> The process tends to begin in the wealthier countries because high incomes create a favorable environment for product innovations; high costs create a favorable environment for innovations in techniques, and cheap and abundant credit creates a favorable environment for financing these and all other kinds of innovations. Moreover, as innovators in wealthy countries reap abnormally high rewards relative to effort, over time the environment for innovation in these countries improves further, thereby generating a self-reinforcing "virtuous circle" of high incomes and innovation.

High incomes, high costs and high rewards in the wealthy countries comprise a synergy that motivates innovators to take risks. Poorer countries will tend to suffer because: (a) low incomes provide few incentives for product innovation; (b) the need to keep costs low prevents enhancements in technology; and (c) the presence of a cheap and abundant labour force limits the need for productivity improvements. All of these elements tend to generate a self-reinforcing cycle that makes poor countries almost redundant to the world economy, especially in the knowledge-intensive era. The current section and the following one will show that the four Asian cases discussed here are lagging further and further behind the USA and Japan with respect to patents.

The number of patent filings by residents can be regarded as a measurement of a nation's competitiveness, because patents constitute a substantial reservoir of intangible assets that generate wealth in a knowledge-intensive era.

The criterion of patent filings by residents is a matter of some debate. However, for our purposes here, it is an acceptable measure. Three points need to be addressed in advance. First, the quantity of filings represents the strength of a nation's R&D competencies by demonstrating how many applications per year are sent to patent offices. Secondly, the number of filings by residents shows a nation's R&D capabilities and the country's ability to rival others in high-tech sectors. The data regarding filings by non-residents will instead show R&D internationalisation, as many transnational corporations apply for patents in various places to protect their intellectual property.

Thirdly, it is unreasonable to argue that it is easier to gain patents in advanced economies than in developing countries. Evidence seems to support the general supposition that it is easier to get patents granted in developing economies than in the advanced ones. Take Taiwan, where 64% of patents filed by Taiwanese residents at the patent office between 1991 and 2005 were granted. However, of patents applied for by Taiwanese at the USPTO between 1998 and 2005, on average only 48% were granted (Taiwan Intellectual Property Office, 2000-06, 2001). From this example, we see that it is more difficult to obtain a patent in an advanced economy. Besides, as will be shown below, yearly more patent applications are filed in the USA and Japan; this adds to the difficulty of being granted in advanced countries to some extent because a substantial number of patents already exist. Hence, when we compare patent filings by residents, it is highly likely that we are using less strict standards to evaluate the performance of R&D activities in developing economies than those in advanced ones. The real R&D gap between developing nations and advanced economies may be larger than revealed in the data set out below.

Although the impact of patents is the subject of considerable dispute, in many respects, such as the effects on encouragement of innovation and on enhancement of public welfare (e.g. Bessen and Hunt, 2004; Boland, 2004; Schatz, 2004), it is generally agreed that more patents lead to a more advantageous position in the market. We will show that, like R&D expenditures, patent statistics indicate an ever-increasing knowledge gap between the four Asian developing countries examined here and the two advanced economy cases. We compare patent filings by residents in this section and investigate numbers of patents granted by the USPTO in the next. We believe that the US market is very competitive – if not the most competitive in the world – and the numbers of patents granted by the USPTO can be a direct indication of a country's technological strength in the world's largest market. We separate the past two decades into four periods in order to see the developing trends. Table 4 compares the numbers of patent filings in the USA and Korea by residents.

In the past two decades, patent filings by residents per year in the USA increased greatly, from 74,231 in 1985-90 to 185,432 per year in 2001-06. In Korea, the increase in patent applications in the 1990s is indeed noticeable, despite the financial crisis. The numbers increased from 5502 cases per year in 1985-90 to 98,728 per year in 2001-06, with the highest growth rate being 403%. But the absolute number differences between the USA and South Korea remained huge, increasing from 68,729 in 1985-90 to 86,704 in 2001-06. Although the rate of the difference was negative (−6%) in 1996-2000, it was 23% in 2001-06. The gap appears difficult to overcome, at least in the short term.

We find similar results when we compare patent filings in the USA with those in India. India lagged behind the USA by 73,198 cases per year in 1985-90, and the difference increased by 38%, 30% and 38% in the ensuing periods. In 2001-06, there were 180,345 more patent filings in the USA than in India (Taiwan Intellectual Property Office, 2000-06; 2001; World Intellectual Property Organization, 2007). In short, the gap between India and the USA continues to increase.

Japan's R&D performance is well known. In fact, Japanese residents apply for the largest number of patents in the world. Table 5 reveals that Japanese residents have applied for increasingly larger numbers of patents than Taiwan residents.

Table 4. Patent filings by US and South Korea residents 1985-2006

Year	1985-90	1991-95	1996-2000	2001-06
US residents (A)				
No. of patentsfiled	445,388	511,530	667,240	927,163
Filings per year	74,231	102,306	133,448	185,432
Growth rate (%)		38	30	39
South Korean residents (B)				
No. of patentsfiled	33,011	138,435	315,003	592,369
Filings per year	5,502	27,687	63,000	98,728
Growth rate (%)		403	128	57
A – B (Difference per year)				
Number	68,729	74,619	70,448	86,704
Growth rate of difference (%)		9	−6	23

Source: Taiwan Intellectual Property Office (2000-06; 2001) and World Intellectual Property Organisation (2007).

Table 5. Patent filings by Japan and Taiwan residents, 1985-2006

Year	1985-90	1991-95	1996-2000	2001-06
Japanese residents (A)				
No. of patents filed	1,834,468	1,657,867	1,787,367	2,163,940
Filings per year	305,745	331,573	357,473	360,657
Growth rate		8%	8%	1%
Taiwanese residents (B)				
No. of patents filed	113,701[a]	135,691	168,097	255,166
Filings per year	18,950	27,138	33,619	42,528
Growth rate (%)		43	24	27
A – B (Difference per year)				
Number	286,795	304,435	323,854	318,129
Growth rate of difference (%)		6	6	−2

[a]This is an estimate. The data before 1991 did not differentiate between patent filings by Taiwanese residents and non-residents. A total of 174,925 patents were filed by both residents and non-residents in 1985-90. Between 1991 and 2000, 65% of the patents were applied for by Taiwanese residents; we use this percentage to estimate the number of filings by residents for 1985-90.
Source: Taiwan Intellectual Property Office (2000-06; 2001) and World Intellectual Property Organization (2007).

In terms of the magnitude of difference per year, an increasing trend from 1985 to 2000 is obvious, with only a slight decline in the rate (−2%) in 2001-06. None the less, the gap in the number of patent applications filed by residents in Japan and Taiwan remains enormous – 318,129 per year for the most recent period. In addition, the gap between the two economies grew in three of four periods in the past 20 years. Hence we doubt that the −2% growth rate heralds a steady narrowing of the gap in the foreseeable future.

A comparison of patent applications by residents in Japan and China produces similar results. In China, the number of patent applications rose rapidly, from 4071 in 1985-90 to 57,005 in 2001-06, with the highest growth rate being 262%. However, when we look at the growth rate of the difference, we see that the difference between the two countries *increased* in each period until 2001-06. During that period, the rate of the difference was negative (−13%), but the actual difference was still large – 303,652 per year (Taiwan Intellectual Property Office, 2000-06; 2001; World Intellectual Property Organization, 2007).

The above analyses of patent filings illustrate a neglected trend. The R&D chasm between the two developing nations on the one hand and their developed counterparts on the other remains large, with a tendency to increase during most of the periods studied. With our four Asian cases lagging ever further behind the USA and Japan in R&D activities, the future of other developing countries in Asia looks gloomy.

Utility Patents Granted

Countries use different names to categorise patents into two or three groups. Some countries, such as China, France, Germany, Japan, Korea and Taiwan, have three kinds of patents: patent (or invention patent, utility patent), utility model (or little patent) and design (or industrial design). Other countries, such as Canada, Thailand, the Philippines, the USA and the UK, have no industrial design category (Liao, 2003). In terms of commercial benefits, utility patents or invention patents are of greatest importance. Utility patents bring more profits (and sometimes windfalls) to a company, because they involve the highest degree of invention. Here, we discuss only utility patents; we use the term "patent" to mean utility patent or invention patent.

Among the four Asian developing countries, Taiwan has been very competitive in creativity and innovation. According to the Economist Intelligence Unit (EIU), from 2002 to 2006 Taiwan ranked eighth in number of patents granted world-wide, and second in Asia (after Japan). The EIU estimates that in 2007-11 the island will be number six in the world (cited in Chuang, 2007). But what does this advance mean if we compare numbers of US patents granted to Taiwanese firms and residents with those granted to US firms and residents? This section compares numbers of patents granted by the USPTO for: (a) Taiwanese versus US residents; and (b) South Korean versus Japanese residents.

Novelty is one of the major requirements for being granted a patent (Chen, 1996). It is very difficult to obtain a patent from the USPTO, because another company may already own related patents. The more US patents a company owns, the more power it has to protect its interests in the US market. Taiwan ranks fourth in numbers of US patents, behind the USA, Germany and Japan (USPTO, 2006). However, the difference in numbers of patents granted to US and Taiwanese residents has continued to grow, as Table 6 reveals.

Taiwan's growth in patents granted by the USPTO is surely noticeable, from 1417 per year in 1993-95 to 5586 in 2001-06, with correspondingly high growth rates of 118% and 81%. Nevertheless, the gap between the two economies is expanding, from 53,595 per year in the mid-1990s to 79,613 per year in 2001-06; the respective growth rates of the differences were 33% and 12%. In the case of China, perhaps its inventors are still not ready for or interested in the exploration of the US markets; Chinese residents have received few patents from the USPTO. For instance, China obtained only 359 US patents in the second half of the 1990s, and 2246 in 2001-06 (USPTO, 2006). Although this indicates a growth rate of 379%, the total amount of patents granted by the USPTO remains minimal. The Indian case is almost the same. The speed of growth of advanced economies is logically higher than it is in countries with limited technological skills. This trend resonates with the virtuous circle conceptualised by Arrighi and his co-authors (2003) mentioned above.

Table 7 shows that South Korea has been lagging further behind Japan in obtaining patents from the USPTO.

Although the 1997 financial crisis and its aftermath was a major setback for Korean companies, the 181% growth rate of patent filings in 1996-2000 is impressive. Korean residents applied for fewer than 1000 patents per year in 1993-95, and that number grew to 4326 in 2001-06. None the less, when we compare South Korea with Japan, we find the gap has been widening, with 19% rates in the last two periods from 1996 to 2006. The number of patents granted by the USPTO indicates that South Korea's R&D activities are much weaker than those of Japan, with the difference increasing from 21,186 per year in the mid-1990s to 30,023 in the early 2000s. This difference of more than 30,000 patents per year demonstrates a large knowledge gap. South Korea as well as Taiwan has been left even further behind by advanced economies, especially in terms of the total numbers of patents granted.

Table 6. US patents granted to US and Taiwanese residents

Year	Pre-1993	1993-95	1996-2000	2001-06
US origin (A)				
No. during period	1,332,944	165,036	372,074	511,195
Average per year		55,012	74,415	85,199
Growth rate			35%	14%
Taiwanese origin (B)				
No. during period	4980	4252	15,414	33,516
Average per year		1417	3083	5586
Growth rate (%)			118	81
A – B (Difference per year)				
Number		53,595	71,332	79,613
Growth rate of difference (%)			33	12

Source: USPTO (2006).

Table 7. US patents granted to Japanese and South Korean residents

Year	Pre-1993	1993-95	1996-2000	2001-06
Japanese origin (A)				
No. during period	246,823	66,441	139,471	206,092
Granted per year		22,147	27,894	34,349
Growth rate (%)			26	23
S. Korean origin (B)				
No. during period	1767	2883	13,519	25,956
Filings per year		961	2704	4326
Growth rate (%)			181	60
A – B (Difference per year)				
Number		21,186	25,190	30,023
Growth rate of difference (%)			19	19

Source: USPTO (2006).

Is Asia "rising," as many have eagerly claimed? Yes, but it is not making significant gains on the already advanced countries and the gap between them seems to be increasing. We have employed three criteria – R&D expenditures, patent filings and patents granted by the USPTO – to demonstrate the widening gap between advanced economies and our Asian success stories. We suggest that it will be very difficult for these four countries to catch up. For other developing countries, the prospects seem even less optimistic. Late industrialising countries are short of the assets they need to participate in the knowledge-based economy. The momentum that is widening the gap can only increase or stay the same, because competitiveness in the new economy requires the ability to invest heavily, by government or by the private sector.

In sum, the data demonstrate that Asian developing economies are still quite distant from the United States and Japan. Manuel Castells (2000) posits that in the age of informational capitalism, lack of access to information will exacerbate the technical and social exclusion of the billions of extremely poor people in the "fourth world," who are disconnected from globalisation. Without strong IP protection, we believe that, like the people of Castells' "fourth world," participation in the era of intellectual capitalism will be closed. Our four case studies show that there has been successful industrialisation in and through the high-tech sector. However, these countries are being left further behind by the advanced economies. Because frontier technologies are controlled by advanced economies, we can reasonably expect that developing countries will become more dependent on the technologies of developed countries. Thus, it appears that the Pacific Century has not arrived.

From Markets to Courts: Inaugurating the Patent War

This section raises the possibility that multinational corporations fight not in markets but in courts. A company or nation that obtains more patents in related fields and markets can build higher entry barriers. Others are hindered from entering the profitable market by the danger of infringing upon the IP rights of incumbents. The battlefield is switched to the international IP courts, in which any infringement may result in millions, if not billions, in losses. Companies that explore markets without strong IP protection will be impeded somewhere along the line. Litigation has already been shown to be a useful weapon against competitors.

In the 1980s, the major judgments in the Kodak and Texas Instrument litigation in the USA obliged firms in almost all sectors to develop portfolios of patents and to use them defensively. These judgments also caused rapid growth in cross-licensing between companies (Barton, 2004). Thus, in the emerging global knowledge economy, patents play an ever-increasing role in handling risks (Schatz, 2004). For example, Sharp, a leading provider of LCD panels, signed with Chimei (Taiwan) a cross-licensing agreement that includes more than 1000 patents in LCD display technologies (Kuo, 2006). But when cross-licensing is not an option, litigation can be the major means of dealing with competitors. In August 2007, Sharp sued Samsung in a Texas court for infringement, followed by another charge in Seoul in December of the same year (Liang, 2007). Litigation becomes a critical method for gaining a better position before meeting incumbents or entrants in the markets.

In reality, it is not uncommon to see companies use litigation as business strategies in IT sectors. For instance, in Japan, Panasonic sued LG for infringements on the thermo-radiation patents and asked the court for a provisional disposition that would suspend admission of LG's imports at Tokyo customs. LG countersued Panasonic for illegally using its ion panel technologies (Chinalawedu.com, 2004). SanDisk, the leading producer of NAND flash memory, sued 25 companies in October 2007 for infringements in many product areas, notably control chips. Among the 25 firms, PNY, an American enterprise, was the first to express its willingness to reach an amicable settlement, because the USA is PNY's largest market. If SanDisk prevents PNY from selling in the US market, PNY will suffer a great deal (Lian, 2008).

Patent wars have been silently launched. Multinationals in key industries, such as biotechnology, computer software and semiconductors, have created a substantial patent pool to avoid infringing upon competitors' intellectual property rights (Shapiro, 2002). Similar tactics are being carried out in other areas, such as the PC industry (Chinalawedu.com, 2007; Tsai, 2007; Yan, 2007; Yan and Huang, 2007), semiconductors (Lin, 2006), telecommunications (Leopold, 2007), handsets (Shen, 2007) and GPS (Huang, 2006). Another issue is the royalties that less developed countries have to pay for related patents or technologies. Because hundreds of patents may be embedded in a final product, royalties can amount to millions of dollars. For example, China has exported hundreds of thousands of colour television sets to the US market. Not long ago, the US ATSC (Advanced Television Systems Committee) promoted the digital TV standard. The companies owning related patents planned to raise the royalties. Companies would have to pay as much as US$23 per unit (Tsai, 2006) and, in order to gain the technologies, developing countries would be required to pay large royalties as well. The transfer of wealth from the South to the North will exacerbate the current North-South differentiation. In addition, world-wide patent protection is very expensive. The senior counsel of a major pharmaceutical company estimated that the cost of obtaining world patent protection for a significant chemical compound in 1997 was between US$750,000 and US$1 million, and that cost is rising at a rate of 10% per year (as cited in Vonortas and Kim, 2004). Furthermore, it is argued that strengthening patents is conducive to innovation (see, e.g., Martinez and Guellec, 2004). If this is the case, how can developing countries with serious piracy, notably China and India (Dahlman, 2007), innovate to a great extent in the short run?

Much patent litigation is being debated in the IP courts, indicating that enterprises regard such litigation as a defensive business strategy. As Bessen and Hunt (2004: 257) suggest,

> in theory at least, extensive competition in patents, rather than inventions, may occur if firms rely on similar technologies and the cost of assembling large portfolios is not very high. In such an environment, firms may compete to tax each others' inventions and in the process reduce their competitors' incentive to engaging in R&D. The outcome of patent litigation and licensing agreements often depends on the size of the firm's patent portfolios. This creates an incentive to build larger patent portfolios, especially when the firm focuses on patents as a competitive strategy. In this account, firms choose to compete in court, rather than in the marketplace.

These examples suggest that the patent war in global knowledge capitalism has been launched. What Bessen and Hunt are worried about has already happened. Those who can afford lawyers adept in the field of international IPs will have a greater chance of winning in the courts. It will be difficult for countries without large stakes, in Asia and elsewhere, to play such a game.

Conclusion

Do recent achievements indicate that Asia is rising? At first glance, the answer appears to be yes. However, the truth is that advanced countries and a few developing countries have been moving into a new, knowledge-intensive economy in which innovation – reflected in this study by R&D expenditures, patent filings and patents granted by the USPTO – wields great power. In reality, most patents are not converted into commodities and create no economic value. But substantial patent portfolios that constitute an overlapping set of patent rights can raise high entry barriers, and competitors – especially those without enough protection – can get hurt easily because the shrubs in the patent thicket are very thorny. R&D-related activities are more prosperous in advanced economies and, seen from this angle, the earlier lessons learned from China, India, South Korea and Taiwan may not be as instructive as originally thought.

Our tables do show some minus growth rates in differences, meaning that there is some catch-up. For example, there are minus rates in the gap between R&D expenditures in China and the USA and between those in China and Japan. Minus rates also appeared in the gap between patent filings in the USA and South Korea, as well as between those in Japan and Taiwan. However, developing countries' opportunities to successfully pursue frontier technologies are limited. The gap between R&D spending in China and in the USA was still US$200 billion in 2005 and 2006. We doubt that China can catch up to the USA in the short term. In the same vein, the gap between patent applications by residents in the USA and South Korea declined 6% in 1996-2000, but jumped 23% in 2001-06. The Japan-Taiwan gap declined only 2% in 2001-06 compared to the former period. But the actual difference was more than 300,000 patents per year. All in all, these few declines in growth rates of differences are not relevant to the big picture.

Broadly speaking, two parallel trends go hand in hand in the global IT industry. First, the four Asian developing countries have achieved a great deal in their high-tech industrialisation. The second trend, quite the opposite, is often disregarded. Our data demonstrate that the chasm between the innovative capabilities of developing countries and advanced economies has remained vast over time, obscuring the very hope that the two tiger economies, South Korea and Taiwan – followed by the Chinese "dragon" and the Indian "elephant" – represent for other developing countries. Our comparisons, unfortunately, indicate that our Asian exemplars of success are also highly likely to be left further behind in the age of intellectual capitalism. Our research supports the pessimistic views that we are moving toward a two-tier technology society in which North-South distinctions will be perpetuated. Is this the Asian century? Not really.

Notes

[1] The (Asia-)Pacific region has been variously defined as, for example, (a) the five advanced economies of Australia, Canada, Japan, New Zealand and the USA; (b) the three East Asian newly industrialising countries of Hong Kong, South Korea and Taiwan; and (c) the five Association of South East Asian Nations (ASEAN) states of Indonesia, Malaysia, the Philippines, Singapore and Thailand (see, for example, Yue, 1988).

[2] In 2006, National Taiwan University was in the 151-200 range, and India's top two universities placed in the 301-400 and 401-500 rankings.

[3] We agree that R&D expenditure can be one of the measurements to evaluate technological levels, but the numbers of patent filings and patents granted by the patent office in the world's largest market can be more sophisticated criteria, as will be explained later.

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