Asia Business Council

Can Asians Innovate?

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CONTENTS

Executive Summary

Asia's ability to consistently, profitably innovate is at the heart of the drive to raise living standards and competitiveness.

The region's past few decades of rapid economic growth have largely been driven by its ability to become the factory of the world. While developed countries in the West have gradually evolved away from low-cost, labor-intensive manufacturing, Asia has become the world's dominant producer of everything from lighters to cars.

Asia's growth was driven by traditional inputs—capital and labor. Foreign know-how was important. There was little domestic innovation.

There are those who believe, both in Asia and abroad, that Asian companies are little more than copycats. They say that aggressive technology transfer, often coupled with protectionist (or techno-nationalist) policies and weak intellectual property (IP) protection, are all that fuel Asia's industrial and technological rise. If this analysis is correct, Asia is forever destined to play catch-up; there is a danger that economic growth will stall.

This paper takes a very different view. We find that Asian companies are innovative and likely to become more so, thanks to increased technical and scientific capabilities coupled with growing local markets. Indeed, in the last 50 years, Asia's developing economies (especially in northeast Asia) have a remarkable track record of commercial, profitable innovation. As Asian economies have become more sophisticated, they have become more innovative. The challenge now is to build on that success with better institutional and corporate policies.

Many institutional barriers stand in the way of more consistent, commercial, and profitable innovations. Asian companies have a poor record of developing breakthrough commercial products. The legal, financial, and higher-order educational system remains weak, particularly when compared to the United States.

There is no obvious formula to encourage innovation. But there are catalysts that policy makers can employ. Government support, including financial support, is key to providing basic educational and scientific infrastructure. But too much government involvement stifles innovation. Market-friendly policies are necessary, including financial systems that nurture and reward entrepreneurs.

Innovation is hard to define and even more difficult to measure. In economic terms, innovation is an improvement that makes something better or more valuable. It is key to productivity improvements and to higher living standards—the economic equivalent of a free lunch.

Now many Asian economies are looking to increase their technological innovation to generate greater value for their economies and incomes for their populations. Innovation is becoming all the more pressing for Asia because (1) easy technological catch-up gains have already been made; (2) labor force entrants are flat or declining in many places, so the era of cheap labor is finished; and (3) cheap capital is not a sustainable advantage, for a variety of reasons.

This study analyzes select industries in Asia with a track record of success and a high potential for technological innovation. We also look at the overall environment in the region that contributes to innovation. We were fortunate to interview a number of Asia Business Council members on the subject of innovation. Other than these interviews, this study does not look at the vast amount of work that has been done at the firm-specific level.

Particularly promising innovative industries include electronic products (because of the way statistics are collected, these are segmented into computers, IT, and electronics; and information and communication technologies, or ICT); pharmaceuticals and health biotechnology; environmental technologies; and nanotechnology. Findings confirm that Asia is growing in the conventional measures of technological innovation, including the generation of patents and scientific publications.

These rising trends are promising, yet where Asia is lagging is in the creation and adoption of innovations with substantial impact. Generally speaking, Asia has excelled at incremental innovation but not at breakthroughs. With a few exceptions, primarily Japanese, Asia has not yet become the hotbed of major technologies that have achieved widespread influence in global markets.

This next stage of innovation matters because Asian economies need to continue evolving, in order to attain long-term competitive advantage that generates increasing economic value, provides growth for industries, and raises incomes and living standards for their populations.

So what can Asian economies do to innovate with more widespread effects and at a quicker pace? What do they need to create an environment conducive to this next level of innovation?

This study finds that Asia would benefit from focusing on measures that build on but go beyond existing policies and actions to further strengthen technological innovation. These include:

- upgrading science and engineering talent;
- nurturing and promoting learning and entrepreneurial organizations;
- targeting government policies toward promising areas for innovation;
- improving access to finance for new ventures;
- encouraging openness in international technological collaboration;
- strengthening IP protection.

INNOVATION IN ASIA AT A GLANCE

ASIA'S STRENGTHS

Growing innovation output measured by patents and scientific publications

Strong fundamental assets in terms of scientists and engineers, infrastructure, and government funding

Promising industries and companies with a track record of innovation

Openness to complex and integrated products, mentality of paying for value, and pursuit of process efficiency

ASIA'S WEAKNESSES

Science and engineering talent lacks creativity

Hierarchical organizations

Governments are proactive but not sufficiently strategic

Lack of access to finance for new ventures

Focus on growing national prowess rather than global collaboration

Weak intellectual property protection

Introduction

The state and future of Asian innovation is a hotly debated issue among technological innovation watchers. Some have argued that Asia is already becoming a globally competitive innovator. Others have argued that low-cost copycat manufacturing remains dominant and that little real innovation is going on in the region.

Technological innovation requires organizations and individuals to come up with new products and services leading to useful improvements in the economy and the society at large. It typically involves the processes of researching an idea, developing it, and commercializing it into products and/or services for customers. Innovation can be disruptive or incremental.[1] Examples of disruptive innovations are digital photos, which obliterated the traditional film business; steamships, which meant disaster for sailing ships; and word processors, which spelled the end for typewriters. From telephones to muskets, television to plastics, disruptive innovations upend old businesses and create large new business fields.

Asia's past and current innovative strengths have relied more on incremental innovations, typically involving performance improvement of established products for mainstream markets. Asia has a weak track record of coming up with disruptive innovations. Whether it is modesty or simply taking too narrow a view of innovation, many Asians play down the region's strength in innovation. Interviews with Asia Business Council members found that many of them were at pains to stress that key technologies were developed elsewhere (notably the transistor, which Sony commercialized, and the microprocessor/Wintel platform that laid the foundation for Taiwan's strength in PCs). Asian companies, in this account, simply rode on the coattails of more powerful technological leaders.

We believe that innovation is far stronger in Asia than this account suggests. Sony's decision to license the transistor led to extraordinary successes in electronics. Taiwan spawned a powerful electronics industry on the back of the Wintel platform, one that has led to breakthrough products such as netbooks.

Innovation is key to productivity growth once an economy has sustained a basic level of manufacturing output based on low-cost labor and capital.[2] Therefore, most economies in the region need to continue evolving through innovation, whether it be incremental or disruptive, in order to retain or increase their competitive advantage.

To some degree, Asian economies have already seen the transformative power of innovation. In Japan, the growth of domestic technological innovations and foreign diffusion of technology both accounted substantially for the country's competitiveness in the 1960s and 1970s. The East Asian Tigers—Korea, Taiwan, Hong Kong, and Singapore—learned from foreign technologies and built infrastructure to upgrade their indigenous industries and continuously improve their profitability and efficiency. Those measures enabled the Tigers to grow their economies significantly over the past several decades and led to rapid improvements in real incomes and living standards.

A number of studies have tried to rank innovation. Many Asian economies do extremely well in these rankings, including the Asian Tigers and Japan, while the largest emerging economies, China and India, typically lag behind.[3] This may underestimate the capabilities of China and India. For India, business innovation in the IT-enabled services sector has contributed to a new level of income gains and overall competitiveness that could not be achieved only by people or capital working harder. In China, foreign investment and technology-transfer, as well as growing entrepreneurism, have contributed to immense wealth growth.

By many measures, Asia has made huge strides in developing the inputs to innovation, including education and R&D expenditures. Asian students have high math and science achievement. The status of Asian universities has risen dramatically in recent years, according to a variety of global rankings. The number of scientists and engineers in enterprise R&D has risen dramatically.[4] Asian governments have provided funding and built infrastructure for a variety of basic research.

However, as important as inputs are, they do not always lead to tangible outputs. Previously, Asia's rapid growth was largely due to the expansion of labor and capital, but not an improvement in productivity, which should reflect gains in the efficiency with which the inputs are used.[5] Efforts to measure outputs and results of innovation are also necessary, in order to understand the state of innovation of various economies. Doing so will help decision-makers assess whether spending and resources are focused at the appropriate level and on the high-potential areas of innovation.

Methodology

To understand the overall output of Asia's innovative activity, the Asia Business Council study uses quantitative data for two conventional measures of innovation output: patent applications, considered an observable measure of ideas production;[6] and scientific publications, the main channels for disseminating and validating research results.[7] The limitations of patent statistics and scientific publications are well-known. For the former, one criticism is that the quality of patents granted has declined overall as patent regimes have become more liberal. For the latter, the lack of English-language capability may lead to under representation of non-native authors. In addition, these measures miss innovative activity that may be carried out outside these systems, especially at the company level. Nonetheless, the abundance of data across economies provides a useful, objective comparison for this study's purposes. The study is less interested in absolute figures than in cross-country comparisons and trends over time. It analyzes the number and global share of patent applications and scientific publications to understand the overall growth trends, as well as the number of citations for each to understand the relative impact of these patents and scientific publications. Furthermore, quantitative data are supplemented with interviews to obtain qualitative and in-depth country- and region-specific perspectives.

This brief uses patent statistics from the most influential patent organizations around the world, including the World Intellectual Property Organization (WIPO), the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO), the Japan Patent Office (JPO), the Taiwan Intellectual Property Office (TIPO), and the Organization for Economic Co-operation and Development (OECD). It focuses on invention patents, the category of patents considered the most technology-intensive. It also uses scientific publication statistics from Thomson Scientific's *National Science Indicators*, a database containing statistics for more than 170 economies on scientific publications that meet the threshold requirements of having the most highly cited papers within each field and year of data.

The concentration of innovation output can vary widely across different industries and economies. To assess specific areas where recent innovation has occurred for various Asian economies, we analyzed the concentration of patents and scientific publications across industries and economies using the Relative Technological Advantage (RTA) index. The RTA index measures the distribution of an economy's innovative output in each industry relative to that of other economies and provides an indication of which economies have relative technological strength in each industry.[8] For instance, the RTA index for patents for an economy in a particular industry is defined as the ratio of the economy's share of world patents in that industry to the economy's share of total world patents.

An index value equal to 1 means an economy has the same share of worldwide patent applications or scientific publications in a given industry as it does in the aggregate across industries. An index value above (below) 1 means the economy does relatively better (worse) in that industry than it does in its overall share of world patents.[9] RTA indices for both patents and scientific publications therefore allow the assessment of the relative industry advantages and disadvantages of various Asian economies.

Beyond aggregate data, the study also relies on interviews with Council members who are industry leaders to gain a deeper understanding of the common success factors of Asian innovation and the future direction of innovation in the region.

Trends in Patents and Scientific Publications in Asia

The analysis of patents and scientific publications shows clear signs that the quantity of Asian technological innovation is rising over time. However, with few exceptions, the impact of these patents and scientific publications is still limited, as Asia is lagging other regions in terms of international citations for both measures.

PATENTS

Global patent applications are increasingly concentrated in Asia, with China and Korea accounting for the most significant growth among Asian economies between 2000 and 2006 (see Figure 1). Japan, which started early in the innovation game, still filed the largest number of patent applications

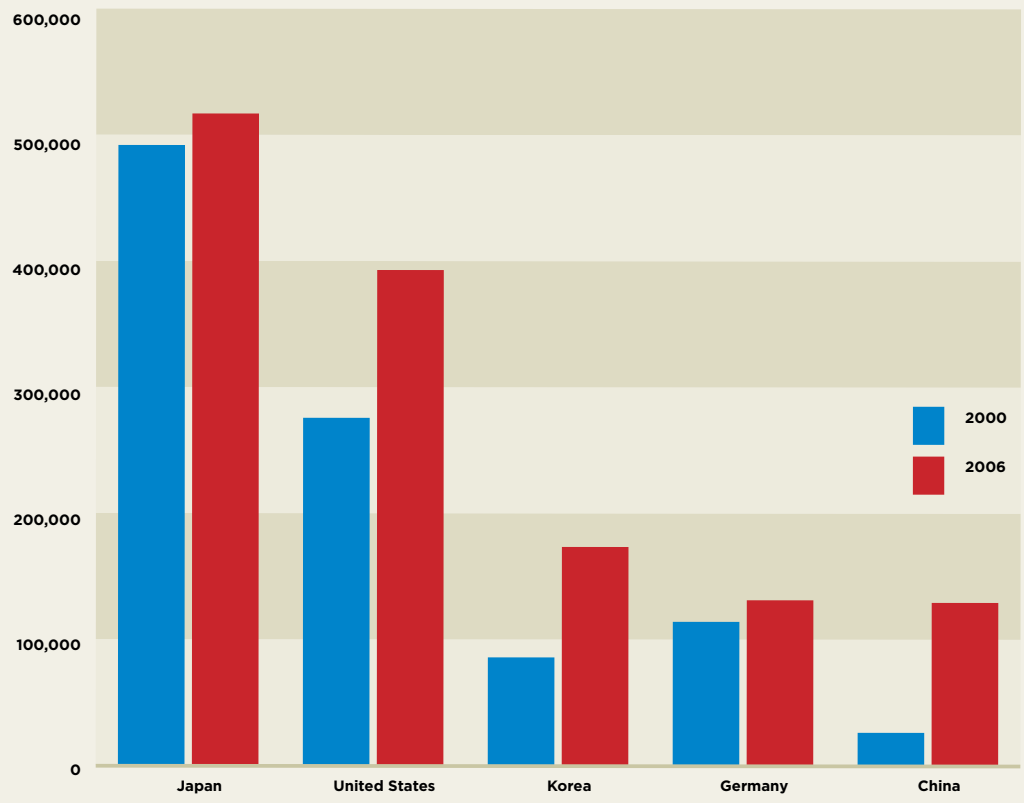

FIGURE 1: QUANTITY OF PATENT APPLICATIONS BY ECONOMY, 2000-2006
SOURCE: WORLD INTELLECTUAL PROPERTY ORGANIZATION STATISTICS DATABASE

worldwide in 2006, though its global share has been in decline. Still, emerging Asian economies have a long way to catch up in terms of patenting activity. China's 2006 total patent applications represent 7% of the global total, compared with 29% for Japan, 22% for the United States, and 10% for Korea.[10]

Patent application numbers tell an important but incomplete story. The number of citations a patent receives has been found to reflect both the technological and social value of a patent[11] and is also correlated with the estimated economic value of inventions.[12] A survey of the realized economic value of patents in Germany and the United States found that the top 10% of patents accounted for over 80% of economic value.[13] Overall, Asia is lagging the United States in the generality of patents, i.e. Asian patents on average receive citations in a narrower range of technological fields. The region also lags in the originality of patents, i.e. Asian patents include citations from a narrower range of technological fields, indicating that they are less likely to depart from traditional disciplines and become truly groundbreaking.[14] At the company level, the United States still dominates in terms of the frequency in which patents are being cited as a basis for other innovation (see Figure 2).

Nevertheless, some Asian companies have been clear frontrunners. Samsung tops the world's companies in terms of patent citations. Sony, LG, Honda, and Toyota are also among the top 10.[15] Other rising stars include India's Tata Motors, which invented the Nano Car. Taiwan's HTC manufactures the Google phone, which is the first smartphone to use Google's Android software, and is developing new open source-based smartphones as well as patented keypad technologies.

Among various industries, Asia accounts for the largest global share of patents in the electrical engineering field, with the most prolific economies in the region (including Japan, Korea, China, India, Singapore, and Taiwan) generating more than

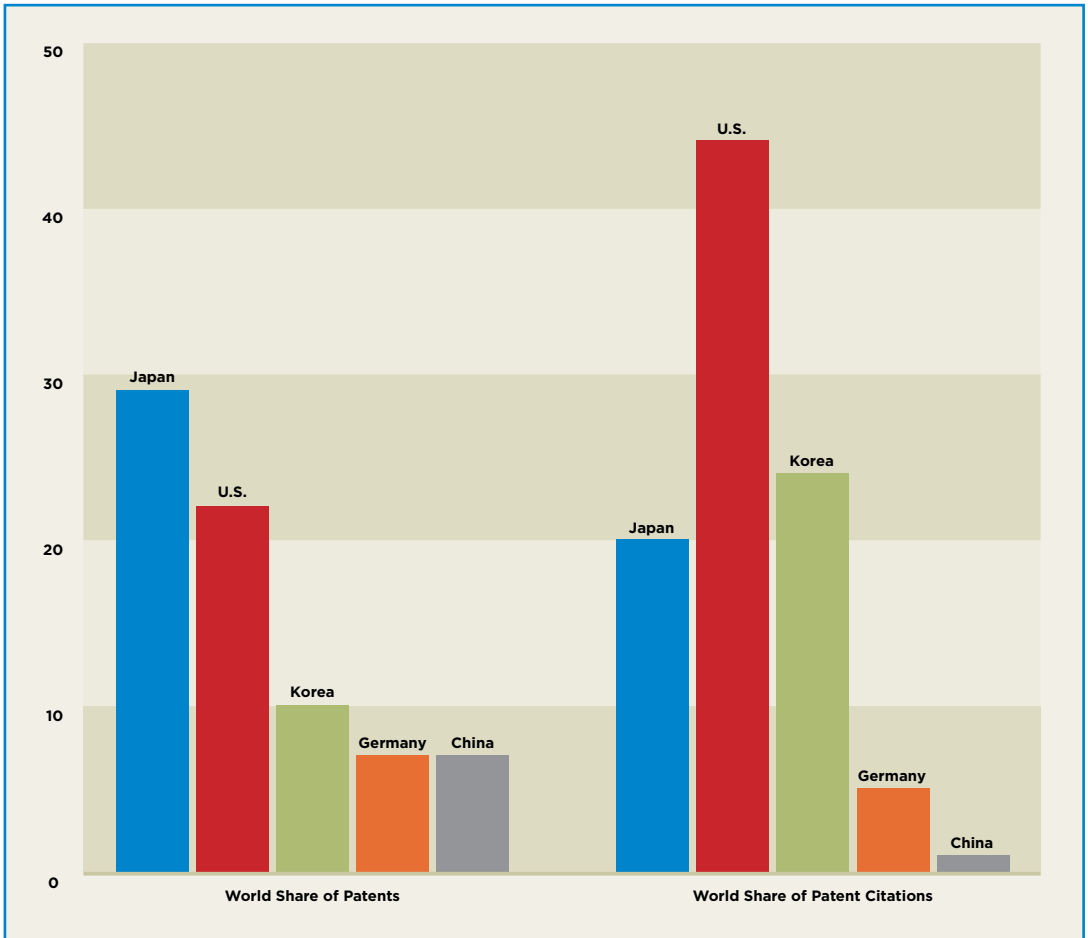

FIGURE 2: WORLD SHARE OF PATENTS AND PATENT CITATIONS BY ECONOMY, 2006 (%)
SOURCES: WORLD INTELLECTUAL PROPERTY ORGANIZATION; PATENT CITATION DATA FROM *BUSINESS WEEK*'S "THE WORLD'S 50 MOST INNOVATIVE COMPANIES" 2007; ASIA BUSINESS COUNCIL ANALYSIS

half of the world's patents in optics, audio-visual (AV) equipment, semiconductors, and computer technology.[16] Comparing individual economies using the RTA index analysis, China has a high concentration of patents in environmental technologies, agricultural technologies, food chemistry, and digital communications; India is specialized in pharmaceuticals, biotechnology, and medical instruments; Singapore has high patent RTA values in ICT and microstructural and nanotechnology; Japan in environmental technologies and optics/AV technologies; Korea in digital consumer products; and Taiwan in computer sciences and electronic engineering.

SCIENTIFIC PUBLICATIONS

Likewise, Asia's global share of scientific publications has increased rapidly, reflecting the emergence of Asian scientists on the global scene. Notably, China's number of published papers has grown from 3,700 in 1985 to nearly 80,000 papers in 2007. Korea and Taiwan also doubled their published scientific papers. Shares of the United States and Europe, on the other hand, have trended downward.[17]

A further measure of international recognition of the impact of scientific publications is the frequency of citations in a given subject area. In terms of recent citations from 2003 to 2007, Asia still lags behind the United States and Europe in the major scientific fields (see Figure 3).[18] The bright spot, however, is that international co-authorship of scientific publications, which reflects the extent to which Asian scientists are seen as credible authorities relative to their overseas counterparts, is on the rise. According to the National Science Foundation, major Asian economies saw increasing trends in their international co-authorship of science and engineering (S&E) articles between 1993 and 2003.[19] While the United States and Europe had the largest shares of co-authors, collaboration within Asian economies also rose. This growing intraregional

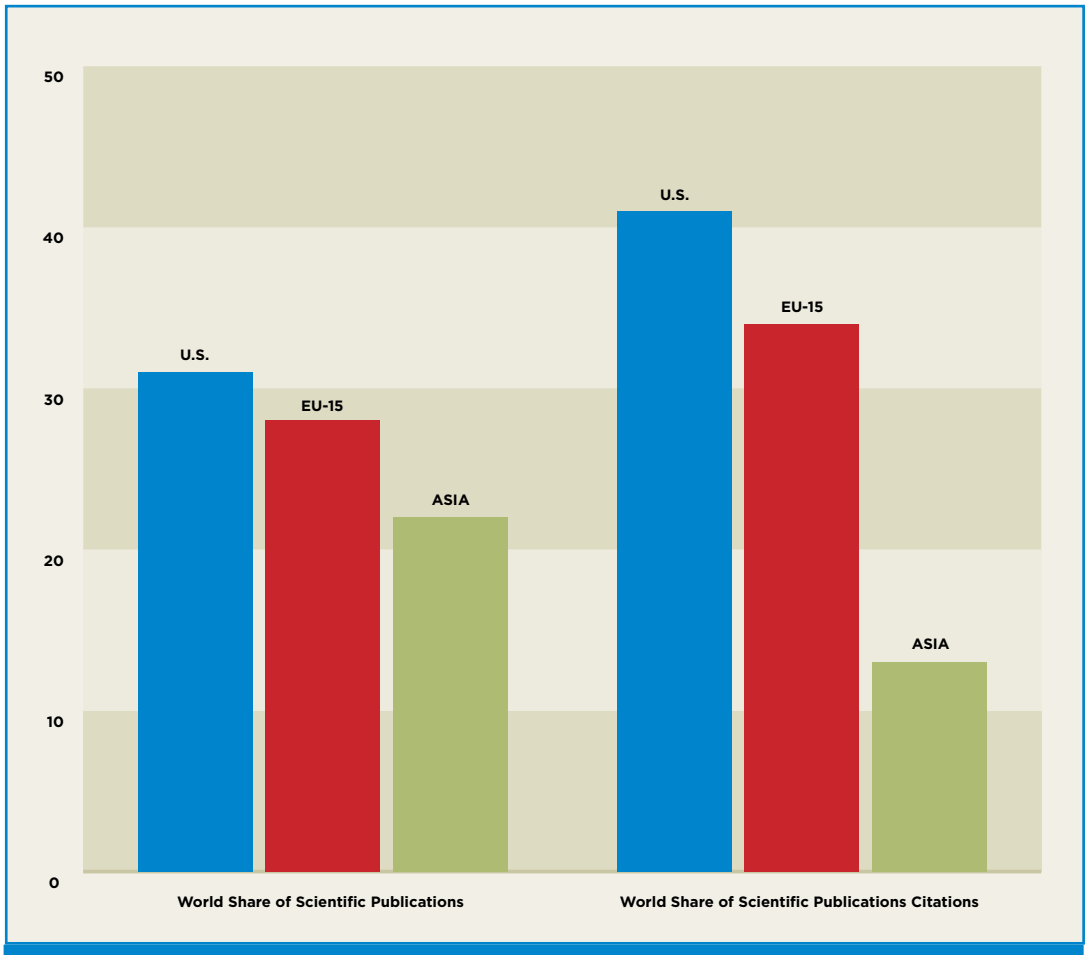

FIGURE 3: WORLD SHARE OF SCIENTIFIC PUBLICATIONS AND SCIENTIFIC PUBLICATION CITATIONS BY ECONOMY, 2007 OR LATEST YEAR (%)
SOURCES: THOMSON SCIENTIFIC *ESSENTIAL SCIENCE INDICATORS 2008*; ASIA BUSINESS COUNCIL ANALYSIS

collaboration of Asian scientists may well increase the influence of the region's scientific publications.

Among industries, Asia has been most prolific in scientific publications in physics, accounting for 37% of papers in that field in 2004, up from 21% in 1990. Engineering and materials science have seen similarly steep increases. In addition, Asian economies differ in their areas of specialization. According to the RTA index for scientific publications, China has concentrated in materials science, mathematics, physics, and chemistry, while India is specialized in materials science, agriculture, engineering, and pharmaceuticals. Singapore has high RTA values in computer sciences and engineering; Japan in chemistry, physics, pharmaceuticals and biotechnology; Korea in computer sciences, materials science, and pharmaceuticals; and Taiwan in computer sciences and engineering.

A combined analysis of the RTA indices for patents and scientific publications suggest several areas of strength within Asia of innovation output and fundamental research.

Results suggest that particularly promising industries for innovation in Asia include ICT; computers, IT, and electronics; pharmaceuticals and health biotechnology; environmental technology; and nanotechnology (see Figure 4). On the other hand, results also reveal some weaknesses. For instance, Asian economies have been relatively weak in mechanical engineering innovations such as transportation equipment (Japanese and Korean successes in autos being notable exceptions), capital equipment, and machinery. Despite government policies in the 1980s that strived to build domestic capabilities in related industries, the reality is that Asia still largely depends on imported equipment. Hence, previous fears that Japan or the Asian Tigers would overtake the West in those industries have turned out to be unfounded.

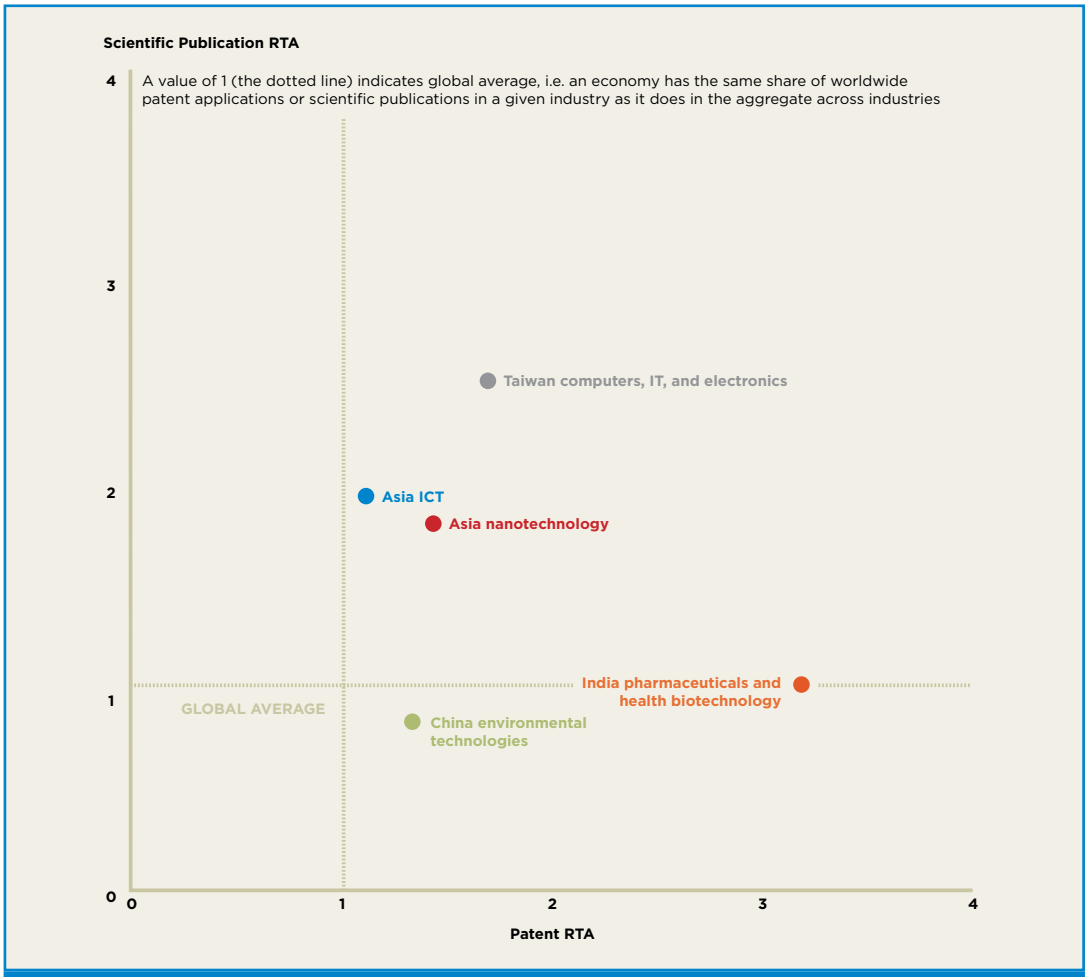

FIGURE 4: SCIENTIFIC PUBLICATION RTA VS. PATENT RTA (TOP ECONOMY/INDUSTRY COMBINATIONS)
SOURCES: WORLD INTELLECTUAL PROPERTY ORGANIZATION; TAIWAN INTELLECTUAL PROPERTY OFFICE; MAHMOOD AND SINGH; ASIA BUSINESS COUNCIL ANALYSIS

INDUSTRY CASE
COMPUTERS, IT, AND ELECTRONICS IN TAIWAN

Taiwan has built a cluster in computers, IT, and electronics, both generating patents and scientific publications as well as successfully commercializing products. Taiwan's main strength is that it created an innovative business approach based on existing technologies, which allowed it to succeed as a manufacturer. It then built R&D capabilities upon its large, low-cost manufacturing base and gradually shifted into low-cost design and services.

Taiwan did not develop innovative capabilities right from the beginning. Rather, the Taiwanese companies MiTAC and Acer rode on existing Windows and Intel platforms and developed the chassis computer that houses all the main computer components. Later, Taiwanese companies developed manufacturing capabilities for more upstream computers, peripherals, and foundries. The semiconductor foundry (allowing for fabless design houses) was a significant innovation by Taiwan Semiconductor Manufacturing Co. (TSMC) that changed the global industry. More recently, domestically developed products as diverse as netbooks and global positioning systems (GPS) have taken off.[i]

Government support in training human resources at the university level, specifically R&D talent, as well as its initial help in setting up the Hsinchu Science Park, were crucial in launching Taiwan's industry. Employee stock ownership and capital market flexibility also made the industry attractive to highly skilled workers. Tax incentives helped businesses accumulate capital for further innovation. These fundamentals in turn contributed to a reverse brain drain of Taiwanese educated in the United States who became entrepreneurs and innovators back home.

As Taiwan lacks a local market, future growth will be driven by overseas markets, from the established U.S. market to the large emerging Chinese market. Promising future innovations include backend content for portable, integrated client communications devices like mobile computers, office automation, and home entertainment that can be enjoyed anytime and anywhere.[ii]

Building globally recognized and marketable brands presents a simultaneous opportunity and challenge for Taiwan. There is a debate over whether Taiwan's future competitive edge will be driven more by stronger branding of its designs or by further expansion of its design capabilities for other global companies. What is clear, however, is that the customers of Taiwan's innovative products and designs will become more diverse. In order to become a truly global player in the industry, Taiwan must continue to upgrade its innovative capacity.

What Will Drive Future Innovations in Asia?

Current trends indicate that Asia will continue to grow its innovation output. On the technological supply side, Asia has a lot of catching up to do in terms of increasing the impact of its patents and scientific publications. Another key driving force of Asian innovation will likely be dictated by the demand from businesses and consumers, particularly those of China and India. The sheer size, growing purchasing power, and evolving needs of these markets will strongly influence the innovative direction of various industries. Export markets have typically determined success or failure. As Asia gets richer, domestic consumers will drive markets. That will likely become a virtuous circle, as companies can benefit from the home-field advantage: They are closer to their consumers, and they have stronger contacts with important players ranging from government officials to media.

The innovations that have gained widespread success in Asia so far reveal a number of key features that these new markets are looking for in terms of future innovations.

INTEGRATION OF MULTIPLE TECHNOLOGIES AND FUNCTIONS

Asia has succeeded in innovations that integrate different technologies and functions into small devices. An early example was the transistor radio that Sony produced and commercialized, which led to the pocket-sized Walkman cassette player. Taiwanese companies' ability to combine the separate components of PCs into chip sets and motherboards redefined the industry. As on-the-go Internet devices, Taiwan's netbooks have successfully integrated various features to meet the needs of mobile computing, including solid-state drives that are silent, sturdy, and fast, and the option of using the Linux operating system with OpenOffice.[20] Mobile phones with wireless Internet functions are also gaining popularity in China, combining users' location base, payment mechanism, and credit checking to enable e-commerce. The unique advantage of large emerging economies such as China is that consumer demand is skyrocketing and yet legacy systems and technologies are less of an impediment than in most developed economies. At the same time, Asian consumers have repeatedly proven to be open to innovative products.

INDUSTRY CASE
ICT IN ASIA

One of the most dramatic changes in the world economy over the past three decades has been the rise of Asia in the ICT industry, both in its global share of consumption and production. Singapore, Taiwan, China, Korea, and Japan have a large concentration of ICT-related patents, as reflected by the analysis of RTA indices for patents. However, the rise of ICT in Asia was by no means uniform, but rather resembles a "kaleidoscope" in terms of timing, sector composition, product types, and market segments.[iii] Korean, Taiwanese, and increasingly Chinese companies have created mobile handsets that have gained initial success in lower-end market segments, while the Japanese have advanced skills in designing, manufacturing, and marketing. Japan came up with parts and components for the Apple iPod, including the lithium battery from Sony and the 1.8-inch Toshiba hard drive.[iv] Most of the ICT companies in Taiwan, Japan, and Korea now outsource assembly operations to China and software and design services to India. The next stage of development for more mature economies will likely involve moving beyond ICT manufacturing and becoming a significant source of new designs and product categories.

Innovations in ICT technologies are set to transform life for populations in emerging Asia. Globalized information flows and technological platforms will enable leapfrogging of emerging economies over fixed telecom infrastructures; remote consumers will be brought into connectivity through mobile telecom and computing; and a dramatic rise in Internet usage in schools will give rise to a new generation of tech-savvy consumers and industry talent.

Innovations that cater to consumers' need for speed, flexibility, capacity, and portability all at the same time can therefore be introduced and adapted to the market. Another advantage to these integrated devices is that their manufacturing processes require multi-skilled workers who are familiar with intensive coordination in design and production. For manufacturing economies in emerging Asia, having a well-developed supply chain that produces these integrated devices will provide positive network effects that are not easily reproduced by overseas competitors.

AFFORDABILITY

As Asia's economies grow, Asian innovators will have increasing opportunities to serve domestic and regional markets. To date, we have seen examples of this in a variety of ICT technologies, ranging from ringtones to text-messaging to Korea's success with massive multiplayer online role-playing games. India's pharmaceutical industry, too, has used a large domestic market to develop innovative products that have found global markets. None of these concepts were invented in Asia. However, a combination of technological globalization, low-but-rising per capita incomes, and savvy, young, and demanding consumers and domestic enterprises are driving innovation in a way that wealthy consumers in developed economies, for whom existing products and services are designed, cannot.

VALUE CHAIN IMPROVEMENTS

Many Asian economies have excelled in innovations that led to direct improvement in existing manufacturing and business processes. While at the time not necessarily recognized as groundbreaking, these innovations have changed where profits are made in industries. Taiwan went from being an assembler of standard parts for U.S. brands (OEM), to designing products manufactured under foreign customers' brands (ODM), to selling under their own brand names, to developing and defining entirely new product categories. Japanese companies improved semiconductor technology and liquid crystal display (LCD) panels from the United States, developed more mature, branded technologies, and mass produced them for global markets.[21] Indian IT services firms calculated that processing work could be done remotely and were the first to roll out the offshore outsourcing model on a large scale. For instance, Infosys calculated that only 20% to 30% of software development work needed to be done in close proximity to the customer and the remaining 70% to 80% could be done remotely. The implementation of this new business model led to a global technology-enabled services revolution. Incremental changes to manufacturing equipment can also lead to dramatic productivity improvements.

INDUSTRY CASE
PHARMACEUTICALS AND HEALTH BIOTECHNOLOGY IN INDIA

India excels in generating patents in organic fine chemistry, pharmaceuticals, and biotechnology. While Indian scientific publications have been focused on other areas including agricultural science and materials science, health biotechnology is a fast-growing area, with the number of scientific publications growing from almost none in the early 1990s to 30 by 2002.[v]

India has risen in competitiveness of the pharmaceutical industry, growing from producers of cheap copycat, generic drugs to a contract manufacturing hub with significant higher manufacturing standards. India ranked fourth in the world in terms of pharmaceutical production volume in 2005.[vi] As of 2007, India had 75 manufacturing units approved by the U.S. Food and Drug Administration (FDA), the largest number outside the United States.[vii] Changes in India's patent law to comply with the World Trade Oganization's Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement that provided product patents to new drugs encouraged Indian companies to invest in R&D of drug discovery and biosimilars. The upcoming patent expiration in 2010 of $40 billion worth of patent-protected drugs provides opportunities for Indian companies to produce generic replacements, and the Associated Chambers of Commerce and Industry of India (ASSOCHAM) believes Indian companies will capture a third of the generic market.[viii] Multiple cities are vying to become hubs of pharmaceutical and health biotechnology excellence, including Hyderabad, Mumbai, Bangalore, Chennai, and Pune, all of which are establishing major facilities with a combination of investments from government, businesses, and overseas enterprises.

While India is just making its start and is a long way from becoming a global leader in biotechnology discoveries, the country has excelled in practical innovations in the area of pharmaceuticals. This is currently driven in part by entrepreneurs devising solutions for providing better-quality, low-cost health care to the broader population. The result has been specialized medical care institutions in areas ranging from cardiology to ophthalmology to diabetes, some of which are in the form of mobile clinics. These services have been marketed to developed-country medical tourists.[ix] In addition, increased international collaboration, especially with the United States and Britain, where India has strong business and diaspora connections, will likely speed up venture capital availability, skills circulation, and know-how transfer.

Policy Changes for Asia

What can Asian economies do in terms of policies to promote further innovation? Asia can focus on several key areas for improvement with the potential to drive innovation across various industries.

UPGRADE SCIENCE AND ENGINEERING TALENT

By the sheer number of its technical talent, Asia should be able to innovate. Altogether, the Asian education system produces the largest number of science and engineering graduates in the world each year. Asian universities produced 1.7 million out of the world's 4 million science and engineering first university degrees in 2004, with China, India, Japan, and Korea accounting for 1.3 million. By contrast, the United States produced 450,000, and the European Union 600,000.[22] But despite the numbers, the U.S. education system at the tertiary level still excels at training critical thinking and problem-solving skills.[23] A promising trend that could have future implications for Asia is the gradual change of student origin in science and engineering in the United States. Students from Asia earned more than 120,000, or 27%, of all science and engineering doctoral degrees awarded in the United States between 1985 and 2005.[24] China, Taiwan, Korea, and India accounted for more than 98,000 of these degree recipients. If these foreign-trained professionals can be attracted to work in Asia, they could have a large impact on innovative activity in the region.

In the past, emerging economies in Asia, notably China, built large, government-supported research structures. However, the quality of primary research output that these institutions produced has not gained worldwide recognition.[25] Japan, India, China, and Taiwan have produced a handful of Nobel laureates in scientific fields. Even though some of these scientists, engineers, and academics were affiliated with universities at home, most of them have worked abroad. Three-quarters of the Nobel science and Fields medal winners from Asia spent the formative years or substantial parts of their careers abroad, mostly in the United States. To some extent this phenomenon reflects the relatively stultifying environment of their home economies in Asia. Just as Nobel laureates do their best work outside of Asia, so too have many of Asia's most creative minds been able to flourish in Silicon Valley in a way that they could not in their home economies.

The future could be different due to the sheer number of students with opportunity to pursue higher education in science and engi-

INDUSTRY CASE
ENVIRONMENTAL TECHNOLOGIES IN CHINA

The worldwide push for renewable energy and environmental products, the acute environmental problems at home, as well as the need to develop new growth industries have led to a boom in environmental technologies in China. One clear advantage that China possesses compared to some developed countries is the speed with which the government is able to install new infrastructure and implement policies in support of these technologies.

Among various clean technologies, China has the largest capacity and market potential in wind energy. With the Chinese government's announcement of its goal to raise wind power capacity to 100 gigawatts by 2020—eight times its current level—China is on its way to becoming the world's largest market for wind energy. At the end of 2008, China already had the world's fourth-largest installed wind capacity behind the United States, Germany, and Spain, and the second-largest new capacity behind the United States. The government has set a 70% domestic component requirement to develop local industry. This means foreign companies will need to work with Chinese partners and transfer technology, which will likely give rise to additional domestic capabilities. In particular, China is attempting to build capabilities in large-size wind turbines and wind farms in order to yield economies of scale and enable easier grid infrastructure construction and demand management. China's largest electric transmission company, the State Grid Corporation, has announced plans to develop a nationwide smart grid by 2020. Although some of the technologies will be imported, China has already developed its own ultra high voltage (UHV) AC transmission lines, which allow heavy electricity flow with minimal energy losses.[x]

Other renewable energy sources hold promise. The solar industry currently exports over 95% of its solar panels to the United States and Europe. The need to reduce cost and improve efficiency is driving innovations in areas such as thin-film solar cells and integrated solar cells. While domestic installed capacity has remained small, China is pushing for stronger domestic industry development as it authorized its first solar thermal power station in suburban Beijing, designed by the Chinese Academy of Sciences, earlier this year.[xi] The government also subsidizes large projects with high installed solar capacity.

Electric and hybrid cars are another focus of innovation in China, given concerns over energy use and environmental pollution coupled with a dramatic increase in car demand. Private car ownership is expected to rise from 29 per 1,000 residents currently to 148 per 1,000 by 2020.[xii] A key barrier to market expansion is that electric cars are still expensive relative to other cars. The Ministry of Science and Technology has launched the "10 Cities, 1,000 Vehicles" plan, where city governments have committed to purchasing hybrid, electric, or fuel cell vehicles in order to encourage more widespread adoption of these vehicles. China also contains large lithium resources in Qinghai and Tibet for developing electric car batteries. Domestic battery company BYD has now partnered with Volkswagen, among other automakers, to develop hybrid and electric cars powered by lithium batteries and explore ways to lower battery costs.[xiii]

neering at home and abroad. Asian academics with global training and exposure could return to teach and conduct research, and overseas talent could return to Asia in search of opportunities to bring their ideas to fruition. Further efforts to cultivate and attract these "new Argonauts," who are overseas-educated, technically skilled entrepreneurs,[26] through developing a more receptive home country environment will help Asia build a more globally competitive talent base.

NURTURE AND PROMOTE LEARNING AND ENTREPRENEURIAL ORGANIZATIONS

Innovation is rarely produced in a closed environment by an individual, but rather, in an environment where ideas are discussed and debated, and where teams of people work together to understand the kinds of innovations that can best meet customer needs. Some of the most innovative companies in Asia have demonstrated the value of a "learning organization," where "it is the hierarchy of ideas that wins rather than the hierarchy of the corner office."[27] Second, organizations must create institutions and systems to collect ideas that come out of these discussions and debates and validate them, conduct pilots, and roll out successful innovations in a big way. Infosys in India, for instance, has software engineering and technology laboratories and a domain competency group, or specialist team, that serve this purpose.

The third key ingredient to innovation is to create incentives for people to contribute ideas. Every quarter, Infosys gives prizes to the top three ideas generated by various groups. Every year, six to nine ideas that have made a difference to customers on a company-wide basis are further rewarded.

Taiwan takes a different approach but nonetheless also de-emphasizes organizational hierarchy and encourages ownership and dissemination of ideas. Since the early days of the IT industry's rise, a stock bonus approach has allowed innovative companies to be 100% employee-owned. Companies tended to be small and entrepreneurial, more similar to a Silicon Valley start-up than elsewhere in Asia. Organizational structures were not hierarchical, but networked. The evolution of Acer's organizational structure has led to a "borderless" headquarters, where all decisions are made by senior management meeting in a variety of places or by videoconference. In other words, although Acer is a Taiwanese company, decisions are not made at the Taiwanese headquarters alone, but by offices around the world as well. Acer also pioneered an intra-entrepreneurial approach, spinning off companies like BenQ that went on to become independent, successful companies in the same industry.[28] Efforts along these lines to change organization structures in support of further innovation will likely be beneficial for Asia.

INDUSTRY CASE
NANOTECHNOLOGY IN ASIA

According to the RTA index for scientific publications, material sciences, physics, chemistry, and electronic engineering have been prolific areas for Asian economies. Japan, China, Singapore, Korea, and Taiwan have high volumes of patent applications in the nanotechnology field. Nanotechnology has applications in multiple domains. In particular, Korea and Taiwan are mostly focused on nanoelectronics, Singapore on nanobiotechnology, and China on nanomaterials.

Asian governments and venture businesses are assuming increasingly important roles in nanotechnology-based innovations and have laid the groundwork for commercialization through establishing world-class R&D infrastructure and human resources in the past several decades. Japan has been investing in nanoscience since the 1980s and is now ranked second only to the United States in terms of government investment. Korea, India, and China have also improved their national initiatives over the past years. However, nanotechnology investments involve high technological uncertainty and their effects are risky.[xiv] It is not clear what sort of system to support long-cycle innovation such as this would look like, but it will almost certainly mean significant government involvement.

Considering that nanotechnology may require more than 15 years of continuous investment to reach commercialization, public financing programs will not be able to provide sufficient funding. One solution is a system in which a different funding source is used in every stage of the growth cycle. Governments could encourage research, interactions among industries, venture businesses, and educational systems to finance the innovation industries through all stages, similar to what the United States has done with military technology spin-offs.

TARGET GOVERNMENT POLICIES TOWARD PROMISING AREAS FOR INNOVATION

Governments generally have an important role to play in fueling innovation. U.S. military spending helped spawn a range of inventions, ranging from semiconductors to the Internet. Taiwan's Industrial Technology Research Institute (ITRI) provided funding for a variety of basic research. The ideas and the talent germinated at ITRI nurtured the island's successful electronics manufacturing industry.

But the amount of government spending alone does not guarantee innovation success. Japan's fifth-generation computer project, to take just one example, benefited from government largesse yet was a failure. Indonesia's President B.J. Habibie invested significant sums of money in a failed attempt to build an aircraft manufacturing capability in the 1990s. Nor, apparently, is a large amount of spending necessary.

Many overarching areas of government policy, including education, human resources, and macroeconomic policies, can benefit technological as well as other areas of the economy. Various Asian governments have, in addition, pursued more targeted measures of innovation policy. Ultimately, Asian economies will likely settle on a level of government involvement that best reflects their histories, ideologies, and public wishes.

However, a number of measures have achieved successes in multiple economies and could be continued, including targeted tax incentives for R&D, the establishment of basic but high-risk science and technology infrastructure, and strategic collaboration of the public and private sectors.

The Indian government has provided fiscal incentives in the form of R&D tax credits or write-offs, which have incentivized Indian IT companies to pursue R&D activities.[29] These incentives have improved average growth rates for the industries that were targeted.[30] The Taiwanese government has also given tax credits for R&D activity and provided funding for new R&D projects.[31] Japan's government offers a flat 10% R&D tax credit, while Korea and Singapore offer tax holidays for R&D activities. All of these have attracted R&D investment by global corporations. While isolating the effectiveness of these tax incentives is difficult, firms and governments have reported increased spending and employment in R&D following these measures.

Beyond financial incentives, governments can also support innovation by providing critical infrastructure. However, in the success cases, governments only played a major role at an initial stage and subsequently let businesses take the front seat. For instance, Taiwan's ITRI has been a key contributor to infrastructure and talent for the IT industry. By 2000, 12,000 out of 15,000 profes-

sionals who had worked for ITRI had entered the high-tech sector in Taiwan, 5,000 of whom were employed in the Hsinchu Science Park.[32] ITRI was also the holder of many patents in the industry in the early days, some of which were shared with SMEs. In addition, four leading Taiwanese companies made up a science advisory council, while government brought ideas from abroad to help Taiwan formulate new legislation and incentive programs to attract more scientific talent. As infrastructure was formed, more trained professionals returned, contributing to a shift of Taiwan from a low-cost manufacturing hub to a low-cost design hub.

Korea's government has also played a facilitating role by sharing risk with private sector companies through government research institutes. Initially, the Korean government implemented explicit industrial policy to promote infant industries. Korea's domestic companies started as suppliers of Japanese and U.S. companies before internalizing and redeveloping technologies of their own.[33] However, it is important to note that the success of Korean consumer electronics in the late 1980s and early 1990s was no longer due to specific government capital investments (though capital costs for favored industries were low thanks to government policy, including control over bank management), but rather to companies' own heavy investment in R&D and global expansion efforts.

Apart from the success of Taiwan and to some extent India in integrating scientific research with patent generation in the IT and pharmaceutical industries respectively, joint efforts by governments and businesses to ensure that fundamental research is translated into private sector innovations have been uncoordinated for the most part. Closer collaboration between the government and private sector in strategic areas could allow innovative companies, institutes, and individuals to tap into the best resources of both. Scientific talent working in enterprise R&D has expanded, and self-funding of R&D in the business sector has increased rapidly in recent years throughout Asian economies. Yet the government remains a major source of R&D spending.

In China, for instance, enterprise funding contributes about 70% of R&D expenditures, a high share for an emerging market. Yet fewer than one-third of large and medium enterprises in China have their own research units. Currently, cooperation between the two sectors is limited, with only around 13% of all business R&D projects consisting of collaborative efforts with government research institutes or higher education institutions.[34]

In India, the government and industry have collaborated through the National Innovation Foundation to finance the Tata Nano Car and low-cost drugs for tuberculosis and psoriasis.[35] This kind of partnership could allow businesses to tap into the personnel and resources of government research and academic institutions and enable scientific research to translate into product testing and development.

However, these efforts must be market-led so that collaboration is focused on areas that achieve the most impact at the company and customer levels.

IMPROVE ACCESS TO FINANCE FOR NEW VENTURES

Finance is key for innovation. Although large companies typically have relatively easy access to finance, start-ups throughout much of Asia do not. Taiwan has the most generous funding environment for small firms; tellingly, it is the economy that seems to be the most innovative in many regards, and the one where a broad ecosystem for ICT products has developed.

Venture capital (VC) has played an increasingly important role in funding new technological ventures. Although government is a major source of early stage innovation funding in some economies, notably China and Singapore, venture capital firms play a crucial role in financing the next stage of growth, linking companies with suppliers, buyers, and additional investors. The venture capital industry in Asia has grown rapidly in recent years, but its ability to nurture innovation remains uncertain. In China, the venture capital industry has developed rapidly ever since the government realized the importance of venture capital in the late 1980s and established the first domestic VC company in Shenzhen. Yet there appear to be far fewer innovative start-ups than expected. The revision of company and partnership laws and regulatory insurance laws in 2007 has led to strong recent industry growth. Currently, China has more than 200 private equity and VC firms.

Venture capitalists need to be able to sell their successful investments. The ability to float initial public offerings (IPOs) is an important part of venture capital exit strategies. In the United States, Nasdaq has successfully launched many innovative companies including Microsoft, Apple, and Google. Korea (Kosdaq) and Japan (Mothers) have had some success with boards for smaller, younger companies. Taiwan-based Council members interviewed for this study pointed to the island's financial markets as key to nurturing innovation.

In China, IPOs on foreign markets account for more than 60% of VC exits.[36] This reflects China's repressed financial market; continuing tight controls over IPOs will dampen financial innovation. The recent announcement, after nearly a decade of discussion, that China will have a growth enterprise market (GEM) to list small companies could be a positive move.[37]

Conversely, loose regulation without adequate legal protection will discourage investors. Hong Kong's GEM board is generally considered to be a

failure. London's Alternative Investment Market (AIM) market has had mixed results.

Finding the right balance between risk and regulation is an elusive, shifting concept. The United States has a strong legal system; the threat of class action lawsuits, although sometimes abused, has served to keep corporate wrongdoing in check and given investors a degree of confidence that they do not generally enjoy in Asia. Regulations that better control the quality of listed companies, including information disclosure requirements, accounting rules, delisting standards, and mechanisms to protect investor interests will be key to the success of China's GEM and similar endeavors around Asia.

ENCOURAGE OPENNESS IN INTERNATIONAL TECHNOLOGICAL COLLABORATION

Some Asian governments are actively seeking to develop indigenous technological capabilities, with good reason. However, techno-nationalism, which is "the desire of Asian states to free themselves from dependence on Western technologies,"[38] may hinder innovative capacity if companies are discouraged from collaborating with competent partners abroad.

Innovation is not a zero-sum game. Innovations originating from one country or region often benefit both domestic and overseas users who are able to adopt them. In the United States, for instance, many players including financiers, entrepreneurs, marketers, and consumers, not just scientists and engineers, contribute to the market success of innovative products.[39] All of the IT industries of Japan, Korea, Taiwan, Singapore, India, and China that have succeeded in innovating have forged overseas ties in terms of trade, licensing, foreign investment, and talent circulation. Protectionism in innovation leading to any kind of discrimination toward foreign companies would not be productive.[40] Rather, innovation in the 21st century will require 21st century tools including management, technology, marketing, and branding, all of which contribute to genuine improvement in people's lives. Movement toward protectionist regimes, especially after the current financial crisis, would only be counterproductive in the longer term.

Recent national policies have also sought to pursue indigenous technological standards as alternatives to existing international standards. One example is China's pursuit of Wired Authentication and Privacy Infrastructure (WAPI), a domestically developed wireless LAN security standard. Despite the International Standards Organization's (ISO) rejection of WAPI as an international standard, China continued to push WAPI-compliant products aggressively at home as an alternative to products based on the internationally recognized Wi-Fi family of standards developed by Intel. This was broadly seen as a techno-nationalistic move that erected trade barriers. China subsequently submitted a revised standard to the ISO. But despite the Chinese government's claim that its code was more secure than Wi-Fi, the standard was still not recognized.[41]

Korea rolled out the Java-based Wireless Internet Platform for Interoperability (WIPI) standard for mobile phones in 2005, which helped streamline various domestic mobile application platforms. But while the standard was successful at home, it effectively kept the iPhone, the Blackberry, and other innovations from entering the market. Consumers failed to benefit, and the limited competition from strong international competitors gave less of a reason for the Korean mobile phone industry to continue with further innovation. The Korean government decided to drop the WIPI standard earlier this year.

Similar efforts of newcomers to set standards will likely become more prevalent in the future. An example is China's current push for its indigenous 3G mobile communications (TD-SCDMA) standard. Eventually, Asian economies, most likely China or India, may account for a high enough share of global demand in certain technologies and industries that regionally or nationally designed standards may gain international dominance. In the meantime, standard-setting policies that may be perceived as techno-nationalistic will likely face international challenges and hurt consumers. Rather, increased participation in international standard-setting organizations, compliance with WTO regulations, openness in technology, and the fostering of fair competition will help improve perceived legitimacy of domestically developed standards seeking to become international.

Indeed, Asian companies should not try to set standards prematurely, as there is more of a danger in pushing ahead too aggressively than in holding back. As an illustration of the way in which companies from small countries can play in the global game, look at the success of Ericsson and Nokia.

Who would have imagined that a Swedish and a Finnish company would be among the dominant global telecoms companies in 2009? And who would have imagined that the United States and Japan would have each failed in their attempts to set telecommunications standards for mobile phones? Yet the triumph of the GSM standard and the continuing success of Ericsson and Nokia are a reminder that innovative companies even from small, high-cost countries can play an outsize role on the world stage. The withdrawal of Japanese companies from handset manufacturing in particular and mobile telecommunications more generally is a sobering reminder that a protected domestic market may hurt, rather than help companies. The U.S. attempt to push a CDMA standard has not helped U.S. companies in the end; the last

U.S. handset maker, Motorola, is struggling for its corporate survival. Consumers have fared little better. Indeed, the overall level of service as well as mobile usage in the United States lags behind other developed countries.

STRENGTHEN IP PROTECTION

Finally, reinforcing IP protection facilitates technological collaboration and openness, reducing company and inventor concerns about products and ideas being stolen and commercialized.

At the moment, some companies in high-tech industries are still hesitant to send high-skilled work to emerging Asian economies. A major concern is that many products and designs produced in Asia are copied. The lack of adequate IP protection prevents both foreign investors and domestic inventors from commercializing their ideas. According to the U.S. House Committee on Small Business, counterfeit goods account for 15% to 20% of Chinese products manufactured in China. Almost 70% of the counterfeit goods seized at U.S. borders originate from China. These goods range from movies, software, to auto parts.[42] Japanese investors are concerned about China's regulations toward software rights and about soft architecture coming with imported hardware being copied.[43]

While Asia still has room for improvement in enforcing IP laws, many domestic governments and institutions have made strides in the right direction. In 2008, China issued an Outline of National Intellectual Property Rights Strategy aimed at promoting the creation and use of innovation, lowering the cost of IP enforcement, and raising the cost of IP infringement.[44] With an increasing number of collaboration projects with overseas universities and global corporations, and increasing economic value associated with commercialized innovations, many Asian economies will likely be taking even more proactive measures on this front.

Questions for Further Research

This study has offered an overview of a topic that is broad and complex, with profound implications for the region's future development. Some topics that could be further explored are as follows:

- comprehensive standards for measuring innovation (and ways to capture currently undocumented innovations at the company level);
- lessons from failures in Asian innovation;
- case studies of disruptive innovations in Asia;
- company-level studies of ways to systematically nurture innovation;
- economic impact of innovation on economies.

Endnotes

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