Chapter 3
Asian Research: The Role of Universities

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Introduction

The West, and most recently the USA, has provided the leadership in the scientific and technological revolution(s) of the last two centuries, and many expect that to continue. But there are new challenges to Western supremacy: (a) Perhaps the most newsworthy are those relating to national security—nuclear proliferation and Internet instability. (b) But also there is the possibility that the West and especially the USA may be slipping across the board relative specifically to new Asian players.

The popular version of recent trends is the Flat Earth perspective (Friedman 2005), that increasing amounts of US secondary S&T are being shipped offshore. Friedman argues that this trend was eased by the new globalizing reduction of trade barriers of the 1990s, but the Internet revolution of the late 1990s enabled a significant acceleration. GM has an India branch for its car design. IBM has major research laboratories in India, China, and Japan. Following on the export of secondary S&T, the new beneficiaries are projected to increase their capability in primary S&T. And thus the S&T world will become flat, or at least there will be a more equitable distribution of peaks and valleys in S&T across the more or less flat Earth.

An earlier version of this chapter was published as "Is the Academic Center Shifting to Asia?" in David Chapman, William Cummings, and Gerard Postiglione (Eds.), Crossing Borders in East Asian Higher Education. Springer, 2010, pp.47–76.

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A. Yonezawa et al. (eds.), *Emerging International Dimensions in East Asian Higher Education*, DOI 10.1007/978-94-017-8822-9_3,

While it may be that the Earth is becoming flat, the particular variant I wish to explore here is the tilting to Asia hypothesis.[1] For a variety of reasons, Asia is beginning to catch up on S&T—and if forward projections can be trusted, Asia could easily surpass the USA in 15 years. And as S&T wages in most parts of Asia are relatively modest, Asian S&T firms may be less inclined to offshore their R&D work. Thus, the research world may tilt upwards to Asia; Asian universities will play an important role in this transformation.

The Beginnings of Asian Higher Education

Before considering the Asia tilt, it will be useful to compare the structure of education and higher education systems. In comparative education, the classic debate focuses on the extent to which educational systems have become more similar or retain distinctive structural differences over the course of modernization/globalization. I think the evidence is overwhelmingly in favor of the differences position (Cummings 2003). Modern education was not created overnight in similar contexts but rather emerged over an extended historical period of 150 years in highly diverse ideological, political, and economic contexts. Thus, rather than a single form of modern education emerging, I argue that there are at least six distinctive models: the French, German, British, American, Japanese, and Soviet models.

These variants were planted in Asia from the mid-nineteenth to the mid-twentieth century—Japan-Korea-Taiwan followed the German-Japanese model, China the Russian, Vietnam-Laos-Cambodia the French, Singapore-Malaysia-Hong Kong-Australia the British, and the Philippines followed the American model. But the colonial era is long past; so to what extent are these legacies still impacting—and to what extent are there converging tendencies? We will keep these questions in mind as we look at recent Asian experience.

Japan is one Asian system that avoided colonial dominance, and it was the first to take major steps towards a distinctive higher education system. Within a few short years of the Meiji Restoration (1868), a new leadership emerged in Japan that declared its determination "to seek knowledge throughout the world" and to accept Western science at the same time as they reaffirmed Eastern morality (Bartholomew 1989). At first, the Japanese focus was on knowledge imitation. A new institute was established to translate foreign knowledge and other new institutes specialized in engineering, shipbuilding, armaments, and other technological areas; subsequently several were consolidated in Tokyo University, which was in 1886 rechristened as the first Imperial University. Over the next decades, numerous

[1] An alternate scenario is, according to the OECD, Education at a Glance 2005, that there may be a current tilt towards Europe. European OECD countries aspire to pass the USA. But the European tilt is nowhere near as prominent at the Asia tilt, at least in a number of indicators we will discuss.

other public and private higher educational institutions were founded, most with a focus on Western science, technology, law, and languages. By the 1920s, increasing emphasis was placed on knowledge innovation, and from the 1970s Japan began to place a stronger emphasis on knowledge creation (Cummings 1990). Some of the themes underlying this shift were drawn from the West and especially from the USA. But as will be argued below, Japan has also fostered some new strategic directions (Kodama 1991).

Over time and especially over the past three decades, other Asian societies have, like Japan, taken bold steps to accelerate the processes of knowledge innovation and creation. Korea, Taiwan, and Singapore are most notable for their bold steps over the past decade or so, but the trend is evident throughout the region. Each nation faces its unique set of opportunities and obstacles that we also acknowledge. One obstacle frequently cited is the supposed Western and especially US dominance of global knowledge production, so, according to this view, the West usually makes discoveries first and similarly is more efficient in translating its basic discoveries into applications; thus, Asia is said to be locked in a peripheral or semi-core position in the global knowledge production (Altbach and Umakoshi 2004; Marginson 2004). While recognizing the obstacles, we will argue that the region has much more potential than is generally appreciated—investment, talent, unique biosphere, humanistic objectives, and a collaborative spirit—and an impressive array of recent accomplishments. This suggests the prospect that the Asian region may be emerging as a new powerhouse of knowledge production.

The Context

Before considering recent trends in development strategies, it will be useful to highlight several relevant characteristics of the region:

A Rich and Distinctive Intellectual Tradition

The Asian region is both the sight of some of world's greatest civilizations that have in past times added immensely to the world's stock of knowledge and of some of the world's most primitive peoples. India has given birth to the great religions and philosophies of Hinduism and Buddhism that include profound insights into the nature of the cosmos, and China is the home of the Confucian political and social philosophy as well as an extraordinary tradition of scientific and technological discovery that superceded the accomplishments of the West at least through the sixteenth century (Needham 1956).

The strong intellectual traditions of these two civilizations provide an important part of the base for contemporary developments. As Shigeru Nakayama (1984) observes, Asia in these early times developed a distinct mode of inquiry, the documentary tradition, which stands in sharp contrast to the Western rhetorical tradition. The documentary tradition trains the mind to build a strong foundation in basic principles, to carefully assemble all of the relevant information, and to take small first steps in discovery as the foundation for a later stage of boldness. The subsequent exposure to Western modes of inquiry complemented the Asian documentary tradition.

Colonialism Stunted the Development of Educational Development and Knowledge Production

Whereas major civilizations and large societies prevailed in India and China, in other parts of the Asian region, notably Oceania and to a lesser degree in the areas now known as the Philippines and Indonesia, human settlement was sparse, social organization simpler, and the practices of writing and recording very limited. For example, the major empires of Indonesia and mainland Southeast Asia largely borrowed their social and political theories from the cultures of India and China.

The cultural and scientific development of much of the Asian region was punctuated by the arrival of Western colonizers and settlers who set about introducing a new layer of externally oriented institutions on old societies. The primary focus of the Western invaders was on the exploitation of agriculture—silk from China, tea from India, and spices from Polynesia and Micronesia.

In order to advance these extractive goals, the colonizers and pioneers set up minimal educational systems leading in most cases to a handful of higher educational institutions focused primarily on law and the humanities, fields believed appropriate for the development of civil servants. In some locations, fledgling institutes for the study of agriculture and the biosphere were also begun—e.g., raffles initiated the Botanical Gardens of Bogor—but in general knowledge production was not given much consideration.

Asian States Treasure Their Autonomy

With the conclusion of World War II, the colonial powers began to depart from the Asian region and there ensued a period of political consolidation. The Maoist victory in China was the first step with the Kuomintang government exiting to Taiwan. From the early 1950s, nationalist guerillas in Indo-China began to mount their struggle against the French and later against the Americans.

The process of state formation led to the emergence of societies that varied widely in terms of ethnic-cultural diversity. For example, India and Indonesia both include many religious and national ethnic groups, whereas Japan and Korea are more homogeneous. In between are nations such as Thailand and Malaysia that favor one group by stressing the cultural assimilation of their minority groups. Occasionally the cultural differences within particular Asian nations become a source of conflict as in the recent protest of the Muslim minority in Southern Thailand. When domestic tensions appear in an Asian nation, most Asian nations view this as an internal matter and restrict their criticism. Myanmar's neighbors have tolerated its repressive system for decades without exerting notable pressure for reform.

During the late 1950s and early 1960s, tensions flared between Indonesia and its neighbors, and Malaysia also experienced a communist incursion. Thus, the region has experienced considerable tension and periodic conflict. As most of the Asian states have, in relatively recent times, had to defend their boundaries against outside incursions, they are wary of foreign penetration.

This wariness about foreign political penetration extends to Asian views on foreign economic penetration. Most of the states of the region have a history of setting up barriers to unwanted penetration of their economies by foreign investment or imports. While South Korea accepted large loans from the World Bank in the early decades of its development, it later placed high priority on closing these loans out and observing clear limits on foreign indebtedness (Stallings 1990). China until recently did not accept World Bank loans or foreign investment; while China's policy has seemingly radically changed over the past decade, it is nevertheless the case that Chinese firms usually maintain a controlling interest in partnerships that involve foreign investment. Looking across the Asian landscape, perhaps only Indonesia has allowed itself to be seriously overexposed by foreign investment.

Asian States Place a High Priority on Economic and Social Development

Partly as a result of the postcolonial history of political struggle, many of the Asian nations emerged with strong states that were accustomed to making the major decisions on the future directions for national development. Some observers refer to the Asian pattern of politico-economic organization as the Development State (Johnson 1982), implying strong leaders, a single party, a high commitment to economic development, and a minimal commitment to democracy. While it cannot be said that the structure of the Asia Development State provides the explanation, it nevertheless is noteworthy that several of the Asian countries have been exceptionally successful in promoting economic development with equity. A World Bank study (1992) highlighted the success of Korea, Taiwan, Singapore, and Hong Kong referring to these as "miracle" economies. The study also suggested that China, Indonesia, Thailand, and Malaysia were near miracles. Since that time, Vietnam has begun to show promise, as have parts of India.

Overtime, several of the Asian states have become more politically inclusive, though usually within a framework of firm political leadership focused on economic development. Increasingly, these states have beamed in on knowledge production as an important key towards furthering national development. Of course, the differences in context outlined above have influenced the respective approaches to knowledge production.

Asian States View Human Resources as the Foundation of Development

Most Asian states recognize the importance of a well-educated population for the realization of development goals and thus stress universal basic education of high quality with considerable opportunities for further education up through graduate studies. In most Asian school curriculums, science and mathematics are featured from the earliest grades, and as demonstrated repeatedly in international studies of academic achievement, Asian young people do exceptionally well; for example, in the Third International Mathematics and Science Achievement Survey, the average achievement scores of young people from Singapore, Korea, Japan, Hong Kong, and China were ranked at the very top among some 40 countries (IEA in NSB 2004, pp. 1–13). Similarly, Korean, Hong Kong, and Japanese youth were at the top in the 2009 PISA surveys of learning in reading and math (OECD 2010). Science and math are featured in the secondary and tertiary levels of Asian education with the result that China, India, and Japan graduate a larger number of first-degree holders in science and engineering than does the United States or Russia, not to speak of the Western European countries. The strong foundation in human resources means that the Asian research and development enterprises have a substantial reserve of candidates when they seek to staff new entities.

Asian States Vary in Their Development Priorities

Virtually all of the Asian nations place a high priority on self-sufficiency and thus have, at least in the past, placed much emphasis on improving the quality and efficiency of their agricultural production. Several nations continue to emphasize agricultural exports as a major component of their national revenues. However, many Asian states have high population densities and labor costs which strain their potential for further gains in agricultural productivity, and thus they have elected to emphasize manufacturing and the services as current and future areas of economic growth. With the stress on manufacturing and service, each nation has choices concerning particular industries to emphasize and whether the focus should be on world-class cutting-edge products or the more efficient production of familiar products. The respective choices have clear implications for national science and technology policies (Low et al. 1999).

Defense-Related Knowledge Production Is Not a Priority

While the region has a history of conflict, especially over the past two decades the level of conflict has considerably subsided. Regional tranquility has been realized, at least in part, because of regional dialogues fostered by organizations such as ASEAN, APEC, and ESCAFE. Thanks to regional tranquility, most Asian regions devote relatively modest amounts of their national budgets to defense budgets as well as to defense-related research and development. Whereas in the USA and Western Europe, upwards of one-third of a nation's R&D expenditures might focus on defense, the typical proportion in the Asian region is one-tenth, leaving much greater scope for commercial and academic R&D.

The Scale of Asian Nations Varies

Asian nations vary immensely in geographic scale from massive China and Australia on the one hand to tiny Singapore on the other. Of even greater importance for the execution of research and development programs is the wide difference in demographic scale: Without a critical density of researchers in a particular area of inquiry, it is difficult for a nation, on its own, to foster major discoveries in research and development. To a certain degree, a high allocation of resources can compensate for small scale as is demonstrated by Finland and Switzerland and in the Asian region possibly by Singapore. Also, small scale leads a nation to buy brains (expatriate researchers) and ideas (technology licensing) alongside energetic efforts at homegrown science and technology. Even so, large nations such as China and India have a natural advantage, as the sheer human scale of their research and development enterprise enhances the probability of identifying native talent and nurturing homegrown discoveries.

New Focus on Knowledge Creation

For most of the past century, knowledge production was centered in the West, and other regions of the world including the Asian region sought to draw on Western knowledge to catch up. Into the 1970s, this strategy was clearly evident even in the case of Japan, the region's most technologically advanced society. For example, Japan's early successes in textiles, steel, automobiles, and electrical and electronic goods were largely based on the application and refinement of imported technology.

However, from at least the late 1960s, Japanese policymakers came to recognize that Japan was pressing on the upper edge of imported technology utilization and thus that the future prospect for low-cost borrowing technology was bleak. Thus, it would be necessary for Japan to place increasing emphasis on the autonomous development of technology. Just as Japan began to make this policy shift, over the next two decades, other Asian nations came to the same conclusion: Korea and Taiwan in the mid-1980s and Singapore, Malaysia, and Australia in the early 1990s. An example is Malaysia's vision 20–20 (Sarji 1993) which, among other innovative concepts, proposes the development of a new information highway and to that end a range of new programs aimed at fostering a homegrown creation of a wide range of information technologies.

The new focus on knowledge creation is accompanied by increased funding for research and development. Whereas in the 1960s, Japan was devoting only about 1 % of its GDP to R&D, this was doubled by the early 1980s and has continued to rise since then. In 2007, it was 3.4 % or 4th in the world. In that same year, the average expenditure for R&D of EU countries was 2.3 %, and that in the USA was 2.7 %. Among other countries in the Asian region, Korea's expenditure for R&D had risen to 3.5 %, Singapore to 2.6 %, Taiwan to 2.6 % (only civilian R&D), and Australia to 2.0 %. Several other countries in the region devote upwards of 1 % to research and development (NSB 2010, pp. 4–34).

The Purpose of Science and Technology

From the earliest days of Japan's Meiji era (1868–1912), increased knowledge of Western science was seen as a means towards increasing national strength in the face of possible Western domination. Japan, avoiding colonization, rapidly became a significant world power and increasingly an aggressive one taking on China in 1894 and tsarist Russia in 1904. While Japan assumed a minor role in World War I, in the ensuing years, it declared a Greater East Asia Prosperity Sphere and proceeded to conquer much of East and Southeast Asia. Science including academic science was mobilized for Japan's militaristic expansion, but this aggressive push was ultimately concluded by a science-based response: the horrific bombings of Hiroshima and Nagasaki leading to Japan's unconditional surrender. With Japan's defeat, the Japanese people concluded and wrote into their new constitution that they wished to have no more involvement in war. And Japan's academic establishment expressed its shame that it had contributed to the wartime effort. Hence, for the future Japan declared that science should be for peace and not war, for the people and not the leaders.

Out of this sober reflection, Japan began to envision a new role for science involving not only the economic prosperity of the nation but also the improvement of the natural and social environment (Nakayama 1991). This vision has been reflected in the subsequent development of Japanese science and technology policy. Official descriptions of Japanese science and technology policy are notable for their humanistic emphasis on such topics as environmental preservation, improving the quality of urban life, and creating a more comfortable setting for older people.[2] The allocations of government S&T resources by purpose in Japan place far less emphasis on defense-oriented science than does the USA or the UK and far more on other areas such as energy, industrial applications, planning of land use, and university research (the funds in the general university funds and nonoriented research categories). The allocations in S. Korea, the only other Asian nation for which comparable data is available, tend to follow the same pattern as Japan—relatively small allocations on defense, more on civilian priorities (including agriculture and land use) and university research (Hicks 2001).

A Distinctive Strategy or Strategies for Knowledge Creation

While science and technology have played a major role in the development of nations for several centuries, it is only after World War II that the major industrial nations, led by the United States, began to develop coherent science and technology policies. Vannevar Bush, then President of MIT and science advisor to the President of the United States, observed that

> . . ...there is a perverse law governing research: Under the pressure for immediate results, and unless deliberate policies are set up to guard against this, *applied research inevitably drives out pure*.

The moral is clear: It is pure research which deserves and requires special protection and specially assured support (Bush 1945, p. 83).

Bush and his colleagues depicted a *linear model of knowledge production* with basic research as the foundation generating fundamental breakthroughs that would foster applications that could then be developed into new products and services. One outcome in the USA was the establishment of the National Science Foundation and the National Institute of Health as federal government sources for basic research funds that distribute these funds to capable scientists on the basis of peer-reviewed evaluations of their research proposals. In the years that were to follow, basic science was strengthened in the USA, especially in the top strata of higher educational institutions that came to be known as research universities. Additionally, the US federal government came to play a prominent role in the support of applied and development research in laboratories of private industrial firms. Thus, the science and technology model pioneered by the USA stressed strong support for basic research and a substantial role for the federal government in the support of both basic and applied research.

[2] As noted below, public funding of research is substantial in all countries tending to average about one-third of all funding, but the government's proportion of funding is largest in the USA primarily due to the US government's substantial commitments for defense-related research. Government's share is somewhat less in the Asian region.

While the US model was able to leapfrog American science into a leadership position in basic science in the postwar period, few other governments had an equivalent level of resources for the actual funding of research. Rather in other settings, the government decided to limit its role to serving primarily as a facilitator of research through providing information and offering tax and tariff incentives while looking to other sources, notably the private sector for funding. This pattern was particularly noticeable in Japan and since then in many of the other Asian nations. For example, whereas in the USA in 1985 nearly 40 % of all research and development was supported by the federal government, the Japanese government only funded 22 % of all Japanese R&D. Over the last two decades, there has been a modest convergence with the US government's share of funding decreasing to 35 % and the Japanese government's share increasing to 25 %. But the basic contrast persists. The Japanese pattern of a greater reliance on commercially funded research is also found in Korea, Taiwan, and Singapore.

The Asian emphasis on applied research and a larger role for the commercial sector in research and development implies a distinctive approach, sometimes referred to as the *interactive model of knowledge production*. In the interactive model, each sector has a substantial role in research and development, and, moreover, each sector devotes at least some effort to all phases of the R&D continuum from basic to developmental research. Also, whereas the linear model assumes that basic research is the source of new research directions, in the interactive model it is acknowledged that important new research directions may be suggested as researchers discover shortcomings in their applied and developmental research. Rather than a unilinear conception of the R&D endeavor, the interactive model makes no assumptions about directionality (Kimura 1995).

The Role of the Universities

Depending on the model, the role of the university differs. In the linear model, the university has a prominent role in basic research and human resource development. Because of the university's considerable funding for basic research, it is able to employ a large army of research assistants to facilitate the research mission. Because of the generous research funding, the university is able to recruit this assistance from around the world and thus is not so dependent on its own efforts for human resource development (Postiglione 1997).

In the interactive model that tends to characterize the approach of several Asian settings, the university shares the responsibility for basic research with the other sectors and thus has relatively less funds to support research and recruit research assistants. However, the universities, especially those in the public sector, have a critical role in the development of human resources for the other sectors. The overall levels of access to higher education are higher than in other regions of the world (NSB 2004, pp. 1–46), and for those young people pursuing higher education, the 1st and 2nd degree training is heavily skewed to science and engineering. For example, in Japan and Korea's public sector, approximately 40 % of all first degrees are in science and engineering. In China, over 50 % are in these fields. By virtue of this S&E emphasis, the university systems of Japan, Korea, and Taiwan each graduate a larger proportion of their college age cohort in the natural sciences and engineering than does the USA (NSB, pp. 2–39). In terms of the total number of first-degree S&E graduates, China, Japan, and India produce about the same number annually as does the USA with Korea not far behind.

Recent Efforts to Stimulate Creative Research in the Academy and Elsewhere

In the interactive model, universities share many research functions with other sectors. But especially in recent years, steps have been taken to improve the research environment, especially at the universities:

- *Increased funding for research, including basic research.* As indicated above, most of the Asian nations are steadily increasing the resources they are devoting to research and development. Parallel with the overall increase in R&D funds, increasing resources are being channeled to the academic sector.
- *Science cities with universities as the core.* In the mid-1970s following on Russian and American models, Japan launched Tsukuba Science City as its first science city. The new and well-funded Tsukuba University was placed in the center of the city, and many government laboratories were moved to this new site. Tax incentives were set up to encourage industrial firms to locate there. Similar developments followed with the relocation of Osaka University and the upgrading of Tohoku University and Kyushu University. Taiwan has established several new science cities, and Singapore has established a Science Park adjacent to the National University of Singapore.
- *Greater autonomy for the universities.* In the imitation and innovation phases of higher educational development, leading public universities in the Asian regions tended to be outposts of national policy and subject to extensive regulation by national authorities. With the new push for creativity, the pervasive public regulations including line-item budgets have come to be perceived as obstacles. To erase the bureaucratic feel of these universities, the Japanese, Thai, and Indonesian governments have sought to make universities autonomous statutory authorities with "full" authority over their resources and operations. These initiatives are being carefully followed by other nations in the region.
- *Ranking universities and/or ranking academic units.* With the shift to greater university autonomy, Asian governments have begun the search for new criteria on which to base public allocations to universities. One possibility is to rank universities and to distribute funds through block grants adjusted by ranking (and other criteria such as total number of students or faculty). China several years ago spoke of focusing central funding on the top 100 universities. In 2001,

Minister Aoyama of Japan spoke of focusing funding on the top 25 Japanese universities. In fact, no government has actually implemented these proposals. However, a related principle has been to rank the component units of the many universities in a system and use these unit rankings for preferential funding. Over the past several years, Japan has experimented along these lines with its "Centers of Excellence" program.

- *Peer review of research proposals*. In the state-regulated university, it was customary to allocate research funds on an equal basis to each academic unit regardless of their productivity or potential. A "new" approach is to require those units and individual professors who desire research funds to prepare a research proposal for anonymous review by a committee of peers. This approach is presumed to elicit more careful development of research programs and to channel funds to those researchers most likely to realize innovative results.
- *Increased support of large- and medium-scale projects of longer duration*. When research funds were limited, there was a tendency to annually distribute small allocations across the university system. As units could expect to get the same modest amount year after year, this approach did facilitate multiyear research agendas. In keeping with the modest funding, these agendas tended to focus on small problems. But in recent years, R&D policymakers have come to understand that big research breakthroughs require big efforts. Thus, in several of the Asian systems, new funding opportunities are emerging which encourage large ambitious multiyear projects. In some instances, these are awarded to individuals or groups who work in the conventional academic units. Parallel to these conventional awards, many new and generously funded research institutes are also being established.
- *Trial periods for prospective researchers*. In many Asian systems, universities were inclined to recruit new staff from among the top students of their recent graduating classes and in keeping with the spirit of "civil service" appointments to offer these new employees the equivalent of lifetime tenure. While this personnel policy guaranteed the loyalty of new recruits, it did not always result in the best choices. As many candles burned out as continued to shine brightly. Recognizing the weight of deadwood, many systems (or particular universities within the respective systems) have introduced a trial period for initial appointments.
- *Efforts to reclaim drained brains*. Asian universities "lose" many graduates to the research and development entities of the USA and Western Europe (NSB 2010, pp. 3–52). The quality of first-degree training in Asian universities, especially in the sciences and engineering at the top-ranked universities, is quite high. Thus, graduates from these institutions tend to be successful when they apply for graduate education in the West. And many who complete graduate education in the West tend to stay on for postdoctoral and other employment opportunities. China and India are numerically the largest suppliers of foreign talent to the knowledge industries of the West, though not an inconsiderable number of young knowledge workers migrate from other Asian countries such as Japan, Korea, Malaysia, and Singapore. But in recent years as the research

conditions in the Asian region improve, this trend may be changing. There is evidence that more Asian students are electing to stay home for graduate studies and postdoctoral opportunities. After two decades of steady growth in the number of Chinese young people seeking overseas graduate education, their numbers appear to be leveling off since 2001.

- *Opening the doors to foreign talent*. Additionally, Asian universities are experiencing greater success in recruiting foreign students for their graduate school and postgraduate fellowship opportunities. For example, in Japan in 2001, foreign students make up 8 % of all Japanese graduate student enrollments in engineering, 10 % in the natural sciences, and 20 % in the social sciences (NSB 2004, pp. 2–38). Asian universities, especially those in the smaller countries that have limited indigenous pools of knowledge workers, are increasing their efforts to attract established professionals from other countries. Most Japanese and Korean universities now have numerous positions available for overseas visiting professors and researchers, and in Singapore higher education institutions advertise internationally for virtually every academic opening. According to one study, Japan in 1999 attracted 240,936 high-skill immigrants, an increase of 75 % over the 1992 figure (Fuess 2001). Singapore has been able to attract many outstanding researchers to its laboratories including recently a noted biochemist who is a Nobel laureate.

Asian Science and Technology Is Gaining International Prominence

The Asian region's new commitment to research and development is beginning to show results. The most obvious indications are in the application of science and technology for commercial purposes:

- Asian countries, most notably Japan and Korea, have steadily increased their numbers of domestic patents over the past two decades as well as their applications for patents in foreign markets.
- Asian countries, especially Japan, Korea, and China, have shifted substantial proportions of their industrial production towards high-tech products. Currently, Korea reports a higher proportion of its industrial production is in high-tech areas than is the case for the USA.
- Asian nations are also beginning to increase their share of high-tech production in the service industries, a market formally monopolized by the USA.
- Finally, over the past two decades, China and the Asia 9 (Korea, Malaysia, Singapore, Taiwan, India, Indonesia, the Philippines, Thailand, and Vietnam) have been expanding their share of the global market for high-tech products. This combination of countries was supplying less than 8 % of global high-technology exports in 1980 compared to 30 % for the USA. By 2008, China

and Asia 9's share had increased to 48 % and the USA share had dropped to 14 %. During this period, Japan's share dropped from 25 to 8 %.

Asian knowledge products, it is often said, are based on foreign technology, but as noted above Asia in recent years has an impressive record in the indigenous development of patents. Japan currently generates twice as much in revenue from the sale of its patents to foreign entities as it spends on the acquisition of foreign technology, and the balance sheets for Korea and Taiwan are about equal.

Related to the emerging strength of the Asian region in knowledge products is the parallel emergence of a more active and creative academy. One illustration of this new creativity is the increasing prominence of articles written by Asian scholars in internationally refereed journals. Focusing on articles in the science and engineering fields, both Japan and Other Asian nations have experienced rapid gains in their number of referred articles over the past 20 years, a doubling in the case of Japan and a quadrupling in the case of other Asian nations. By way of comparison, the volume of articles written by US researchers has been stable over this 20-year period, and the volume written by Western European scholars has increased about 65 %. As a result, in 2007, Japanese scholars alone were publishing 7 % of the world's total, China (including Hong Kong) 7.5 %, and the rest of Asia an additional 7.3 %. While the Asian region total of 22 % is less than the US share of 27.7 %, the Asian proportion has steadily gained in recent years and shows every sign of maintaining that trajectory. While growth in Japan and Korea may slow down, other countries in the region are likely to surge forward.

A noticeable trend in recent scientific publications is the tendency for articles to have multiple authors reflecting collaboration in research projects. Much of the collaboration is between researchers in the same country, but in 2001 the percentage of article coauthored by researchers in two or more countries had risen to 33 % (NSB 2004, pp. 5–47). One factor influencing cross-national coauthorship is the location of graduate study; young researchers who have studied in another country are likely to coauthor with their former professors. Given the numerical prominence of the USA in graduate education, nearly half of the world's coauthored articles involve a US author. However, over the period of 1988–2001, the number of coauthored articles with an Asian author steadily increased. Of special interest is an apparent trend for an increasing proportion of cross-nationally coauthored articles with an Asian partner to involve another Asian partner, while the proportion with a Western coauthor has remained stable (NSB 2004, pp. 5–48). This implies that a new Asian science community may be emerging. It might be noted that bodies such as UNESCO and ASEAN are devoting substantial resources to foster this very outcome.

An indication of the relative prominence of academic research is the frequency that it is cited by other scholars, including citations by scholars in other countries. For the advanced countries, the relative frequency of citation is roughly in line with the relative frequency of publishing articles. Citations for US-authored articles (first author from the USA) made up 43.6 % of all citations in 2001 followed by UK articles with 8.2 % and Japanese articles with 7.3 %. Relative to the above science and engineering giants, articles authored by researchers in other Asian countries were not numerous nor frequently cited. However, their likelihood of being cited has sharply increased between 1992 and 2001: “citation of literature from East Asian authors in China, Singapore, South Korea, and Taiwan more than quadrupled in volume during this period, with the collective share of these countries rising from 0.7 % of the world’s cited literature in 1992 to 2.1 % in 2001” (NSB 2004, pp. 5–49).

Clearly Asian research is becoming progressively more prominent in the international arena. If one were to think back to the time of Sputnik or some other distant scientific splash, no one would have thought of Asian research as capable of making similar breakthroughs. Nor would most researchers outside of particular Asian countries know much about Asian universities and research centers. In contrast, Asia is increasingly in the spotlight. China routinely sends up rockets to launch satellites for commercial and academic purposes, having a reliability record that is superior to that of most Western nations. Japan is viewed as the center of research on earthquakes and volcanoes and also is highly regarded for its work in biotechnology. Scientists in Korea recently announced pioneering work in the cloning of human beings that shocked the world. Asian research, while still more modest in scale than Western research, is hot.

At the turn of the twenty-first century, a Chinese research institution sought to rank the universities of the world using as its major ranking criterion the relative contribution in terms of absolute volume of articles of each university to the world’s corpus of scientific and engineering research (Shanghai Jiao Tong University Institute of Higher Education (SJTUIHE) (2003). Not surprisingly, given the prominence of Western science as reported above, the top universities in the world were in the West. But approximately 15 % of the institutions identified in this survey were from the Asian region including ten in Japan, two in Korea, two in China, two in Australia, and one in Korea. If the focus were on particular fields, in all likelihood the Asian regions would fare better. Engineering is prominently emphasized in many Asian universities, and in the sciences chemistry receives relatively more emphasis and physics and biology less emphasis. Similarly in that the science departments of many Asian-Pacific universities have only a few professors (whereas the engineering departments have many) if the methodology divided the absolute number of published articles by the number of scientists, the faculties of several Asian universities might be ranked at the top. For example, according to one study, the University of Tokyo’s department of chemistry is the most productive chemistry department in the world.

Obstacles to Academic Knowledge Production

While we have suggested thus far that Asian knowledge production has much promise and that academic research is an important component of this promise, it would be remise to ignore the obstacles to realizing this promise.

Practical Bias

Globalization is pushing economies around the world to place increasing emphasis on the commercialization of knowledge. Asian higher education systems from their inception placed an exceptional emphasis on the practical fields of agriculture, engineering, and medicine. At the same time, influenced by the example of Germany science, many researchers in Asian higher educational institutions urged a greater focus on seeking scientific breakthroughs; however, they were a minority in the policy circles. The legacy of a practical focus has made it difficult, despite the recent recognition of the need for greater creativity, to shift resources towards increased support for fundamental research. In a sense, Asian science was "globalized" long before this concept became prominent in international discourse.

Difficult to Change Academic Field Coverage of Academic Sector

The academic structure in the more established Asian universities is likely to have been established several decades in the past taking into account the hot research fields of that era. Over time, science and technology has shifted its focus: Recent examples include the explosion of the information sciences and the biological sciences as well as biotechnology, but given past commitments to the traditional sciences of physics and chemistry and a reluctance to simply add on new academic appointments before closing down old ones, many Asian universities have difficulty in adjusting to the times. They may be overstaffed in the traditional fields and short-handed in the new ones. For example, in Japan much of the interesting biotechnology research is carried out in the faculties of agriculture rather than in faculties of engineering or the departments of biology.

Legalism

Most Asian academic systems have their origins in state-sponsored higher educational systems. These systems were initially under the tight control of a central Ministry of Education that imposed rules on academic life not that distinct from those in the bureaucratic sector. Thus, for example, professors even today are expected to sign in daily to indicate that they are on the job and in at least one system are expected to be on sight at their desks from 9 in the morning to 5 in the afternoon. Annual vacation days are specified and monitored, as are trips to attend academic conferences and both local and overseas research sites; professors who fail to conform to these regulations may be penalized. Other regulations place unusual restrictions on the use of available resources. For example, in Japan it is difficult to use these funds to pay for salaries or certain types of equipment. These legalistic restrictions are always under review and in many instances are becoming liberalized. Even so, legalism continues to frustrate many of the good intentions of academic researchers.

Difficulty in Building Relations Between Academia and the Private Sector

The original purpose of many Asian universities was to train human resources for the modern sector, not to assist in the public-private effort of knowledge production for development. Due to the public status of many universities, regulations were established to protect the institutions against undue influence from the outside. Thus, grants from private organizations were to be monitored to insure they did not induce favoritism or corruption by the professor public servants. Moreover, in the national tax laws, these grants were to be considered as a routine expense of the private firm rather than as a tax-deductible act of charity, hardly an incentive for generous private sector support of uncertain academic research. When professors considered visiting private sector laboratories to carry out aspects of their research agenda, they also encountered obstacles. Formally, they were expected to report these excursions and limit them to a certain number of days each year. Additionally strict regulations were established in relation to any "personal" benefit they might receive such as honoraria or travel funds. Barriers of this kind have not made it easy for universities to cooperate with the corporate sector in knowledge production. Of course, these barriers are always under review and have, in many instances, been liberalized in recent years.

Shortage of Qualified Researchers

In that many universities are public institutions, most of the appointments to university posts are guided by civil service regulations or special adaptations of those regulations designed for "independent" universities. But the adaptations tend to be minor and often place serious obstacles in the way of professors who seek to hire research assistants or other support staff for their work. Often for staff to be hired, a new position has to be created, and long-term resource streams have to be specified, but as research funds are time restricted, the fulfillment of these conditions is difficult. Thus, the Asian university researcher is likely to be short-handed in terms of support staff for their research projects.

Obstacles of these kinds can be found in any academic system, and as their effects come to be spotlighted, steps can be taken to remove them. It is certainly the case that many of these obstacles have been reduced in recent years. Nevertheless, they still seem to loom larger in the lives of Asian academics than is the case in other parts of the world.

Conclusion

Regardless of where one comes out in the numbers game, there is little question that the Asian region is steadily expanding its presence in the global platform for knowledge production. The region for nearly three decades has been acknowledged as a leader in knowledge utilization, especially the manufacture of high-quality high-technology products. Over the last decade or so, the quality of basic research carried out in the region has also gained recognition. As one illustration, over the last decade ten Nobel prizes have been awarded to Japanese scientists. Of equal note, two have been awarded to Japanese novelists.

The academy plays an important role in Asian knowledge production but so do the other sectors of society. A relatively greater proportion of Asian research and development funds comes from the corporate sector than is the case in the West, and a smaller proportion comes from government. We have suggested that the more even distribution of funding across sectors in the Asian region suggests a distinctive interaction model of knowledge production. Nakayama adds that civil society might be added as another component of the Asian model along with the universities, the corporate world, and government; he notes, for example, that civic groups have provided the leadership in promoting environmental research and putting brakes on defense-related research. In a sense, the civic groups are encouraging a humanistic dimension in Asian knowledge production that may be more muted in the West.

While many generalizations about Asian knowledge production have been advanced in this paper, it is important to stress that each of the areas included in this study (Japan, Korea, China, Singapore, Malaysia, the Philippines, Indonesia, Oceania, and India) is unique. As outlined at the beginning, they have different contexts, traditions, and resources. It does appear that there is a sentiment in the region to enhance intra-regional collaboration and that there has been much progress in this regard. Thus, it is possible to point to a common direction in the strategies for academic sector knowledge production in the region. At the same time, there are distinctive national visions and achievements.

The role of the universities in increasing the prominence of Asian knowledge production has different explanations by country. In the more established university systems such as Japan, Korea, and Taiwan, the new creativity seems to be a function of increased resources and their more effective distribution, as the actual size of the academy has been relatively stable. In contrast in other settings, notably China, Singapore, and Australia, there has been a combination of increasing scale and increasing resources.

An interesting line of speculation would be to propose that the different academic systems of the Asian region might develop distinctive directions of excellence in the decades ahead. Japan appears to have strength across the board. China is notable for its achievements in space and in computer-related areas. The Philippines is notable for its training of doctors and other health personnel and with an infusion of increased resources might show promise in the health-related

Table 3.1 Distribution of government R&D budget appropriations in selected countries, by socioeconomic objective: 2000 or 2001

Socioeconomic objective	USA −2001	USA −2001	Germany −2001	France −2000	UK −2000	Russian Federation −2001	South Korea −2001
Total (millions of US dollars)	86,756	23,153	17,946	14,605	10,030	5,889	6,195
Exploration and exploitation of the Earth	1.2	1.9	1.8	0.8	1.3	1.5	1.5
Infrastructure and general planning of land use	2.0	*4.4*	1.7	0.6	1.2	1.2	*4.2*
Control and care of the environment	0.7	0.8	3.1	2.9	1.6	1.6	*4.5*
Protection and improvement of human health	*24.8*	3.9	4.0	5.8	*14.6*	2.0	7.1
Production, distribution, and rational use of energy	1.5	*17.4*	3.4	3.9	0.5	2.0	4.7
Agricultural production and technology	2.5	3.5	2.4	2.1	4.1	*9.9*	*8.4*
Industrial production and technology	0.5	7.5	12.1	6.3	1.7	11.4	*29.5*
Social structures and relationships	0.9	0.9	4.5	0.8	4.1	2.0	2.6
Exploration and exploitation of space	7.1	6.7	4.7	*9.8*	2.2	*10.1*	3.2
Research financed from GUF[a]	NA	*34.8*	*39.0*	21.6	19.6	NA	NA
Nonoriented research	6.3	13.8	16.1	19.8	12.1	14.0	*18.5*
Other civil research	0.0	0.0	0.1	2.3	0.3	0.9	0.0
Defense	*52.7*	4.3	7.1	23.2	*36.6*	*43.5*	15.8

Source: National Science Board. *Science & Engineering Indicators – 2004* from OECD, unpublished tabulations (Paris, 2003); and OECD, *Main Science and Technology Indicators* (Paris, 2002)

Notes: Conversions of foreign currencies to US dollars are calculated with Organization for Economic Co-operation and Development (OECD) purchasing power parity exchange rates. Percents may not sum to 100 because of rounding. US data are based on budget authority. Because of GUF and slight differences in accounting practices, the distribution of government budgets among socioeconomic objectives may not completely reflect actual distribution of government-funded research in particular objectives. Japanese data are based on science and technology budget data, which include items other than R&D. Such items are a small proportion of the budget; therefore, data may still be used as an approximate indicator of relative government emphasis on R&D by objective

GUF general university funds, *NA* not available separately

[a]USA, Russian Federation, and Korea do not have a category equivalent to GUF

sciences. Agriculture and horticulture are strong throughout the region and lend support to future breakthroughs in biotechnology. This is a region of great academic promise, and it is destined to claim an increasingly central position on the world's stage (Table 3.1).

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