Brain Drain or Brain Circulation?: What international cooperative strategies can foster the cultivation of science-based human resources and promulgate their contributions to global innovation system? *

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1. Introduction

One of the dilemmas that policy makers in most of the developed countries have recently faced is the fact that national innovation initiatives that each country is pursuing in its own interest interfere with each other. This comes into sight particularly in the field of human resources. As science-based industry has become a key drive of the national economy, it is urgently needed to foster highly educated researchers and scientists not only for the developed countries but also for the emerging ones like China and India. However research universities, the most suitable organizations to create science-based human resources are concentrated in a small number of the countries like the United States and Europe. Naturally, talented persons want to study in better research institutions and human resources are easily crossing the national borders.

As a result, it is difficult to use academic education programs in the highly developed countries exclusively for their own national interest even though they are financially supported by their governments. National policies of higher education have been increasingly shifted their focus to the encouragement of international collaboration. It may be no exaggeration to say that science-based human resources now belong to the international public domain. In addition, it is now important to cultivate science-based human resources capable of taking the initiative in the development of independent efforts and international collaborations to solve pressing global problems. What international cooperative strategies can foster the cultivation of science-based human resources and promulgate their contributions to global innovation system? What is the most useful model to coordinate different actors of each country-government, university, and industry-with intent of developing a global innovation system?

The aims of this article are to survey a theoretical framework on collaborative aspects of knowledge creation, and to contextualize what many scholars have discussed with respect to the broader background of related studies on university graduate education, the cultivation of scientific human capital, and knowledge transfer through the mobility of human resources. Finally we will conclude by suggesting that international collaborations are important not only for developing resources in Japan but also for gaining an overall understanding of the global innovation system.

2. Theoretical framework on collaborative aspects of knowledge creation

What are some ways to motivate and promote international collaboration in the field of human resources?

* This short article is based on the talks and discussions we made at the Global Innovation Ecosystem Conference held on June 30, 2007 at GRIPS.

Do we need to intensify the mobility of human resources? The following section explores some theoretical frameworks for understanding how important collaborative activities are in the development of scientific knowledge.

Some of the results of human mobility are the ability to develop network links with centers of excellence in the scientific world and the increased connection with "knowledge hubs" in global collaboration networks. In order to absorb and utilize the most advanced innovations, it is essential to have an increased contact with the centers that are creating new knowledge, new expertise, and new frameworks. It is also important to be familiar with the methods for producing this knowledge (Cohen, Nelson, and Walsh, 2002). In other words, we will be able to acquire new knowledge by belonging to an epistemic community. The concept of an epistemic community was first developed by philosophers and international anthropologists and then applied to studies of global governance (Haas, 1992). The essence of this concept can be defined as a group of agents sharing common models, language and messages in order to create a mutual understanding (Cohendet and Meyer-Krahmer, 2001). A research hub of scientific knowledge literally exemplifies "an epistemic community," and it is crucial for ambitious researchers to be connected with such an intellectual cluster, in which *star scientists* get together, face-to-face contact is possible, cutting-edge experiments are carried out, and tacit information is abundantly available (Zucker and Darby, 1996 ; Darby, Liu and Zucker 1999).

By its very nature, the production of scientific knowledge is closely related to research hubs and the cluster formation of a knowledge economy. In a research hub, two types of knowledge production are available; one through formal collaboration in learning and the other through more informal and spontaneous exchange of information (Foray, 2004). In addition, some scholars have stressed an evolutionary process of epistemology by which researchers establish new scientific knowledge by accumulating hundreds of insights scattered and embedded among researchers (Machlup, 1984). Based on this understanding of a collective process of knowledge formation, we can argue that clustering expertise, information, and scientific acumen into a core region is a key factor in the creation of truly original ideas. To quote Audretch, "the theory of knowledge spillover […] suggests that the propensity for innovative activity to cluster spatially will be the greatest in industries where tacit knowledge plays an important role" (Audretch 1998).

3. Higher education programs in Japan

Turning our eyes to situations in Japan, Japanese universities seems to have been very weak at producing mobile human resources in science and technology. Indeed the ineffectiveness and malfunction of Japanese universities in fostering internationally oriented researchers and scientists have been often highlighted by the scholars who have compared Japanese universities with those of other countries, in particular the United States (Hane, 1999). Also it is often argued that Japanese universities had failed to measure up to global standards for developing educational programs. It is no exaggeration to say that for universities, good graduate students function as both important sources of new research and as substantial creators of new knowledge. Sachi Hatanekana in the GIES conference insists that in Japan there has been insufficient emphasis on the importance of doctoral degree holders in promoting an international atmosphere in Japan's scientific world. An increase in young ambitious PhDs would insure that new ideas in a global scientific community are incorporated into the established structure of education and routine academic research. Considering this situation, we want to stress that Japanese higher education programs should be reconstruct urgently so that they fit the international

standard of science-based human resources. As an apparently successful model that Japan should refer to, many scholars have brought up US research universities and their graduate programs. The United States has long been a major destination for graduate study for international students, particularly in the field of science and technology. Although the number of students from overseas has been drastically decreasing since "September 11", the US remains a holy grail for potential scientists and plays an important role in circulating educated brains around the world.

Why has Japan failed to produce "world class talents"? What is the main problem? Japan's present method of utilizing highly-educated personnel certainly lags behind what is considered common practice in international circles. As Richard Dasher asserts in the GIES, Japan has faced difficulty in providing incentives for scientists to move from their home country and institutions and to prove their ability in a global setting. There is a kind of dichotomy between top-ranked scientists and the majority of ordinary researchers in Japanese scientific community. The former tend to be regular contributors to professional journals, active members of a global scientific community and their mindsets *per se* are international. This is in opposition to the latter, who are not interested in crossing national boundaries in the job market. This has created a hierarchical separation between top-ranked elite scientists and the majority of others, which has hindered the creation of global research hubs in Japan.

However, we can argue that this phenomenon is in line with the literature; the productivity distribution of researchers is heavily skewed and the fact that a minority of researchers are producing a majority of publications may be explained by network and cumulative effects. Lotka (1926) was one of the first authors to mention this phenomenon. David (1994) showed that this inequality is at the core of the US system, depicting the fact that initial conditions play important role in the career path of researchers.

How can we encourage the globalization of Japanese university education? What is the most effective method of improving graduate programs in Japanese universities? What is the key ingredient for promoting Japan's contributions to the global science community? Considering the past studies in this field, three strategies may be identified. First, it is urgent to encourage the mobility of the human resources across national borders, thereby breaking the current isolation of Japanese researchers and developing links to global innovation networks. To that end, we need first and foremost to "open" Japanese graduate programs. Second, in order to promote human mobility and to internationalize graduate programs in Japan, it is necessary to intensify international collaborations between Japanese scholars and researchers in foreign scientific canters and emerging knowledge communities. Third, we would argue that international collaboration should not be limited to research activities with scholars in developed countries such as the US and Europe, but it is high time that we expand it to include East Asian countries. In the following pages we will articulate these issues respectively in the three sub-sections.

3.1 We will explore possible agendas for "opening" Japanese graduate education system. As some of the participants argued, it is important to recognize the role that foreign graduate students have played in the research community in the US. Also the migration of scientific human resources and its impact on Japanese society will be briefly discussed.

3.2 The second topic is the mobility of scientific human resources and international collaboration. We would like to stress that global collaboration is not only a requirement for improving national innovation and

competition, but more importantly it is an urgent issue related to solving pressing global problems.

3.3 Finally, we will briefly explore various methods by which the expansion of international collaboration in the global science world is fostering a close relationship among East Asian countries, particularly exemplified by the case of Singapore.

3.1 " Opening" Japanese graduate programs

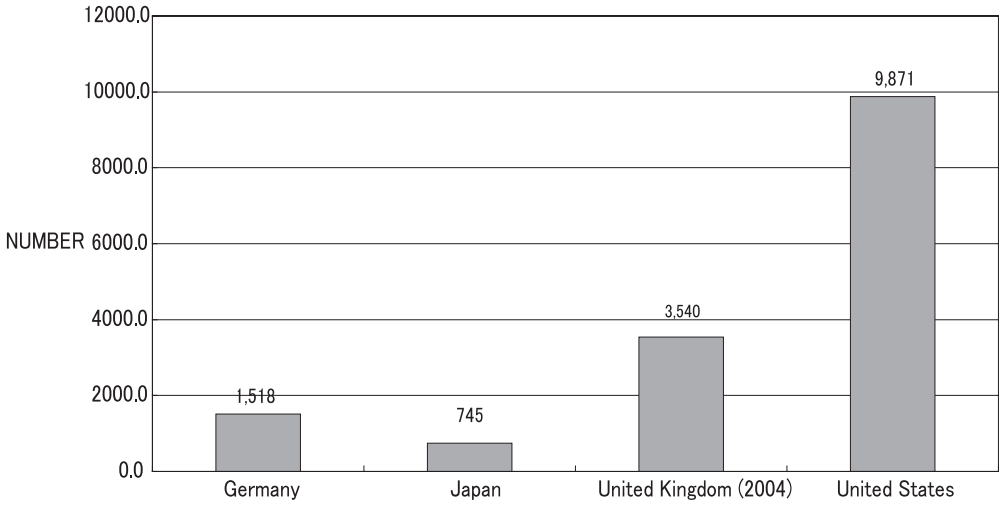
Nowadays it is almost a *cliché* to say that our generation has witnessed the arrival of the knowledge economy, the advancement of science-based industries, and the increased importance of the highly skilled employees, particularly those who have doctoral degrees. Well before it became a *cliché*, American research universities attracted many talented students in science and engineering from all over the world. From the beginning of the Cold War period, a great number of eminent scientists emigrated from Europe, USSR and Asian regions in order to pursue the highest level of scientific research.

In the aftermath of WWII, *Science*, *The Endless Frontier* (Bush 1945) laid down the foundations for the US government to assume responsibility for supporting basic research at universities. This responsibility became manifest with the creation, in 1950, of the National Science Foundation. Universities undertook a major shift in order to focus their activities on basic research, which had become not only respectable, as opposed to a more applied approach during the prewar period, but widely perceived as what universities ought to be doing (Rosenberg and Nelson, 1994). So-called "open academic system" and "open science model," which emphasized the importance of basic science research, created exceptionally good research environments in American academic institutions.

Against this background, the importance of graduate degree holders was first recognized in the US after WWII and this recognition led to the creation of outstanding graduate programs which have been the main source of science-based human resources (Lowell 1999). Research universities in the US have provided a powerful mechanism for producing highly-educated human capital and so over the past few decades, many other countries have attempted to adopt or imitate a similar graduate system. The enormous influx of government funds in the form of grants and contracts, first from the Department of Defense, and later more from the National Institute of Health, definitely made the US a focal point for attracting and educating potential scientists as well as facilitating the circulation of scholars around the world (Rosenberg and Nelson, 1994; Mowery et al., 2004).

It is important to point out that an important lesson that Japanese universities can learn from the US is that a drastic increase of foreign students is possible in graduate programs in science and technology. For example, in 2003 more than one-third of total US science and engineering doctoral holders came from other countries. Foreign born scientists with doctoral degrees reached 57.4% in computer science, 57% in electrical engineering and (the lowest figure) 32.7% in the biological sciences (National Science Foundation 2006). There is no doubt that without these competent foreign-born graduate students, US research universities would not be able to maintain graduate programs, much less expand them to a standard so high that many other countries wish to emulate them (Finn, 2005). We need to establish a systematic strategy for attracting foreign students who want to receive PhDs from Japanese universities: one of the most effective ways of promoting a global consciousness. Unfortunately, as *Figure 1* shows, the doctoral degrees earned by foreign students in Japan are far less than in other countries.

Figure 1: Doctoral Degrees Earned by Foreign Students



SOURCES: Germany—Federal Statistical Office, Prüfungen an Hochschulen 2003 (2004); Japan—Government of Japan, Ministry of Education, Culture, and Science, Division of Higher Education, special tabulations (2005); United Kingdom—Higher Education Statistics Agency, special tabulations (2005), and United States—National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

The biggest reason why the US has attracted these talented students is the massive financial support from universities and the federal government in the form of graduate fellowships, teaching assistantships, research assistantships and other financial support for post-doctoral positions. As many researchers have pointed out, these methods are the primary source of support for more than 75 percent of the foreign doctoral recipients at US universities. These lucrative funds have been an intellectual and financial magnet for foreign students. However, Japan's weak integration of foreign students is one of the main reasons for Japanese universities' failure to globalize their intellectual atmosphere. It is often reported that students from Asian and developing countries are reluctant to stay in Japan after they obtain a degree. Also the immigration rules in place do not facilitate access to employment in Japan. In addition, Japanese universities are notorious for their high rate of academic inbreeding: that is to say, faculty positions for persons who receive graduate training at the same academic institution (Barker 1998). In such a closed culture of academia, it is extremely difficult for foreign students to get an academic position, which inhibits them from keeping an intellectual tie with the networks of their *alma mater*. Japanese universities urgently need to realize the importance of foreign students and their role in building social networks and international collaborations.

The intellectual networks that students from different origins can build up are one of the most important factors in improving the Japanese graduate system. Recently many scholars have argued this from the perspective of "diaspora network effect," particularly in the cases of Chinese and Indian graduates from the

US universities (Graeme, 2003; Arora *et al*., 2001). There might be a political criticism in giving government financial support to foreign students, but as Kiyoshi Kurokawa states in the GIES, even if they return in their home countries, the investment in those individuals does benefit the receiving as well as the sending countries. The returning of highly-skilled human resources often creates transnational social networks for developing knowledge transfer and business connections, which encourages intensive international collaboration. Even though a considerable number of foreign graduate students do not intend to return to their home countries and decide to become immigrants, they seldom break human and institutional ties with their original countries. Their contacts with former colleagues and educational institutions promote an international network of research agendas and knowledge transfer. Often these highly educated scientists are able to easily move across borders, among different industries and firms. The international movement of these people has been recognized as a powerful source of knowledge transfer which leads to the global utilization of scientific innovations (Mahroum 2001).

Japan's current situation in which most researchers are isolated from the global research community is a serious obstacle to national competitiveness. More than that, the hierarchical structure of the Japanese scientific community and their inward-oriented behavior has hindered researchers from playing an active role on the international stage. To be linked to the global innovation networks and to attract the critical mass of talents (both national and international) that enable cutting-edge research, Japanese universities should embark on a radical reform toward "opening" their graduate education.

3.2 Mobility of human resources and the development of international collaboration

Whereas cross-border migration of highly-educated people has expanded remarkably in the rest of the world, Japan has been notoriously reluctant to accept foreign scholars and researchers as equal partners in Japanese academic institutions and organizations. It goes without saying that the US is a leading country for human mobility in the field of science and technology (Johnson, 1998). Now, increasingly, Europe is also developing exchanges and interactions among educated people. One excellent program in Europe is the so-called the *Erasmus Program*, which was established in 1987 to foster teacher and student exchanges within the EU region. Since its creation, 1.2 million students have benefited from studying abroad for short periods. In 2007, the European Commission integrated its various educational and training initiatives under a single umbrella, the *Lifelong Learning Programme*. With a significant budget of nearly €7 billion for the period from 2007 to 2013, it replaced existing programs, which ended in 2006[a].

Unfortunately, however, there is no equivalent program in East-Asia, although some countries have reached bilateral agreements on student exchange. Japan lags behind again in terms of government support for student exchange or international collaboration. With the enactment of the Science and Technology Basic Law on November 15, 1995, the Japanese government is obligated to firmly commit financial support to the development of international exchange programs under the *aegis of Science and Technology Basic Plans*, first from FY 1996 through FY 2000, second from FY 2001 through FY 2005, and then third from FY 2006 through FY 2010. Since then, many programs backed up by the Japanese government have been launched. As the *White Paper on Science and Technology* (MEXT, 2006) stressed, "Science and technology creates intellectual assets that should be

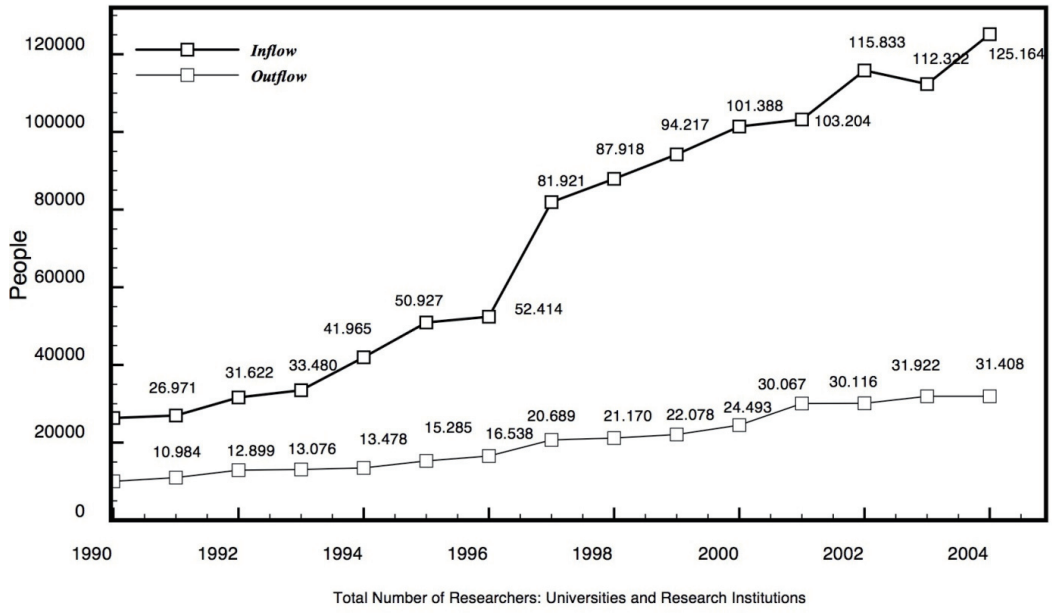
[a] See http://ec.europa.eu/education/index_en.html for more details

the common property of all mankind, and also contributes to the resolution of various global issues." Valuing international collaboration should be common-sense among makers.

In this perspective, the Human Science Frontier Program (HSFP), based in Strasbourg, first called by a former Prime Minister of Japan, M. Nakasone, in 1987, can be mentioned as a pioneer example of the international research agenda initiated by the Japanese government. This program aims at providing research grants for projects that involve collaboration between teams in different countries, and long- and short-term fellowships for post-doctoral scientists who wish to work in a different country and workshops. The HSFP facilitates scientific collaborations, for which it would otherwise be difficult or impossible to provide funds through traditional or national research granting agencies. From 1990 to 2006, the HSFP has funded 696 research grants submitted by more than 40 nationalities. Since its beginning, five research grantees went on to win the Nobel Prizes; one of them is a Japanese citizen. The HFSP succeeded in promoting productive cross-cultural collaborations, and in stimulating interdisciplinary research.

Despite all these efforts, however, it is hard to say that human resource exchange programs have been successful in Japan: the number of people who have crossed national borders is comparatively low. We can confirm this fact at two levels. At the student level, in 2005 there were only 79,000 Japanese students studying abroad and 120,000 foreign students in Japan (MEXT, 2006). At the researcher level, *Figure 1* shows the number of foreign researchers invited to Japan and Japanese researchers dispatched overseas. We can see a striking unbalance between the inflow and outflow of researchers. From these figures we can extrapolate and say that there is lack of researcher mobility, especially outflow, despite of the top-down efforts by the government.

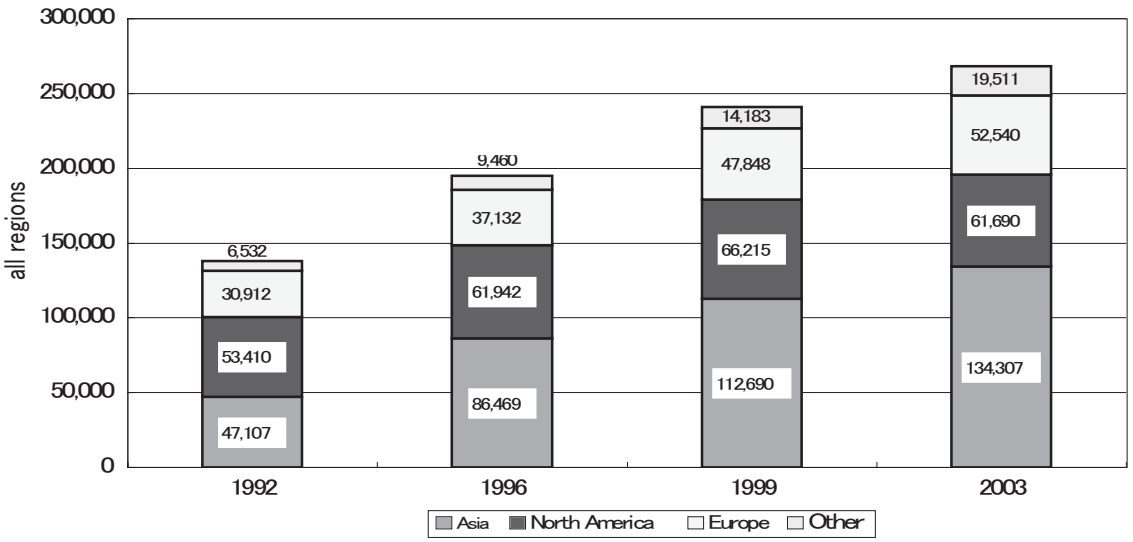
Figure 2: Inflow and Outflow of Researchers in Japan



Source: Graph adapted from MEXT (2006, p. 357)

At the same time, however, as Atsushi Sunami in the GIES has exemplified, the Japanese companies represented by IT and software industry are getting more and more dependent on the highly skilled foreign human resources of science and technology. It is true that the software companies of Japan often go into outsourcing software development abroad particularly to China and India, and the inflow of high-skilled workers from Asian countries is increasing as *Figure 3* shows. Based on this high demand for scientific employees, we argue that Japan should break the traditional inward-looking policy of protectionism and look more at East Asia countries with respect to making the best use of international science-based human resources.

Figure 3: High Skilled Worker Visas in Japan



SOURCES: S. Fuess, Jr., Highly Skilled Workers and Japan: Is There International Mobility? University of Nebraska (Lincoln) and Institute for the Study of Labor (Bonn) (2001); and Japanese Statistical Handbook (2004).

Finally we mention that the growing quest for international collaboration is not simply the result of the myopic view of Japan's national innovation policy. As many of the researchers have pointed out, serious consideration by policy-makers of the development of international collaborations for the sake of broader concerns and challenges, such as population growth, environmental issues, climate change, and poverty alleviation is long overdue. Further, highly educated researchers should be regarded as available and indispensable human resources who work for a global community. Therefore, the request to reconstruct and internationalize the graduate education in Japan is not only for self-centered national interests, but more importantly, for solving urgent concerns that the global scientific community is facing. To that end, an effort to foster international collaboration among a wide range of Japanese researchers and scientists is what is needed most. Japan can make an important contribution by providing its highly qualified experts to the rest of the world. To achieve this objective, fostering an international mindset among Japanese researchers is definitely an urgent matter that needs to be realized.

3.3 Expanding international collaboration among and within East Asia

For the last decade, the global scientific world has witnessed a drastic enlargement of scientific researchers' collaborative activities bridging national and institutional boundaries. This change has led to an interdependence in the scientific community and has been driven by several factors. First, as we have discussed, graduate programs in the universities of developed countries have admitted foreign students. Second, international collaborations are becoming easier because of reductions in transportation costs and the development of e-mail and the Internet. This virtual mobility of human resources, which is sometimes called "Brain Wave" (Carayannis and Campbell, 2006), allows researchers to locate collaborators and share data with them. Third, the production of scientific knowledge has begun to require the combination of knowledge, expertise, perspectives and techniques which extend beyond a single institution.

The development of the international collaboration has been focused mainly on the major industrialized regions of the world: the United States, the European Union, and Japan. Recently, however, collaborative activities have expanded beyond the cooperation between these major players. The US formerly played a key role in pushing forward international collaboration, but Europe and other countries have been expanding their collaborative networks to Asian countries like India and China, in a lesser extent Japan. This change is reflected in the increase in the number of coauthored publications in science and engineering journals. The US share of the world's internationally coauthored articles fell between 1988 and 2003, from 51% to 44%. Its share of co-authorship on the international articles with the EU-15 and Japan fell from almost 50% to 40%. On the other hand, researchers in many other developing regions within East-Asia, Eastern Europe and the former USSR did collaborative research. For example, India increased co-authorship with Japan and East Asia-4, while its links with the US and the EU decreased.

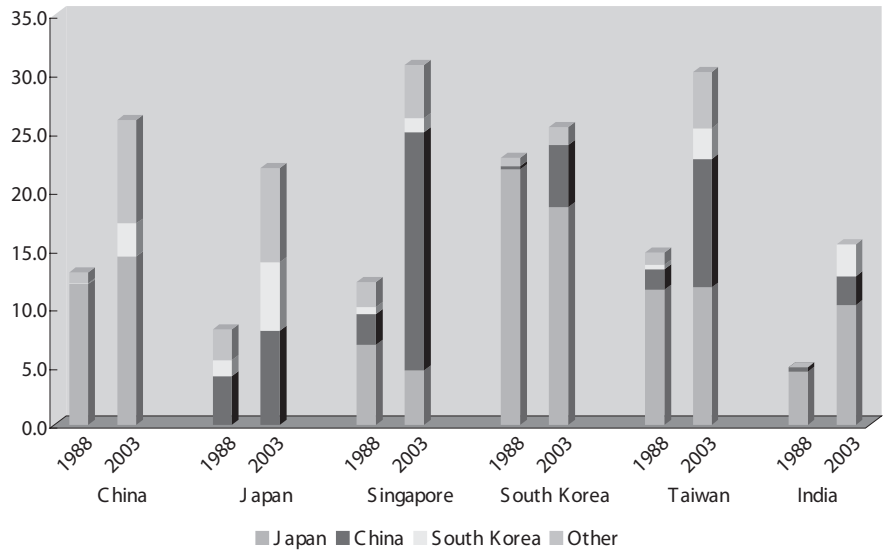
The emergence of East Asia as a new leading sector for global scientific innovations has been discussed by many scholars. During the last decade Singapore has succeeded in transforming herself from a manufacturing center of local regions to a knowledge-based economy incorporating high-tech industries and knowledge-intensive business hubs (Poh Kam Wong, 2001). The National University of Singapore (NUS) has been a major player and contributor to Singapore's shift toward business based on scientific knowledge and intellectual property, and to the development of entrepreneurial mindsets. Singapore is now aiming to become a major hub in the global innovation ecosystem during the 21st century, attracting global innovators, nurturing indigenous and globally competitive innovators, and building connectivity to other global innovation hubs. Wong believes that NUS can play a significant role in this vision of Singapore through its "Open Innovation, Entrepreneurial University" model. In so doing, NUS has taken advantage of international cooperations: the Singapore-MIT Alliance program; Building Global R&D Links: the International Campus for Research Excellence and Technological Enterprise (CREATE) initiative; and Building Nodes of Global Excellence: the Research Center of Excellence (RCE) initiative.

Although the country is smaller than Japan, Singapore's experience may provide some instructive suggestions to Japan. The Japanese system of innovation (JSI) has been quite efficient in the catch-up process characterized by rapid economic growth and modernization. Now that Japan is facing the strong need to be a center of technological frontier and the focal place to breakthrough a new innovation (Goto and Odagiri 1997), international collaboration with emerging East Asian centers of excellence is urgently needed.

Considering the statistical trends of co-authorship, it is likely that this trend of expanding international

collaboration with East Asian countries may already be under way. In 1988 the share of articles which Japanese scientists coauthored with foreign researchers was 9%, but this number increased to 22% in 2003. Of these coauthored articles, collaborations with of East Asian researchers, particularly with Chinese scholars, show surprising increases, as shown in *Figure 4*. On the other hand, US partners' involvement in collaborative works is beginning to decline in relative term. A similar trend can be found across Asia. East-Asian countries' partners have been mainly Japan but with the growing intraregional industrial and economic relationships; collaboration with China is gradually increasing.

Figure 4: Co-authorship, East-Asia Countries on International S&E articles



SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index, http://www.isinet.com/products/citation/; ipIQ, Inc.; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

4. Conclusion

We have discussed the role of research universities in creating globally competent scientific talent, drawing on the past experience of the US, and critically examined Japan's weak position in global innovation networks. Research universities are no doubt a key factor in advancing the scientific base, and with their close collaboration with national and international research hubs, they will be able to provide economic sectors with a well-educated international labor force. However, what matters far more is the creation of a free and collaborative environment, which, through the interrelated forces of competition and cooperation, will foster universities as centers of excellence in scientific innovations.

No less important is the mobility of highly educated and talented students, graduates and scholars in a global setting. What has been referred to as "brain circulation" is a key ingredient in combining collaborative activities in the global scientific world and the competitive process of innovation creation. It is extremely important

that universities be trans-cultural and interdisciplinary centers which can embrace the highly cooperative environment of mobility and integration, as opposed to a contentious and exclusive place of emigration and separation. The hope that many scholars have emphasized of developing such a cooperative movement by way of human mobility seems to be related to the ongoing arguments of re-establishing the academic domain as a public place protected from burgeoning commercialization and the privatization of open scientific knowledge. What we have to build urgently must be the model of the university as a global commons which can produce worldly shared insights.

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