Part III.
Mobility of Human Capital and Workers

Promoting the Mobility of Human Resources in Science and Technology (HRST) in the Asia-Pacific Region:
Policy Agenda for Cooperation

Myungsoo Park

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I. Introduction

1. Role of Science and Technology in the Modern World

The future does not just happen; it results mostly from the work of mankind. People have always thought about the issues that will affect the future. In modern times, science and technology have become the key driving forces for not only economic growth but also quality of life and the health and security of our world. The practice, command, and use of science have become increasingly important in addressing many critical global issues. At all levels, scientific knowledge and appropriate technologies are central to identifying solutions for economic, social, environmental, and many other problems. New technologies are already reshaping the way we live, think and work. As we all have seen since the 1990s, information and communication technology and the related technological developments, embodied by the Internet and cell phone, have already had a big impact on society as well as industry.

2. Impact of Globalization on Human Resources in S&T

With ever developing science and technology (S&T), human resources have taken on an increasingly important role in the economic success of

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nations. Still, changing economic and social conditions affect the ways in which S&T human resources are sourced and the decisions employers make about investing in hiring and training. The S&T communities across Asia-Pacific economies are facing an era of rapid and unprecedented change. As the contributions of science and engineering research and education continue to be critical determinants of economic growth, quality of life, and the health and security of our planet in the 21st century, the environment in which these activities occur is becoming more and more global.

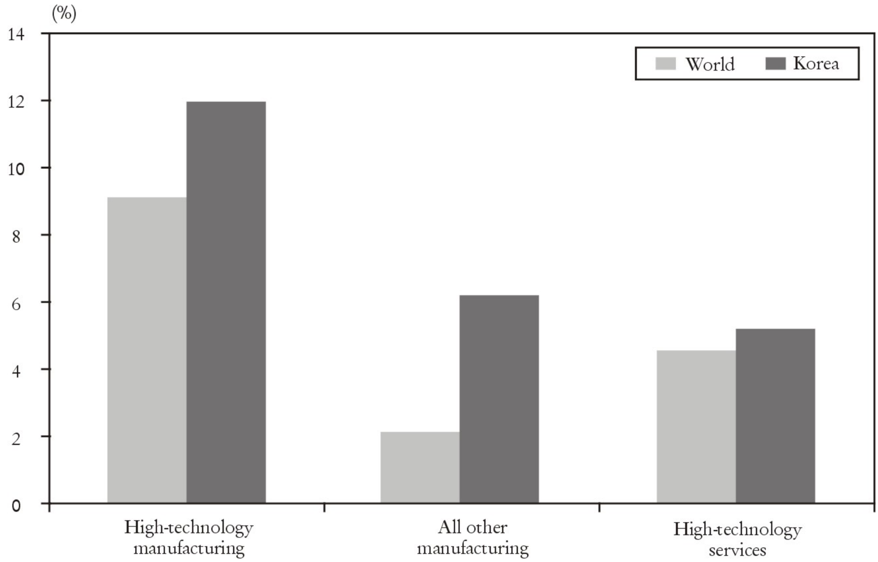
Globalization means the worldwide integration of nations through trade, capital flows, diffusion of information, movements of people, and operational linkages among firms and other organizations. Flows of people, goods, services, and ideas are transcending national borders on an unprecedented scale. Events in one country now have major effects in countries geographically far removed, sometimes instantaneously. It has been a key feature of the last decade of the 20th century and becomes even more important now. Advances in transportation, information, and communication technologies have diminished the importance of international boundaries. Both the volume of information and its rate of diffusion are expanding rapidly throughout the world.

There is an urgent and vital need to address this critical point that is supposed to most significantly impact the S&T community and the way in which it contributes to our economies now and in the future. It would surely supply new directives for S&T human capacity building and influence the recruitment, retention, and training of highly-skilled manpower.

3. Purpose of the Paper

As the contributions of science, technology, research, and education continue to be key determinants of economic growth in the 21st century, this paper will focus on ways to enhance human knowledge resources in the Asia-Pacific and East Asian region. The paper sets two goals to realize this vision. The first goal is to develop recommendations for increasing the mobility of scientists and engineers internationally. The second is to develop recommendations for an effective leadership role for Korea in strengthening the framework for international mobility of human resources in S&T.

Figure 1. Global Industry Sales Average Growth Rate by Sector (1995-2003)



Source: NSF, Science and Engineering Indicators 2006 (2006)

II. Mobility of S&T Human Resources

1. S&T Human Resources in a Knowledge-based Economy

High-technology industries are driving economic growth around the world. As seen in the last decade, manufacturing output in the world shifted resources to produce higher value-added, technology-intensive goods. The global market for high-technology goods is growing at a faster rate than for other manufactured goods. During the recent 8-year period examined (1995-2003), high-technology production grew at an inflation- adjusted average annual rate of nearly 9.1%, compared with 2.1% for other manufactured goods. It was almost four and a half times the rate of growth for all other manufacturing industries. During this period, Korean economic activity in high-technology industries was especially strong, recording 12.0%, led by manufacturing in those industries producing communication and computer equipment.

High-technology industries are R&D intensive; R&D leads to innovation, and firms that innovate tend to gain market share, create new product markets, and use resources more productively. These industries tend to develop high value-added products, tend to export more, and, on average, pay higher salaries than other manufacturing industries. Moreover, industrial R&D performed by high-technology industries benefits other commercial sectors by developing new products, machinery, and processes that increase productivity and expand business activity.

The competitiveness of a knowledge-based economy has come to be based on the scientific and technological capacity, which is defined by the capability for knowledge creation and creative human resources. It requires a consistent system of development, diffusion, and application of knowledge that has been evolved through communication between science and industry. It is also based on the scientific capability to absorb innovative technology. Thus S&T human capital has become a key success factor in economic growth.

2. Mobility as a Means of Sharing Knowledge

It is S&T human resources that create and disseminate knowledge and constitute organizational teams for research and development. Policies for developing a nation's capacity for science, technology, and innovation should be directed to improve access to the existing stock of knowledge and create new knowledge.

This can be achieved by enhancing the creativity and mobility of S&T human resources. Furthermore, economic growth increasingly depends on scientific research, and many of the present and foreseeable challenges for industry and society can no longer be solved at the national level alone. Sharing research and scientific know-how between countries and communities is more crucial than ever. It is the key to improving economic growth, building sustainable development, tackling poverty, and creating a worldwide network for the advancement of science and technology. It needs, among other things, more abundant and more mobile human resources.

The exchange and/or mobility of the scientists and engineers—cross-border linkages between scientists and their institutions on one side as well as linkages between the various actors in society—is a key component in relation to the key issues of investing in human and institutional capital resources. The intensified science and technology cross-flows are important for strengthening the economic linkages, and the exchange of scientists and engineers constitutes an important component of the cooperation among nations. Specifically, mobility is a core element in strengthening cooperation at all levels, and is acknowledged to be the most effective way of training skilled workers and disseminating knowledge.

III. Changing Context of International S&T Activities

With mobility a critical factor in the development of science and technology, changing economic and social conditions, mobility has taken on an increasingly important role in the ever-accelerating process of globalization in the 21st century.

1. International Education of S&T Students

The realization of the importance of science and technology to quality of life and economic growth and the recognition that people are the main agents of knowledge transfer have led many countries to strengthen their higher education systems. This has become necessary in the science and engineering fields to meet the needs of the 21st century workforce.

The recognition of the importance of a skilled workforce for economic growth has led to international competition for workers and the evolution of a global and highly mobile S&T workforce. We see the most prominent example of this in the United States. Though experiencing decreasing human capacity of their citizens in S&T fields, science and engineering enterprise benefits from the international exchange and from the contributions of foreign-born scientists and engineers who migrate to the United States and work in the universities and research laboratories.

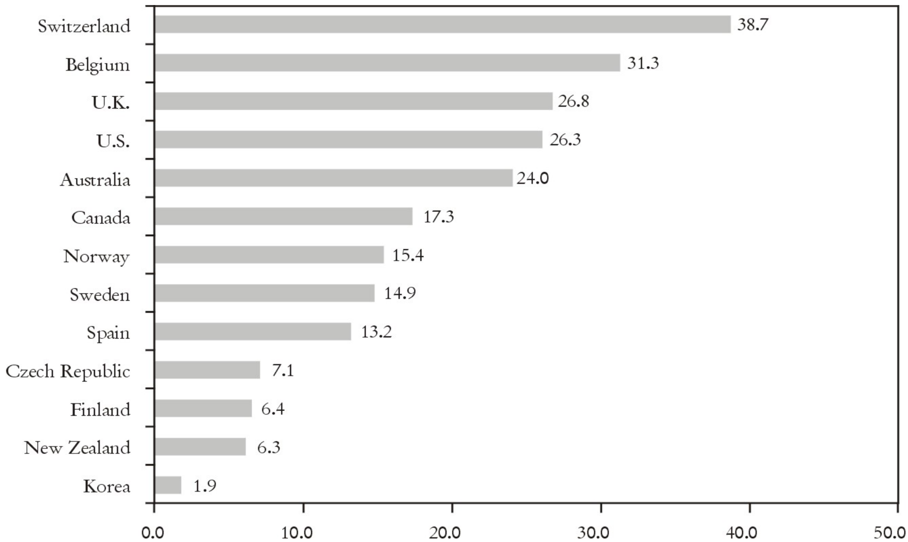
As many industrial countries attract a large number of foreign students to their universities, international mobility of doctoral students is one of the indicators of the globalization of both the higher-education sector and research system. The numbers are of particular interest for two reasons. First, they are an important subset of S&T human resources as they have completed tertiary education. Second, they are involved in R&D activities abroad while preparing their degree.

It also highlights the attractiveness of advanced research programs and, in some cases, the existence of career opportunities for junior researchers in the host country. During their doctoral studies and afterwards, these researchers contribute to the research carried out in the host country. When returning home, they bring back new competencies and links to international research networks.

The share of foreign doctoral students in total enrolment differs widely

Figure 2. Share of Foreign Doctoral Students (2002)

(As a percentage of total doctoral enrolment in host country)



Note: 2001 for U.S., 2000 for Canada

Source: OECD Science, Technology and Industry Scoreboard 2005 between Korea and other developed countries. Non-citizen students represent more than a quarter of all doctorates in Switzerland, Belgium, the United Kingdom, and the United States, but less than 2% of the doctoral population in Korea. In 2002, the number of doctoral students that Korea hosted was less than 650, while the United States hosted almost 79,000 foreign doctoral students, the largest number. The United Kingdom is the second major host with over 22,000 students.

The contrast is most striking when the number of foreign doctoral students is judged on the basis of the population of R&D researchers of each country. While the R&D researchers of Korea is one-ninth of that of U.S., the number of foreign doctoral students is less than one- hundredth of that of U.S. Also, while the number of researchers of U.K. is slightly larger than that of Korea, the number of foreign doctoral students is almost 34 times that of Korea.

This is the reason Dr. Suh, the president of KAIST of Korea, recently declared all classes would be taught in English with at least 50 foreign students attracted each year. It was based on the judgment that, though the intellectual level of KAIST students is judged to be on par with those of the top 20 schools ranked in USA and there are many professors who conduct world-class research, KAIST is not acclaimed as a world-class university.

2. Growing Need for Global Cooperation

As scientific and engineering enterprises are becoming increasingly global,

Table 1. Number of Foreign Doctoral Students and R&D Researchers

2002	Foreign Doctoral Students (persons)	R&D Researchers (thousand persons)
Korea	650	142
United States	79,000	1,261
United Kingdom	22,000	158

Note: Number of R&D researchers in 1999 for U.S. and in 1998 for U.K.
Source: OECD, Main Science Technology Indicators, 2006
MOST, Report on the Survey of R&D in S&T, 2005

the international boundaries have become considerably less important in structuring the conduct of research and development (R&D). International mobility of S&T personnel gives rise to the globalization process.

While mobility is being utilized as an instrument for the transfer of scientific knowledge, the conduct of S&T research has become more international between individual researchers or groups of researchers, both through formal agreements and through more informal collaboration. The big impetus behind this phenomenon is the proliferation of complex and expensive projects requiring large facilities and specialized instrumentation.

The so-called mega science projects require association among many nations to make the total cost affordable for those participating. They are the Global Climate Change Program, the International Geo-sphere Biosphere Program, and the International Human Genome Project, to name a few. With the expansion of the domain of research and development and with the active integration of technologies, more technological resources from non-domestic research facilities are demanded. Researchers' requirements for geographically specific materials and facilities transcend national boundaries. In addition, many research problems, both disciplinary and multidisciplinary, require scientists and engineers in different countries to work together. Globalization of R&D is characterized by increasing international collaboration among scientists and growing reliance on cooperation among firms, researchers, and governments to achieve greater technological innovation at lower costs.

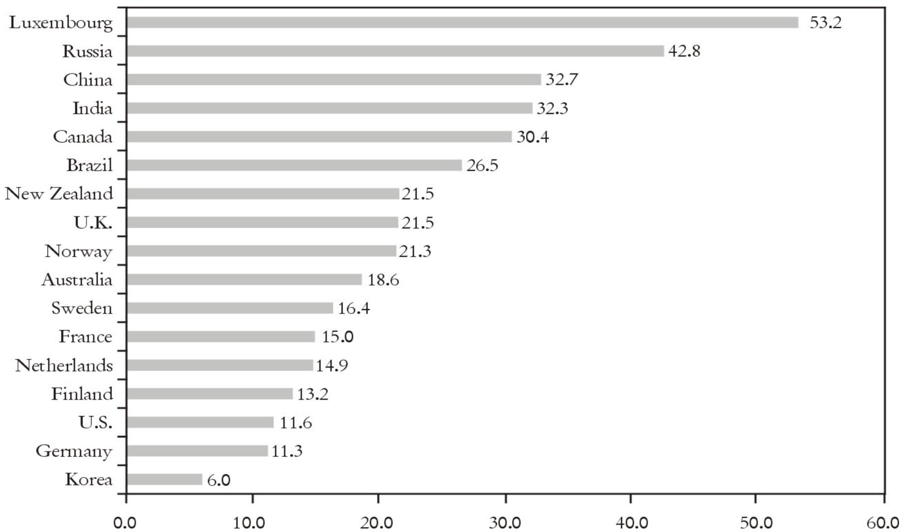
Growing globalization might be viewed as not only to increase the international conduct of science but also to advance the scientific process by providing opportunities for more open and timely communication, sharing, and validation of research findings. Two indicators are adopted here to show the globalization in this aspect. One is the co-invention of patents and the other is the gross expenditure on R&D (GERD) financed from abroad.

Co-invention of patents provides an indication of the global dimensions of the conduct of scientific activity. In 1999-2001, 6.7% of all patents filed at the European Patent Office (EPO) were the result of international collaborative research. Usually, globalization tends to be high in small countries and in large developing countries. For example, 53.2% of patents with an inventor from Luxembourg also have at least one inventor from another country. The Russian Federation, Belgium, Hungary, China and India also have a high share of EPO patents with foreign co-inventors. Of the six largest OECD countries, the United Kingdom is the most internationalized, with more than 20% of its patents the result of international collaborative research, while Korea is the least internationalized with 6%.

In the age of global competition, the response to competitive factors has led to changing forms of cooperative activities. As the risk and cost accompanying the technological innovation increase exorbitantly, joint development and cooperation between firms and between countries are widely pursued.

Research collaboration internationally is on the rise in the industrial sector as well with a rising number of formal cooperative arrangements or alliances between firms. In addition to benefiting science communities, international S&T collaboration and partnerships are also viewed as ways to open and expand markets and increase opportunities for global economic exchange.

Figure 3. Share of Patents with Foreign Co-inventors (1999-2001)



Note: Patent applications filed at the European Patent Office
Source: OECD Science, Technology and Industry Scoreboard 2005

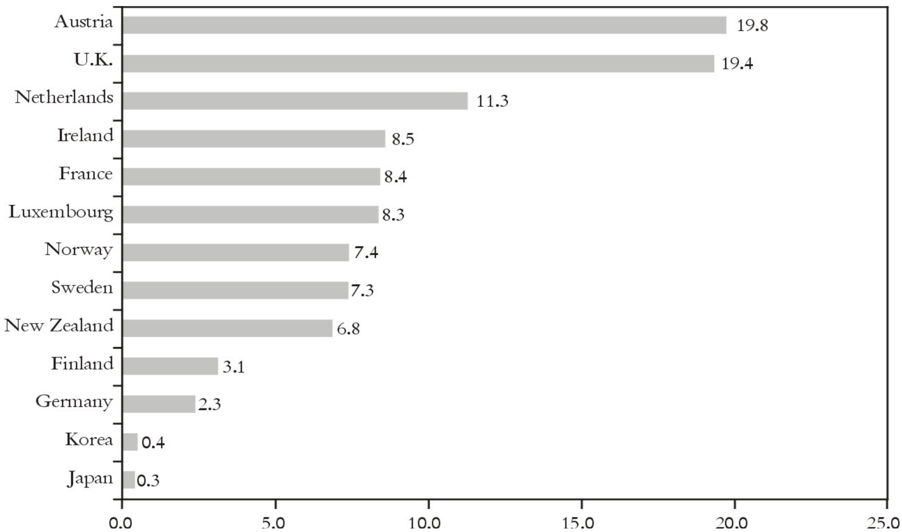
They are demonstrated in the form of the growth of overseas R&D by way of both contracts and subsidiaries and an increase in the number of industrial R&D laboratories abroad. In pure economic aspects, the response to competitive factors has also accelerated changes leading to cooperative activities. In reality, lots of the interregional alliances between firms sharing research and technology have been found in two emerging areas—information technology and biotechnology.

Reflecting increasing globalization of R&D activities, the proportion of R&D funding, being provided by foreign sources rises in a number of countries. In 2003, foreign R&D spending in Austria and the U.K. as a proportion of gross expenditure of R&D reached more than 19%. This is also quite evident in the case of Korea. Though Korea recorded a meager 0.4% in 2003, it represents a large increase in comparison to 0.01% in 1995.

3. Needing Global Solutions

Another aspect of how the environment in which S&T activities occur is

Figure 4. Percentage of GERD Financed by Abroad (2003)

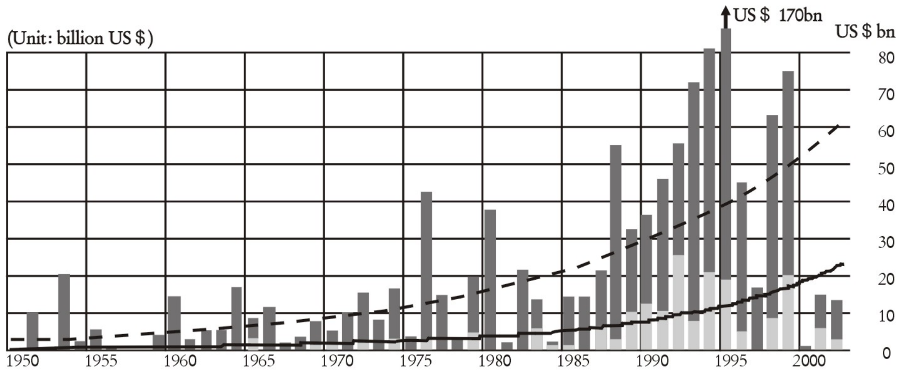


Source: OECD, Main Science Technology Indicators, 2006 becoming more globalized can be found in a growing array of issues that are global in nature wherein science and technology renders effective solutions to dealing with these global issues. They include, for example, climate change, genetically modified organisms, energy conservation and utilization, infectious diseases, disaster prevention and management, national security, population growth, intellectual property rights, and open exchanges of scientific information.

The recent epidemics like the illness known as SARS (Severe Acute Respiratory Syndrome) and AI (Avian Influenza) are cases that require scientists in different countries to work together. To cope with these problems, a concerted international effort is needed to increase countries' preparedness. International S&T cooperation can lead to better equip capabilities and strategies that help reduce the impact of these problems and disasters.

Many parts of the world have experienced serious natural disasters associated with unusual climate changes. It is anticipated that the occurrence of extreme weather and climate events may become more frequent due to global warming and the more erratic behavior of the ocean, such as the El

Figure 5. Economic Losses Due to Natural Disasters



1950～59	1960～69	1970～79	1980～89	1990～99
42.1	75.5	138.4	213.9	659.9

Source: Münchener Rück Munich Re Group, Annual Review: Natural Catastrophes 2002, 2003

Nino phenomenon. The global economic loss due to extreme climate recorded US$660 billion for the 1990s, which is an exorbitant increase from the US$42 billion in the 1950s. GNPs were substantially reduced during the last major El Nino years, particularly over the Southeast Asian region. The effects of climate change are expected to be greatest in developing countries in terms of loss of life and relative effects on investment and the economy.

Since the impacts of climate change are not limited to any one country or region, any effort to deal with it will have to be internationally coordinated. A concerted international effort is needed to increase countries' preparedness for natural disasters. Natural disasters extract a heavy toll on both lives and property, with extensive human and financial losses. The increasing concentration of population in areas that are prone to such disasters magnifies the impacts of such events. The projected distribution of economic impacts would increase disparity in the "quality of life" between developed and developing countries.

International science and engineering cooperation can lead to both better predictive capabilities and strategies to reduce the impact of these disasters. However, disagreements exist over the extent and significance of global cooperation and the costs and benefits of measures proposed to reduce it. To be successful, it will also necessitate at least general agreement on the science underlying the various positions and the active participation of scientists and engineers familiar with the various and complex aspects of the issue.

The safety of genetically modified organisms is another issue about which there is a great deal of controversy. There has been considerable international pressure for establishment of a bio safety protocol that regulates such organisms. Protecting human health and reducing the spread of infectious diseases, such as AIDS, tuberculosis, cholera, and ebola, also require a concerted international effort and advances in science and engineering.

These and other complex and systemic biological, economic, political, and ecological problems of the 21st century will demand more information, more participation by the scientific and engineering communities of all nations, and more cooperation between these communities and political decision-makers. These issues will not only affect national security but could also affect future global security. Increased international collaboration in S&T research and education will itself help expand the knowledge base for scientific consensus. International S&T cooperation also helps build more stable relations among countries, communities, and individuals by creating a universal language and culture based on commonly accepted values of objectivity, sharing, integrity, and free inquiry. Acceptance of such values is critical to the resolution of many problems and issues being addressed in the international arena.

4. Mobility of HRST: Key to International Cooperation

Mobility, a well-known and effective way of training researchers and disseminating knowledge, is a core element in research development. However, the continuation of international mobility of the S&T workforce relies on a policy of openness that encourages the free movement of scientists and engineers across national borders. And after 9/11, it needs an extra framework of appropriate national security considerations. Also, mobility is not an end in itself, but an instrument by which research results can be optimized. It ultimately brings added value by:

- Improving the quantity and quality of research training by offering the best available opportunities regardless of where this expertise is situated;
- Fostering research collaboration internationally throughout different regions and between the academic and business worlds through networking;
- Enhancing the transfer of knowledge and technology among the different actors of the research and innovation system, including industry;
- Raising the scientific bar for individual researchers and furthering the creation of international centers attractive to researchers from all over the world;
- Increasing the efficiency of research by pooling together competence and experience, providing better dissemination of research results, as well as optimizing the use of research infrastructure and research funding opportunities; and

- Demonstrating the openness of the Asia-Pacific region and attracting competent researchers from around the world.

Furthermore, as S&T are undergoing rapid development, researcher mobility has become critical. The movement of people and the knowledge they carry with them is a key flow in national innovation systems. Personal interactions, whether on a formal or informal basis, are an important channel of knowledge transfer not only within industry and between the public and private sectors but also among nations. People and webs of personal networks mediate the transformation of scientific knowledge into practical application across institutional barriers and national borders. Creativity of a scientist can come to fruition only when creativity is stimulated through the free exchange and interaction with others. In this regard the inter-regional researcher flow needs to be promoted in the Asia-Pacific and East Asian region.

IV. Review of Policy Activities

1. Korea

With regard to the globalization of human resources in science and technology, the Korean government has introduced various measures. It actually started in 1981with easing restrictions for Korean students studying overseas. In 1994, a program named "brain pool" started inviting overseas scholars, including foreigners. Scientists exchange programs also were initiated between Korea-Russia and Korea-China. In 1999, faculty positions became open to foreigners at national universities.

The most active approach for the "opening" was taken when the Korean government declared the "Initiatives for S&T Internationalization" in 2001. The purpose was twofold. One was to help Korean post-doctoral students and researchers to study and do research in foreign universities and research institutions. The other was to induce foreign researchers into Korean S&T activities. Since then, foreign researchers have been able to participate in national R&D projects, and the Science Card system has been adopted to allow foreign scientists and engineers to stay longer and more freely. Also, universities have been accepting more foreign students, and some lectures are being given in English. Bilateral governmental agreements and programs for the exchange of scientists, such as S&T cooperation between Korea-Japan, Korea-China, and Korea-Russia among others, have been signed and executed as major instruments for increasing mobility since 1994.

With all these efforts though, the openness or the globalization of human resources in science and technology in Korea have not yet made much progress.

2. Asia-Pacific Region

In recognizing the role of education in building human capacity and its effects on productivity, APEC economies have endeavored to build S&T human resources individually and in collaboration. With the beginning of the 21st century, APEC economies agreed on measures for building human capacity in science and technology. They were the Beijing Initiatives, recommendations of the S&T Policy Forum, and communiqué of the Science Ministers' Meeting among others. Through all these meetings, it was accepted that the globalization of economic activity and the trend towards knowledge-based industries have all generated the ensuing demand for S&T human resources. However no specific measure has been adopted to actually enhance the mobility of scientists and engineers.

Beijing Initiatives (2001)

The initiative originated from the vision laid out by the APEC Leaders in Brunei, who committed to put in place a policy framework that would enable all people in the APEC economies to have individual or community-based access to the services of the Internet by 2010 and to triple the number with access in the APEC economies by 2005. They placed particular stress on the importance of human capacity building to ensure that everybody could benefit from these goals. They also emphasized the importance of partnerships across the widest spectrum of stakeholders to develop the necessary policies and programs to effectively respond to the challenge of human capacity building. Though the Beijing Initiatives explored better approaches and came up with a series of innovative and interesting ideas on human capacity building within the region, the mobility of S&T workers was not covered.

APEC S&T Policy Forum (2001)

APEC Science and Technology Policy Forum (Penang, 2001) identified human capital as the key to economic growth and improved quality of life in a global knowledge-based economy. The level of scientific, technical, and soft skills required in all industry sectors is constantly increasing. Thus, building high-quality and adaptable human capital is vital for all nations and their industries. The challenge, therefore, is to ensure that all APEC economies can respond successfully to the demands for human capital required in the new economy.

The recommendation regarding mobility was to "create exchange programs between economies (developed and developing) for educators, students and workers to acquire specific S&T skills, access to mutual learning and teaching opportunities, and enable train-the-trainer programs."

APEC Science Ministers' Meeting (2004)

The theme of the APEC Science Ministers' Meeting was to enhance the capacity of science, technology, and innovation to deliver sustainable growth across the APEC region. One of the key policy issues under that heading was human capacity building. They recognized that the globalization facilitated by the rapid spread and use of information and communication technology gives rise to such issues as how scientists, researchers, and policymakers work with each other; and the availability and use of scientific and technological information, in particular balancing effective protection of intellectual property rights against ensuring the appropriate availability of public good information derived from research and development. It was also underscored that there is a need to ensure the workforce within APEC economies is equipped to meet the

Table 2. Researchers and Amount of R&D of Europe

	EU-25 nations	Korea	U.S.	Japan
Number of Researchers per 1,000 total employment	5.7	6.4	9.6	9.9
R&D as a % of GDP	1.8	2.6	2.7	3.1

Source: OECD, Main Science Technology Indicators, 2006

scientific and technological needs of today and the challenges of the future. And some specific challenges, including the importance of facilitating mobility of research skills, were discussed, but no specific action was taken to enforce the necessary measures.

3. EU Case: Marie Curie Actions

Europe lags behind in the size of the pool of S&T human resources and in the amount of monetary funds, both of which are considered to be critical factors in the development of science and technology. Europe tries to overcome the serious shortages in personnel and money by cooperation and collaboration among nations as well as S&T communities.

Compared to the Asia-Pacific region, the EU has a long record of encouraging researcher mobility in the field of education and training. The Erasmus program was set up in 1987 to provide assistance for university students to study at higher education institutions in another European country. Since 1984, researchers looking for opportunities to spend time working abroad have benefited from the Marie Curie fellowships and research training networks, which are an important part of Framework Program begun in 1984.

Nowadays, as a Human Resources and Mobility (HRM) activity of the Sixth Framework Program, Marie Curie Actions are aiming for the development and transfer of research competencies, the consolidation and widening of researchers' career prospects, and the promotion of excellence in European research.

■ The budget is €1,580 million and is largely for the financing of training and mobility activities for researchers.

- The actions are open to researchers in all fields of scientific and technological research from the EU Member States, from countries associated with the 6^{th} Framework Program, and from third countries.
- Eligibility for the various schemes is based on research experience and expertise, not age. Covers all levels from researchers at the start of their career to world-renown researchers.
- The actions are open to business, universities, and institutions active in research.

Target researchers

To take part in most of the Marie Curie Actions, a researcher must be prepared to move countries. Mobility is defined using the following criteria:

1. The researcher should not be a national of the state in which they plan to move and carry out their research;
2. The researcher has not lived, worked, or studied in that country for more than 12 months out of the three years immediately prior to either the time of application or the start of their work (depending on the action).

The opportunities open to individual researchers depend on their level of research experience. There are two main categories of researchers eligible for funding as is shown below.

Table 3. Category of Researchers for MC Actions

Early-stage researchers	Researchers at the beginning of their research career with less than four years' active research experience (e.g., researchers undertaking a doctoral degree)
Experienced researchers	Researchers with more than four years of active research experience or those with a doctorate degree. (For some actions, researchers with more than ten years of experience will not be eligible.)

Programs and Activities

Individual researchers taking part in a Marie Curie Action have two options:

- To apply directly to an institution that has been selected for a Host-Driven Action.
- To prepare a project together with a host institution of the researcher's choice and submit it to the Commission.

Research organizations can apply to the Commission for funding to provide the following types of training opportunities for researchers of any age or nationality:

- Initial Training: This is best suited to researchers at the beginning of their careers and is normally focused on structured training (e.g., via tutorials, courses, and acquisition of complementary skills in addition to training-through-research).
- Transfer of Knowledge: This is mainly aimed at institutions that want to develop their research capabilities via the hosting or assisting of researchers with more experience or specialized knowledge. In particular, multidisciplinary and inter-sectoral exchange will be encouraged.
- Advanced Training: This type of training provides an environment where experienced researchers can receive advanced or specialized training.
- Other Facilities: This includes funding for the organization of conferences and training courses or for hosting world-class researchers either as Marie Curie Chairholders or as team leaders in Marie Curie Excellence Grants.

Under these schemes, the host institutions will be selected by the Commission and will be given the freedom (within certain guidelines) to select the researchers who will benefit from the training or who will participate in the transfer of knowledge.

V. Challenges and Roles of Korea

Vision

The effort to enhance mobility is to cooperate in identifying and taking actions with a view to removing present obstacles to the mobility of researchers and to facilitate the creation of a genuine cross-border scientific community. Exchange of scientists and engineers would encompass all fields of research in the public and the private sectors as well as all age categories and stages of a career, e.g., Ph.D. students, early-stage, mid-career, or senior researchers.

Korea would share its knowledge and skills with other neighboring nations and also from other areas of the globe, allowing it to improve its own scientific resources and to forge lasting partnerships that complement broader foreign and domestic policies.

This will make the Asia-Pacific region an attractive place for the world's best scientists to work, encouraging the return of those who left to complete their training or pursue careers abroad and bringing together the scientific communities, companies, and researchers of other countries in the region.

Working together would result in top quality research to tackle some of the world's most pressing problems and deliver sustainable growth in the Asia-Pacific region. It would also contribute in greatly enhancing the capacity of S&T human resources in Korea.

Principles and Strategy

The reasons behind the migration of personnel internationally may generally divided into two perspectives. The one, of the supply side, is the desire for economic opportunities abroad that are better than those available at home. The other, of the demand side, is the migration policies in receiving countries. This is usually true for S&T personnel in developing countries but also in advanced countries when there are insufficient employment opportunities for large numbers of S&T graduates owing to low business R&D spending and few job openings in the public research sector.

For S&T personnel and engineers, however, extra non-economic factors, such as host country conditions for excellence in teaching and research are especially important. Individual career strategies also affect the propensity to migrate and choice of destination. For scientists, mobility becomes a means for career development, so enhancing his/her prestige and reputation. The presence of innovative, high-technology industry is an important motivating factor for skilled human capital as are the developing centers of excellence for scientific research. Therefore, framing the conditions under which technological innovation and entrepreneurship may expand are important for making a country attractive to highly skilled workers, both domestic and from abroad.

Bearing these points in mind, the basic scheme for the mobility strategy of scientists and engineers is to devise an improved research system where mobility is a central element during the different stages of the researcher's career, that is to make transnational mobility enrich the researchers throughout their careers. In order to achieve this, a more favorable environment for transnational and/or inter-sectoral mobility throughout the research career must be developed.

The achievement of these objectives can be supported with the removal of obstacles to mobility and added financial incentives. Because mobility is is reliant on the easy migration of people and their families, depending on the duration of stay, most of the obstacles are associated with career and living environment. The strategic items to consider in creating a more favorable environment for the migration of researchers internationally can be categorized along the following priority areas:

- Financial issues: Mobility is hindered by inadequate funding. Difficulties covering financial necessities and insufficient opportunities result in an absence of positions, fellowships, return and/or re- integration grants, etc., especially at mid-career and senior researcher levels.
- Recruitment methods and conditions: Scientific and engineering positions are often still not advertised internationally. Also, there are difficulties related to the recognition of credentials from other countries. For positions in the public sector, researchers may still face citizenship restrictions imposed by the law and regulations.

- Return and career development: In many cases, mobility is often not sufficiently appreciated. For researchers without a permanent position, e.g., fledgling Ph.D.s, there is a fear of being left "out of the system" if they go abroad. Also, mid-career researchers who have been away from their national research system for some years often have difficulties obtaining a position on returning home. For more established researchers, leave of absence can be a disadvantage to career advancement. Research undertaken abroad or in other sectors may not be adequately appreciated.
- Admission to the country and access to employment: Immigration restrictions may hinder mobility. Korea, for example, grants specific types of visas to foreign researchers with good credentials. But to open the door more widely, the problems linked to visa, residence permit, and work permit requirements need to be resolved.
- Social security rights and fiscal issues: Differences in the social security systems and levels of taxation among nations may make migration unattractive. Mobile persons often have to pay contributions for benefits they cannot enjoy nor receive compensation for, e.g., social security benefits and medical insurance. Foreign researchers, who are obliged to leave the country at the end of their planned stay, may lose their pension contributions if there is no bilateral social security agreement between the relevant countries. Also, bilateral taxation agreements are necessary between relevant countries.
- Family issues: These need to be emphasized as researchers normally either move with their family or need to keep close contact with the family remaining in the home country depending on the duration of the stay. The partner often has difficulties finding a job in the new country or to take leave from his or her present job.
- Gender: Finally, specific attention needs to be paid to the gender aspect of mobility. Generally speaking, women researchers continue to face more serious obstacles to career progression than men do. Specific obstacles arising from the structures, procedures, and criteria governing migration need to be addressed to ensure mobility equality for women scientists.

Recommendations for Actions

Korea now boasts of Daedeok Innopolis, which has been reorganized from the Daedeok Research Complex as a world-cluster signifying Korea's commitment maintaining its high-tech prowess. Daedeok Innopolis, being a center of excellence for scientific research, would be a magnet for attracting highly-qualified S&T personnel.

In implementing the strategy to create a more favorable environment for the exchange of researchers, this paper recommends two types of actions: the first aims at removing obstacles to the mobility of researchers throughout their career. The second aims at building up the financial measures required to reach a critical mass of mobile researchers.

Actions aimed at improving the environment and providing financial support

The first type of action, based on short- and long-term perspectives, aims at improving the practical environment for researchers in the Asia-Pacific region and establishing the necessary conditions for effective mobility.

<u>Improving the information flow</u>

Collecting data and utilizing each nation's existing exchange program will launch the mobility program and expedite the setup of mechanisms at the national and scientific community level. For instance, establishing a cyber labor market, i.e., a web platform for scientists and researchers where research institutes, and various organizations in need of scientists and researchers post job offers specifying required qualifications, would provide the necessary centralized forum. Scientists and researchers who want to build up new experiences register with personal and profession information. The Internet portal is a very efficient tool for linking researchers seeking jobs and the organizations looking for applicants across national boundaries. Not only for research and development, but also for the dissemination of newly emerging technologies, it would act as a bulletin board for recruiters and applicants.

Improving practical assistance to researchers

Setting up mobility help centers in each country will assist foreign researchers in dealing with legal and administrative matters. The assistance will include support for integration into the working and social environment of the host country, including taxation and intellectual property rights. The objective is to encourage host organizations to take more responsibility for their visiting researchers. The center would deliver practical information on accommodations, daycare, or education for children and give advice on job opportunities for the accompanying partner. The center would be a source of information that can be input to discuss and propose laws encouraging mobility among nations.

Legal improvements

Improvements are needed in the legal situation affecting migration, access to employment, social security, and taxation. It would have to start by examining the general measures currently being in force in each nation, such as the Science and IT Card in Korea. Multilateral tax and social security agreements among nations would also have to be reviewed. Educational data and qualifications are an important source to judge and admit foreign scientists and engineers. One way of applying the common criteria is to jointly qualify diplomas, credentials, or the requirements for eligibility.

Providing appropriate financial support

For developing a critical mass of mobile researchers, the creation of a favorable environment for the mobility of researchers is necessary but not always sufficient in itself. It must be supported by a system of financial incentives.

In providing these incentives, it is of paramount importance that the financial mechanisms go beyond the mere financing of fellowships. Such issues as the return and re-integration of researchers to and from visiting countries and the situation of families need to be taken systematically into consideration.

On this basis, a significant increase and diversification in the availability of funding opportunities and provisions of more open and systematic access to funding for researchers must be developed. In doing so, the government needs to be encouraged to make research project funding more dependent on mobility aspects by taking transnational and inter-sectoral mobility more systematically into consideration in selection criteria and promotion schemes.

Utilizing the best practice

The demonstration of best practices can be utilized to raise public awareness about the necessity of the mobility of scientists and engineers. The understanding and appreciation of the value of mobility for the advancement of science and technology would prompt and upgrade the level and coverage. Benchmarking the best practices would identify the common criteria for the professional situation of the researcher. This, in turn, allows applying the reciprocal treatment for visiting researchers through coordination.

Coverage of Actors, Levels, and Areas in Two Stages

First Stage: Take off

In the initial stage, the mobility scheme needs to be built up by launching immediate actions for implementation. It would start by listing the policies for enhancing mobility that are currently being enforced in each nation and selecting those that have common factors among the nations. Those selected policies could be immediately implemented out with little or no modification.

The major portion of the exchanges in the first stage would be through government-led research projects. Also, the exchange of the researchers could easily be vitalized for a growing array of issues that are global in nature. These issues include climate change, environment conservation, infectious diseases, and disaster prevention and management. The major actors will be post-docs, early-stage researchers and persons undergoing training among others.

This beginning would create the dynamics for increased mobility and would identify ways to increase financial support by the different actors involved.

Second Stage: Maturity

Based on the improvements and acceleration achieved for ongoing multilateral exchange programs in the first stage, studies on obstacles, institutional and non-institutional, that hinder exchange practices would obviously be identified. Ways and means of reducing barriers and obstacles for mobility and promoting financial incentives would have been found and amended by trial and error.

The second stage is to promote new personnel exchange programs to meet the specific needs of the Asia-Pacific region. These include training programs, mission trips, policy dialogue and working groups, fellowship programs, and joint projects, providing researchers with the opportunity to work in their laboratories for a period of time. The training programs would include offering R&D management training and specific technology training, e.g., clean technology. Science and technology fellowship programs would be offered to enable young scientists and engineers to conduct research at universities and research centers.

The major portion of the exchanges in the second stage would be expanded to cover not only government projects, but also university and research institutes. The area and issues of research would encompass the basic sciences, like mathematics. The major actors will include mid-career and senior researchers.

The mutual certification of qualifications for certain technologies would be put into full operation. Joint degree programs for MAs and PhDs among the universities of the region would be established, issuing mutually authorized diplomas.

VI. Conclusion

This paper has emphasized the changing nature of the world, characterized by increasing globalization and greater reliance on science and engineering. These factors force the Korean government to re- examine its role in international science and engineering research and education, especially its management and promotion of international S&T collaborations and the relationship of science and engineering for the solution of global problems.

The development of an effective framework to enhance mobility of human resources in S&T in the international arena is a critical priority for assuring Korea's global leadership in the decades ahead. The framework must be based on clear and effective policy principles and objectives. The findings and recommendations presented in this paper identify key areas for attention and action. And it needs to adopt and execute the recommended actions until internationally mobilized personnel reaches critical mass.

The ability of scientist and engineers to contribute to societal goals and to address global problems relies to a high degree on global communication and cooperation in science and engineering. International cooperation would help build sustainable development in and throughout the Asia-Pacific and East Asian region by:

- Encouraging globally shared values rooted in scientific inquiry
- Increasing global research capacity for global problem-solving
- Promoting mobility on a global scale
- Enabling global sharing of tools and information
- Bridging the North-South divide in scientific and technological capacity

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Executive Summary

As the contributions of science, technology, research, and education continue to be key determinants of economic growth in the 21st century, this paper will focus on ways to enhance human knowledge resources in the Asia-Pacific and East Asian region. The paper sets two goals to realize this vision. The first goal is to develop recommendations for increasing the mobility of scientists and engineers internationally. The second is to develop recommendations for an effective leadership role for Korea in strengthening the framework for international mobility of human resources in science and technology ("S&T").

International mobility is considered a key driver to enhance S&T capacity. It ultimately adds value to S&T by 1) improving the quantity and quality of research training by offering the best available opportunities regardless of where this expertise is situated; 2) fostering research collaboration internationally between the academic and business worlds through networking; 3) enhancing the transfer of knowledge and technology among the different actors of the research and innovation system, including industry; 4) raising the scientific bar for individual researchers and furthering the creation of international centers attractive to researchers from all over the world; and 5) increasing the efficiency of research by pooling together competence and experience, providing better dissemination of research results, as well as optimizing the use of research infrastructure and research funding opportunities.

However, the international mobility of the S&T workforce relies on a policy of openness that encourages the free movement of scientists and engineers across national borders. The effort to increase mobility involves identifying and taking actions to remove present obstacles to mobility and to facilitate the creation of a genuine cross-border scientific community. The achievement of these objectives requires both the removal of obstacles to mobility and added financial incentives. Because mobility is reliant on the easy migration of people and their families, depending on the duration of stay, most obstacles are associated with career and living environment. The strategic items to consider in creating a more favorable environment for the migration of researchers can be categorized along the following priority areas: financial issues, recruitment methods and conditions, return and career development, admission to the country and access to employment, social security rights and fiscal issues, family issues, and gender.

To implement the strategy for a more favorable environment for the exchange

of researchers, the paper recommends a set of actions aimed at improving the practical environment for researchers in the Asia-Pacific region and establishing conditions conducive to increased mobility. These include improved information flow, increased practical assistance to researchers, better legal conditions, appropriate financial support, and utilization of best practices.

Increased mobility is expected to enhance global communication and cooperation in science and engineering. International cooperation will also lay the foundation for sustainable development in Asia- Pacific and the East Asian region.