4. Opportunities for Enhancing the Korean-U.S. S&T Relationship

The S&T relationship between Korea and the United States is in the process of shifting away from what might have been called a "senior-junior" relationship or a "center-periphery" relationship toward a more balanced relationship between scientifically advanced countries. As S. C. Chung (2001) has noted, Korea's transition to world-class S&T capacity has tracked with the transition of the scientific community overall toward global R&D. This has resulted from a deliberate policy to move Korea from foreign assistance to reciprocal multinational cooperation. Happily, Korea's transition has coincided with, and been able to take advantage of, the global information revolution. Korea is one of the most highly networked societies in the world, allowing researchers to take full advantage of dynamic networks emerging in global science. These transitions present opportunities for policymakers in both countries to consider shifts in priorities and perhaps a reorganization of the binational relationship.

The binational relationship still retains a number of characteristics and features that were crafted under a center-periphery model while Korea was developing its S&T base. Some of the features of this relationship, such as the special cooperative program sponsored by NSF and MOST, are no longer optimal. In order to enhance the relationship, it may be beneficial to restructure it to better fit both the changing nature of global S&T and the changing dynamics between the two countries. Figure 4.1 illustrates this change: As many factors converge to encourage a greater networked dynamism in science, more and more projects emerge in the spontaneous-distributed quadrant. Hierarchically organized and structured research projects—while still valid for many subjects—are increasingly being displaced by dynamic, networked projects that rely on distributed, coordinated research activities.

This emerging organization of science—allowing researchers to work in their home laboratories and link with others around the world—has considerable benefits for the Korean-U.S. relationship. Although the two countries are so far apart geographically, they have a close relationship in science. Their relationship could become a model of using ICT to further enhance collaboration. Using ICT means that resources will be more effectively shared, that the cost of travel and relocation of scholars will be reduced, and that real-time tasks can be allocated

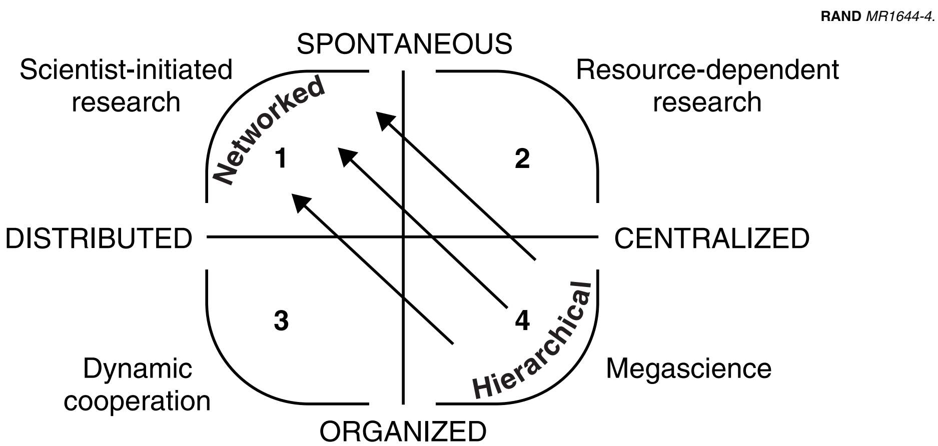

Figure 4.1—Organizational Structure of ICRD: Information Flows

and conducted in several places. This distributed allocation of science helps build capacity in a number of places, further enhancing the dynamism and benefits of the relationship.

Forging a More Balanced Relationship

It is widely recognized that the United States is currently the world center for science. It has been recently recognized that Korea has improved its scientific capacity to the point where it is among the scientifically advanced countries, at least in some important fields (Wagner et al., 2001). This fact leads to several discussion points for enhancing the Korean-U.S. relationship:

- Point: An initial premise might be that it is more to the advantage of Korea than to the United States to collaborate in science. In other words, the premise is that the United States has little to gain scientifically from the relationship. If we assume that the center-periphery model is valid here, and it is arguable that it is, then it would make sense for Korea (and for other countries) to collaborate, imitate, and adapt the scientific system practiced in the United States in order to build up its own capacity.

  Counterpoint: While the center-periphery model has many points for consideration, it does not account for the global dynamic networks that have emerged on top of the national science systems. This metanetwork creates "invisible colleges" of experts to which U.S. scientists seek (as well they should) to be a party. Accordingly, a vibrant collaborative relationship in the fields where Korea has significant strength is in the interests of the United

States as well as Korea. Moreover, Luukkonen et al. (1992) have shown that in a specific discipline, one country can become an intellectual center, with others seeking to collaborate with it. This phenomenon does not require a country to have the largest R&D investment, just a well thought-out strategy. Thus, Korea could take the lead in specific fields where it has strength or interest, and the United States could benefit from the enhanced investment.

- Point: The United States is among the world leaders in almost all fields of science, suggesting, again as an initial premise, that it would make sense for Korea to seek to collaborate with the United States in any field in which it seeks to build capacity.

  Counterpoint: Collaboration has been shown to be an effective method of capacity building (Wagner et al., 2001). However, an unequal collaborative relationship based on capacity building creates dependencies and feeds a perception of inferiority that may not be in the best interests of Korea over the long run. Collaborating in the areas of the *greatest strength* makes more sense, based on what we are learning about the dynamics of cooperation among scientifically advanced countries. It would be useful to match collaborations where Korea has strength—physics, chemistry, and an emerging capability in biomedical research—as a way to target areas for cooperation.

- Point: Moving the relationship to a new level may require new government-to-government agreements and new programs to target areas of strength.

  Counterpoint: Although a restructured ISTA agreement may be useful, and new programs may help shift targets, this may not be the best way to enhance the relationship. Successful collaborations work from the bottom up (they are identified by scientists themselves), are peer reviewed, and result from shared interests rather than common targets. The relationships among the scientifically advanced countries are robust because they encompass the interactions of hundreds of individual scientists seeking to work with the best people in their fields.

In summary, special emphasis in the bilateral relationship should be placed on collaborating in areas of strength and common interest, should take advantage of ICT and the infrastructural investments in both countries, and should be bottom-up and peer reviewed. Restructuring the Korean-U.S. relationship to better match the enhanced position of Korea and to reflect the networked, distributed nature of global science cannot be done in a single stroke. In the near term, enhancements may need to be tailored to the type of scientific activities that are of interest. Moreover, as we have discussed, the extent to which science policy has an effect on the nature of the S&T conducted between the two nations depends heavily on the funding source, the nature of the scientific questions, the location of resources, the interests of scientists, and so on. Policymakers have a direct influence over only a small portion of the overall relationship. Thus, an enhanced relationship would have aspects of each of these features, taking account of the dynamics of different types of sciences and the characteristics of collaboration as well as roles for the private sector. For other parts, setting an agenda or providing infrastructure can help, but only in an indirect way. In still other cases, policymakers have no impact on the nature of the relationship. The following section discusses enhancements as they may apply to each of the four quadrants of Figure 4.1, ones that broadly represent the dynamics of collaboration. Table 4.1 summarizes the points in each of the four sections.

Maximizing Spontaneous-Distributed Activities

Spontaneous-distributed ICRD activities, located in quadrant 1 of Figure 4.1, are those activities emerging from the interests of individual scientists and then taking place as physically remote interchanges from an investigator's home lab. If we were to refer back to the "iceberg" in Figure 1.7, these activities would be "below the waterline" in the team section. These types of projects are often funded through grants made either to the individual investigator or to a research institution. Each grant is generally small compared with the cost of participating in a megascience project. Links among researchers are often robust and active, and may include representatives from more than one scientific discipline. The learning that takes place as part of the research is often contained within the team during the course of the project, which, on average, may be a period of three years, but the end results are usually codified in a scientific journal paper.

International partners in these types of projects often come from similar institutions (e.g., university labs, metrology labs) within scientifically advanced countries. As we have found in other research, collaboration is most successful when the capacity of the participants to conduct research is roughly equivalent (Wagner et al., 2001). The projects are time-limited, and, in the majority of cases, the links between the researchers become "quiet" when the project has ended.

Table 4.1

Characteristics of Participation in Different Types of ICRD

	Corporate → Team → Interpersonal			
Functions and Organizational Issues	Organized-centralized ICRD: megascience	Organized-distributed ICRD: Human Genome Project	Spontaneous-Centralized ICRD: global climate change research"	Spontaneous-distributed ICRD: teams
Methods of funding	Institutional funding, often centralized in a single organization run by a supranational staff; national funds pooled	Contracts or grants generally provided to teams based on peer review; funds sometimes provided directly to institutions; national funds sometimes pooled	Mixed financing, sometimes directly to institutions, others in pools of funds to teams of international researchers	Grant-based research, usually to an individual or small team; ICRD participants are self-funded
Entry, interaction costs for government participation	High costs associated with joining and maintaining a position in large-scale equipment investments; interactions can require extended visits	Medium costs involved in joining an established project and supporting national researchers; interactions involve ICT, conferencing	Medium-to-high costs of conducting equipment-based experiments, sharing data; interactions can require expensive travel	Low cost overall, project-based research; interactions use ICT
Organizational structure	Hierarchical/ structured, with researchers sharing common research goals, ongoing research, and findings through a centralized program or through a well-defined set of core journals	Networked/ structured, researchers choose topics and conduct experiments remotely, share results with larger program	Hierarchical/ structured, concepts about what research to pursue being suggested by groups of researchers; data shared with large groups	Networked/ unstructured, with researchers creating networks that interact based on project needs
Government Influence		High → Medium → Low		

Table 4.1—continued

	Corporate →	Team →	Interpersonal	
Style of knowledge output	Codified, with researchers writing findings and sharing these with colleagues and a wider scientific community	Tacit-experiential, with researchers first learning from each other as the work proceeds, sharing know-how with a larger group; publication follows	Codified, data driven, with researchers pooling knowledge into a larger set of data that is drawn upon by many	Tacit-experiential, with researchers first learning from each other as the work proceeds; publication follows
National-level partnerships	"Top-down," heterogeneous partnerships involving advanced and developing countries, researchers from small and large institutions, funding sometimes provided from nongovernmental organizations	Mixed-homogeneous, with scientific goals guiding national investments; governments and industry often involved in organization, funding	Mixed-heterogeneous, with scientific goals set at the global level, governments and industry involved in agenda-setting, participants from advanced and developing countries, small and large institutions	"Bottom-up," homogeneous and unstable, researchers generally coming from similar institutions in scientifically advanced countries, partnerships forming and breaking up based on research question
Government Influence		High →	Medium →	Low

Examples of these types of projects between Korean and U.S. researchers include:

- A joint study on agent-based cross-language information retrieval.[10]
- A comparative study of the prevention of dental problems in the United States and Korea.
- Joint studies on alternative energy sources.

[10]Researchers from Sookmyung Women's University in Seoul are working on this project with researchers at the Language Technologies Institute of Carnegie Mellon University. The Korean language offers many important and unique research challenges to digital libraries research. Solutions for information merging and retrieval from Korean/English corpora can be generalized to other non–alphabet based languages, including Japanese and Chinese.

One way to aid the growth of these relationships between Korean and U.S. scientists is to reduce transactions costs: sponsor workshops and symposia, offer liberal travel grants, and build bandwidth to ensure that work in progress as well as published material is widely available digitally to scientists in both countries. This could include creating virtual collaboration in specific fields of common interest, or holding a virtual conference on important research subjects.

Participating in Organized-Distributed Activities

Organized-distributed activities, quadrant 4 in Figure 4.1, are those where teams of participants from different countries share a common research goal. These are generally formal team partnerships such as the recently completed Human Genome Project and the ongoing IMS initiative. Like the spontaneous-distributed research activities, these types of distributed projects appear to be increasing in number and have attracted the interest of both policymakers and scientists. Often these projects will have mixed financing, with contributions from various sources and in varying modes (Wagner et al., 2002). These can include government and foundation grants, contracts, private-sector funding, and shared funding. The costs involved in initiating or joining programs like these can be significant. As a result, smaller countries are often unable to participate in them.

Communication within these team activities has features of both networks and hierarchies. Researchers communicate in ways similar to spontaneous-distributed research projects, but there is often a central coordinating office that also provides a communication function. At times, a central office may connect researchers to each other in order to facilitate connections. Data created in the course of these activities is often shared first within the research group and then published formally.

Organized-distributed research activities have the advantage of being able to include a range of partners, although often, the ability to provide financial contributions determines the cohort of participants. These programs can find ways to include private-sector partners, as well, and this can be a source of additional financing.

Lee (2001) suggests that Korea should reinforce its ongoing participation in these types of activities and join new projects such as the post–Human Genome Project and Human Frontiers Science Project. These types of activities offer significant benefits to Korea. Among the benefits are contacts with researchers from countries with which Korea has not been a traditional partner. This could help to extend Korea’s international partnerships in a way that would enrich its science base.

Governments of both countries could consider several ways to enhance their relationship in the organized-distributed projects. Among these may be to consult with each other should either one consider proposing a new project to the international scientific community. A second way may be to set aside funds to encourage *teams* of Korean and U.S. researchers to participate in programs such as the IMS initiative. A third way may be to develop a joint evaluation tool with which to assess the effectiveness of existing activities and to offer this tool to other countries participating in team-based ICRD. A fourth way would be to invite private-sector ideas, financing, and leadership in dynamic research projects using this organizing principle.

Joining Organized-Centralized Activities

Organized-centralized activities, quadrant 3 in Figure 4.1, have traditionally been referred to as megascience projects. They include activities that are well known among the international scientific community such as CERN, ITER, and the ISS. These programs have characteristics of “corporate” collaboration, and are at the “tip of the iceberg” in Figure 1.7. Funding is often contributed by member governments to a shared pot, creating a single location and a supranational staff. They often involve the building of expensive research facilities such as a synchrotron.

Lee (2001) suggests that Korea initiate Korean-led megascience projects utilizing existing facilities like Pohang Collider Laboratory and Asia Pacific Theoretical Physics Center, and establish a megascience supporting system. Indeed, participating in these types of projects can bring prestige and excellent contacts along with them. Nevertheless, the costs involved are also high and require a multiyear commitment. As such, they tend to crowd out other types of R&D activities that may in fact help build a more robust international network.

The organization of these activities has traditionally been hierarchical, with researchers sharing common goals. While multidisciplinary studies are found within these programs, they generally focus on the research questions of concern to a single discipline of science, such as high-energy physics or aeronautics. The results of the research are usually codified in publications or in large-scale equipment. One benefit of this type of investment from the point of view of developing countries is that they use expensive facilities at marginal cost. However, researchers from countries that are not full members often find that their access to facilities is quite limited (OECD, 1997).

The growth of the Korean-U.S. relationship will probably benefit more from attention to growing the bottom-up research activities rather than focusing on this type of top-down investment. These are expensive activities with investments made in fields where the United States and Korea often have a strong relationship already—such as physics. It may be worth considering taking a balanced approach to all four types of ICRD: If such an approach were taken, attention to this megascience could wait while other types received more needed attention.

Choosing Among Spontaneous-Centralized Activities

Spontaneous-centralized activities, quadrant 2 in Figure 4.1, are those where a common research subject requires the collective efforts of interpersonal and team-based researchers. Common research questions include climate change, infectious disease, pollution, potable water supply, the science of the arctic, the health of the oceans, the movement of tectonic plates, and the welfare of endangered species. In many cases, the research activities surrounding these types of questions are globally coordinated—even if this is a loose configuration. Projects such as the Ocean Drilling Project and studies supporting the research questions before the Intergovernmental Panel on Climate Change have features of both spontaneous research and centralized organization. Funding for these projects is often mixed and can come from governments, nongovernmental organizations, and industry. The global nature of these questions means that international teams form with relative ease; an international team often enhances chances of receiving funding.

At times, participating in these projects can be expensive: Funding of the retrofitting of a ship to take part in arctic research or funding the launch of an atmosphere-monitoring satellite is costly. These types of investments mean that some coordinating function and government-to-government negotiation takes place. In addition, these projects can be data-intensive: Storing and making data accessible can also require a significant financial investment.

The global nature of the questions and the particularity of the location of the subjects of study mean that most governments have an interest in promoting this type of research. Organizations with global interests are also likely to fund these types of programs. The shared nature of the funding can often mean that some countries or individual research teams can participate without a great deal of up-front costs. An example of Korean-U.S. cooperation of this type is the analysis of the seismic response of the Jualien Containment Model, using extensive seismic response data recorded within the Jualien, Taiwan, 1/4-scale model of a nuclear containment structure to validate a set of mathematical models and computer codes. These mathematical models and computer codes have been used to calculate the seismic response of important structures when the effects of the interaction between the structure and the surrounding soil are significant. The Jualien experiment is being conducted by a consortium of organizations including the Electric Power Research Institute and the NRC in the United States, and institutions from Taiwan, Japan, Korea, and France.

Both governments have an interest in promoting this type of research on key global questions. These programs are perhaps the easiest to justify to stakeholders and legislatures. As a result, the Korean-U.S. relationship in these types of programs should be examined and possibly strengthened. One way to do this is to encourage the creation of data that can add to global understanding. A joint project to enhance efforts to create and share needed data on climate change, for example, would be a good way to enhance the binational relationship in a global context.

Conclusions and Policy Recommendations

Over the past two decades, in part due to explicit policy and in part to bottom-up growth, the United States has been the principal partner in Korea's quest to increase national S&T capacity. The United States has been Korea's most frequent partner in ICRD projects. U.S. universities have trained tens of thousands of Korean scientists and engineers. The United States government has maintained a special program to encourage the relationship, and has an active bilateral agreement to encourage cooperation. The United States has also been a key source for technology transfer, through investments by U.S. firms or imports of U.S. technology.

One outcome is strong collaborative research ties between scientists and engineers in the two countries. Another is enhanced S&T capacity in Korea as well as the rise of centers of excellence in specific fields. As the binational relationship has grown, and Korea has continued investments in the infrastructure needed to support a strong S&T sector, Korean science has emerged into world-class status in many fields. The development goals of both parties have borne fruit.

All this has helped Korea to transform from what Alice Amsden (1989) calls a "rapid imitator" to a country with a robust national innovation system. Indicators such as the number of patents awarded, publications in scientific journals, numbers of S&E professionals, and investment levels show that the country is rapidly joining the ranks of scientifically advanced nations. S&T policy reforms and new R&D initiatives are being implemented to firmly secure Korea's place in the community of scientifically advanced nations.

The position of the U.S. S&T community in world science has also changed. While the United States is at the frontier of most areas of scientific research, it is not the leader in every field. The nature of certain scientific problems and the costs of research for global problems provide an incentive for the United States to work cooperatively with other nations. The need for the United States to seek international partnerships, and to tap foreign centers of excellence, has also grown. The U.S. S&T sector has become increasingly interlinked with other nations, but it still remains (in terms of percentages of coauthorships, for example) less internationalized than other countries.

The United States continues to support S&T collaboration with Korea; support for the relationship in some science policy circles is strong. However, in other policy circles, concern grows as Korea continues to strengthen its competitive position in technology-based exports. The extent to which technology transfer from the United States is feeding Korean competitiveness remains a point for discussion. Some say that Korea benefits more from the bilateral S&T relationship than the United States does. Whether this is true is not the point: This uneven relationship may come into question as Korea's economic competitiveness continues to grow.

These factors suggest that the time has come for a new S&T policy agenda for the bilateral relationship. The information we provided above about the structure of collaboration, the strengths of the two countries, and the ways in which they form policy about international collaboration can certainly help to instruct a discussion about the relationship. In addition, the following points may also aid discussion.

1. Continue the shift away from a center-periphery relationship toward a "centers of excellence" model.

A shift away from a center-periphery relationship has already begun—for example, the AID no longer provides special science programs for Korea. Other special U.S. programs that target aid to Korean science should be phased out over time. Optimal cooperation will most likely result from bottom-up initiatives by individual scientists in both countries. Policies to encourage this, such as special Web-based links, data, and information, should be considered. A joint project on machine translation might help to improve a key technology that would aid the relationship.

Although we suggest that the U.S. government discontinue special funds for the bilateral relationship, special funds created by the Korean government to encourage U.S. researchers to work with Korean collaborators may continue to be useful. Many Korean researchers involved in international collaborations are from the top universities in Korea where research facilities are excellent. Opportunities to access these facilities physically or virtually may be welcomed by U.S. researchers. With the recovery of the Korean economy, private industry might be encouraged to enter into public-private partnerships and invest in these special research funds to encourage U.S. researchers to visit Korea.

2. Expand the dialogue on S&T infrastructure.

Bilateral cooperation on the costs of scientific infrastructure, with a point of identifying opportunities to leverage investments, would be useful. Such discussion can also address important issues related to scientific research, including policies and regulations on technology transfer, intellectual property rights protection, ethics in research, and environmental impact. This may be especially important in emerging scientific areas such as biotechnology, where laws and ethics are still in their early stages of development. Korea could sponsor international forums for discussion, support joint research to examine issues of concern to Korea (as well as both countries), and fund visits by U.S. experts to Korea to give lectures and sit on advisory panels. Such interaction may also help to better inform foreign experts and policymakers of efforts and conditions in Korea and facilitate dialogues to address potential problems and conflicts that might arise at the international level.

3. Further internationalize science in Korea.

Korea has been seeking to make its R&D environment more supportive of international R&D collaborations, and this appears to be a positive trend. The United States could benefit from reviewing Korea's set of policies in this regard. In addition, Korea can draw further lessons from the United States on the management of research laboratories to better support international R&D collaborations. Korea could use advisory boards that include scientists and engineers from the United States and other scientifically advanced countries to ascertain whether new measures, including review and evaluation of grant proposals, are implemented and how successful they are. The results would also be of use to the United States.

4. Diversify Korea's participation in global science.

Building on existing strong ties between researchers in both countries, Korea might consider increasing support for Korean researchers to be involved in multilateral R&D efforts based in the United States or led by the United States. However, Korea should move beyond its reliance on the bilateral relationship with the United States and seek to strengthen ties with other scientifically advanced countries. This might include steps toward increasing Korean involvement in distributed and large-scale international science projects and efforts to expand Korea's S&T ties with other countries. Apart from funding to support participation of Korean scientists in these efforts, Korea will also have to invest in sharing the cost of facilities, equipment, operations, maintenance, and administration of these multilateral R&D efforts wherever they might take place. Experience gained might help Korea to internationalize science in Korea and exercise S&T leadership at a regional and world level as articulated in its Vision 2025 plan.