Promoting Science and Technology for Development:
The World Bank's Millennium Science Initiative [1]

By

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Background

The ability of a society to produce, select, adapt, and commercialize knowledge is critical for sustained economic growth and improved quality of life. Today, a handful of the world's richest countries produce the overwhelming majority of new scientific and technological knowledge, and they derive great benefit from its use. Countries in this exclusive group enjoy the fruits of a virtuous circle, in which the concrete benefits of research help produce the wealth and public support needed to continue the investigation of science's "endless frontiers."

Meanwhile, the most of the rest of the world's nations struggle, with varying degrees of success, to establish scientific and technological research systems that can invigorate their economies and provide solutions to their social needs. Unfortunately for developing countries, the logic of S&T research systems favors the scientifically strong becoming stronger. Countries that want to improve their S&T capacity have to make extra efforts to gain and maintain the "critical mass" beyond which benefits start to accrue. To make matters worse, this process is long term and full of uncertainty, and scarce resources are always under pressure from competing needs.

Despite the difficulties, there are good reasons to hope that aspiring countries can make progress in closing the gaps that separate them from scientifically-advanced countries. First, new information and communications technologies are providing unprecedented access to existing knowledge, and are virtually erasing the disadvantages of physical distance as a factor for research collaboration. Second, more is being learned about the process of innovation, and the policies and practices that make investments in S&T effective. Third, the international science community is by nature open, and marked by a culture of freely sharing basic knowledge. Within the community, tremendous goodwill exists to help strengthen science throughout the world.

The Rationale for Supporting Excellence in Research

Knowledge is a critical determinant of economic growth and standard of living. A strong consensus, reflected in recent policy statements from the OECD, the World Bank, and others, is emerging: *knowledge is the most important factor in economic development.* The OECD concluded that "underlying long-term growth rates in OECD economies depend on maintaining and expanding the knowledge base."[3] The World Bank's 1998/99 World Development Report states that "Today's most technologically advanced economies are truly knowledge-based…creating millions of knowledge-related jobs in an array of disciplines that have emerged overnight," and "the need for developing countries to increase their capacity to use knowledge cannot be overstated." Improving this capacity is becoming a pre-requisite for sustained economic growth and improved quality of life.

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[3] OECD 1998, "Technology, Productivity, and Job Creation: Best Policy Practices." P.4.

World Bank senior management is committed to working with clients who are developing strategies to narrow knowledge gaps with the advanced countries.

Knowledge is transformed into goods and services through a country's National Innovation System. Knowledge by itself does not transform economies. Its benefits appear when it is employed within a complex system of institutions and practices known as a National Innovation System (NIS). An NIS is a web of: (i) knowledge producing organizations in the education and training system (such as universities and research institutes); (ii) the macroeconomic and regulatory framework, including trade policies that affect technology diffusion; (iii) communications infrastructures; and (iv) selected other factors, such as access to the global knowledge base or certain market conditions that favor innovations. A NIS is effective to the extent that these elements are developed and work in harmony.

Cutting-edge research is an essential part of an effective NIS. New knowledge drives innovation. In most cases,[4] there are several reasons why at least some of a country's researchers should be at the forefront of their disciplines. First, even in cases where innovation policy is primarily concerned with adaptation rather than production of knowledge, the intellectual rigor required usually results from "pursuing the leader" at the forefront of discipline. Second, since so much of scientific knowledge creation involves the "free exchange" of ideas among colleagues worldwide [all of whom are seeking recognition and prestige], countries integrate best and benefit most when they have knowledge to offer. For countries of a basic level of scientific development, it is possible to be an absolute follower and taker from the world's knowledge base—but such a strategy is neither efficient nor sustainable. In the long-term, countries that wish to use knowledge must also get involved in its production. Third, university-based research—relatively small compared with other university activities—has a disproportionately large effect that energizes both educational and innovation systems.

Science and technology are intertwined. There is still much truth in the common view that the most important technological breakthroughs occurred because scientists were investigating nature—not because they were looking for applications of their research [e.g., Faraday's and Maxwell's work was pure science, but it facilitated Marconi's and others' work on wireless communication]. However, because it is increasingly true that new technologies give rise to new sciences and disciplines [e.g., chemical engineering], it is most accurate to view science and technology as intertwined. According to Richard Nelson,[5] this intertwining is the principal reason why technology is advanced through the work of men and women who have university training in science and engineering. It is also "the principal reason why, in many fields, university research is an important contributor to technological advance, and universities as well as corporate labs are essential parts of the innovation system. Thus the problems that originate in industry are not explored only by industrial scientists. They feed into, and stimulate, the entire scientific community."

Trained human brains are the most effective knowledge transfer and adaptation mechanism. Innovation is not a linear process of "science push" leading to applications. The idiosyncratic nature of scientific and technological advance is best promoted by individuals who are comprehensively trained in their disciplines. Proper incentive systems are necessary, and discrete

[4] Depending on stage of development. Among the most impoverished countries, there a certainly more pressing priorities than developing research excellence. Other countries must decide very selectively how they will spend their limited resources on national knowledge strategies. These countries may be too poor to be effective participants in the global knowledge system. Above a certain level of economic development [that typically found in most Latin American countries, for instance], it becomes essential to take part in global knowledge production and use.

[5] R.Nelson, National Innovation Systems: A Comparative Analysis, New York: Oxford University Press, 1993. P.7.

actions such as tech transfer via trade in goods also contribute. But, in the long run, the expertise gained through training is the decisive factor in the economic impact of technology transfer.

Good science is international. Nature does not respect political boundaries. In response, science has evolved as an international endeavor. Those who work at the forefront of their disciplines seek to interact and collaborate with their peers regardless of where they are. Conversely, researchers need access to global interchange of knowledge to avoid obsolescence and insularity.

Anonymous peer review and competitive funding facilitate quality and productivity in science and technology. Allocation practices that rely on anonymous review by qualified scientific peers and open, transparent, merit-based competition for resources are nearly universally acknowledged as the most effective means of distributing research resources. In such systems, scientific recognition is the foundation upon which careers are built, and access to resources is the means to recognition. This creates strong incentives for researchers to maximize their productivity, by adding graduate students and spending their budgets wisely. As a result, in such systems *the most-highly selected researchers tend to be the most efficient and productive.*

Fostering development through support for research excellence

As part of its mandate, the World Bank seeks to assist countries that wish to increase the contribution of S&T to poverty reduction and economic development. A principal instrument to doing this is the Millennium Science Initiative, or MSI.

In its most basic form, the MSI is an umbrella for new lending, through which the Bank's client countries can borrow to improve their scientific and technological capacity. Projects under the MSI generally take the form highly selective competitive funds to support research. These funds will differ according to a country's specific needs and circumstance, but they share a few essential characteristic. All MSI project would provide targeted support that focuses on (i) research excellence; (ii) human resources training; and (ii) linked to partners in the international science community, and in the private sector.

With respect to research excellence, a goal of the MSI is to raise the standards for output and performance by concentrating resources on a highly selected group of researchers, and providing funding and working conditions that approximate those of their colleagues who are at the cutting-edge of the discipline. The supposition is to demonstrate that relevant, world class research can be done anywhere in the world, and within the budgets of most developing countries. More importantly, MSI projects seek to demonstrate that the process for selecting the best researchers—through open and transparent competition guided by peer-review—is also a highly cost-effective way to invest in S&T. Experience shows that, once introduced, these type of state-of-the-art practices in research funding tend to spread throughout a national research system, further improving cost-effectiveness.

Human resource training is central to the MSI because in top systems, the best researchers attract and train the most bright young students. These in turn go on to industry and academia, where their highly-trained minds are the most effective known means of technology transfer. In under-performing systems, by contrast, researcher are often isolated, doing their own research at great expense, and spending little time training and producing the next generation of investigators. MSI project focus maximizing the training of human resources undertaken connection with the funded research, thereby raising the productivity and cost-effectiveness of the research

In addition, the MSI seeks to ensure the quality and relevance of research by making certain that the researcher are connected to leading peers internationally, and to potential collaborators in the private sector. While not limited to applied or "downstream" work, MSI projects will use a variety of

mechanisms stimulate research commercialization, and to place students in private industry. At the same time, the MSI supports activities that help investigators from the developing world in collaborate with leading colleagues, regardless of where they are found.

Finally, all projects under the MSI will be bureaucratically streamlined, with a light management structure that is within international standards for administrative costs and efficiency. As part of this, the MSI projects will fund the performance of the research itself where it is found, and not the construction of buildings or major infrastructure for new center or institutes. The basic form of an

MSI projects—although they vary according to individual country circumstance--would usually conform to the following structure:

- Resources contributed to a competitive fund to support research, situated within some part of the participating country's national research system;
- Rules for the competitive allocation of these resources, through selection committee composed of distinguished researchers of international stature;
- A light administrative structure that assists with logistics of the selection process and the implementation of the research the grant recipients
- A Board of Directors that oversees the process and approves policy for the MSI

While the amount of awards will vary, MSI projects will usually follow a two-tiered system. In the first tier, a very small number of truly international level groups are selected for longer-term funding (5-7 years or longer). In a second tier, promising groups, often composed of younger investigators, are awarded shorter (3-5 year) grants that may be renewable. MSI funding is also used for specific international networking activities that may be outside the grant process.

Origins of the MSI

The MSI was conceived at a meeting of top-level government officials and distinguished researchers from the South, convened by Chile's President Frei. As a result of this meeting, a number of participants came together to form Science Institutes Group (SIG), dedicated to promoting development by closing the gaps in S&T between the developed and developing worlds. With the support of the Packard Foundation (a private, US based foundation) the SIG has continued to engage scientists and government leaders to garner support for revitalizing science research in the developing world. At the same time, the World Bank and the Government of Chile co-financed the first MSI project, in April, 1999.

The Expected Benefits from MSI Projects

A model for the transparent, merit-based allocation procedures that forge "cultures or quality. An important goal of the MSI is to serve as a model of good practice in science funding—one that will be copied by other research agencies within a national science community.
In underperforming research systems, it is common to find an aversion to the difficult choices necessitated by true competition for resources. Typically, anyone with reasonable scientific credentials can "survive", when survival means bad infrastructure, obsolete equipment, and inadequate professional autonomy. By contrast, advanced scientific countries will usually have flagship funding agencies in which only the top researchers get considered for funding, but those who are funded are given the resources and freedom to do their best work. The introduction of allocation procedures that favor the most qualified tends to create a vocal group that seek to maintain fair, open processes. This group wants the opportunity to compete and be rewarded according to their objectively-evaluated merits. The sense of resignation to an unfair status quo can be overcome through this type targeted intervention. As countries attempt to transition from one system toward the other, researchers must become accustom to abiding by decisions [of qualified peers] that nourish the best and starve the

inadequate among them. Resistance to this change is common, but perseverance for a sustained period (10 years or more) typically results in research community that is healthier and much more dynamic.

Increased training opportunities for young people, and reduction of "brain drain." In countries where the MSI will operate, there is typically found a dearth of quality graduate training opportunities for bright young minds; training systems often lack quality and dynamism, taking a long time to produce a few graduates. All research funded through the MSI be directly connected to increase provision of training opportunities for graduate students. In connection with their research—and as a requirement for selection--investigators will be expected to train and advise the maximum feasible number of graduate students. This should help form "critical mass" of highly trained human capital. In addition, by improving conditions for research, countries create incentives for their most talented to remain at home. Most developing countries are still losing scientists to OECD countries, where funding is more secure and opportunities are greater. Improving working conditions for top scientists is one means of reducing or reversing this deleterious outflow.

Global and regional connections to other researchers. All MSI projects will seek to promote a myriad of linkages: to the private sector, to colleges and secondary schools, to the institutions in which they are housed, and to other centers and universities. The selection process itself will help disseminate the activities of the MSI host countries abroad. The research projects will similarly provide opportunities for international collaborations through long-term and visiting professorships, post-doctoral and doctoral positions. Through these and other activities, MSI projects will seek to diminish the traditional isolation felt by researchers in the developing world.

Frequently asked questions

Who is the World Bank's partner in a given MSI project?

The World Bank, as per its charter, lends to the governments of its member countries. The project implementing agency or organization is chosen by the government, and is usually the relevant branch of the government itself. This might be, for example, the national science foundation or national academy of science, or a branch of a ministry that funds research. In some cases, the government may designate state, municipal, or even non-governmental organizations to implement a World Bank project.

Does the World Bank itself select and fund individual "Centers of Excellence"?

No. The World Bank works as a partner with the national government (or designated representative) in a client country to finance a project for that particular country. The client country and the World Bank agree to the project design, implementation period, and financing. The responsibility for implementing the project rests with the borrower, and the World Bank supervises aspects of implementation.

The World Bank itself does not participate in specific decisions regarding the selection of grant recipients under MSI projects, nor does it directly fund individual research centers or research projects.

How does a country participate in the MSI?

For a country to participate in the MSI, its government must formally request a project from the World Bank. Usually, the designated interlocutor, most often the Ministry of Finance, sends a letter the relevant World Bank Country Director outlining the rationale for the project within the context of the country's development goals. This normally occurs after intensive dialogue within the country, involving the relevant government agencies and civil society (the science and technology community

in the case of the MSI), and between the country and the World Bank through periodic meetings to discuss the Bank's assistance strategy for the country.

What is the Role of the Science Institutes Group?

The Science Institutes Group is composed are leading science policymakers, researchers and directors of prestigious scientific institutes who share an interest in improving scientific capacity in the developing world. The SIG is an informal advisor to the World Bank for the Millennium Science Initiative. SIG member were crucial in conceptualizing the idea for the MSI, and the group is currently working with the support of the Packard Foundation to increase the contribution of science and technology to development. Among the SIGs members are presidents of both the Third World Academy of Sciences and the International Council of Scientific Unions .

The SIG has can be useful partner for countries that are considering participation in the Millennium Science Initiative. The group can act as a convenor and "honest broker" in bringing together stakeholders to discuss and plan strategies for science and development. Although SIG does not officially represent the World Bank, it has deep understanding of the MSI and how a country might best benefit from participation. Those interested in further information about the SIG should contact the secretariat at via email at "sig@ias.edu", or visit the group's website at "www.ias.edu/sig".

What can I do if I would like to see an MSI project in my country?

Whether you are a government official, an active researcher, a science or university administrator, university official, a entrepreneur interested in technology, or none of the above, the process is the same: begin a dialogue within the most interested community about how your country might benefit from participation in the MSI. Bring together the "stakeholders" from a diverse parts of the S&T community, and stimulate a debate on the merits of participation in the MSI. When the idea has been endorsed, consider involving the your government's designated interlocutor with the World Bank.

Can the World Bank recommend that a country undertake an MSI project?

The World Bank sustains an active dialogue with its client countries on the best ways of achieve the particular development goals, but decisions regarding projects are the country's own, and should reflect it own priorities. The World Bank introduce technical considerations on why a given country might benefit from an investment in S&T, but the decision to request a specific project ultimately rests with the country's own authorities.

What is the process for preparing an MSI project and how long does it take?

Once the Bank has responded positively to a country's request to borrow under the MSI, the "project preparation" phase begins. In this phase, the World Bank and country counterpart teams begin a diagnostic analysis of the country's S&T system, to determine how best to integrate an MSI project. This analysis coincides with discussion of the country's specific goals and priorities, and the types of project designs that are compatible. Depending on the size of the investments, the time to approval can take as little a few months or as much as a year. Length of the preparation process will be influence by a number of factors, such as the previous existence of descriptive information about national research systems.

What are the potential benefits from a successful MSI Project?

The expected immediate or short-term benefits of an MSI project would be from the scientific research outputs and increased training opportunities, and the integration with the international scientific community. Over the longer term, as changes improvements in a country's national research system spread, the main benefits may include a diminution of "brain drain"; as national researchers see their own system as more comparable to options abroad, and stronger links between the research and productive sector, as MSI researchers interact with partners from the private sector.

How long has the MSI been operational?

The first pilot MSI project for Chile was approved by the World Bank on April 30, 1999. The second pilot MSI project for Venezuela was approved on April 24, 2000. Inclusion for MSI project components in S&T sector projects for Mexico and Brazil was effective in 2001.