Background

Chile’s scientific community garners well-deserved respect in the region and worldwide. The country has made significant and fruitful efforts to move towards a leadership position in research among industrializing countries. While progress has been substantial it has not yet matched the country’s aspirations and much remains to be done.

Although, there are no observed specific inequities within Chile’s advanced research system, the country’s education system has room for improvement. In higher education, while gender equity has been attained, there is still an uneven concentration of enrollment in the top income quintile, 65 percent, while the two lowest quintiles merely reached 25.6 percent in 2000. In terms of postgraduates, Chile produces less than 100 Ph.D.s per year and would need to be producing on the order of 3,000 per annum to reach a level comparable to the knowledge-based OECD economies. Similarly, Chile has one scientist for each thousand economically active inhabitants, while the developed world has an average of five scientists per thousand.

In 1998, President Eduardo Frey hosted an International Convocation on Science and Technology. Invitations were extended to 12 internationally respected scientists, the

The Chilean Salmon and the Millennium Science Initiative (MSI)

The Millennium Institute for Applied and Fundamental Biology (Instituto Milenio de Biología Fundamental y Aplicada, MIFAB) is directed by Dr. Pablo Valenzuela. The Institute has 11 senior scientists, 6 associate scientists, 12 post docs, 39 PhD students, 42 master degree students, 10 technicians and administrative personnel.

MIFAB was established in 2000 as one of three Millennium Science Institutes in Chile, and it has already shown remarkable results, several which have potential implications for the Chilean industrial sector, especially in the area of genome research and research on infectious biological agents. During 2001, MIFAB analyzed and patented the DNA sequencing of a bacteria (Piscirickettsia salmonis) which causes infections of the Chilean salmon. By assisting in diagnosing infections diseases, informing treatment options and potentially leading to vaccines, these findings could have a major impact on the Chilean economy. The institute has also made important progress by identifying the Hantavirus Andes, a pathogen that affects salmon production, and in investigating potential diagnostic tools and treatments. Another promising line of research concerns the bacterium Alexandrium Catenella (red tide), and it is estimated that diagnostic tools and preventive measures are within immediate reach.

To make the story even more exciting, MIFAB also has a line of research which investigates a virus which attacks vineyards (Vitis Vinifera). Here progress is being made towards diagnosis and improvement of viral resistance in the gene pool of the grape.

The Millennium Science Initiative has demonstrated its vitality by not only providing substantially improved levels of advanced human capital in research fields of high economic relevance, but in few years it has, through strategic investments in state-of-the-art research, provided research results which have the potential of greatly improving the profitability of Chile’s salmon and vine industries. Bon appétit.
The Millennium Science Initiative project became the responsibility of the Ministry of Planning and Cooperation (MIDEPLAN) with a Secretariat established in February 1999. The World Bank and the Government of Chile in March 1999 negotiated a loan (LIL, See Box 1) for $5 million with a counterpart contribution of $10 million from the Chilean Government. A high-level consultative body with international participation, the MSI National Commission, was created in July 1999 to oversee the project (see Box 2). MSI is an excellent example of the effective use of the Bank’s LIL instrument to obtain results on the ground.

**Box 1**

**What is a Learning and Innovation Loan (LiL)?**

The learning and innovation loan (LIL) supports small pilot-type investment and capacity-building projects that, if successful, could lead to larger projects that would mainstream the learning and results of the LIL.

**Special design features**

LILs do not exceed $5 million, and are normally implemented over 2 to 3 years—a much shorter period than most Bank investment loans. All LILs include an effective monitoring and evaluation system to capture lessons learned.

**When are LILs used?**

LILs are used to test new approaches, often in start-up situations and with new borrowers. LILs may be used to build trust among stakeholders, test institutional capacity and pilot approaches in preparation for larger projects, support locally based development initiatives, and launch promising operations that require flexible planning, based on learning from initial results.

**Box 2 - The Structure of MSI**

The **Board of Directors** is composed of distinguished Chilean and foreign leaders from academic, business and public sectors and is chaired by the Minister of Planning. Its main functions are to determine which proposals are submitted to the President concerning the program, decide on the Annual Action Plan proposed by the Program Committee, and make final decisions on the selection of project proposals, and evaluate the overall progress of the initiative.

The **Program Committee** is composed of 7 scientists, representing the disciplines of biology, chemistry, computer science, engineering, mathematics and physics. Scientific oversight is entirely in the hands of this completely international committee, convened by Dr. Phillip Griffiths of the Princeton Institute of Advanced Science. The Committee has overseen proposal guidelines, calls for proposals, peer reviews, and has provided advice on the entire initiative.

The **Executive Secretariat** located in MIDEPLAN is responsible for management and overall administration of the MSI Program.

The **Science Institutes and Nuclei** are selected through a public competition. These institutions and research groups seek to: (i) advance scientific and technological research; (ii) train young scientists in the context of research; and (iii) seek out multidisciplinary interactions and collaborative network activities both nationally and internationally and generate flexible linkages with peer institutions; and (iv) extend scientific progress to the public and private sectors, particularly education, industry and services.

**Objectives**

The MSI Program sought to revitalize Chile’s science and technology (S&T) system by supporting advanced training of human capital by world class scientists engaged in cutting edge research. It sought to demonstrate the effectiveness of transparent merit-based allocation procedures and investigator autonomy in improving the quality and efficiency of scientific research and training.

The LIL partly financed a competitive fund to support 3 world-class research groups (Science Institutes) and 10 emerging groups of high quality (Science Nuclei), providing adequate levels of medium term funding to enable the best scientist to compete with their international peers. The aim was to allow these centers and groups to perform frontier scientific research and provide training to graduate and post graduate fellows. The program was also designed to disseminate the new knowledge through
education and extension programs, links with the private sector, and partnerships with other institutions.

Results on the Ground

The Centers of Excellence were created between March 1999 and September 2002, when the Learning and Innovation Loan was closed. Over this period, the Bank was able to assist Chile in creating an excellent environment for advanced research and learning.

The project has successfully met its learning and development objectives by demonstrating how to do business in advanced scientific research, in a cost effective manner and in ways that will strengthen Chile’s National Innovation System. The main outcomes of MSI are:

- Science and technology are receiving increased attention by the Government of Chile, and other governments in the region;
- The project has established a fair, open, and merit-based selection process which have been acknowledged and accepted by the scientific community;
- The project has improved the productivity of Chile’s top researchers;
- Opportunities for and quality of advanced training have increased (i.e., a growing pool of young scientists, trained by well-recognized scientists and leaders in several disciplines, is being created in Chile);
- Several forms of collaboration increased significantly under the project’s auspices; and;
- A monitoring and evaluation base is being constructed which can serve as a platform for improved S&T policy;

Lessons Learned

Demonstration of Best Practice for Supporting the Best. A limited investment, under highly selective competitive processes, which follows international best practice procedures, can have a disproportionately high impact on performance and productivity in an S&T system. Beneficiaries and stakeholders respond positively to being judged using transparent, objective, selection procedures, even when they do not win. The international community will participate actively-in “give and take”- when conditions for research are adequate. International participation in Chilean science has been excellent with a measurable multiplier effect.

Effective use of Investments. Autonomy in spending resources and diminished bureaucratic burdens is crucial to making science effective. Grants need to be large enough to allow research groups to compete at or near levels found anywhere in the world. Once a grant has been received it is equally important that the Bank not hinder progress through cumbersome procedures. The Bank’s main concern should be the transparency and fairness of the bidding process that leads to the selection of grantees, it should be left largely to the borrower to assure the pertinence of the succeeding activities with related procurement under each grant only bring subject to the Bank’s ex post review. It should also be noted that, not surprisingly, the best research teams will rapidly reach the limits of their physical infrastructure, suggesting the need for targeted follow-on investments in these groups.

Improved Performance of the Elite Scientists. It is possible, within a short timeframe, to rapidly expand training opportunities for the most advanced human capital, and quality can be improved through incremental investments that allow senior researchers to devote themselves full-time to their professional responsibilities. It is clear that a country like Chile can “catch-up” with the industrialized countries in this respect, provided that the incentives and financing structures affecting human capital in its S&T system are appropriate. Similarly, these conditions can stimulate repatriation of highly skilled human capital and reverse brain drain. Finally, the Chilean private sector lags behind its OECD counterparts in turning science into innovation. More effort is needed to identify specific linkage mechanisms.

Requisite Entry Conditions. Some initial factors are essential for success: (i) harmony between government priorities and sectoral policies; (ii) ownership of the “Centers of Excellence” program by the stakeholders with the involvement of beneficiaries in program design and implementation; (iii) the existence of emerging teams of critical size, irrespective of their physical location, committed to cooperative research; and (iv) recognition and autonomy of research teams and their leadership.

Cohesive Government Performance. A well targeted – but small – investment can shake-up a S&T system. It is, however, critical to aim at subsidiarity and coherence in Government policies and practices. Therefore, transparency in communication between Government players is of critical importance and can be facilitated by international, indirect, participation in the program, for example as members of program committees, peer reviewers, external program reviews, and supervision teams. Further, a lack of continuity in funding and coherence of science policy are a constant threats to gains. The Government should resist the temptation to neglect fundamental science and social sciences, which are important components of the National Innovation System.
## Moving Forward

The outcomes of the MSI have allowed Chile to increase its participation in the generation and dissemination of scientific knowledge. Chile has realized the benefits of creating a concentration of the best and brightest around the most experienced scientists and has reached a critical point for competing in highly selected fields of research. Although it is too early to assess the full impact of the project, there are positive indications that the LIL has created the desired pressures on scientists and managers to work as teams and perform their best, putting their limited resources to the optimum use.

### Table 1 - MSI Science Nuclei and Institutes

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<th>Science Nuclei</th>
<th>Institution</th>
<th>Website</th>
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<tr>
<td><strong>Research Focus</strong></td>
<td><strong>Institution</strong></td>
<td><strong>Website</strong></td>
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<tr>
<td>Condensed Matter Physics</td>
<td>Universidad de Santiago de Chile, Physics Department</td>
<td><a href="http://www.nucleo-milenio.cl">http://www.nucleo-milenio.cl</a></td>
</tr>
<tr>
<td>Metal Dispersed Systems, Applications to Fine Chemistry</td>
<td>Universidad de Concepción</td>
<td><a href="http://www.udec.cl/">http://www.udec.cl/</a></td>
</tr>
<tr>
<td>Valparaiso Center for Cellular and Molecular Neurosciences (CNV)</td>
<td>Universidad e Valparaiso, Science Faculty</td>
<td><a href="http://www.cnv.cl">http://www.cnv.cl</a></td>
</tr>
<tr>
<td>Millennium Nucleus in Developmental Biology</td>
<td>Universidad de Chile, Science Faculty, Odontology Faculty.</td>
<td><a href="http://www.uchile.cl/facultades-/ciencias/">http://www.uchile.cl/facultades-/ciencias/</a></td>
</tr>
<tr>
<td>Center for Advanced Studies in Ecology and Research on Biodiversity</td>
<td>Universidad de Chile, Science Faculty, Santiago</td>
<td><a href="http://www.biodimvil.cl">http://www.biodimvil.cl</a></td>
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<th>Science Institutes</th>
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<tr>
<td>Centro de Estudios Científicos (CECS)</td>
<td>Independent</td>
<td><a href="http://www.cecs.cl">http://www.cecs.cl</a></td>
</tr>
<tr>
<td>Millennium Institute for Fundamental and Applied Biology (MIFAB)</td>
<td>Fundacion Ciencia para la Vida, Pontifica Universidad Católica de Chile, Universidad Nacional Adndres Bello</td>
<td><a href="http://www.mifab.cl">http://www.mifab.cl</a></td>
</tr>
<tr>
<td>Millenium Institute for Advanced Studies in Cell Biology and Biotechnology (CBB)</td>
<td>Universidad de Chile Science Faculty</td>
<td><a href="http://www.cbbmillennium.cl">http://www.cbbmillennium.cl</a></td>
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### Notes

The Millenium Science Initiative is also active in Venezuela. Learn more by searching our project database at http://www.worldbank.org

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