Information and Communication Technology in Chile*

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Abstract

In this report we present an overview of Information and Communication Technologies (ICT) in Chile. This study covers the current situation of ICT in Chile, like political and economic background, ICT infrastructure, ICT policies and funding. It also shows what the research network looks like and describes the present situation of Software Technologies in Chile. Finally the current research collaboration on ICT with other countries is described. The report concludes with a special section dedicated to Internet and E–commerce.

1 Introduction

In Chile, when talking about Information and Communication Technologies (ICT), we usually understand applications which take advantage of communications or computing technologies. The approach taken in this report is, however, much broader. In our case, we will consider ICT to cover those aspects often referred to as Computer Science (CS) and its related fields of research, as well as the already mentioned applications.

Previous reports can be found in [3, 4], although the present study is more focused on research issues. We also include some information contained in [2]. Additional and valuable information can be found in [1, 5], from which we have borrow some parts.

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We begin this document by presenting, in Section 2, the current situation of science and technology in Chile. Next, in Section 3 we narrow the discussion to those political and economical aspects relevant to ICTs. In Section 4 we describe the current state of the research network and the ICT industry in Chile. We end in Section 5 by presenting some concluding remarks and suggestions for the future.

2 Science and Technology in Chile

Currently in Chile, only around 0.6–0.7% of the GDP is invested in Science and Technology research, which is small in comparison to developed countries in which this number rises to about 2–3%.

The newly elected President of our country, Mr. Ricardo Lagos, promised, when he addressed the nation before plenary congress on May 21st 2000 [6], to double the resources on this matter to reach an investment of over 1% of the GDP in the area by the end of his six years Presidential period. He also said that the first task the present government has set preference on is, to incorporate Chile into the technological revolution that is happening in the world.

Perhaps the main reason for these low numbers is the little participation of private funds in science and technology R & D funding. This can be seen in Figure 1.

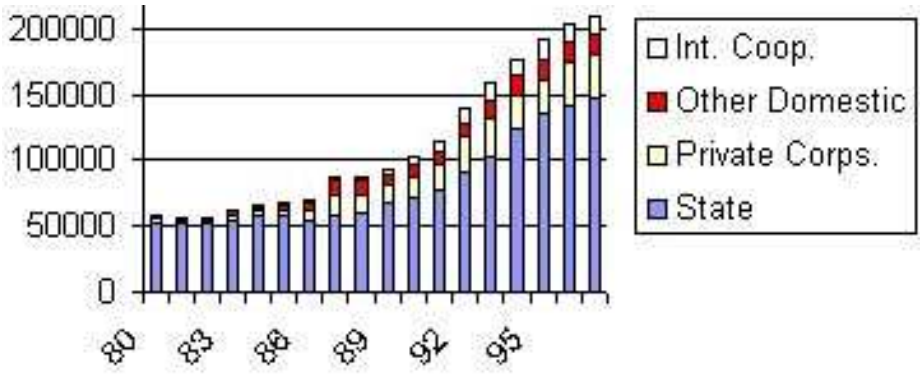

Figure 1: R & D Spending in Chile (in Chilean pesos) Source: CONICYT

There are three (main) ways through which state's funds may be invested in science and technology: CONICYT[1], CORFO[2] and MIDEPLAN[3]. Nevertheless, almost only the former has to do with academic research. The other two support productive sectors (industry) and regional development, respectively.

[1]Comisión Nacional de Investigaci'on Científica y Tecnológica. www.conicyt.cl
[2]Corporación de Fomento. www.mideplan.cl
[3]Ministerio de Planificación. www.mideplan.cl

CONICYT was created in 1967 as an advisor entity for the government in science and technology matters. Its main responsibilities include: defining science and technology policies, promoting and funding research, supporting the formation of human resources, supporting international cooperation on research, etc. Although, in the last decade, its contribution to financing research has grown in about seven times[4], we still need a better mechanism, to draw more private funds into research activities and reach a funding scheme similar to that of developed countries, in which most of the spending is done by private enterprises.

3 ICTs in Chile

Besides the traditional funding[5], CONICYT has defined priority areas to which extra resources shall be granted. These, however, do not include ICTs[6] so what is left for ICT funding is just a (small) slice of the whole national R & D budget. The ICT scientific community has proposed the competent authorities changing this situation by setting it as a priority area or creating a national research institute for ICTs.

Currently, the ICT industry in Chile represents 1,4% of the GDP. Although a somewhat low number, we must take into account that it is greatly influenced by the fact that no physical ICT goods (or very few) are produced in Chile. Another important factor in this number is the low participation of the state, given that, even though the state represents about 22% of the GDP, it consumes only a 6% of the ICT market.

This situation is expected to change in the forthcoming years, thanks to the shift of priorities given by the new government. As stated by President Lagos on May 21st 2000:

> "Chile must assume a leading role between the countries which use ICTs, specially Internet, as the engine for progress. A progress which shall be based on the flexibility of enterprises and not their size, on the intelligence of our people and not their geographical closeness, on cooperation and not on rivalry".

The government is currently promoting a generalized plan to modernize the state. The main goal is to provide an example to the private enterprises and drive the adoption of new technologies into the productive sector. Some successful examples of this initiative are the tax return operations and the public purchases network. The former received 467,051 filings, which represents 25.7% of the total number of tax return forms for the year 2000, and a growth of 523% with respect to the previous year.

[4] It reached over USD $70 million dollars in 1999.

[5] See Section 4.1.3.

[6] At the moment they only include marine biology and oceanography, and Applied Mathematics. Four other areas will eventually be included in the program according to the availability of resources. These are: physiology and plant biotechnology, geology, environmental issues and materials science.

In his speech, the President insisted on the need to catch the wave of the technological revolution we are living. Some concrete actions to be taken in the next months include:

- A law regulating digital signature is soon to be dispatched to the congress for debate (before July 2000). This should not be a new law, but indications to modify the current legislation.
- In the next three months the government will launch network of public workstations, usable by all people in the country.
- CORFO and the state owned bank (Banco del Estado de Chile) will give credit to 100,000 emerging enterprises, so they can acquire up to date computing equipment and receive proper instruction on its use and that of Internet.
- The President also called to incorporate our workers, scientists, universities, etc., into the productive sector to achieve innovation and progress. He proposed, together with the government of Argentina, to create a binational house in Silicon Valley, where to send our best talents from business and creativity.

3.1 ICT Infrastructure

Perhaps what makes Chile a better candidate to take a leading role in the technological revolution that any other country in the region is its infrastructure in ICTs.

ICT infrastructure in Chile must be one of the most advanced in Latin America, if not *the* most. This makes the country a natural target for investors who want to start business in Latin America, or want to develop new technologies taking advantage of the already established infrastructure and the relative low man-power cost of a developing country.

Also, according to the Chilean Association of Information Technologies (ACTI), the growth of the ICT industry is expected to be greater than that of the country. If the country's economic expansion is projected at 6%, the ICT industry should reach an estimate 10% growth.

Chile has more computers per capita that any other country in Latin America, reaching around 790,000 units which corresponds to over 50 PC's per every 1,000 habitants. At present the number of Internet subscribers reaches nearly 1.2 million users. This number considers almost half of the enterprises of the country, including small ones. If this number continues to rise at the present rate (see Figure 2), we should reach first place in Latin America in this category as well.

Although regional leaders in Internet usage, these numbers correspond to a penetration rate of only about 8,3%, low compared to the 60% of USA.

During the 90's, the educational program included the usage of ICT. For this matter, the *Enlaces* network was created in 1992 as a pioneer program with 12

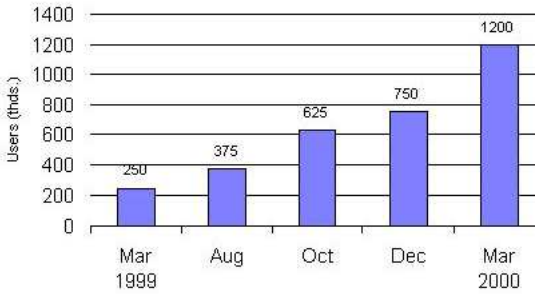

Figure 2: Internet users in Chile. Source: Booz-Allen & Hamilton; CCS, MSDW, IDC.

schools of Santiago. In 1998, Telefonica CTC Chile, donated telephone lines and granted free Internet access to all members of the network. Nowadays, Enlaces connects over 38,000 computers in 5,200 schools, providing Internet access to over 2.5 million students, which represents about 90% of the total number of students in Chile. By the end of 2005, all the schools in Chile shall be connected to the network and the number of computers doubled.[7]

Telephony is perhaps the most advanced industry sector in the country. Chile was the second country in the world to have all its switching done digitally. We now have 200 telephone lines per every 1,000 habitants. In 1994 a multi-carrier long distance system started, which lowered the fares notoriously, having one of the most competitive prices in the world. More recently, the mobile telephony sector, which covers the whole nation, has registered an important growth rate in the last couple of years. This boost was triggered when the regulation was modified so only the calling party would be charged for the calls. This made the penetration rate for cellular phones reach 13.79% in March this year.

Regarding networks, Chile was the first country in LA to install a fully operational ATM network covering the whole country (in 1994). At present, Santiago has 4 fiber-optic rings which cover all the communication needs of the city. Similarly, two fiber-optic networks cover the whole country. These, rent their bandwidth to whoever needs them, i.e. ISP's.

4 Current Situation of ICTs in Chile

4.1 Research on IT

4.1.1 Where it is done

Research on CS and IT is almost exclusively done at universities. The interaction between industry and academic centers is rather weak on research activities.

[7] So said the President when he addressed the nation on May 21st 2000.

4.1.2 Competitive Advantages

For countries like Chile, that is, for developing countries, research in a field such as Computer Science has some advantages over other (more traditional) research areas. Some of these include:

- Area mainly based in human resources and added value products. This allows non heavily funded research programs to compete at international level because no special (expensive) equipment is required.
- Wide economical and social impact in the short term. Most of the research performed in Chile has almost immediate impact on areas such as: Education, Software Industry, Web technologies and Industry in general.
- Currently, CS research output is small but of high quality. This is backed up by Tables 1 and 2, which compare the quality of the work done in the country with top-level international research.

Name	Citations
Udi Manber	596
Gaston Gonnet	394
Bernard Lang	306
Ian Munro	140
Christian Queinnec	120
The following are Chilean researchers:	
Ricardo Baeza-Yates	201
Javier Pinto	93
José Miguel Piquer	80
María Cecilia Rivara	56
Gonzalo Navarro	45
Patricio Poblete	32

Table 1: Top CS researchers. Source: Based on citations in ResearchIndex Website (CS Demo Collection in the Web with 220,000 documents and over 2.5 million citations).

- Although the research network in Chile is relatively small, the number of publications produced by it situates the country as second overall in Latin America in 1990–1998, and first per capita (see Table 3).
- We count with an organization called The Chilean Computer Science Society (SCCC) [8], created in 1984. This Society organizes and supports several research activities and keeps the CS community together and participating in a collaborative and friendly atmosphere. Its annual meeting:

[8] www.sccc.cl

Article	Citations
Bowman, Manber, et al., INET'95	111
Huet and Lang, Acta Informatica'78	52
The following articles are, at least, (co-)authored by a Chilean researcher working in Chile:	
Lang, Queinnec and Piquer, ACM POPL'92	49
Pinto, Ph.D. Thesis'94	45
Baeza-Yates, Culberson and Rawlins, Inf. and Comp.'94	35
Pinto and Reiter, ICLP'93	35
Baeza-Yates and Gonnet, Comm. ACM'92	33
Piquer, PARLE'91	22
Baeza-Yates and Perleberg, CPM'92	17
Rivara, IJNM'84	15
Baeza-Yates and Gonnet, JACM'96	15
Navarro and Baeza-Yates, TOIS'97	13
Manber and Baeza-Yates, IPL'91	14
Carlsson, Munro and Poblete, SWAT'88	10
Baeza-Yates and Navarro, SIGMOD'96	10

Table 2: Top CS articles. Source: Based on citations in ResearchIndex Website (CS Demo Collection in the Web with 220,000 documents and over 2.5 million citations).

"Jornadas de la Sociedad Chilena de Ciencia de Computacion (SCCC)", includes the International Conference of the SCCC, which is the only general CS conference in Latin America having an international level[9]. The proceedings of the International Conference are published by the IEEE Press and the meeting itself is to be sponsored and co-organized by the IEEE CS from 2001.

- Finally, and perhaps what might boost Chile's research network in Computer Science in the next couple of years, is the fact that students from all over Latin America are coming to Chile for their graduate studies. At the moment there are 3 internationally recognized PhD programs, two in CS (PUC since 1993 and U. de Chile since 1997) and one in Mathematical Modeling (U. de Chile), which includes research on theoretical CS. Chile currently receives students from Argentina, Bolivia, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Nicaragua, Panamá, Paraguay, Perú, Uruguay and Venezuela, both in Masters and PhD programs. Those PhD programs have already graduated about 10 students. Foreign researchers of recognized quality participate in the students' PhD committees.

[9]It is the only conference in Latin America for which the National Council for Scientific and Technological Development of Brasil (CNPq) supports publishing and travel expenses of its researchers.

Country	Computing	Per capita	Applications	Per capita
Argentina	63	1.8	298	8.4
Brazil	**401**	2.5	**570**	3.6
Chile	108	**7.4**	125	**8.6**
Mexico	74	0.8	272	2.8
Venezuela	49	2.2	95	4.2

Table 3: Latin-American Publications between 1990 and 1998. Source: CompuMath Citation Indes, ISI.

All these factors have contributed to reaching a high level quality, both in research and graduate study programs. As an example of the recognition obtained, in 1995 the Dutch Government financed, through its MEMI program, the creation of a MSc in Computer Science program at the University Mayor de San Simon (Cochabamba, Bolivia). Three universities are involved in this program: Utrecht University, University of Chile and the Catholic University of Chile (PUC). The last two must dictate half the courses and advise all the master's theses.

4.1.3 Research Funding

Funds for CS research come mostly from CONICYT, which is the national agency for research in science and technology. Two are the main funding programs:

FONDECYT It is the most obvious program to apply for CS researchers and is equivalent (in spirit) to standard NSF grants. These grants generally apply to all fields of science and technology which makes them quite competitive. They support student allowances, technical support staff, books, journals, equipment, transport of *local* researchers, etc. Their duration has recently been extended from 3 to 4 years allowing two co-researchers with a maximum grant of up to USD $80,000 per year. Once a FONDECYT grant has been obtained it is possible to apply for the "Support to International Cooperation Program" (see Section 4.1.4), which makes it possible to invite foreign researchers to Chile to collaborate in the project.

FONDEF For these programs participation of industry is mandatory (technology transfer). They involve larger amounts of money, i.e. a grant of USD $800,000 for the total duration of project, which cannot exceed 4 years. This grant should only account for 60% of the project's total cost. The remaining 40% must be supplied in equal proportions by the beneficiary institution and private enterprises. Participation of foreign researchers is often supported, and applied research is possible and encouraged.

4.1.4 International Cooperation Program (Research)

International cooperation is based on bilateral agreements between CONICYT and its foreign counterparts. This is the way CONICYT promotes and supports the interaction between domestic and foreign scientific communities. These projects usually last for 1–4 years. The most common cooperation mechanisms, for which financing is shared, are:

- Transport and exchange of researchers involved in joint projects. From the point of view of CONICYT, this generally translates into an airline ticket for the Chilean researcher, and a daily allowance of USD $50 for the foreign counterpart for a maximum stay in Chile of 30 days.
- Formation of human resources via scholarships (PhD) and study-abroad allowances (Only for some of the binational programs).
- Organization of seminars, workshops, conferences, courses and symposia.
- Exchange of information, specialized documentation and publications in the area of Science and Technology.

Because these are almost the only grants available for a wide variety of scientific disciplines, they are very competitive and their funds quite limited (on the Chilean side).

In the following we list the most relevant agreements signed by CONICYT with research funding agencies in other countries. Some examples of past and ongoing projects are given.

USA Through the National Science Foundation (NSF). Projects usually last 1–2 years, but require a very complex application process on the US side, essentially the same form as for a regular NSF proposal. Nevertheless, they have more flexibility on expenses than on the Chilean side.

1. 1994–95 NSF-CONICYT "Desarrollo de Heuristicas para Problemas de Optimizacion". Miguel Nussbaum (PUC) and Michael Pinedo (Columbia University, NY, USA).
2. 1999–2000 NSF-CONICYT "Handling Inconsistencies in Databases". Leopoldo Bertossi (PUC) and Jan Chomicki (Monmouth University, New Jersey).

Germany Through the Deutsche Forschunsgemeinschaft (DFG), the Bundesministerium für Bildung und Forschung (BMBF) and the Deutscher Akademischer Austauschdienst (DAAD)

Current research projects with German institutions include:

1. 1999–2000 DFG-CONICYT "Inspección Visual de Superficies Texturadas utilizando Técnicas de Procesamiento de Imágenes". Javier Ruiz del Solar (Univ. de Chile) and Mario Koeppen (Fraunhofer Institut IPK, Berlin).

2. 2000–2001 BMBF-CONICYT "Processing of Color Textural Image Information". Javier Ruiz del Solar (Univ. de Chile), Nickolay Bertram (Univ. Kaiserslautern), Aureli Soria-Frisch, Mario Koeppen and Christoph Nowack (Fraunhofer Institut IPK, Berlin).
3. 2000–2001 BMBF-CONICYT "Environmental Information Systems for Simulation, Prediction and Visualization of Air Pollution". Achim Sydow (GMD - FIRST, Berlin) and Leopoldo Bertossi (PUC).
4. 2000–2001 BMBF-CONICYT "Definition of a Conceptual Data Model with Flexible Integrity Constraints Management Capabilities". Bernhard Thalheim (Technische Universitaet Cottbus) and Marcela Varas (Univ. de Concepcion).

France Through the Comité d' Evaluation et Orientation de la Coopération Scientifique avec le Chili (ECOS), Centre National de la Recherche Scientifique (CNRS) and Institut de la Recherche pour le Développement (IRD – ex ORSTOM).

1. 1994–1997 ECOS-CONICYT "Calcul Parallèle, Réseaux de Neurones et Automates Cellulaires". Michel Cosnard (Ecole Normale Supérieure de Lyon) and Eric Goles (Univ. de Chile).
2. 1994–1997 ECOS-CONICYT "Mathématiques de Images". Alain Le Mehaute (Ecole Normale Supérieure des Télécommunications de Brest) and Florencio Utreras (Univ. de Chile).
3. 1997-2000 ECOS-CONICYT "Complejidad y Dinámica de Procesos de Interacción Local". Michel Morvan (Univ. Paris VII) and Eric Goles (Univ. de Chile).
4. 1998–2000 ECOS-CONICYT "Action Logic for Planning, Database Updates and Temporal reasoning". Camila Schwind (LIM-CNRS) and Leopoldo Bertossi (PUC).
5. 2000–2002 ECOS-CONICYT "Estimación, Control y Supervisión de Procesos Biotecnológicos Agroalimentarios". Paul Molin (ENSBANA) and Gonzalo Acuña (USACH).
6. 2000–2002 ECOS-CONICYT "Búsqueda de Patrones y Aplicaciones". Maxime Crochemore (Univ. Marne la Vallée) and Ricardo Baeza-Yates (Univ. de Chile).

UK Through the British Council (BC) and the Royal Society (RS).

Japan Through the Japan Society for the Promotion of Science (JSPS).

Italy Through the Consiglio Nazionale Delle Richerche (CNR).

Portugal Through the Instituto de Cooperaçao Cientifica e Tecnológica Internacional (ICCTI).

Spain Through the Consejo Superior de Investigaciones Científicas (CSIC) and the Comissionat per a Universitats i Recerca de Catalunya (CUR).

Mexico Through the Consejo Nacional de Ciencia y Tecnologia (CONACYT).

Brazil Through the Consejo Nacional de Desarrollo Cientifico y Tecnologico (CNPq).

Argentina Through the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET).

South Africa Through the Foundation for Research Development (FRD).

Venezuela Through the Consejo Nacional de Investigaciones Cientificas y Tecnologicas (CONICIT).

Cuba Through the Ministerio de Ciencia, Tecnologia y Medio Ambiente (CITMA).

Colombia Through the Instituto Colombiano para el Desarrollo de la Ciencia y la Tecnologia (COLCIENCIAS).

Korea Through the Korea Science and Engineering Foundation (KOSEF).

4.1.5 Other agreements, funds, opportunities

- The Information Science and Data Analysis Program, CIAD[10], of the Catholic University of Chile (PUC). It was created in late 1999 and currently involves the departments of Computer Science and Statistics of this university in multidisciplinary research activities. It is expected to expand to other related scientific areas in the near future, according to its fund raising capabilities.

- The Iberoamerican Program for Cooperation in Science and Technology for Development[11] (CYTED), created in 1984 by an agreement signed by 14 Latin American countries, Spain and Portugal, supports applied research, technological development and innovation in the region.

- The Franco-Chilean Laboratory (CNRS–Univ. de Chile): the Center for Mathematical Modeling. This laboratory was created as one of four international laboratories of CNRS, based on long-standing, fruitful cooperation between French and Chilean researchers in the field of mathematics. On the French side it is supported by the French embassy in Chile (besides the CNRS), and on the Chilean side by CONICYT and the University of Chile. The CNRS will appoint tenured researchers to this laboratory for periods of one or two years. The CNRS, CONICYT and the University of Chile will allocate resources for laboratory operations.

[10] bertossi@ing.puc.cl
[11] http://cyted.aeci.es/

- Alexander von Humboldt-Stiftung (Germany). The Humboldt foundation grants annually up to 500 Humboldt Research Fellowships to highly qualified non-German scholars aged up to 40 and holding a doctorate, enabling them to undertake a long-term period of research (6-12 months) in Germany.
- Chilean/German Agreement on Technological Research at the ministry level (BMBF/MinRREE):
  - IT is one of the five areas of science/technology involved in the agreement.
  - A First Kickoff Chilean/German Workshop on IT was held in Santiago in September 1999[12]. The second one will be held in Berlin in January 2001.
- The Swedish Foundation for International Cooperation in Research and Higher Education (STINT), established in 1994, supports advancing international relations with other nations, culturally, economically and scientifically. In this context there is one current project involving a Chilean researcher:
  1. 1999-2000 "Languages for Modeling Action and Change". Patrick Doherty (U. Linkoping) and Javier Pinto (PUC).
- Specific programs of universities, e.g.
  - PUC: foreign professors/researchers can be invited to take part in PhD committees.
- "Fundación Andes": Visiting professors program (on each side). Offices in Argentina, Brazil, Chile.
- IEEE Computer Society and ACM distinguished lecturers program.
- There is an ACM SIGMOD's Committee just created to foster DB research in Latin America.

4.1.6 Research Network

As usually happens in developing countries, most resources, population and opportunities are centralized in large urban centers. Chile and its ICT research network are no exception, thus most research centers are located in Santiago, the Capital. However, research groups all over the country collaborate/support each other when working on the same subject. Because of Chile's particular geography, this collaboration is mostly done by electronic means.

Most of this collaboration is made possible and encouraged by the Chilean Computer Science Society (SCCC), created in 1984. In particular, through the

[12] http://dcc.ing.puc.cl/~bertossi/

"Jornadas de la Sociedad Chilena de Ciencia de Computacion (SCCC)". This meeting includes an International Conference, a Chilean Meeting and Workshops (Distributed Systems, Computers in Education, Teaching of Computing, etc.).

Main areas of research on IT in Chile are:

- Database & Information Systems and Knowledge Representation: Universidad Católica de Chile (Santiago), Universidad de Concepción (Concepción), Universidad Católica del Maule (Talca), Universidad Católica del Norte (Antofagasta), Universidad de Tarapacá (Arica).
- Information Retrieval: Universidad de Chile (Santiago).
- Theory of Computing, Algorithms and Cryptography: Universidad de Chile (Santiago), Universidad de Tarapacá (Arica), Universidad Católica del Norte (Antofagasta), Universidad de Magallanes (Punta Arenas).

  Chile has a small but strong theoretical computer science community. For instance, the latest edition of *The Art of Computer Programming* by D.E. Knuth has index entries for Ricardo Baeza-Yates (3 references), Jorge Olivos (2 references) and Patricio Poblete (5 references).
- Distributed Systems: Universidad de Chile (Santiago), Universidad Católica de Chile (Santiago), Universidad Técnica F. Santa María (Viña del Mar), Universidad de Santiago (Santiago).
- Software Engineering and Applications (Collaborative Systems, Computer Graphics and Software Engineering): Universidad de Chile (Santiago), Universidad Católica de Chile (Santiago), Universidad Técnica F. Santa María (Viña del Mar), Universidad de Santiago (Santiago).
- Artificial Intelligence: Universidad Católica de Chile (Santiago), Universidad de Concepción, Universidad de Chile (Santiago), Universidad Técnica F. Santa María (Viña del Mar), Universidad de Santiago (Santiago).
- Programming Languages: Universidad Católica de Chile (Santiago), Universidad de Chile (Santiago), Universidad Técnica F. Santa María (Viña del Mar).
- Computers in Education: Universidad Católica de Chile (Santiago), Universidad de Chile (Santiago), Universidad de la Frontera (Temuco)

Although research on IT in Chile is satisfactory in terms of quality, it is weak in quantitative terms, in relation to the needs of the country. Almost every industrial and comercial activity is based on the application of IT. Research in the former areas, that is needed to make Chile become a developed country, requires application and development of innovative IT technologies. Also research on IT alone is important to the country's development. From this point of view, much more research and many more researchers are needed in Chile.

The biggest challenge now consists in increasing the critical mass of the established research groups and creating groups to do research in the new, emergent problems, methodologies and technologies. For this we need to attract young, talented people to academy and research activities. This is difficult given the favorable conditions of the job market that make young people go to work at industry, where usually no research is carried out.

It is necessary to create the conditions to enrolle young people in graduate studies, academia and research.

4.2 Software Technologies in Chile

Born in the eighties, Chile's software industry experienced an important growth during the late 80's and early 90's, which encompassed big hopes for the future and positioned it as one of the most promising industry sectors in Chile for the coming years.

Since then, however, it has decayed and only some isolated successful cases arise from the general context and are seen as guides for recuperating lost opportunities.

These hopes were supported by the historical record of USD $40 million dollars worth in exports during 1992–1993. Nowadays, not only has the exports level dropped to about USD $6–8 million[13], but so has the domestic activity. Although no obvious reasons for this decay arise, both researchers and entrepreneurs blame the quality of the developed software, the poor marketing abilities and the lack of leading edge technologies incorporated into their products.

This scenario should change in the next couple of years due to several factors:

- During the mid-nineties, INTEC Chile[14] decided to help domestic enterprises improve the development process of their products. It had detected that there did not exist a methodology to develop software that would allow the industry to mature and consolidate itself.

  With this in mind a project was born, which included companies interested in overcoming this problem, and was called SPIN Chile. The quality model used for this purpose was the CMM norm, a model which guides the companies in increasing levels of maturity. The difference of with norm ISO 9000 is that it is focused on software and that it integrates 5 maturity levels in an enterprise, showing the steps to follow to reach excellence.

  This is how, in 1996, INTEC applied the S-PRIME methodology to evaluate the companies forming SPIN Chile. From the results it was possible to deduce the weak spots in the industry, which were related to product quality and sloppy labor.

  Having ended the project in 1997, INTEC organized a series of courses and workshops focused on attacking these weaknesses. These courses in-

[13] According to estimates made by ACTI.

[14] Institute for Technology (a governmental office)

cluded: Foundations of Software Engineering, Introduction to CMM, Software Quality Assurance, Configuration Management and Requirement Specification. This should now allow to elaborate a product capable of competing in foreign markets.

- More recently, the Chilean software industry has shifted its target to creating special-purpose software for specific applications based on Chilean expertise. Such is the case of the forest management software. This example can be applied to all other fields in which Chile has a specific know how and are at world class level, such as mining and salmon culture. We should also be able to take advantage of the fact that there are industries such as banking that, although similar to the rest of the world, we are better positioned than other countries in the region. This gives as an advantage over European countries or the US because of our regional know how.

- Some exceptions in Chilean software industry stand-out and are worth mentioning. Such is the case of Motorola Chile, whose Chilean Center for Software Technology, opened in March 1999, will focus primarily on developing software to support Motorola's business units that serve original equipment manufacturer (OEM) customers and distributors in the imaging and entertainment, communications/wireless, networking/computing and transportation end-markets. "Software developed at the new center will enhance Chile's leadership in the 'digital millennium'," said Hector de Jesus Ruiz, executive vice president of Motorola, Inc., and president of Motorola Semiconductor Products Sector. The manager of this center is a PhD. in Software Engineering, former professor at the Catholic University of Chile (PUC).

  Another interesting case is that of SONDA, a Chilean software company created in 1974. Since then it has experienced a sustained growth that has made it possible to expand its market coverage to countries all over Latin America, by creating branch offices in Argentina, Brasil, Colombia, Ecuador, Guatemala, Perú, Uruguay and Venezuela.

- Finally, the government, through its Economic Affairs Department, is decided to promote business related to e-commerce, adoption of new technologies and Internet [15], which should greatly impact the software industry. This involves 6 specific projects:

  1. E-commerce. A law to regulate electronic documents and digital signature should be sent for debate to congress during June 2000.
  2. In the next three months the government will launch network of public workstations all around the country. The first one is due in Valparaiso on June 22, 2000.

[15] Presented before the press by the Subsecretary of the Department of Economic Affairs Alvaro Díaz, June 2, 2000.

3. From December 2000, an on-line information system for enterprises will be available.
4. The government will promote useful web content for all population sectors. This program is supported by the Interamerican Development Bank (BID) 2001–2005.
5. The market development division of the Economic Affairs Department is working together with the telecommunications agency to promote competence and market transparency.
6. The foreign commerce department represents Chile in international negotiations regarding E-commerce.

5 Conclusions

1. The government has just announced promising policies and guidelines that can make us be optimistic with respect to financing of research and adoption on/of IT. Scientific and technological development is a priority for the new government.

2. With respect to ICT infrastructure, Chile is in a leading position in Latin America (LA).

3. The quality of research on IT in Chile is very high in comparison with the others countries in LA.

4. Chilean graduate programs in IT are attracting many students from other countries in LA.

5. There is a problem of critical mass in research groups and a lack of them in emergent IT methodologies. Attracting young and talented people to graduate studies, academia and research is the most difficult challenge.

   Creating funds for scholarships is a priority, including talented undergraduate students and foreign graduate students.

6. The creation of a "National Research Institute on IT" is necessary. It can be implemented almost in a virtual modality, by taking advantage of ICTs. For this, funding from the government and industry is required. [1]

   The Institute should play a leading role in attracting young people to research, via under graduate and graduate scholarships, post doctoral research, research projects with industry involving young researchers, etc.

7. Most of research is done at universities, with industry playing a minor role. It is crucial to involve industry in research. The interaction of academia and industry has to be promoted and supported. The government has to play a fundamental role by making attractive to industry to carry out and support research and hire young scientists to develop creative activities inside their organizations.

Scholarships should be created to help finance research internships at the industry by both students and facultu members.

8. There are reasons to be optimistic about the software export industry; decisions and policies are being implemented to take Chile back to a leading position in this area.

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