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Chile - Science, Technology and Innovation

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The purpose of this paper is two-fold. First of all, the paper aims to make an in-depth assessment of the factors, which constrain and facilitate the innovative capacity of Chile. Second, it will analyze the Chilean government initiatives for the science, technology and innovation development and their results in order to establish the priority areas for knowledge-related policies. Therefore, the paper is organized as followed:

The first chapter examines the economic environment of Chile and its impact on STI. To do so, it first analyzes general economic performance indicators and economic structure, especially, the share of high-technology industries and services and the competitive advantages of Chile's economy: This leads to the study of international trade and competitiveness of Chile in the world market. Next, the attention is drawn to the institutional framework, and one of its most important features as related to the STI, the IPR protection. Before drawing preliminary conclusions about Chile's innovative environment, two final paragraphs are devoted to investigation of the role of foreign direct investment for innovation and the status of the venture capital market.

The second chapter directly addresses the main features and challenges of STI in Chile. It first resumes the STI infrastructure, including the analysis of the Chilean decision-making system for STI and the evaluation of S&T policies. The subsequent paragraph reviews the trend of national STI expenditures, classified by financing and executing sectors. The concluding paragraph examines the output of Chilean innovative system in terms of scientific publications and personnel, patents and technological transfers, and basis for the development of innovative networks in the country.

The final section summarizes main findings, followed by policy recommendations.

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INTRODUCTION

The ability to create, distribute and exploit knowledge has become a major source of competitive advantage, wealth creation and improvements in the quality of life.

These changes imply that science, technology and innovation (STI) are now key to improving economic performance and social well-being. However, if governments want to obtain the benefits from this transformation they will have to put the right policies in place. Limits on public spending, increased competition and globalization, changes in the drivers of the innovation process, and a better understanding of the role played by science and technology in economic performance and societal change, have led governments to sharpen their policy tools. Increasingly, government must become a facilitator, enabling business and consumers to adapt to the demands and opportunities of the new economy.

The most recent volume of the *Latin American Competitiveness Report* makes the following observation: “The main competitive weakness of the Chilean economy is the country’s relative lack of ability to innovate and adopt technological change” (Vial & Cornelius, 2002: 176). Thus, despite remarkable economic achievements in Chile, enormous challenges remain for government policies for science, technology and innovation development.

Methodology

Science, technology and innovation are seen as the main tools for economic development of a country. Although the nexus between them is very close in reality, science, technology and innovation policies are considered to be different (M. Dodgson, 2000).

For that reason, science policies are here understood to involve government policies for promoting science in universities and research laboratories, while technology policies address the development of important generic technologies, such as information technology (IT) and biotechnology.

Therefore, *science policy* aims at increasing and improving the capacity of the nation to create and respond to new scientific opportunities and options, and *technology policy* aims to develop specific technological resources and infrastructure. By contrast, *innovation* *policy* is considered to be those efforts by governments that encourage the creation, accumulation and diffusion of new products, processes, and services by firms.

Basically, an *innovation* is a change, which leads to improvements. For the purpose of this paper, the innovation will be hereafter understood as technological innovation, which includes product innovation – commercialization of products with new qualities or characteristics, and process innovation – the transformation of materials, human resources and/or methods of work. The basic difference between innovation and invention is that the former aims to transform the new idea into capital, while the later considers the discovery independently of the commercial interest.

In all cases, however, an essential feature of effective policy is the need for flexibility and adaptation seeing they the challenges confronting the country change over time (M. Dodgson, J. Bessant, 1996).

As studies of national systems of innovations show, it's ultimately the technological capabilities of firms that determine nations' technological, and economic performance. Which implies that science, technology and innovation policies should result in improvements in the technological capabilities of firms.

Technological capabilities enable firms to efficiently accumulate, assimilate, and adapt appropriate technology ("technology diffusion capability") and create new technologies based on research and development (R&D), which creates first-mover advantages in the market and generates potential income from licensing agreements ("technology creating capability").[1]

R&D covers three activities: basic research, applied research, and experimental development. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. When there is a significant time lapse before the "results" of basic research can be applied, this is considered long-term research whose results are sometimes utilised at a much later date and to ends not foreseen by the initial researcher (OECD, 1999).

[1] As M. Dodgson point out, technology diffusion capacities depends primarily on the government's selection and support of munificent technologies and provision of good technological infrastructure, when technology creating capacity depends on good scientific training, opportunities for linking with scientific expertise in universities and research labs, and effective intellectual property rights (IPR) protection.

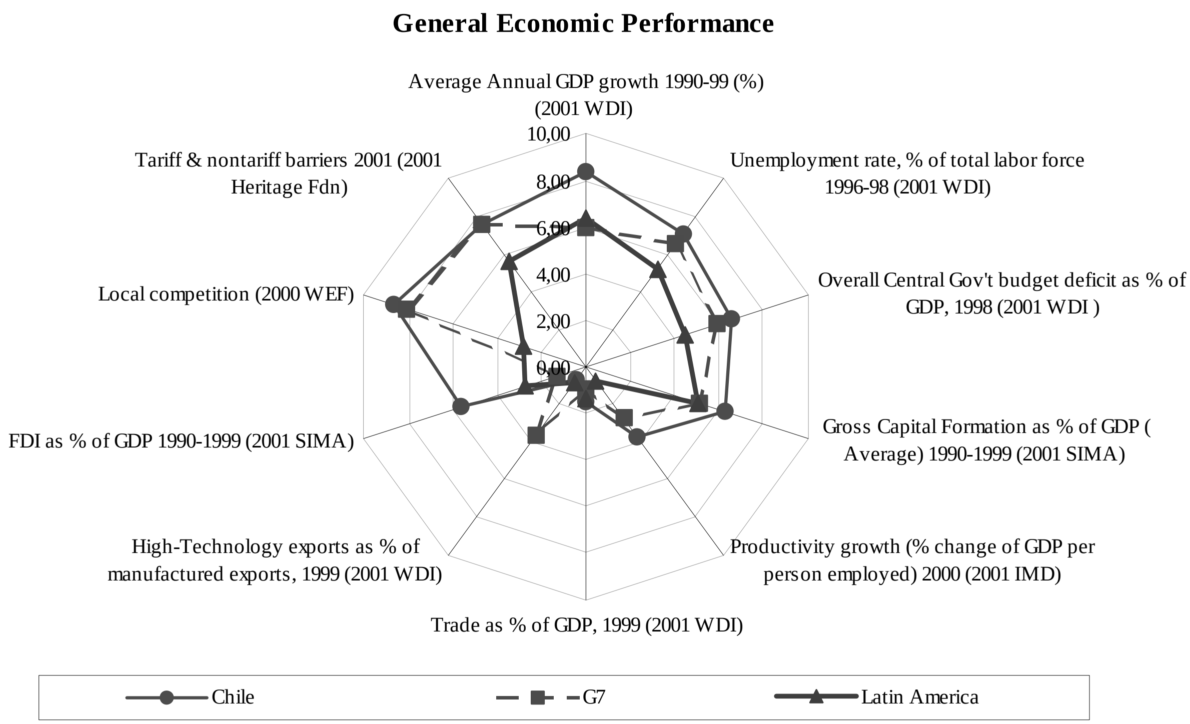
ECONOMIC FUNDAMENTALS FOR KNOWLEDGE-BASED DEVELOPMENT

General Economic Performance

The strategy adopted by Chile for economic development in the last few decades - unilateral trade liberalization, implementation of large-scale structural reform to attract foreign capital and privatization of state-owned companies - brought about an important economic push in the country. In fact, the Gross Domestic Product (GDP) grew at an average annual rate of 6.6% between 1984 and 1989 and this dynamic behavior has continued over the last decade, reflected in an annual average growth rate of 6.3%.

As a result, Chile is one of the region's most dynamic and promising markets, which outpaces in several areas not only regional, but also the world's leading economies (as shown in the Graph 1). Its strength and attractiveness lie not in its size (population of 15 million people), but in the energy and professionalism of its entrepreneurs, the transparency of its regulation, and the predictability of its decision-makers.

***Graph 1*. General Economic Performance Indicators**



* The data used for scorecards was kindly provided by the World Bank Institute's program on Knowledge for Development (normalized database, with each of the variables normalized on a scale of zero to 10). The regional averages were calculated by the author. Several data was missing for the least developed of Latin-American countries.

Chile’s public and private external debts at the end of 2000 were, respectively, US$ 5.5 billion and US$ 31.3 billion, and the government continues to pay down official debt. Chile's credit rating remains the best in Latin America despite the general lack of confidence in emerging markets that resulted from the successive Asian, Russian, and Brazilian financial crises of the late 1990s.

The strong job creation and corresponding decline in unemployment (which had fallen to 5.5% in mid-1998) of the last several years reversed in late 1998 as growth slowed. Unemployment reached highs of 8-10% in 1999 and has not fallen significantly since then. The growth in real wages of more than 5% annually in the middle of the last decade ended during the recession but has since picked up, and real wages have on average risen faster than inflation. The latter has gradually declined over the last few years ending 2000 at 4.5%. These symptoms of potential future stagnation draw attention to the possible ways of a transition to the next phase of economic development, namely innovation-led development.

Technology evolution in general, and the development of science, technology and innovation in particular, do not solely depend on the initiative, drive and knowledge of certain modern-minded policymakers, although these qualities are indispensable. This evolution also depends on a set of economic, social and institutional conditions, established and matured over time, as well as other acting parties who, directly or indirectly, currently or potentially, intervene in technology innovation processes (Urzùa, 2001).

Chile’s ability to respond to rapid technological change greatly depends on the availability of the right set of skills and well-functioning product and capital markets as these factors sustain an environment conducive to innovation and receptive to new technologies.

The following analysis sets out to describe the fundamental factors, which impact on the overall economic situation, and thus, determine the environment for the science, technology and innovation development in Chile.

Economic Structure and Competitiveness

The main conclusion that could be drawn from the first glance at the Chilean economic structure, shown in the Table 1, is it’s growing divergence from the trend followed by the developed countries: the share of agricultural production increase steadily; the level of the industrial sector is maintained by the mining sector, while manufacturing mark the tendency towards loosing importance of the industrial sector. The decreasing share of services is also worrying.

Agriculture, Forestry and Fishing

The 'Agriculture, Forestry and Fishing' is one of the most competitive sectors of Chilean economy. The resent development of fruit and wine productions and their success in the international market, proved the ability of Chilean producers to implement the last technological innovations in the productive system and the tight competition in the world marked. As Mullin and al. (2000) point out, the strengths in Chilean applied research currently lie in agriculture, forestry and fisheries.

Table 1. ***Economic structure, as % of GDP***

	1980	**1990**	**1999**	**2000**
Chile				
Agriculture	7.3	8.7	11.6	11.4
Industry	37.4	41.5	36.8	37.5
Manufacturing	*21.5*	*19.6*	*17.4*	*17.4*
Services	55.3	49.8	51.7	51.0
Latin American Countries*				
Agriculture	10.1	9.6	8.5	8.2
Industry	39.4	37.3	31.6	32.4
Services	50.5	53.1	59.9	59.5
G7				
Agriculture	3.0	2.0	1.7	1.7
Industry	37.0	35.0	31.0	30.0
Services	60.0	63.0	67.3	68.3

* At the basis of eight countries: Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela.

Source: The World Bank regional database, OECD.

Services

On the supply side, services are fairly modern and competitive and account for half of GDP, with trade and catering at 16.8% of GDP in 2000, financial services at 13.6%, transport and communications at 9.3% and personal services (including health and education) at 5.7% (EUI Country Report, 2002).

Sectors such as communication and transport are now more technology-intensive than many manufacturing industries. Knowledge-intensive services, such as computing and consultant services, have experienced very rapid growth and are important sources of innovation. Many other services have become more innovative following the implementation of ICT in service delivery, the competition-enhancing effects of regulatory reform and the increased role of networking in the innovation process.

Over the past decade, Chile has fostered a domestic telecommunications market that is one of the most competitive in the world. They have seen technology as a key way of ensuring the country's place at the table with—and, in the case of its important agricultural exports, on the table of—the world's leading economies.

In less than ten years, the Chilean telecommunications sector has leap-frogged huge steps towards providing the nation with modern, fast and efficient means of communicating with each other and the rest of the world. Although Chile is not a *producer* of technology (World Development Report 1999/2000), it has shown an impressive technological growth by being a *user* of technology.

After the privatization of the biggest national companies, Chilean telecommunications has gone from a nearly 100% state-run sector meeting minimal technology and service standards to one of the most active private telecom service markets in the world, with major investments in digital local and long-distance telephony, advanced cellular and wireless service, cable television and satellite. Furthermore, it is considered one of, if not the most competitive, market in Latin America partly due to the fact that it offers very few barriers to foreign investment/ownership *(*Euromoney, December 1998). Table 2 shows just how competitive Chile is compared to some of the most developed Latin American countries. It is second to Argentina in basic and mobile telephony, but dominates in the number of PCs and Internet hosts, two critical aspects of Internet development.

Table 2. ***ICT Development Indicators in Leading Latin American Economies***

	Chile	**Argentina**	**Brazil**	**Mexico**
Phone lines/1000 people	180	191	107	96
Mobile phones/1000 people	28	56	28	18
PCs/1000 inhabitants	54.1	39.2	26.3	37.3
TV sets/1000 inhabitants	223	289	316	251
Internet hosts/10000 inhabitants	20.18	18.28	12.88	11.64
Source: World Development Report1999/2000				

Industry

A systematic loss in the industrial sector's relative importance in GDP generation can be observed within the domestic economy. It can even be seen that a large segment of the branches of the economy with important links between industries also tend to lose their relative importance in GDP and employment generation.

Table 3. ***Manufacturing Structure in Chile, %***

ISIC		Contribution in Total Manufacturing, 2000	Value Added, per Sector, 1999
Low- technology Industries		***56.0***	***49.9***
311-314	Food Products	30.4	32.1
321-324	Textiles, Leather and Footwear	9.8	4.1
331-332	Wood Products	4.8	4.2
341-342	Paper, Printing and Publishing	11.0	9.5
Medium- low- technology Industries		***26.4***	***32.3***
371-372	Metals	6.7	16.1
353-356	Petrochemicals	10.9	7.8
361-362+369	Non-Metallic Mineral Products	3.6	4.6
381+390	Fabricated Metal Products and Other Manufacturing	5.2	3.8
Knowledge-based Industries[2]		***17.6***	***17.9***
351-352	Chemicals	12.0	13.2
382-383	Machinery and Transport Equipment	5.4	4.5
385	Professional & scientific equipment	0.2	0.2
Total Manufacturing		**100**	**100**

Source: *Instituto Nacional de Estadísticas* (National Institute of Statistics)

Furthermore, the country's specialization is directed towards the exploitation of natural resources and food-processing related industries, while manufacturing output continues to lose importance (Table 3). The share of knowledge-based industries in manufacturing, whose production is generally directed towards domestic consumption, amounts only to 17.6%, while export-oriented Food Products (30.4% of total manufacturing output in 2000), textile, wood and paper industries are responsible for around half of manufacturing output.

Hence, the competitive advantages of Chile are not related with technological capabilities notwithstanding a favorable macroeconomic and institutional framework.

[2] All industries are to some extent dependent on knowledge inputs. However, some industries rely more on knowledge than others. The term "knowledge-based industries" usually refers to those industries, which are relatively intensive in their inputs of technology and/or human capital. OECD "Classification of industries based on technology" (OECD, 1999, p.106) uses the International Statistic Industrial Classification, second revision with four digits, but only three-digit classification is available for Chile. Nevertheless, since only tree digits are used to classify low and medium-low technology industries and the fourth digit helps to distinguish between high and medium-high-technology industries, we have regrouped the last two categories into 'knowledge-based industries' for the case of Chile.

As shown in Table 4, at an international level the value-added per capita for the manufacturing sector (MVA) has grown considerably over the last few decades, starting off in the 1980s with a much lower value than the other Latin-American countries, until reaching higher levels than the regional average by the end of the nineties, and always maintaining a far higher value than the average for developing countries (2.2 times higher in 1998). However, when the Chilean industry's MVA per capita is compared with that of developed countries, there is a noticeably large difference, with the 1998 value for developed countries some 7.6 times higher than the Chilean one.

Table 4. ***Chile in International Comparison of Manufacturing Value-Added***

Indicator	Year	Chile	Latin-America	Developing countries	Developed countries
MVA per capita (US$)	1980	441	694	161	3.712
	1990	486	586	203	4.430
	1997	667	642	290	4.829
	1998	648	646	291	4.880
Share of MVA in GDP, %	1980	21.3	24.4	19.5	22.9
	1990	20.9	22.2	21.2	22.0
	1997	18.3	21.2	24.0	21.6
	1998	17.4	21.3	24.0	21.4
Real average annual growth rates of MVA, %	1970-1980	-0.8	5.7	6.8	2.9
	1980-1990	3.6	1.3	5.3	2.8
	1990-1998	5.7	3.2	6.9	2.2
Real average annual growth rates of per-capita MVA, %	1970-1980	-2.3	3.2	4.5	2.1
	1980-1990	1.9	-0.6	3.1	2.1
	1990-1998	4.1	1.4	5.2	1.5

Source: UNIDO, 2001

There are several factors that explain the manufacturing industry's low MVA per capita in comparison with developed countries: (i) increased intensity of production of products based on low value-added natural resources; (ii) a relatively low level of education amongst the Chilean industry workers, especially at a technical and operational level; and (iii) the low level of technology used by the industry.

Likewise, the high percentage of micro and small size enterprises (MSE) and small and medium size enterprises (SME) in Chile,[3] also holds great importance for understanding the low value-added generated by the manufacturing sector. In fact, MSE and SME production is mainly orientated towards the internal market, showing a very low export performance and a rather poor level of technology. "The use of out-of-date and over-used machinery is

[3] Up to 1997, 68% of the country's companies were MSE and 29% were SME.

common in these enterprises, and the introduction of modern production management and organization systems is not common" (Alarcón and al., 2000).

Small start-up firms are generally considered as more flexible and unencumbered than large established firms and essential to the "creative destruction" that occurs in periods of technological change. Start-up firms are important sources of new ideas and innovation and may have an advantage over larger established firms in emerging areas where demand patterns are unclear, risks are large, and the technology has yet to be worked out (OECD, 2000a).

Heavy procedures and bureaucracy could become an important barrier to the development of new projects and production activity. In Chile this issue is less salient compared to other countries on the continent, but it is still an essential element to take into consideration as shown in Table 5. Many "successful" OECD economies, such as Ireland, Canada, Finland and the United States, have relatively low administrative barriers for start-ups, while the procedures is still very numerous and lengthy in Chile.

Table 5. *Company start-up costs*

Country	Procedures	Days	Cost [US$]	As % of GDP
Canada	2	2	280	0.01
Argentina	12	71	2.116	0.23
Brazil	15	67	3.375	0.67
Chile	***12***	***78***	***612***	***0.12***
Mexico	15	112	2.452	0.57
Source: Shielfer, A., *The Regulation of Entry*, Harvard.				

Finally, the progressive tariff system used by some developed countries represents a significant obstacle. A good example is the case of the United States, one of Chile's major export markets where high value-added products are specifically discouraged by the application of tariffs which increase progressively according to the level of value added over and above that of the raw materials utilized.

In synthesis, the country's production structure is not connected to the current technological scientific revolution or the new information technology. It is primarily a traditional structure, dominated by commodity export industry (De Mattos and al., 1998).

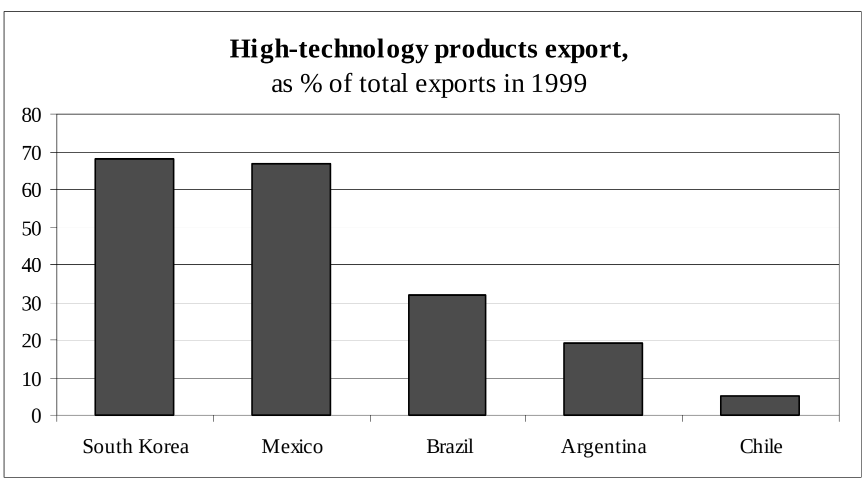
International Trade and Foreign Competition

Throughout the last two decades, the Chilean economic growth has been driven by exports. Chile has one of the simplest and most transparent regulatory systems in the region for trade and business. A fixed 7% (2002) import duty on most products from those countries without a free trade agreement will be reduced to 6% by 2003. Careful review of regulations and full compliance with guidelines will ensure more successful and trouble-free operations in Chile. Chile maintains import and export licensing requirements, but they are more for statistical purposes rather than control. Only agricultural products and a few sensitive items face restrictions.

Consequently, Chilean exports increased by 400% between 1985 and 2000, diversifying in terms of variety of goods and number of market destinations. 46% of these come from industry, 8.1% from agriculture, 0.3% from the forestry sector and 0.1% from the fishing industry (Urzúa, 2001).

However, if exports are classified according to the sector from which their input materials originate, then 46% are derived from the mining sector, 19% from the agriculture and fishing sector, 11.6% from the forestry sector, 11.4% from the fishing industry and only 10.8% from the industrial sector. Therefore, high-technology products represent only 5% of the Chilean exports, which is significantly below the levels of other regional leaders and South Korea (Graph 2).

Graph 2. ***The Share of High-Technology Products Exports in 1999***



Source: UNDP, 2001.

The extreme dependence on low value-added exports, based on the exploitation of natural resources, and the increasingly negative technology balance of trade, emphasize the lack of technological capabilities of Chilean firms. Chile has been successful in making more efficient and sustainable use of its natural resource base to improve its citizens' standards of living. However, it seems unlikely that Chile will be able to maintain strong performance of the past decade if innovation and technology adaptation do not show up in a more diversified and technologically advanced compositions of exports.

Chile's reliance on exports and its desire for market diversification have led it to seek opportunities to expand several current or potential markets. Chile joined the Asia Pacific Economic Cooperation (APEC) organization in 1994 and is currently associated member with MERCOSUR. The country has signed additional trade agreements with a host of nations in various regions of the world—including free trade agreements with Canada and Mexico—and it remains an active participant in the negotiation of the Free Trade Area of the Americas (FTAA). Moreover, Chile has within the last three years signed trade agreements with the world two largest free trade areas: the European Union and the USA.

Box 1. *Chilean Economy Adopting International Standards*

The development of exports in the USA and European Union has imposed increasing quality requirements, which has given some domestic producers the incentive to certify their products according to international standards such as ISO9000 and ISO14000. Nevertheless, only few domestic companies have adopted international certification systems. By 2000, 177 Chilean companies held an ISO9000 certification of which 11% were manufacturing companies, while only 10 companies held ISO14000 certification, mainly large-scale companies in the mining and forestry sectors. Despite the low penetration of internationally recognized certification, it should be pointed out that Chile has been quick to ratify international regulations.

Source: International Intellectual Property Alliance, 2001.

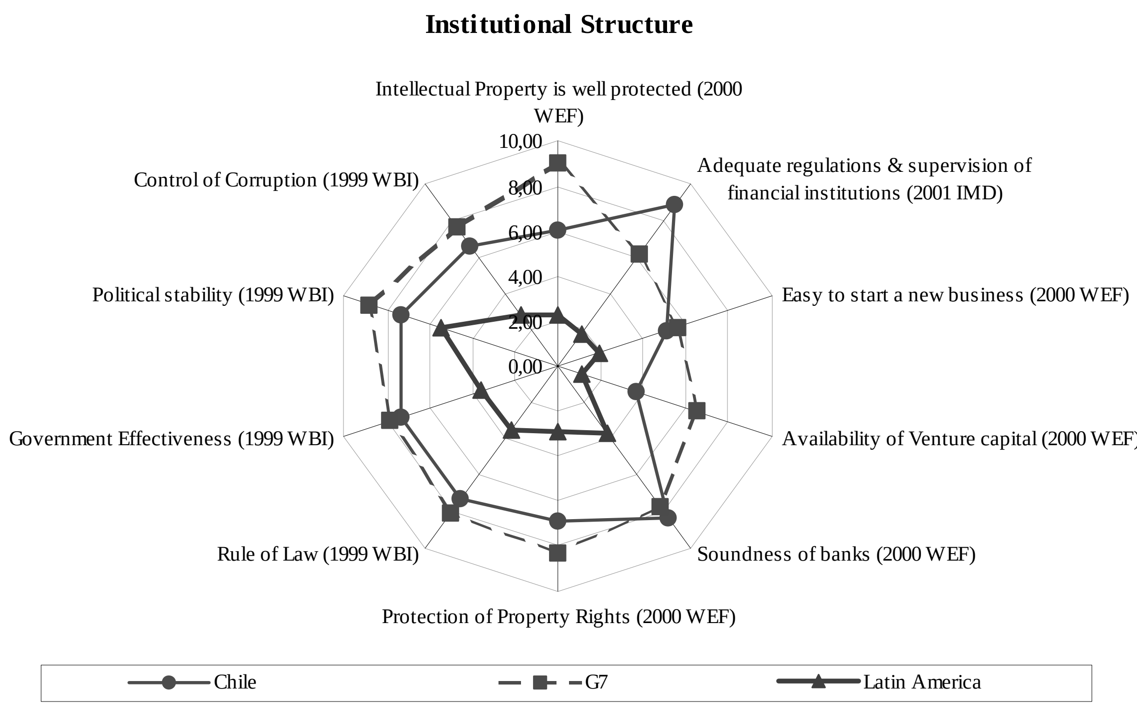
Institutional Framework

Chile's attractive and competitive business environment is the result of a policy strategy that has focused on building sound macroeconomic fundamentals and strong institutions, promoting competition and international integration. Political and social stability, together with the existence of open and competitive markets, guarantee a secure business environment.

Stable and transparent rules, an efficient and independent judiciary, and a dynamic and innovative private sector that constitutes the main engine of growth, are all factors that further enhance the country's position as the most competitive economy in the Latin American region (Graph 3).

The private sector will only invest in innovation and in efficiency-enhancing technology if competition forces it to do so and if it can expect sufficient returns. Liberal reforms and privatization contributed to the development of open market, and the recent changes in the intellectual property rights (IPR) protection aim to improve motivations for innovative activities.

Graph 3. ***Institutional Structure Indicators in Chile***



IPR-protection

Technology development in the industrial sector requires a patent rights system developed to motivate investment and connection with the world of knowledge and the use of more efficient technology. A patent rights system accelerates technology absorption and transfer through technology contracts established with definite legal objectives protected by a legal framework,[4] as is the case in Chile for industrial design, utility models and invention

[4] The strength of IPR regimes is determined not only by laws and regulations adopted by individual countries to establish legal rights and broad protections for all types of IPR, but also by the existence of effective institutional systems for administering and enforcing IPR. As the enforceability of IPR varies greatly from

patents. A sophisticated Patent Rights System would spread the use of the vast heritage of knowledge available in the international patenting system.

Chile has a full legal framework with legal bodies to protect institutions' investments in research and development (R. Lorenzini, 1997). Today there are sixty Science and Technology Centers in the country with the potential to benefit from the patent rights (*Consejo Nacional de Producción Limpia, Estudios* 2000). However, the National Patent Rights System requires more than a full legal framework. It also needs: industrial creativity, fostering creation and expression, formation and training, cultural formation, information services, support services and public system adjustment, amongst other things (Del Valle, 1996).

The scientific-technological and production world is practically absent, with only two real involved parties: the State, who registers rights and performs legal tasks in litigation cases and the lawyers' offices, who represent companies for this purpose. The level of activity in technology and production is very low and demonstrates limited use of the potential opportunities existing in this subject. According to the study of Mullin et al. (2000), the main impediment to successfully implementing an effective intellectual property regime is the low commercial value placed on IP by Chileans.

However, Chile has recently amended significant changes to its intellectual property system, gradually improving it according to the development and internal requirements of the country.

First, a new industrial property law, enacted in 1991, has fixed a basic and common proceeding for the granting of patents, trademarks, utility models and industrial designs as a way of facilitating to the right-holders the procedures of their applications. The same law created a special Court of Appeal for industrial property matters, which reviews, revokes or confirms any decision of the administrative authority. For the first time in Chile, the law regulates the relationships between employee-inventors and employers. It defines the way in which rights to an invention should be apportioned (S. Escudero, 1996).

The next step forward was the copyright amendment law of 1992, which *inter alia* provides for the establishment of a new private management system for collecting copyright fees from authors.

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one country to another, it has become clear that laws that seem alike on paper may have substantially different effects in countries with different market structures and enforcement mechanisms (Maskus, K. E., 2000).

Finally, in 1999 the Government of Chile introduced a new IPR legislation draft with the intention of bringing Chile's intellectual property regime into agreement with the World Trade Organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).

Nevertheless, this legislation has still not been enacted and reportedly is not TRIPS-consistent, even in its draft form.[5] Among other issues, the draft law does not provide adequate protection for confidential test data, and inadequate enforcement against piracy and counterfeiting also remains a serious problem, as does the large backlog of pending patent applications. Furthermore, Chilean Courts of Appeal have been supportive in cases where the trademark has been "stockpiled" but gone unused, but less so in cases where investments were made in use of the trademark. In either case, proceedings can be lengthy (2-4 years) and expensive ($5.000-$10.000 +) with a low success rate (*Chile Country Commercial Guide*, 2002).

Box 2. ***Policy Recommendations for Improving the IPR Protection in Chile***

Several immediate actions could be taken by Chilean authorities to counter the piracy problem, for example:

- The police (*carabiñeros*) should be instructed to give priority to copyright anti-piracy actions, especially in the cities of Santiago, Concepcíon, and Valparaiso.
- The police should investigate pirate manufacturing and distribution centers and operations. Similarly, street vendors should be arrested and prosecuted so that this pervasive problem is tackled.
- The civil police and administrative authorities should also act to prohibit the sale of pirated materials in the streets.
- The police should coordinate their investigations and actions with customs officials as well as finance ministry officials, given the problems with piratical materials entering Chile and persons avoiding tax collections.

Source: International Intellectual Property Alliance, 2001 Special 301 Report.

Thus, Chile moved from "non-robust IP systems" towards "trade-facilitating systems" of IPR regime according to the terminology of Sherwood,[6] which signifies that the country achieved some progress in innovation and human skills development, mobilizing investments in the low-technology sectors and risk capital. However, the system still needs

[5] According to Inter-Agency Committee on Intellectual Property Rights 2001 Report. http://www.piacipr.com/watchlist/2001/countryordinary07_chile.html

[6] Sherwood defines three levels of protection for intellectual property: a non-robust level, a level which facilitates trade, and a robust level that stimulates local investments, and notes that maximum benefits from robust IP protection exist in countries with a fairly open trading system (Sherwood, 2000, pp.58-59).

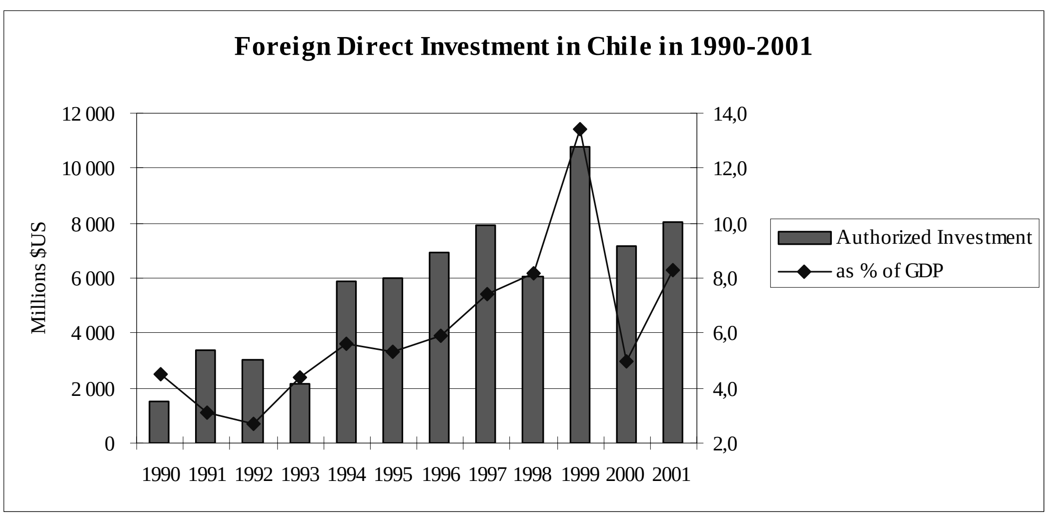
significant improvements in order to attain the stage of investment-stimulating system, providing highly skilled labor, planned and constant innovation and optimal level of risk capital and investment in high technology.

Foreign Direct Investment (FDI)[7]

Foreign direct investment is one of the ways to participate in the knowledge revolution and to facilitate transfer of technologies from the most developed economies: it remains significant sources of innovative ideas and concepts and may take on greater importance as the complexity of innovation at the technological frontier makes it increasing difficult for individual firms and countries to engage in innovation (OECD, 2000a).

Chile, more than most other Latin American countries, has provided a transparent and stable legal and economic environment to attract foreign investment. While many other nations have placed significant restrictions on foreign direct investment (FDI), Chile realized that providing foreign firms with fair, non-discriminatory rules was the best method to encourage investment in growing the productive capacity of the country. As a result, FDI comprises approximately 6% of Chilean GDP, while also accounting for 64% of total capital inflows, both high levels relative to most nations.[8]

Graph 4. ***FDI in Chile***



Source: Foreign Investment Committee

[7] All the data in this paragraph was provided by Foreign Investment Committee.
[8] Federation of Chilean Industries, http://www.businesschile.com/

From 1990 to 1992, investments averaged an annual US$ 1.7 billion, but from 1993 flows increased dramatically, reaching a record US$ 10.3 billion in 1999 (which represented an increase of 45% over 1998). In 2000, foreign investment registered a drop, but soon recovered and reached US$ 8.1 billion in 2001 (Graph 4).

In fact, Chile was the first Latin American country to receive an investment-grade credit rating from international rating agencies, including Standard & Poor's and Duffand Phelps. More importantly, it has been able to maintain this rating throughout the recent financial crises affecting all emerging economies, and currently holds the lowest risk rating in Latin America.

Between 1985 and 2001, investments in natural resource industries (Mining, Forestry, Fishing, Aquaculture and Agriculture represented 34.6% of total materialized FDI, while service industries accounted for a further 22.9%, followed by the Electricity, Gas and Water industries (18.0%) and Manufacturing (13.4%).[9] Thus, technology transfer via FDI is very limited as this investment is mainly oriented towards sectors with intensive natural resource use, which are not very dynamic on the technology front and generate fewer spillovers than the high-technology industries. The attractiveness of the Chilean market consists primarily in the institutional stability and the abundance of primary materials, while, for example, the South Korean competitive advantages lie in the area of technological absorption capacities, creativity and innovative productiveness.

Box 3. ***Regulatory framework and legal impediments***

A key component of Chile's successful attraction of foreign investment has been the establishment in 1974 of Decree Law 600 or DL 600, which allows 100% foreign ownership of enterprises in Chile in most important industries.

Nevertheless, Chile regulates the inflows and out-flows of capital and profits. An equity investment in Chile must remain in the country for at least one year according to Decree Law No. 600 of Chile’s Foreign Investment Law. In April of 2000, however, the central bank modified certain internal rules, which now permit capital to enter and leave freely without the one-year holding requirement.

Source: Pascual, R., and K. Stockton, 2000.

[9] Foreign Investment Committee.

Even if Chile was open to FDI, there was little attention either to generation exports trough them (as there was in Singapore) or to directing these investments to new high-technology sectors where they might generate externalities as local firms observed their behavior and local employees left to form their own firms or work for domestic companies (Pack, 2000).

Venture capital

Differences in financial systems, particularly the degree to which they are able to finance risky projects, may affect innovation in emerging industries and therefore growth, as new firms have limited access to finance and may be unable to grow or invest in innovation. Countries with well-developed financial markets and active venture capitalists may be better geared towards innovation and the reallocation of capital to such new industries than countries where traditional banking plays a dominant role (OECD, 2000b).

An important part of Chile's successful macroeconomic performance is related to its healthy public finances. However, despite favourable legal conditions and regulatory structures, Chile has not been able to attract a large amount of venture capital, which could be partly explained by (i) the governmental control of the foreign investment in the resent past, (ii) its conservative financial and corporate sectors and (iii) the limited size of the national market.

Venture capital refers to equity investment in new firms. It is a major source of funding for new technology-based firms in countries like the United States and it is pivotal in promoting radical innovations often carried out by new firms.

Venture capital, a key element of private equity finance, has become a major source of funding for new technology-based firms in recent years and thus a major contributor to radical innovation. It is a major factor in the development of technology start-ups, as it is primarily aimed at the commercial implementation of a major innovative idea or technology. The development of mature venture capital market is one of the key challenges for Chile. According to Eduardo Bitran, general manager of *Fundacion Chile*:

> "It is worrisome how in Chile, we have not developed capital markets that generate seed capital, venture capital and the conditions needed for developing all types of opportunities." (Chile: Financing the New Economy, 2000)

Foreign investors also confirm that the whole attitude toward borrowing money is extremely conservative: venture capital means risk, which doesn't go with the Chilean culture according to various accounts.[10] Chilean entrepreneurs traditionally start by using capital from friends and family and, once they are big enough and at relatively low risk, entrepreneurs switch to private equity financing, without passing through the intermediate financing steps, namely "seed capital", "angel investors",[11] and "venture capital". These three financing sources are not yet considered when a traditional Chilean businessman thinks about starting a company, which makes access to capital very difficult.[12]

There are also a series of legal restrictions on the types of investment used for entrepreneurial projects. And, despite the fact that reforms recently made to the capital market make it easier to create venture capital funds, these funds generally do not invest in newly created projects, but rather take on companies that already have a few years under their belts.

However, with the massive penetration of the Internet in Chile and initiatives from private organizations like *Fundacion Chile* and from the public sector, CORFO (Chile's Economic Development Agency), Chile is heading in that direction. In fact, President Lagos emphasized during his presidential address that his administration was committed to the development of an Internet culture and of venture capital.

At the government level, the economic development agency (CORFO) is taking measures to improve the financial situation for entrepreneurs and support a maturation process for innovative ideas that have no credit history. It has a program to match venture capital investments of up to approximately U.S. $54,000 so that risks and benefits are shared. The projects have to have a significant innovation angle and good growth perspectives.

[10] According to Kathleen Barclay, the Senior Country Officer for Chase Manhattan Bank and vice president of AMCHAM.

[11] Angel investors are successful entrepreneurs who invest in companies in their same line of business. This type of investment is very common in the United States, but rare in Chile, which is partly due to its small domestic market that doesn't allow a sufficient risk diversification.

[12] Another challenge, cited by many, is the fact that failure is not accepted in Chile. In the United States, failure is considered an almost necessary part of the learning process, but in Chile, a businessman who goes bankrupt is not given a second chance, and is certainly not well looked upon. Chilean society doesn't tolerate failure the way business failure is viewed within the United States, so the cultural risks entrepreneurs face are greater (AmCham Chile, 2002).

Box 4. ***Fundación Chile***

The *Fundación Chile* represents a unique Chilean experiment. It is a technology center that improves the technical performance of economically important sectors by creating new companies, rather than by attempting to upgrade the technological performance of existing firms. It launches demonstration companies as a means of commercializing new technology, and later sells those enterprises once they have become viable. According to its representatives, it has launched thirty-six such ventures. Seventeen have been sold, and the most successful six of these have generated more economic activity than the total cost of the Fundación during its existence.

Source: Mullin et al.

In the early 1990s, four "risk capital" funds, dedicated to investing in small- and medium-sized companies (SME), have emerged in Chile. The funds, totaling about $100 million in capital altogether, have all been publicly traded, and are, in part, designed to be a conduit for Chilean pension funds to invest in small business (J. Pitch, 1995).

One of the examples is ChileTech Risk Capital Fund, which primarily invests in agribusiness, forestry and marine resources businesses. ChileTech's goal is to invest in highly innovative enterprises, which seek to be competitors in the global marketplace, and those that possess barriers to entry beyond financial resources.

The Fund was organized as a joint venture between Ventana-Chile and its strategic investors, *Fundación Chile*, the Multilateral Investment Fund ("MIF") of the Inter-American Development Bank, and *Eurochile*, a joint venture between the Chilean government and the European Union aimed at being a bridge between the Chilean and European Union business communities. The Fund is also receiving support from CORFO, a Chilean government agency that provides significant resources toward the development of the private sector in Chile.

Ventana-Chile, the Fund's investment manager, is the newest member of Ventana's family of companies involved in the management of global private equity funds. Ventana's experience covers over 20 years of investments in fast-growing high technology firms. This experience spans several industries and sectors, including electronics, communications, healthcare, and environmental.

Founded in California in 1974 with an international focus, *Ventana* has sponsored eight private equity growth funds totaling over $230 million under management, leading to a total of 74 investments to date. These investments create access to a collective base of over

200 world-class scientists, researchers, and business advisors who work directly with the Strategic, Scientific, and Business Advisory Committees of these funds. Additionally, ChileTech's portfolio companies will be able to access the capital that Ventana's existing partners make available for follow-on investments. Many of these Investor-Partners, representing 17 countries, have played an instrumental role in the $2.60 billion in follow-on private and public financing which Ventana's portfolio companies have received to date (*Fundacion Chile*, 1998; Multilateral Investment Fund, 2002).

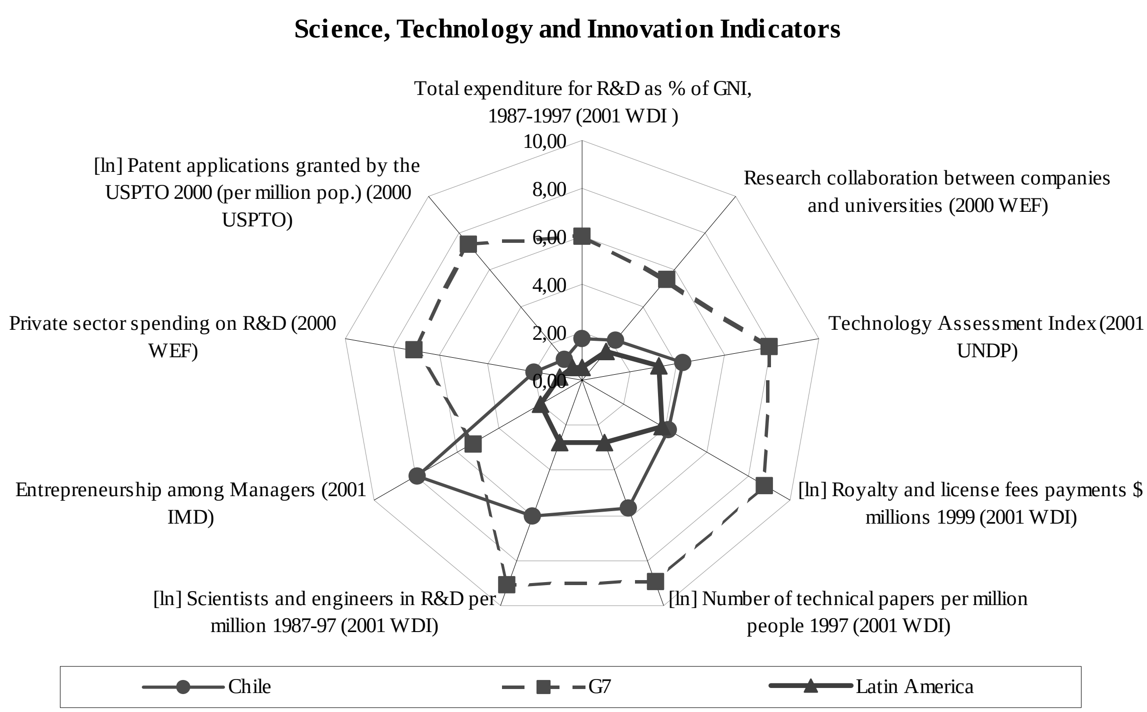
However, Chile's high domestic savings rate (fostered in part by mandatory retirement contributions administered by private pension fund management firms) continues to ameliorate dependency on short-term foreign capital to finance investment. The country's high rate of investment suggests that the venture capital might grow rapidly in coming years.

Science, Technology And Innovation In Chile: Features And Challenges

While Chile is on pair with the most successful countries in the world in terms of social development and general economic indicators, it clearly lags the level of developed economies in the innovative field. In such key areas, as ‘Total R&D expenditures’, ‘Private sector spending on R&D’, ‘Royalty and license fees payment’, and ‘Patent applications’, Chile is far behind the level of world technological leaders (Graph 5).

From this viewpoint, Chile cannot be said to be prepared for a knowledge-based society, and this is reflected in the World Competitiveness Reports which places Chile in a middle position amongst 49 countries, but near the bottom with regard to technology and production (Industrial Production, Productivity, Research and Development Spending, Research, Development and Patenting Personnel). As a result, for the ‘Technology assessment index’, [13] Chile has a rather poor mark, slightly above the LAC average.

Graph 5. ***Chilean STI Indicators***



[13] The Technology Assessment Index (TAI) focuses on four dimensions of technological capacity: The creation of technology, the diffusion of recent innovation, the diffusion of old innovation and human skills. See UNDP, 2001a for further details.

Nevertheless, considerable efforts in basic science development and educational infrastructure have paid off in terms of increasing 'Numbers of technical papers' and growth in the stock of 'Scientists and engineers in R&D'. This is encouraging, and reveals, together with a high score for the 'Entrepreneurship among Managers', a significant potential for the future growth of the innovation activities.

Science, Technology and Innovation Infrastructure

Decision-making System for Science, Technology and Innovation

Chile has a variety of policies, programs and policy instruments dealing with scientific research, technological development and innovation, as well as technology diffusion. Still, the government does not appear to have a strong and coordinated policy for the development of national S&T capacities and does not see S&T as critical in resource allocations.[14]

CONICYT and the Presidential Advisory Commission on Scientific Matters are the main government institutions responsible for the development of public policies and distribution of funds.

CONICYT - *Comisión Nacional de Investigación Científica y Tecnológica* (Chilean National Council for Science and Technology) is "…designed to advise the President of the Republic on the planning of scientific and technological development."[15] However, at the present time CONICYT is not structurally organized to provide advice seeing that most of its resources go into the day-to day administration of financial instruments in support of scientific research and technological development.

Comisión Asesora Presidencial en Materias Científicas (Presidential Advisory Commission on Scientific Matters) is another advisory body, with some limited functions in the science field (excluding engineering and technology). In addition, it has few resources for a secretariat function, thus limiting its capacity to commission policy studies to underpin its discussions.

As reported by Mullin and al. (2000), both bodies have similar functions, but are unable to assure the proper coordination of internal policies and efficient allocation of the

[14] A thorough analysis of Chilean innovation system, and, especially, on the institutional level, was developed by J. Mullin and al., which served as a main source of information for this paragraph.
[15] Chilean Decree (Ministerio de Educación 1971. Artículo 1. p. 1).

resources. The absence of clear policy recommendations has created numerous conflicts of interest between the growing number of Chilean institutions involved in research financing.

Furthermore, several important funds were created under the umbrella of CONICYT and the Ministry of Economy:

- FONDECYT - the National Fund for Scientific and Technological Development, founded in 1992, with the objective of financing high level scientific and technological research projects in all areas of knowledge, irrespective of the field or of the institution involved.
- FONDEF, founded in 1991, has a special mission to strengthen and help to improve the capacity for scientific and technological innovation of national R&D institutions, by financing projects with high quality, significance and impact in order to improve the productivity and competitiveness of the principal sectors of the economy.
- FONTEC - Fondo Nacional de Desarrollo Tecnológico y Productivo, finances projects in technological innovation, technology transfer, and technological capacity building and infrastructure. The fund is wholly directed towards private companies that provide either goods or services, from any sector.[16]

Among these main establishments, several funds were created in more particular areas, as: *Fondo de Desarrollo e Innovación* (FDI), responsible for disbursing funds to the CORFO institutes; and specialized sectoral funds, as *Fondos de Estudios Avanzados en Áreas Prioritarias* (FONDAP, Funds for Advanced Studies in Priority Areas), *Fundación para la Innovación Agraria* (FIA, Foundation for Innovation in Agriculture), *Fondo de Investigaciones Mineras* (FIM, Fund for Mineral Research), and *Fondo de Investigación Pesquera* (FIP, Fund for Fisheries Research).

The main public research institutions are universities, which are mainly responsible for education, but are also the principal site of basic research for the country; and *Corporación de Fomento de la Producción* (Corporation for the Promotion of Production - CORFO) that bring together five technological institutes.

Accordingly, Chile does not appear to have a high-level mechanism to examine broadly science, technology and innovation policies. The lack of government policy framework and

[16] In practice, the largest number of grants is awarded in the area of manufacturing, with agriculture the next most favored sector.

coherence of organizational structure emerges as the main shortcomings of the public decision-making system in the matter of science, technology and innovation.

The public research institutions are rarely at the forefront of technology and it would be a mistake to regard them as technological vanguards of the economy (Lundvall, 2000). In sectors with a rapidly evolving technology frontier, the public sector is likely to learn the proprietary knowledge with a significant lag.[17] At the same time in the less innovative sectors much information can be identified and purchased by individual firms.

Though, this considerations do not imply that the public sector have no role to play in diffusing technology among the firms, especially those with average and low technological capacities. Thus, the public research institutions function of speeding up knowledge diffusion in the economy can be more important than the direct contribution to the development of brand-new technologies.

S&T Policies and Incentives

Typically, Chilean policies have neither protected nor privileged any specific sector. As a result, the Chilean government has primarily focused on crosscutting science policies and less so on technology policies, leaving the innovation without much attention.

More recently, the Chilean government has become more aware of the importance of technological progress for the future development of the country and its competitiveness in the world market. This has resulted in a variety of programs:

- the Science and Technology program (BID-I),
- the Technology Innovation Program,
- the production promotion program SERCOTEC, and
- Millennium Science Initiative Project.

Science and Technology Program: the intention of this program, launched in 1992 and completed in 1995, was for the Government to support economic growth. It was based on three funds: FONTEC, FONDEF y FONDECYT, and responsible for a total budget of US$161 million, consisting of a contribution of US$93 million from the IDB (Inter-American Development Bank) and the rest donated by the Chilean government. This Program elevated the political level of decisions, concentrating the areas of R&D within the

[17] As concluded by OECD studies of private and public sector research activities (Pack, 2000).

Ministry of Education, the technological research and innovation within the Ministry of Economy and finally, it elevated the category of some institutions whilst others were created, namely MIDEPLAN and AGCI.

Technology Innovation Program: this was a continuation of the Science and Technology Program, carried out between 1996 and 2000. It reoriented the Sistema Nacional de Ciencia y Tecnología (National System of Science and Technology) towards a Sistema Nacional de Innovación (National System of Innovation). It integrated new funds, based on cooperation between institutes (CONICYT, CORFO, Ministries of Economy and Agriculture) and the presence of directors in different funds at the same time. This Program was wholly funded by the domestic budget for a slightly higher amount than the above.

Programa de Fomento productivo del Servicio de Cooperación Técnica (Program for the Promotion of Productivity by the Technical Cooperation Service), SERCOTEC: This government program has been in operation since 1952 and was created in order to promote and support initiatives to improve competitiveness of micro and small size enterprises and strengthen the development of management capabilities among businessmen. SERCOTEC operates through a variety of programs and tools, supporting both manufacturing companies and other sectors. During 2000, SERCOTEC worked with 16.709 enterprises in all 13 regions of Chile, investing US$18 million. 761 projects were financed in total, principally of a collective nature in the sectors of small-scale fishing, industry, trade, services and craftwork.

Millennium Science Initiative Project (MSI Project): in 1999, the Chilean Ministry of Planning and the World Bank jointly developed a learning and innovation project financed by the World Bank with an overall investment of US$ 15 million. The project aimed at revitalizing the Chilean S&T system by supporting advanced training of human capital by world-class scientists engaged in cutting edge research. Successfully ended in 2002, a completion report stated of (i) helping to attract more attention from the Government of Chile to S&T issues, (ii) improving the productivity of country's top researchers, (iii) increasing the opportunities for advanced training and scientific collaboration, and furthermore provided several important lessons for the future development programs (as described in Box 5).

The Executive Opinion Survey indicates that most Chileans view government expenditures as being relatively efficient – for example, subsidies tend to improve competitiveness rather than help obsolete industries to survive, social spending is adequately targeted to most underprivileged sectors, etc.

Thus, with the introduction of funds such as FONDEF and FONTEC, Chile set out a public system of direct incentives to support S&T development. However, a great deal of suspicion still exists with respect to indirect incentives. Although this caution may prove well founded, there is a growing body of international experience in tax incentives for R&D and innovation, which is generally found to have a positive impact on research activities.

Box 5. *Lessons Learned from Chilean MIS Project*

Demonstration of Best Practice for Supporting the Best. Even limited investment, distributed on transparent, objective, and selection procedures, has a high impact on performance and productivity of an S&T system.
Effective Use of Investments. Autonomy in spending resources and diminished bureaucratic burdens is crucial to making science effective. Additionally, infrastructure in Chile is not keeping up with growing demand.
Improved Performance of the Elite Scientists. Chile has the conditions for catching-up in terms of human capital by rapidly expand training opportunities for the most advanced human capital. The quality of training can be improved with incremental investments that allow senior researchers to devote themselves full time to their professional responsibilities.
Entry Conditions could influence S&T policies, for example: (i) harmony between government priorities and sector policies; (ii) involvement of beneficiaries in program design and implementation, and (iii) recognition and autonomy of teams and leadership.
Cohesive Government Performance. Transparency in communication between Government players, continuity in funding and coherence of science policy are of critical importance for the performance of the National Innovation System.

Source: Implementation Competition Report on a Loan for the Republic of Chile for a Millennium Science Initiative Project, World Bank 2002.

A first step in the direction of developing a system of indirect incentives which the government trusts might be to refine the scheme for rewarding donations to universities by providing some form of tax benefit for donations aimed at supporting R&D.

Currently the only government incentive for funding research, apart from partnership in the various funds, is the 50 percent tax deduction permitted for donations to universities. The response to this somewhat unfocused measure has been strong, with donations rising by a factor of 20 since the beginning of the 1990s to a current figure of around US $30 million.

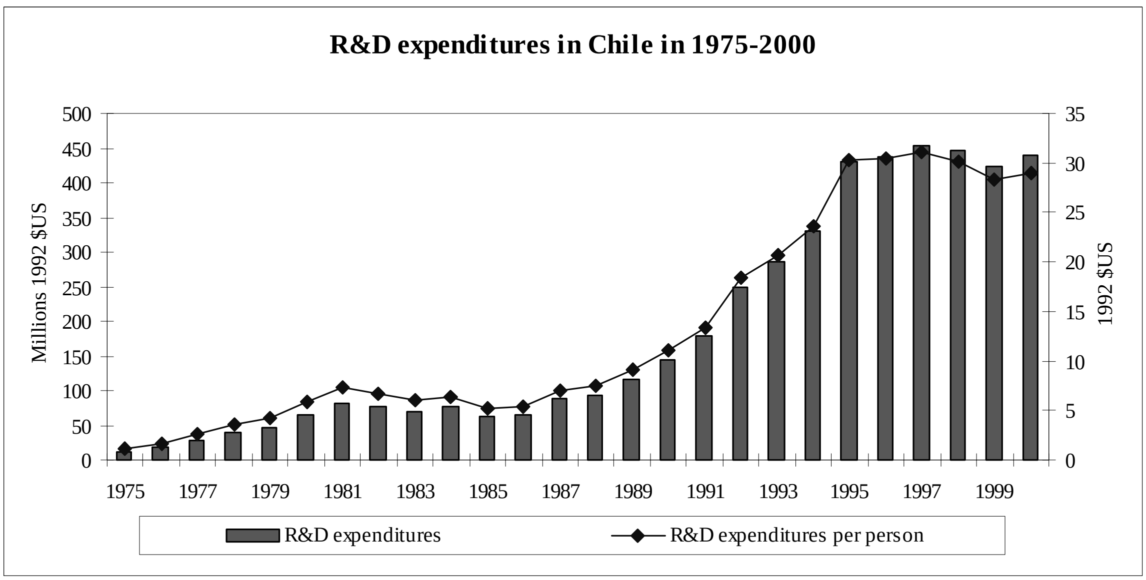
National Expenditure on Science, Technology and Innovation

The Trend of the Total Expenditure

Chile is now devoting more resources to the generation and diffusion of knowledge (Graph 6). An important part involves expenditure on innovation, which includes R&D, but also expenditure on design, marketing, training and financial and organizational change. All of these contribute to the innovation process to some extent, but unfortunately data for Chile is only available as regards the R&D.

R&D expenditures have increased steadily in Chile throughout the last 30 years, attaining US$450 Millions in 2001, which is 40 times more than in 1975. On average, Chilean R&D expenditures increased by 17% each year in 1975-2000 (Graph 6).

Graph 6. *R&D Expenditures in Chile*



Source : *Instituto Nacional de Estadísticas* (INE)

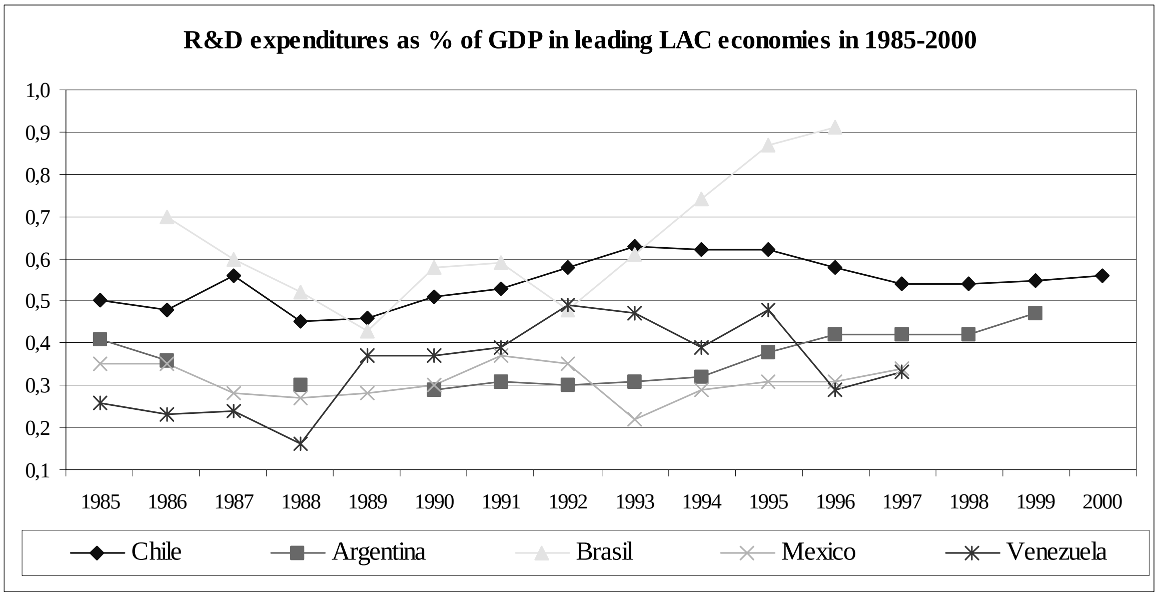
Likewise, Chilean expenditure per resident grew by approximately 15% per year in 1975-2000, which has implied an increase in expenditure per capita from US$1.12 in 1975 to US$ 29 in 2000.

In both absolute and per resident terms, Chile is far from the level of benchmarking economies (USA spent US$ 247 Billions in 1999, which means US$ 914 per resident).

Chile also lags the level of Brazil (US$ 6.6 Billions or US$ 41.7 per resident in 1996) and Argentina (US$ 1.3 Billions or US$ 36.1 per resident in 1999).

The most commonly used indicator for international comparison purposes is the ratio of expenditure on R&D to GDP. As the Graph 7 shows, in 1985-2000 Chile spent 0.55% of its GDP on R&D. However, it still lags the level of Brazil and most developed economies, especially the USA (2.74%, not in the Graph 7).

Graph 7. ***R&D Expenditures as % of GDP***



Source : RICyT

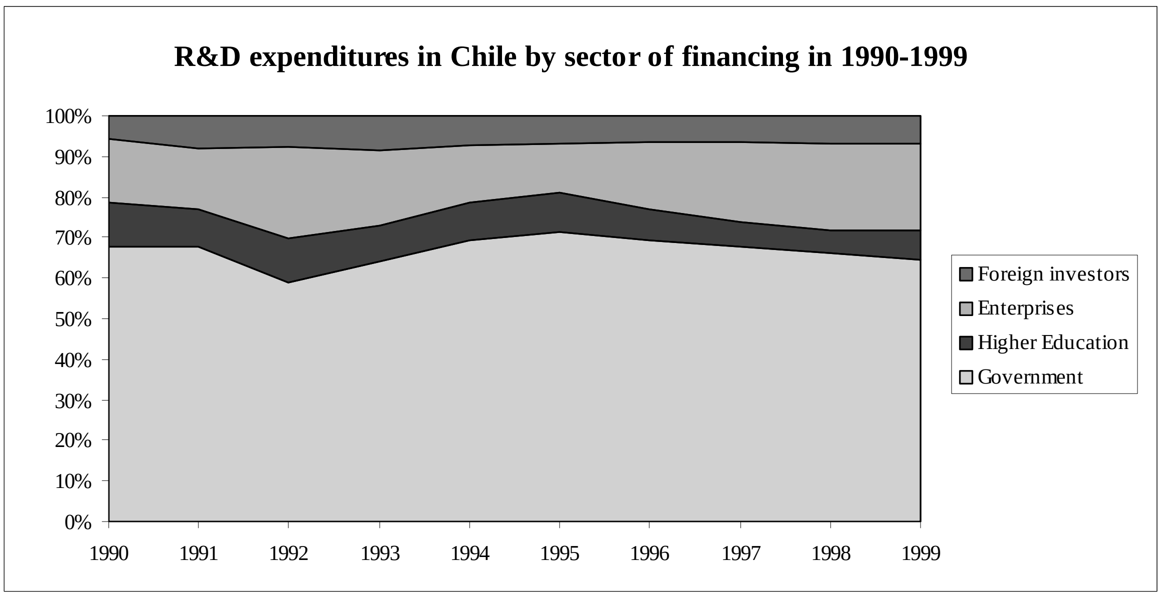
Expenditure by Financing Sector

In 1990-1999, the Chilean government invested US$ 2,265 Millions in R&D, which is 67% of the national R&D expenditures of the period (Graph 8). Adding another US$ 274 Millions allocated to higher education R&D expenditures, total public expenditure amounts to 75% of Chilean R&D spending, which goes in line with the regional trend: On average, 70% of R&D expenditures in Latin America comes from the public sector (T. Hansen, N. Agapitova and al., 2002).

Foreign investors also make a significant contribution to R&D investment in Chile: US$ 238 Millions in 1990-1999, which is approximately 7% of the national spending. This is the highest number in Latin America and is largely due to the favorable environment created by the Chilean government.

Traditionally, the private sector has not been strongly involved in funding R&D in Chile. This could be due to either (i) the lack of integration of Chilean science into an overall innovation framework, and/or (ii) the dependence of the economy on the export of raw materials, as pointed out by Mullin et al. (2000). Scientific activities have been seen as the responsibility of the state, either via the universities or the technological institutes. As a result, the contribution of business enterprises in the R&D was extremely limited until 1990.

Graph 8. ***R&D Expenditures by Financing Sector***



Source : RICyT

After 1990, policy stability and improvements to the property rights regime have encouraged private R&D expenditure, which grew by four times during the last decade from US$ 23 Millions in 1990 to US$ 93 Millions in 1999.[18] Nevertheless, it represented only 21.5% of Chilean R&D investments in 1999, which is lower than the business

[18] CONICYT is aware of the current deficiencies in statistical reporting of private sector spending on R&D, and acknowledge that the data that they publish is likely to under represent the true magnitude. However, even correcting for these statistical limitations, the picture, which emerges, is still one of significant under-investment.

enterprise share in financing the R&D in Venezuela (44.8%), Brazil (30.6 %) or Argentina (26%) in 1999, as shown in the RICyT data.[19]

The structure of Chilean R&D expenditures compares well with other regional leaders, as shown in the Table 6. However, it's altogether different from the world's leading economies, especially the USA, where the share of business expenditures grows consistently and now represents 68.5% of the national R&D spending.

Table 6. ***R&D financing by sector in leading LAC economies and USA in 1999 (or closest year)***

	Argentina	Brazil	**Chile**	Mexico	USA
Government	40.4%	57.2%	**64.3%**	71.1%	27.5%
Higher Education	29.1%	2.8%	**7.3%**	8.6%	2.4%
Enterprises	26.0%	40.0%	**21.5%**	16.9%	68.5%
Foreign investors	2.6%	0.0%	**6.8%**	2.5%	1.6%
PNP	1.9%	0.0%	**0.0%**	0.9%	0.0%
TOTAL: (In millions of US$)	1 321	6 574	**425**	1 382	247 000
Per person: (In US$)	36.12	41.74	**28.27**	14.75	913.98

Source: RICyT, ricyt@ricyt.edu.ar

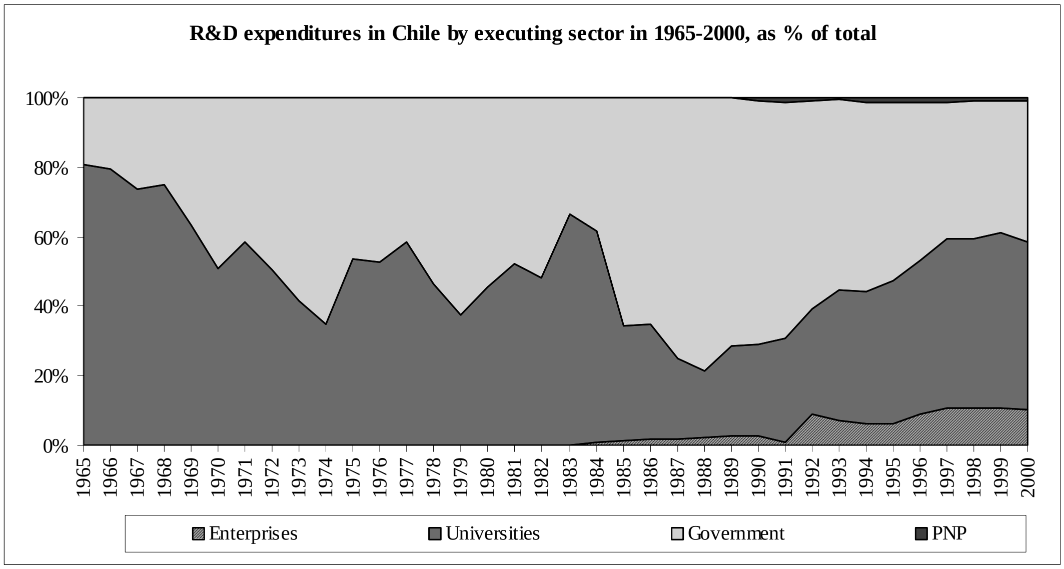
The Chilean public authorities have become aware of the importance of private investment in R&D activities, and several funds such as FONDEF and FONTEC, now require a financial contribution from the private sector as a primary condition for project approval. There is evidence that elements of the private sector have begun to realize the potential rewards that research embedded into their business processes can bring.

Expenditure by Executing Sector

The role of public sector in the R&D is even more dominant with regard to execution of R&D than financing: Until 1992, the overall financing (99.4% in average in 1965-1991) was directed to the public sector, with various sharing between higher education and government bodies (Graph 9). Since 1992, the participation of business enterprise in the research activities increased, but it is still very low oscillating around 10% of R&D activities.

[19] The business sector's share of total R&D expenditures may be overestimated in several LAC countries, because in some cases it includes expenditures of publicly owned firms. This appears to be the case in Brazil, where public enterprises provided one third of industrial funding in 1998. Accordingly, if R&D financing by public firms was counted as part of the public sector, the business sector's share in Brazil would be an estimated 16% in 1998, compared to the official figure of 61%.

Graph 9. ***R&D Expenditures by Executing Sector***



Source : *Instituto Nacional de Estadísticas* (INE)

The OECD studies[20] suggest that in countries with a large public role in R&D, such as Mexico and Turkey, the technological absorption capacity of the business sector is often not very well developed.

However, it should be noted that the role of the private sector might be seriously underestimated, as the expenditure on R&D is not recognized explicitly as a tax write-off; it is counted merely as a general cost. There is, therefore, no financial reason for firms to record R&D expenditure.[21]

Table 7. ***R&D execution by sector in leading LAC economies and USA in 1999 (or closest year)***

	Argentina	Brazil	**Chile**	Mexico	USA
Government	40.7%	11.0%	**46.7%**	71.1%	7.0%
Higher Education	29.5%	43.5%	**42.7%**	8.6%	13.9%
Enterprises	27.5%	45.5%	**9.7%**	16.9%	76.1%
PNP	2.3%	0.0%	**0.9%**	0.9%	2.9%
TOTAL: (In millions of US$)	1 321	6 574	**425**	1 382	247 000

Source: RICyT, *ricyt@ricyt.edu.ar*

Under any circumstances, the actual share of Chilean private sector participation in the R&D was one of the lowest in LAC in 1999, only higher than in Peru, and far behind Brazil

[20] OECD, 2000b.

(45.5%), Argentina (29.5%) or Mexico (16.9%) not to mention the USA where 76.1% of R&D activities are performed by the private sector (Table 7).

Table 8. ***Selected indicators from the surveys on private firms' innovation activities in Latin America***

	Argentina	**Chile**	**Colombia**	**Mexico**	**Peru**	**Venezuela**
	1992-1996	1995	1993-1996	1994-1996	1997-1999	1994-1996
Firms with own R&D department	18,0%	22,3%	12,7%	21,7%	5,5%	15,8%
Firms that developed any innovative activities	72,6%	66,2%	75,4%	63,4%	8,0%	60,0%
Product-improving firms	71,0%	34,2%	50,0%	52,6%	48,4%	59,3%
Process-improving firms	71,0%	37,6%	70,0%	51,3%	71,7%	72,5%
Firms hiring consultant services	20,1%	30,3%	63,8%	N/A	61,0%	9,8%
Number of questioned firms	1,639	541	885	1,322	8,972	1,382

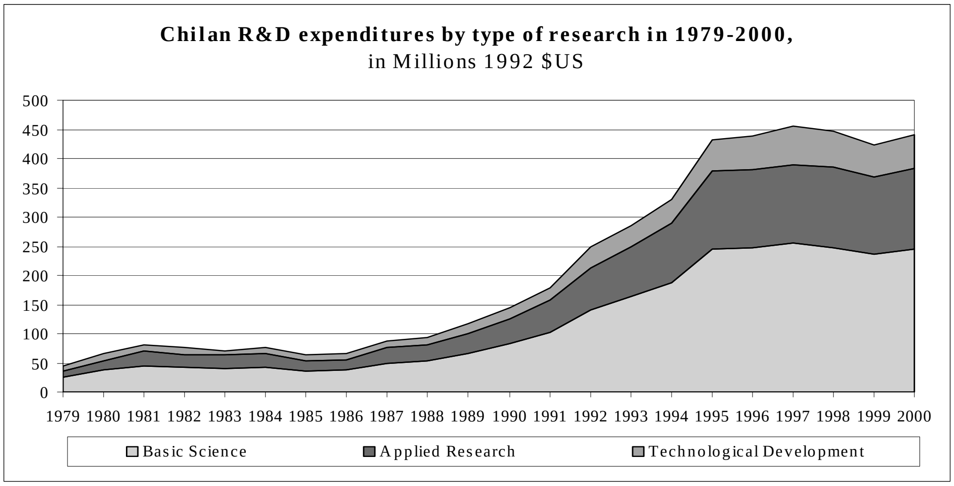
Source: Anllo and Raffo, 1999, *Indicios* Nº11-12, http://www.ricyt.edu.ar/anlloraffo.pdf

Astonishingly, the share of private firms possessing their own R&D department is the highest in among LAC, but it does not result in the highest share of process and product innovative firms, which is, inversely, one of the lowest in the region (Table 8). Furthermore, only one third of the interviewed firms were subcontracting another organizations to undertake scientific development, which implies a relatively low level of cooperation among private sector and research institutions.

Government investment can be further broken down by type of research, as in Graph 10. Such a breakdown shows that basic research is clearly the government's priority, receiving the largest fraction of the allocations: on average 56.5% for 1979-2000. Growing part was allocated to the applied science, which share rose from 24.6% or 11.2 Millions of 1992 US$ in 1979 to 31.6% or 139.2 Millions of 1992 US$ in 2000. Experimental development received only 13.1% of investments in the average in 1979-2000.

[21] CODELCO (Chilean National Copper Company), for example, claims to spend US$ 20 million (both in-house and contracted out). But this figure is not recorded on financial statements.

Graph 10. ***R&D Expenditures by Type of Research***

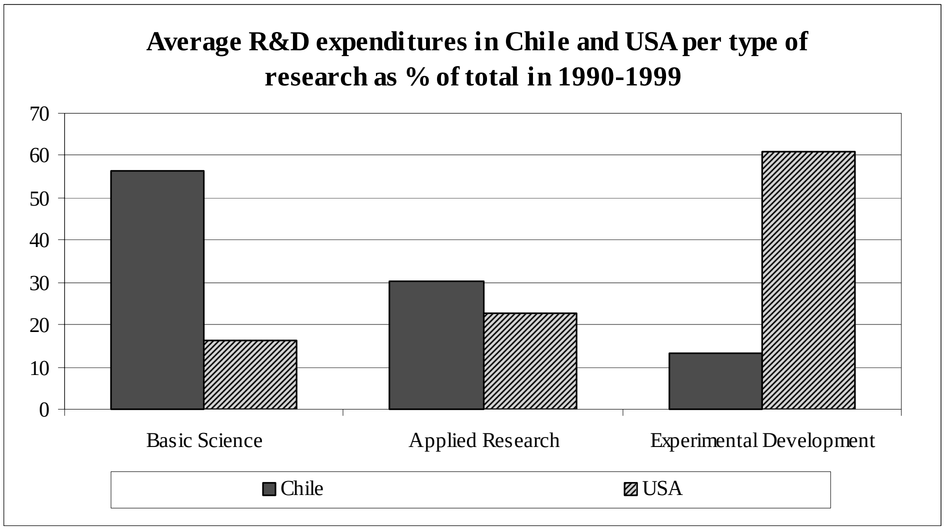


Source : *Instituto Nacional de Estadísticas* (INE)

This trend marks a clear gap to the world's leading economies. While Chile and the USA allocate similar share of expenditures to applied research (30.5% in Chile vs. 22.7% in USA in average in 1990-1999), USA clearly privileged experimental development area (60.9% vs. 13.4% in Chile in average in 1990-1999) at the expense of basic research (16.4% allocated in the USA and 56.4% in Chile in the same period) as shown in Graph 11.

'Basic Science' is traditionally a priority area for public authorities, while business firms tend to commit to the 'Experimental Development'. In the developed countries with an important participation of business sector in R&D activities, the share of investment in 'Experimental Development' is considerably higher than that in 'Basic Science', which contribute to the commercialization of scientific discoveries, and in consequence to the innovation development.

Graph 11. ***R&D Expenditures by Type of Research in Chile and USA***



Source: RICyT.

The situation is quite different in Chile: even if the public investment rose by factor of 3 in 10 years, thus promoting the scientific research and invention, the passive role of the private sector and therefore the inadequate level of investment in experimental development, resulted in the poor national innovative capacities.

According to the R&D investment structure, steadily rising private investment, mainly directed to science purposes, resulted in the increasing capacity of Chile to create and respond to new scientific opportunities and options. At the same time technology policies that aimed to develop ICT were highly successful providing the country with one of the most developed telecommunications system in the region, which signify a considerable progress in technology diffusion capabilities. Unfortunately, in order to further promote the technology creation capabilities of Chile, the government should concentrate its efforts on innovation policies, targeting a greater involvement of business firms in R&D financing and performing.

Measuring Science, Technology and Innovation

Science: Scientific Publications and Research Personnel

The output of science-oriented policies and scientific research is varied: it includes improvement of skills (especially for doctorates and post-doctorates), new scientific instruments and intermediate products, new methods, prototypes and publications. The last is the major output in that it partly captures the others and, in addition, contains the abstract knowledge, which is the essential form of most discoveries *(e.g.* formula, proof of scientific facts) (OECD, 2000a).

It should be noted that bibliometrics could only be considered as an indicator measuring the relative intensity of scientific, but not innovative, activities, since the process of discovery does not automatically result in the economic utilisation of new knowledge. This fact should be especially taken into consideration in Chile, where private sector contribution in research is rather limited. They also reveal little about the effectiveness in promoting an environment for research training, the social and economic value of the research and the extent to which undergraduate instruction has been enriched by the research activity – some of the key roles of publicly supported research. Finally, they say little about the societal outcomes of that investment (Mullin and al., 2000).

The growing investment in R&D in basic science has had a positive result on the performance of Chilean researchers in terms of scientific publications, which is considered by the country's public authorities as a main measure of scientific productivity.

Box 6. ***Major facilities for big science - the observatories***

Chile is extremely fortunate in possessing the natural conditions to enable it to attract major international scientific infrastructure. The country has hosted scientific events at international astronomical observatories in the Atacama Desert for over 30 years. Citation rates for articles published by Chilean astronomers are higher than those published by other types of Chilean scientists. If Chile wishes to be at the cutting edge of world knowledge-development, there is no more promising area than astronomy for it to achieve this. The fact that the astronomers play in a different league to other Chilean scientists is underscored by the relative costs of the equipment to which they have access. FONDECYT currently has an equipment ceiling of about US $40,000, but the observatories cost at least a thousand times as much.

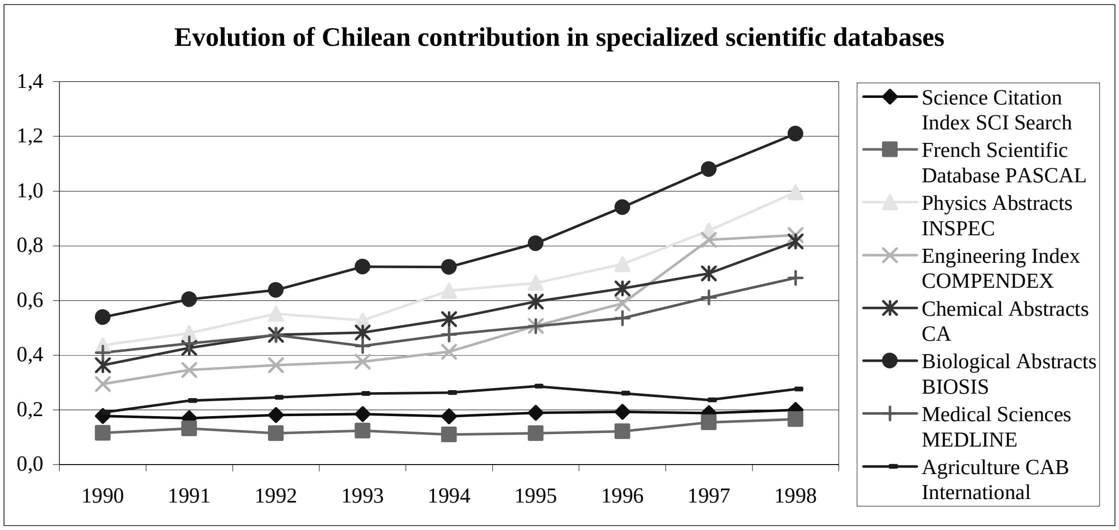
Source: J. Mullin et al.

The number of publications increased steadily in 1990-1998 (Graph 12). It should be noted that Chile provided more articles for the specialized scientific databases, which is partly due to the countries exceptional natural conditions (see Box 6), high level of economic specialization and public priorities in specific research areas.[22] For instance, the

[22] The use of publications as a measure of productivities by Chilean public authorities were criticized for (i) a narrow interpretation of excellence (imposing the traditions of the physical sciences on other disciplines); (ii)

number of publications in biological sciences grew faster that in the other fields, which is one of the spillovers of the development of fruit and wine industries.

Graph 12. ***Scientific Publications***



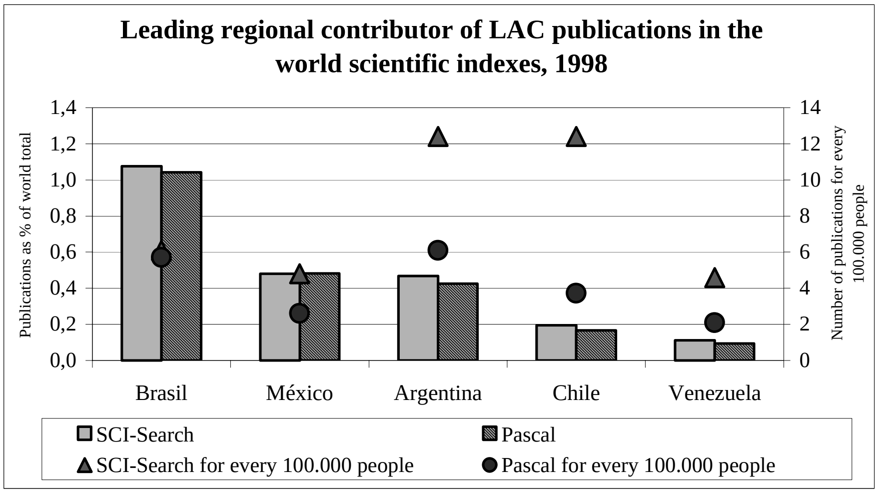
Source: RICyT, 2000.

However, the Chilean contribution to the world science is still limited: in 1998 Chilean researchers were mentioned only in 0.19% of the overall citations in SCI-Search (Science Citation Index Database) and 0.17% of citations in the French scientific database PASCAL (Graph 12). In the same year, Brazil contribution to the same databases amounted to 1.06% and 1.04% respectively, while Mexico and Argentina cited at around 0.42% of publications in both databases.

Conversely, in terms of number of publications for every 100 000 people, Chile achieved good results, being at the top of LAC with 12.4 publications in SCI-Search, and the third performer for PASCAL with 3.8 citations in 1998 (Graph 12).

a bias against certain fields of research (geography, biosystematics, engineering); and (iii) a reinforcement of traditional modes of doing science while discouraging research targeted at social and economic problems and multi-disciplinary research groups (Mullin and al., 2000).

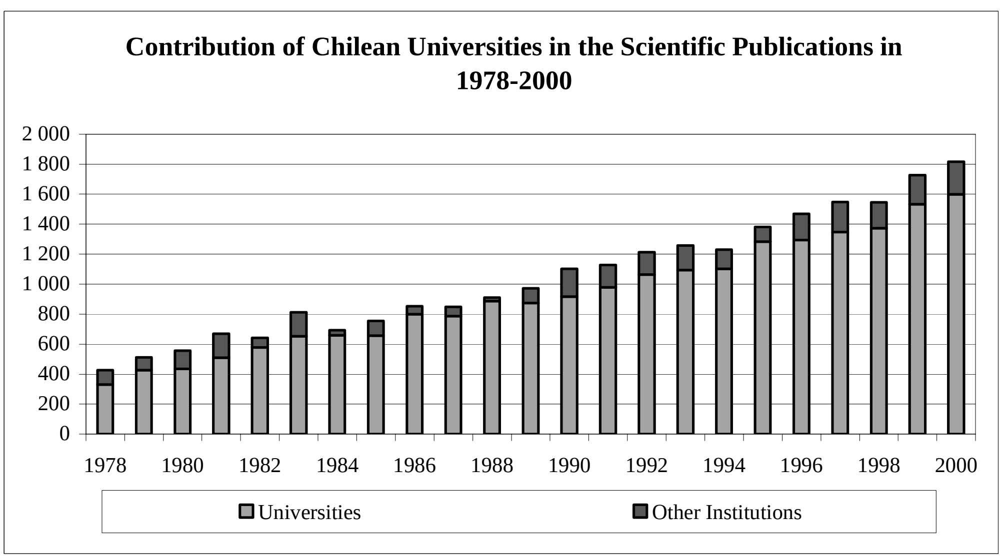
Graph 12. ***Leading Regional Contributors in LAC Scientific Publications***



Source: RICyT, 2000.

The universities of Chile, notable in their range and number, are the principal sites of basic research for the country: for example they carried out more than 90% of the Chilean scientific publications since 1978 (Graph 13).

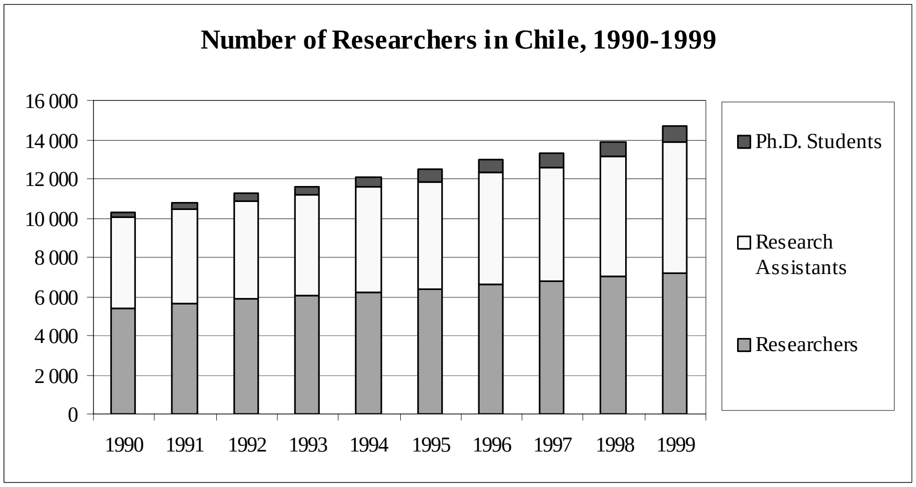
Graph 13. ***Universities' Contribution to Chilean Scientific Publications***



Source: ISM. Krauskopf y R. Pessot, Arch. Biol. Med. Exp. (1980) 13: 195-208; (1983) 16: 17- 27; (1985) 18: 225-239; (1987) 20: 283-294; M. Krauskopf y A.M. Prat (1990) 23: 51-64; ISI, Institute for Scientific Information: 1989-2000 ; *Indicadores Científicos y Tecnológicos*-2000.

The other important output of Chilean science-oriented policies is a growing number of researchers in Chile, which increased by 42% during the last decade (Graph 14).

Graph 14. ***Number of Researchers***



Source: RICyT, 2000.

The biggest growth rate was registered in the number of Ph.D. students, which increased by 14% anually from 246 students in 1990 to 780 students in 1999. This is encouraging, seeing that PhD turnover has been very low in Chile : 64 doctoral degree were earned in Chile in 1999. compared to 3604 in Brazil, 730 in Mexico and 408 in Argentina. In fact, only 4 Chileans of 1 Million earned doctoral degree in 1999, which lags not only the USA (151 per 1 Million) but also Brazil (21), Mexico (17), and Argentina (11), as shown in the Table 9).

Table 9. ***Earned Science and Engineering (S&E) Doctoral Degrees, 1999 or latest available year***

	ll doctoral degrees	All S&E doctoral degrees	Doctoral Degrees for every 1 Million People	Field					
				Natural Science	Math and Computer Science	Engineering	Social and Behavioral Science	Agriculture	Non-S&E
USA	41.140	25.953	151	9.989	1.935	5.337	7.727	965	15.187
Argentina	408	382	11	218	8	41	18	97	26
Brazil	3.604	2.176	21	924	85	492	299	376	1.428
Chile	***64***	***55***	***4***	***49***	***5***	***1***	***1***	***0***	***8***
Mexico	730	498	17	236	15	67	141	39	232

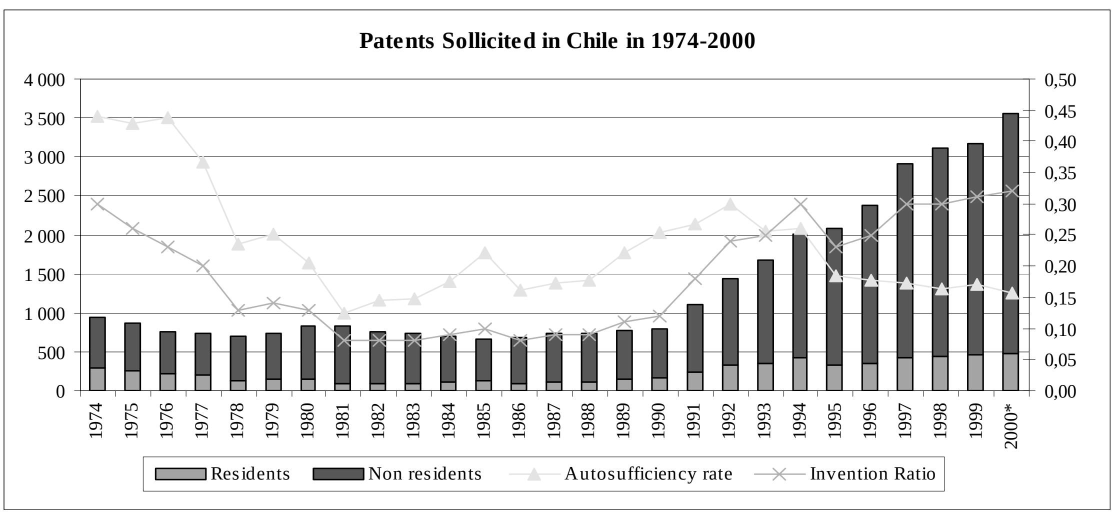
Source: RICyT, 2000; Science & Engineering Indicators, 2002.

Technology: Patents and Technological Transfer

Patent-based statistics are the most widely used indicators of the output of innovation activity because of their importance for the commercialization of new products and processes and data availability. However, many inventions are not patented, and the propensity to patent differs across countries and industries. Another drawback is related to differences in patent regulations across countries, which make it difficult to compare across countries. Finally, the added value of patents varies significantly: Some patents have no industrial application, whereas a few have huge value.

Nevertheless, after the examination of the number of patents solicited in Chile in 1974-2000, the most obvious conclusion is that the innovative capacity of Chile is less developed, and, especially, less dynamic than the scientific one. First of all, no progress has been made until the recent past when Chile opened its market to FDI: the number of solicited patents stagnated at around 250 per year for residents and 500 for non-residents. Since 1991, the number of solicited patents has been rapidly growing, but only as a result of applications registered by non-residents. Therefore, the autosufficiency rate of Chile is decreasing, emphasizing its growing dependence on technology transfers from abroad (Graph 15).

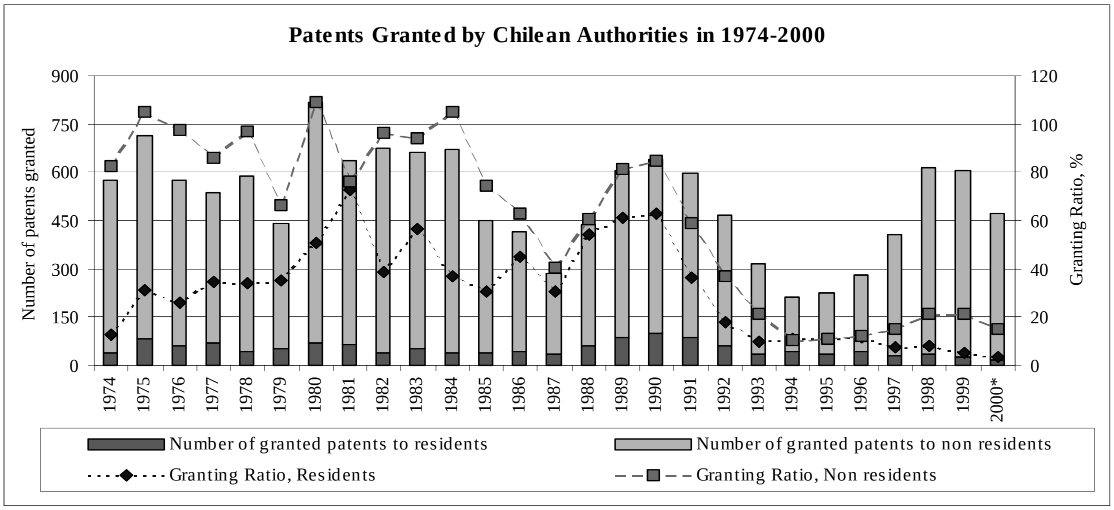
Graph 15. ***Solicited Patents***



Source: CONICYT.

Left alone, the fact of growing dependence of Chile on technological transfers is not worrying: a number of recent studies about the acquisition of technological capabilities in Korea and Taiwan cite the role of foreign technology transfers as much more important than that of publicly supported research institutes (Pack, 2000).

Graph 16. ***Granted Patents***



Source: CONICYT.

What is more important, is that the number of patents granted by Chilean authorities is very low for both resident and non-resident applicants: since 1991 only 17% of solicited patents was granted for non-residents, while for resident this indicator is even worse – 9% for the same period (Graph 16). As a result, Chile is a regional outsider in terms of absolute number of patents: less than 3600 patents were granted in Chile in 1992-2000, compared to, approximately, 15000 in Argentina, 20000 in Brazil, and 32000 in Mexico.[23]

The low granting ratio for foreigners could be partly explained by the impact of the dependency theory on the views of policy makers (Packenham, 1992), raising suspicions against technology transfers whether in the form of equipment or disembodied knowledge provided by license agreements.

However, the recent intensification of international collaboration in science and technology has resulted in a growing number of joint patent applications applied by inventors with different countries of residence. This kind of international collaboration between researchers can take place either within a multinational corporation (research facilities in several countries) or through a research joint venture between several firms (OECD, 2000a).

In this regard, some important initiatives have been implemented in Chile since 1995. For example, the Biotechnology Center of Excellence Corporation (BCEC), a private non-profit agency based in Massachusetts, USA in collaboration with the Northern Regions Center (NRC) of Hokkaido, Japan signed an agreement with *Fundación Chile* to promote joint research activities in agriculture, aquaculture, forestry and food processing. The focus on specific and practical economic development challenges presented by the Chilean context allows the foreign counterparts to work with Chilean researchers on problems relevant to that country's priorities. The agreement is designed to facilitate technology transfer to Chile resulting from research interaction among all three areas. The collaboration is designed to enable applications of research to product development and commercial stimulation among small and medium enterprises in Chile. In USA, the Massachusetts Foundation for Excellence in Marine and Polymer Sciences and the Marine Biological Laboratory in Woods Hole are also involved, as are the Hokkaido-based Northern Regions Center, the Hokkaido Central Fisheries Experimentation Station, and the Hokkaido Food Processing Research Center (Quezada, 2001).

Innovation: Towards Networking Economy?

It has become widely recognized in recent years that innovation processes are characterized by a considerable degree of interaction between different actors, involved in scientific, technological and productive activities, *i.e.* networking.

The growing role of innovation and technological change can be linked to changes in the innovation process. Innovation has become more market-driven, and innovation surveys for 12 European countries suggest that over 30% of manufacturing turnover is based on new or improved products (OECD, 2000b). More of the financing of innovation is now directed towards new firms and risky projects. Innovation is more global, arises from many sources and is spread more widely across sectors, including services, thus broadening the basis for economic growth.

[23] RICyT: data for Brazil for 1990-1998.

Science related policies developed by the Chilean government have strengthened the country's capacity for research and instilled a culture of open dissemination of research through publications. However, academic interests and a narrow disciplinary approach to research continue to separate the processes of discovery from utilization of knowledge (Mullin and al., 2000). And there is little coordination between different research performers such as the technological institutes and universities. Due to the ambiguous way of public financing of research activities, technological institutes see universities as competitors rather than partners. This sense of competition must be heightened in a situation in which part of the researchers' salaries are dependent on the winning of research grants.

Nevertheless, there are some initiatives of joint activities between public institutions involved in research and related technical activities: the Ministry of Mines, a geological survey, the Institute of Geophysics at the Universidad de Chile, the Antarctic Institute, CIMM and CODELCO. But there was little coordination or cooperation among them. In other Latin American countries, serious attempts are now being made to coordinate technology-development activities within broadly defined "production chains" (*cadenas productivas*). The *Acuerdos Sectoriales de Competitividad* in Colombia, and the *Agendas Industriales, Sociales y Regionales* of CONICYT in Venezuela are two examples. Chile might consider experiences such as these in order to strengthen interactions within its NSI.

Incubators represent the first vital stage for starting a business, after all the initial planning has been done. They may provide a physical infrastructure for entrepreneurs to set up their first office, although there are virtual incubators as well that do not offer this. Incubators also support tasks a business has to tackle, like marketing and searching for funding (AmCham Chile, 2002).

One of the few incubators in Chile is Endeavor, a not-for-profit multinational organization that promotes entrepreneurship in emerging markets. It has been operating in Chile since 1997. The purpose of the organization is to insert the idea of entrepreneurship into public discourse by visiting schools and universities, and by carrying out a series of workshops in conjunction with AmCham (see box 7).

Box 7. ***AmCham Promotes Innovation***

AmCham is Chilean-American Chamber of Commerce, that has taken a very active role in supporting entrepreneurship and innovation in Chile. Its Entrepreneur Committee organizes a series of activities to educate Chile's business community about innovation and its economic benefits. Committee has established strategic alliances with three different entities: Endeavor, the Corporación de la Producción y del Comercio (CPC) jointly with Inacap, and the Universidad del Desarrollo.

The AmCham/Endeavor alliance has organized a series of monthly workshops for this year that cover every aspect of entrepreneurship, from generating an entrepreneurial spirit, to converting ideas into reality, to identifying sources of financing.

Source: Chilean-American Chamber of Commerce, 2002.

At a government level, CORFO has recognized the importance of entrepreneurship and is also providing incubator services. Over the past two years, CORFO's FDI has helped finance university incubators in Santiago (*Universidad de Chile*), *Concepción, Temuco,* and *Valparaíso*.

In the private sector, Shell Chile has also been operating an incubator *Savia Nueva* for the past 14 years in the Metropolitan Region, and for 12 years in Region V. It invites young people between the ages of 18 and 25 to apply for incubation support and the only prerequisite for application, reviewed by a committee of 200 consultants, is a good idea and the desire to start a company.

Strengthening the links between science and industry can be beneficial to both universities and other research institutions on the one hand, and firms, on the other. Universities seek industry contacts to ensure good job prospects for students, to keep curricula up to date and to obtain research support. Leading research universities seek strategic alliances with firms in order to consolidate their position in innovation networks and to establish their place in the market for knowledge. The main benefit for firms is often improved access to well-trained human resources, although they also look for access to new scientific knowledge, networks and problem-solving capabilities. There are several ways in which research institutions and business interact, including public/private research networks, research con-tracts, licensing, joint publications, flows of students from universities to industry, and so on. Some channels are of specific interest, as they pose new challenges for policy. Spin-off firms from universities and other research institutions, for instance, are a vital component of innovation networks and play an increasingly valuable role in most countries (OECD, 1999).

In Chile, the cooperation between the private sector and research organizations is also limited. Some universities are starting to have offices designed to assist researchers in their dealings with clients. As a result, 31.8 % of firms acknowledged having benefited from innovations from universities and 16.2 % from public research institutes. Some 25 % of firms actually signed contracts with universities, and 14 % signed them with public research institutes. Furthermore, 60 % of firms reported having carried out some type of joint innovation with client firms. However, it is important to point out that external interactions were not assigned a crucial role by the firms themselves. Most firms reported that the principal source of new ideas was their own personnel (Melo, 2001).

Although there are some links between business and universities, particularly at the human-resources level (for example, there is a tradition of part-time professorships being held by businessmen), the university mentality is not geared to solving problems within a business timescale. Accordingly, funding is a lesser problem compared to the inward orientation the researchers.

However, there are success stories of industry-university collaboration. REUNA, the Chilean Internet Company, made significant progress due to the farsightedness and drive of engineers with strong university links.

Knowledge-diffusion mechanisms in Chile appear inadequate, particularly with regard to supporting SME. The government places a lot of emphasis on generating knowledge, but none whatsoever on diffusing it. Where the larger firms used to rely on their corporate research for the ideas to be used by their suppliers, they now outsource many innovations. The smaller, technically specialized firms are expected to be highly innovative, but they must look increasingly to the universities and national laboratories for the new ideas (Scherer, 2001). Furthermore, in emerging areas, where demand patterns are unclear, risks are large and the technology has not yet been worked out, small firms have an advantage over large established firms. They can be more flexible and more specialized and may also be better than large firms at channeling creativity and providing the right incentives (OECD, 2000a).

Chile seriously needs to introduce a series of measures to strengthen competition, facilitate networking and co-operation, strengthen links between science and industry and increase returns to investment in R&D.

Experience suggests that governments cannot create networks from scratch. They can some-times reduce firms' reservations about inter-firm co-operation, although building sufficient trust may take time. Long-term network facilitation programs, such as the United Kingdom's Foresight program, may help to bring together government, science and business. The success of networks may also depend on other resources, such as access to a key technology or to important foreign markets. In some cases, governments can help to address such problems.

The mobility of scientists between science and industry is also an important channel of interaction.

SUMMARY AND POLICY RECOMMENDATIONS

Liberal policies, based on solid and reliable institutions, succeeded to create a favorable macroeconomic environment for Science, Technology and Innovations in Chile. ***However, while scientific and, to a certain extent, technological development has been remarkable during the last decade, it remains disconnected from the economy and as such do not lead to continued product innovation and higher living standards.***

This reduced level of innovation activities in business enterprises seems to be caused by the low value attributed to innovation by Chile's population, private sector, and, until recently, by the government. Promoting STI in the everyday life and, in particular, innovation in the private sector clearly rises as a major challenge for Chilean future.

Therefore, a new policy paradigm focused on innovation could be developed, in which the government assumes the role of a supporting partner to the private sector in developing and deploying new technologies in a global economy. In this new role, the government could consider the following (subset) of general innovation policies:

- *A legal basis for cooperation between industry and government bodies*, including license agreements, property rights, and financing, could be implemented, in order to make it easier and faster for an innovative culture to emerge.
- *Focus attention on innovation in private firms*, with an emphasis on SMEs, and the promotion of linkages between national R&D institutions and industry. For this end, a set of indirect incentives—similar to those found internationally—could be developed, which reduce the firm's cost of STI related activities. In the case of R&D, legislation could be considerably more permissive than in general.
- *Development of venture capital market* could boost innovative activities providing financial basis for innovation.
- *Strengthening of innovative entrepreneurship*, which the government could address trough education and indirect incentives. Attention could be given to incentive structures for researchers, and on policies to increase the mobility of personnel within the science system and between science and industry.
- The other important policy tool for promotion of innovation and private-public scientific cooperation is the establishment of centres of excellence. These help to create and diffuse knowledge and can act as the core of innovation networks.

The country has already made the first steps towards an effective making its innovation system more effective. However, there remains considerable scope for further progress and for learning about successful approaches to scientific advances, innovation and economic growth in Chile.

REFERENCES

Alarcón et al (2000) “Pequeñas y Medianas Empresas Industriales en Chile”CEPAL.

Alvarez, Roberto and Raymond Robertson, 2000. “Exports and Innovation: Evidence from Chile and Mexico”, *7th Annual Conference on “Empirical Investigation in International Trade”*, University of Colorado, Boulder, November 3-5. 2000.

Alvarez, Roberto and Raymond Robertson, 2001. “Exposure to Foreign Markets and Firm-level Innovation: Evidence from Chile and Mexico”, Unpublished, Universidad de Chile and Macalester College.

AmCham Chile, 2002. “Entrepreneurship in Chile: Just a Buzzword?”, *AmCham Journal*, June 1.

Brunner, José Joaquín, 2001. *Chile: Informe e Índice sobre Capacidad Tecnológica*, Santiago de Chile and Viña del Mar: Universidad Adolfo Ibañez, Instituto de Economía Política.

Carter, A.P. 1994. *Measuring the Performance of a Knowledge-based Economy.* Working Paper no.:337. Brandais : Brandais University, Departments of Economics

Chile Country Commercial Guide, 2002. U.S. Department of Commerce, Washington DC. http://www.usatrade.gov/Website/CCG.nsf/CCGurl/CCG-CHILE2002-CH-4:-00683BE2

Chile, 2001. EUI Country Profile, The Economist Intelligence Unit, London, UK. http://www.eiu.com/schedule

Chile, 2002. EUI Country Report, The Economist Intelligence Unit, London, UK.

Chile, 2002. EUI Country Report, The Economist Intelligence Unit, London, UK.

Chile: Financing the New Economy, 2000. Special International Report Prepared by *The Washington Times* Advertising Department, June 28.

Copyright protection in Chile, 2002. International Intellectual Property Alliance 2002 Special 301 Report, pp.334-342.

Costa, Ionara, 2001. “ Ownership and Technological Capabilities in Brazil”, DRUID Working Paper No 01-06.

De Mattos C. and al. 1998. “Reestructuración, Crecimiento y Concentración Territorial de la Industria: El Caso de la Región Metropolitana de Santiago”, Programa de

Investigación Internacional, "Grandes Regiones Metropolitanas del Mercosur y México".

Del Valle, 1996

Dodgson, Mark. 2000. "Policies for Science, Technology, and Innovation in Asian Newly Industralizing Economies", in Linsu Kim and Richard Nelson (eds), *Technology, Learning, and Innovation*, Cambridge University Press.

Dodgson, Mark, and John Bessant. 1996. *Effective Innovation Policy: A New Approach*, London: International Thomson Business Press.

Edmunds, John C. and Thomas P. McDermott, Roberto Darrigrandi, Vesna Mandakovic, 2001. *Venture Capital in Chile*, Institute for Latin American Business - Babson College.

Escudero, Sergio, 1996. "Achieving TRIPS Level Protection in Chile", Industrial Property Department of Chile, presented in *APEC Industrial Property Rights Symposium*, Tokyo, August 1996.

Fundacion Chile, 1998. *Annual Report on Technological Innovation*.

Hansen, Thomas Nikolaj, Natalia Agapitova, Lauritz Holm-Nielsen & Ognjenka Goga Vukmirovic, 2002. "The Evolution of Science & Technology: Latin America and the Caribbean in Comparative Perspective", Backgroung Paper for LCSHD 2002 Regional Study: *Knowledge in Latin America and the Caribbean: Reconsidering Education, Training and Technology Policies*, World Bank, Washington DC.

IADB, 2001. *Chile – Programa de Desarrollo e Innovación Tecnológica (CH-0160) – Propuesta de Préstamo*, Washington, DC: Interamerican Development Bank.

Johnson, Pitch, 1995. "Venture Capital Spans the Globe", in *Exploring international extensions of the American venture capital model,* http://www.redherring.com/mag/issue20/venture.html

Kim, Linsu and Richard Nelson (eds). 2000. *Technology, Learning and Innovation: Experiences of Newly Industrializing Economies*, Cambridge University Press.

Lorenzini R. (1997) "Impacto de los Acuerdos Comerciales en el Sistema de Propiedad Industrial Chileno", Estudios Sociales N° 91/Trimestre 1. CPU, Mayo de 1997.

Lundvall, Bengt-Åke. 2000. "A Broad Prospective on Innovation in Newly Industrializing Economies: Commentary" in Linsu Kim and Richard Nelson (eds), *Technology, Learning and Innovation: Experiences of Newly Industrializing Economies*, Cambridge University Press.

Macario, Carla, 1998. "Restructuring in Manufacturing: Case Studies in Chile, Mexico and Venezuela", Desarrollo Productivo; n. 44. CEPAL, Santiago**.**

Malerba, F. (1989) *Learning by firms and incremental technical change* Working paper, Università degli Studi, Brescia.

Malmberg, Anders and Peter Maskell. 2001. "The Elusive Concept of Localization Economies: Towards a Knowledge-Based Theory of Spacial Clustering", DRUID Working Paper.

Maskell, P. (1998). "Successful low-tech industries in high-cost environments: The case of the Danish furniture industry". *European Urban and Regional Studies* 5: 99-118.

McDermott, Thomas P. and Julian E. Lange, 2000. "Entrepreneurship in Argentina and Chile", Report on interviews with 81 Experts on Entrepreneurship, Private Equity, and Venture Capital, Institute for Latin American Business - Babson College.

Melo, Alberto, 2001. *The Innovation Systems of Latin America and the Caribbean*, Inter-American Development Bank.

Mullin, James, Robert M. Adam, Janet E. Halliwell and Larry P. Milligan, 2000. *Science, Technology, and Innovation in Chile,* Ottawa: International Development Research Centre.

Multilateral Investment Fund, 2002. http://www.iadb.org/mif/investment_page/english/chiletech.html

Nelson, Richard, 1993. *National Innovation Systems*, New York: Oxford University Press.

OECD, 1997. *National Innovation Systems*, Paris: Organisation for Economic Co-operation and Development.

———. 1999. "OECD Science, Technology and Industry Scoreboard: Benchmarking Knowledge-Based Economies". Paris.

———. 2000a. "Science, Technology and Industry Outlook." Paris.

———. 2000b. "Science, Technology and Innovation in the New Economy", OECD Observer Policy Brief.

Pack, Howard. 2000. "Research and Develoment in the Industrial Development Process", in Linsu Kim and Richard Nelson (eds), *Technology, Learning and Innovation: Experiences of Newly Industrializing Economies*, Cambridge University Press.

Packenham, Robert. 1992. *The Dependency Movement*. Cambridge: Harvard University Press.

Pascual, Reinaldo, and Kilpatrick Stockton. 2000. *"Venture Capital in Latin America",* From Issuing Securities supplement, *Corporate Financ*e, September.

Primo Braga, C., C. Fink & C.P. Sepulveda, 2000. Intellectual Property Rights and Economic Development, World Bank Discussion Paper No. 412, March 2000

Quezada, Fernando. 2001. "Trilateral models in international R&D cooperation", *Science, Technology and Innovation Program Viewpoints*, http://www.cid.harvard.edu/

RICyT. 2000. *El estado de la ciencia: Principales Indicadores de ciencia y tecnología. Iberoamoricanos/Interamericanos*. Buenos Aires: Red Iberoamericana de Indicadores de Ciencia y Tecnologia.

Scherer, F.M. 2001. "U.S. Government Programs to Advance Technology", Revue d'Economie Industrielle, n° 94, pp. 69-88.

Sherwood, R. M., "The TRIPS Agreement: benefits and costs for developing countries," *International Journal of Technology Management*, Volume 19, No.1/ 2, 2000

Treverton, Gregory F. and Lee Mizell, 2001. The Future of the Information Revolution in Latin America: Proceedings of an International Conference, RAND.

UNDP, 2001. *Human Development Report – Making New Technologies Work for Human Development*, New York and Oxford: Oxford University Press.

Urzúa, Osvaldo, 2001. " Development of Manufacturing Industry and Sustainable Development", National Report for Rio + 10 - World Summit on Sustainable Development, September 28th 2001.

Vial, Joaquin Vial and Peter K. Cornelius (eds.) *The Latin American Competitiveness Report 2001*-2001. New York and Oxford: Oxford University Press.

Warner, Andrew M, 2000. "Economic Creativity" in *Global Competitiveness Report 2000/2001*. Geneva: World Economic Forum.

WEF, various years. *Global Competitiveness Report,* Geneva: World Economic Forum.

World Bank, 1999a. *Project Appraisal Document on a Proposed Learning and Innovation Loan (LIL) in the Amount of US$5 Million to the Republic of Chile for a Millennium Science Initiative Project*, Washington DC: World Bank.

——, 1999b. Knowledge for Development – World Development Report 1998/99. Washington DC: World Bank.

——, 2002. *From Natural Resources to the Knowledge Economy – Trade and Job Quality,* "World Bank Latin American and Caribbean Studies – Viewpoints" Washington DC: World Bank.

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