

Strategies to capture biotechnology opportunities in Chile

Cristian Hernandez-Cuevas*

Cambridge MIT Institute
University of Cambridge
Tennis Court Road
Cambridge, England
Tel: 44 0 1223 742314
Fax: 44 0 1223 334162
E-mail: C.Hernandez-Cuevas.02@cantab.net

Pablo D. T. Valenzuela

Fundación Ciencia para la Vida
Millennium Institute for Fundamental and Applied Biology
1943 Marathon Avenue
Santiago, Chile
Tel: 56 02 239 89 69
Fax: 56 02 237 22 59
E-mail: fundacion@bionova.cl

Keywords: business enhancer, consortium strategy, government, technology and industry

Two complementary strategies are proposed to help develop the biotechnology industry in Chile. The objectives of such propositions are based on identifying business opportunities, which can be transformed into biotechnology projects that complement the competitive advantages of the most active areas of the Chilean economy. As a result, the establishment of these initiatives may create the proper business environment where good information, investors' safeguards and economic incentives would be provided to encourage investors to support new biotechnology ventures focused on mining, aquaculture, forestry, as well as wine and fruit production. In addition, a complete description of the Chilean biotechnology industry is provided. Amongst other characteristics, this report shows that the industry lacks financial support from venture capital and foreign investors, has a relatively modest proportion of highly qualified employees that work in Research and Development, presents insufficient patent productivity and is mostly regulated in terms of the use of GMOs.

Biotechnology development may be considered as an opportunity to contribute towards health, create wealth and improve the productivity and competitiveness of nations (Holm-Nielsen and Agapitova, 2002). Biotechnology offers the opportunity to improve the value of goods produced with old technologies, exploit new resources and create environmentally friendly solutions to a variety of problems

that developing countries are currently facing (Gil et al. 2002). Furthermore, the Food and Agricultural Organisation (FAO) also remarks that biotechnology is one of the value added disciplines that can be applied by Latin American countries to improve their efficiency and competitiveness.

Within this context, there are 643 plant biotechnology laboratories in 32 countries of Latin America and the Caribbean (LAC) with 2349 research and academic graduates and 1542 postgraduates that are members of the FAO sponsored Technical Cooperation Network REDBIO that is under operation since 1991 to develop biotechnology as a key issue for the sustainable use of regional genetic resources, promoting the safe and responsible application of the technologies, specially in fragile environments; and enhancing the regional development of new strategic technologies, such as molecular genomics, and encouraging the applications, whenever feasible, of advanced biotechnology tools in crop integrated management and sustainable production systems (Rota and Izquierdo, 2003).

BIOTECHNOLOGY INDUSTRY IN LATIN AMERICA

Biotechnology companies started their operations in Latin America in the late 80's, mainly producing industrial enzymes, biopharmaceuticals and diagnostic kits (Gil et al. 2002). The late onset of that industry was mainly a consequence of inefficient support programmes, an almost non-existent investment community and a very modest

* Corresponding author

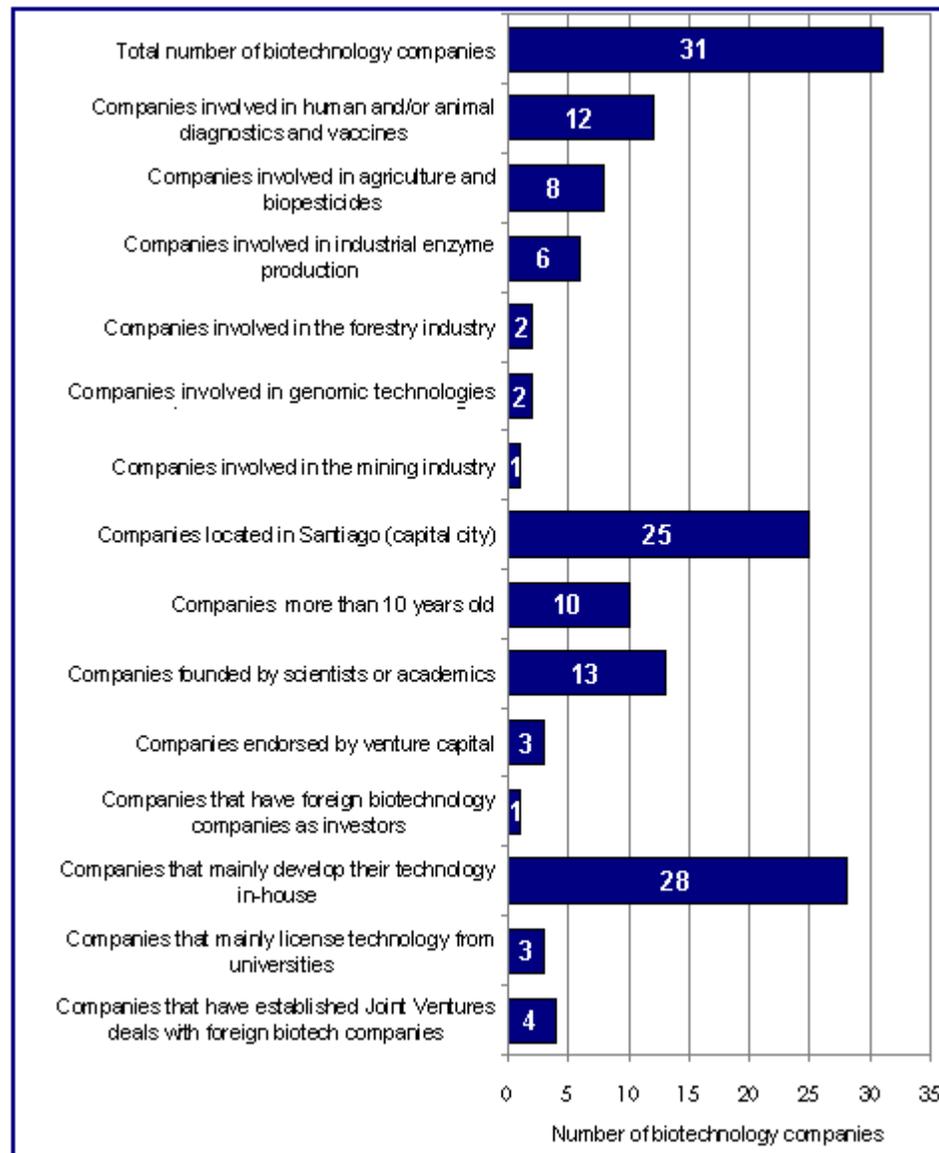


Figure 1. Description of the Chilean Biotechnology Industry as of December 2002
Source: National Commission for the Development of Biotechnology, Chile.

local Research and Development capacity (Solleiro and Castañon, 1999; Gil et al. 2002).

Presently, in Latin American countries, Research and Development is conducted in higher education institutions while industry participation in these activities is marginal (Solleiro and Castañon, 1999). In practice, technology imports are the main mechanisms for acquisition of technological capability in those countries, which become technology consumers instead of technology developers, and thereby set aside the opportunity of capturing the high margin value-added biotechnology markets (Bustamante and Bowra, 2002).

The distribution of biotechnology firms across Latin America correlates with the existing Research and

Development capacity of its different countries. Thus, larger countries have larger numbers of biotechnology firms while smaller countries present smaller numbers of companies (Solleiro and Castañon, 1999). However, according to Solleiro and Castañon, biotechnology firms in Latin America are 'mainly small [organisations] that work with fairly simple technology' (Solleiro and Castañon, 1999).

Nevertheless, a number of Latin American countries have been implementing several major changes that may contribute to the establishment of a sustainable biotechnology industry. According to Da Silva (Da Silva et al. 2002), privatisation of state-owned enterprises, infrastructure development (research institutions, science parks), establishment of capital markets, achievement of

trade agreements and implementation of macro economic as well as political reforms are some of the characteristics that position Brazil, Argentina and Chile as the best candidates in terms of their potential to develop biotechnology .

SCIENTIFIC INNOVATION AND BIOTECHNOLOGY DEVELOPMENT IN BRAZIL

As can be seen from Table 1, Brazil hosts 350 biotechnology companies (or 2 companies per million residents) that accounted for US\$ 7 billion in sales in 2002. Most biotechnology activities are conducted in the south east of the country where two biotechnology clusters, Sao Paulo and Minas de Gerais, lead the sector and account for 72% of the installed capacity (www.infoexport.gc.ca).

As shown in Table 1, Brazil's scientific innovation and

biotechnology industry are considerably more substantial than that of Argentina and Chile. On the whole, Brazil invests a larger proportion of its GDP in Research and Development, publishes more scientific papers and has more patenting activity than the other Latin American countries presented in Table 1. Moreover, Brazil and the US show similar rate of patenting approval (48% and 53% respectively) and enjoy the same average profitability per biotechnology company (US\$20 million per year).

SCIENTIFIC INNOVATION AND BIOTECHNOLOGY DEVELOPMENT IN ARGENTINA

On the other hand, Table 1 shows that Argentina hosts 250 biotechnology companies (or 6.6 companies per million residents) that accounted for US\$ 75 million in sales in 2002. Despite the fact that Argentina has half the number of researchers and invests a lower proportion of its GDP in

Table 1. Comparison of scientific innovation and biotechnology development between Brazil, Argentina, Chile, United Kingdom and United States of America.

	BRAZIL	ARGENTINA	CHILE	UK	USA
Population millions (2002)	175.09	38.0	15.6 ^c	58.8 ^e	282.1 ^h
N ^o of biotechnology companies (2002)	350 ^b	250 ^a	31 ^d	550 ^f	1,457 ⁱ
N ^o of companies / population (10 ⁶)	2	6.6	2	9.3	5.16
Total revenues of biotechnology industry (In US\$ million, 2002)	7,000 ^b	75 ^a	10	4,700 ^f	28,500 ⁱ
Total revenue (10 ⁶) / N ^o of companies	20	0.3	0.32	8.5	20
N ^o of biological researchers (2000)	20,233	9,587	1,860	47,000 ^g	446,890
N ^o of companies / N ^o of biological researchers (10 ³)	17	26	17	12	3.2
% of GDP invested in Research and Development (2000)	1.05	0.44	0.56	1.83 ^g	2.68
N ^o of scientific publications identified via Medline (2000)	4,021	1,466	555	27,931	146,622
Total N ^o of patent applications (including residents + non residents, 2000)	19,325	6,633	3,683	21,580 ^j	295,000
Total N ^o of granted patents (including residents + non residents, 2000)	9,269	1,587	620	2,962 ^j	157,495
N ^o of granted patents / N ^o of patent applications	0.48	0.24	0.17	0.14	0.53

Sources: Iberoamerican Network of Science and Technology Indicators

- a: The biotechnology market in Argentina, 2003 ;
- b: The biotechnology market in Brazil, 2002;
- c: National statistics Bureau, Chile;
- d: National Commission for the Development of Biotechnology, Chile;
- e: 10 Downing street website, UK Population 2001;
- f: BioIndustry Association, UK;
- g: UK Research and Development website;
- h: U.S. Census Bureau ;
- i: Biotechnology Industry Organization;
- j: UK patent office.

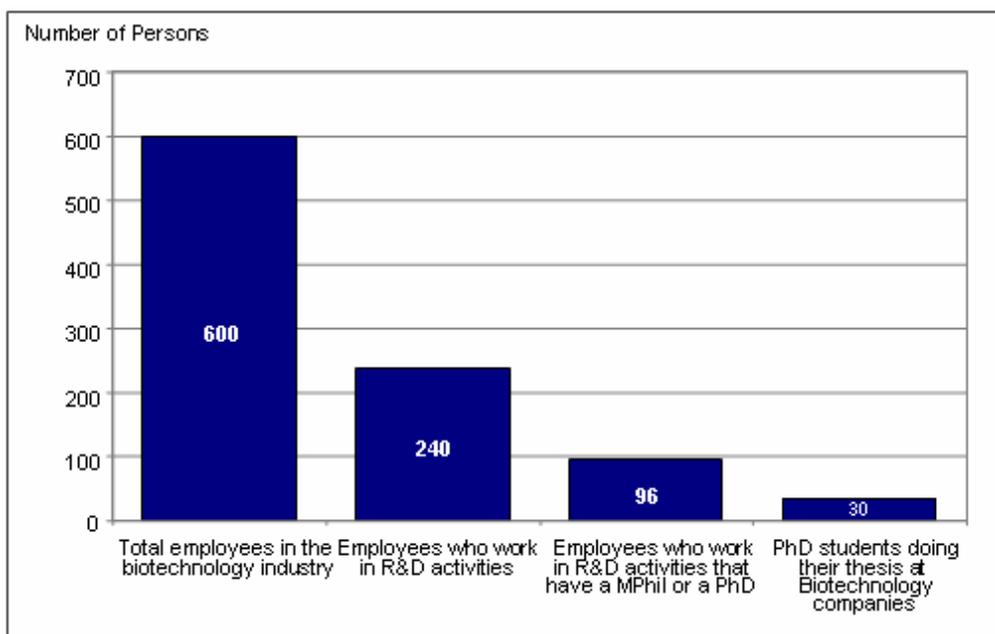


Figure 2. Description of the Human Resources related to the Chilean biotechnology industry, as of December 2002.
Source: National Commission for the Development of Biotechnology, Chile.

Research and Development, it has nearly the same number of biotechnology companies as Brazil. However, these companies account for an industry that is approximately 94 times smaller than that present in Brazil. According to Table 1, Argentina has the highest proportion of biotechnology companies per thousand biological researchers (26 companies) and the lowest average revenue per company (US\$ 0.3 million).

SCIENTIFIC INNOVATION AND BIOTECHNOLOGY INDUSTRY IN CHILE

Table 1 shows that Chile hosts 31 biotechnology companies (or 2 companies per million residents) that accounted for US\$ 10 million in sales in 2002. Taking into account the size of Chile and consequently the size of its biotechnology industry, Chile is 11 and 2.5 times smaller than Brazil and Argentina respectively, in terms of population. Conversely, Brazil and Argentina have biotechnology industries that are 700 and 7.5 times larger than the one existing in Chile, in terms of revenue.

Despite this difference, Chile and Argentina have a very similar ratio of total revenue of the industry per biotechnology company (approx. US\$ 0.3 million per company), suggesting that the biotechnology industry in Chile is similar to the one in Argentina in terms of revenues but smaller in terms of overall size. In addition, according to Table 1, Chile has the same proportion of companies per million inhabitants (2 companies) and companies per thousand biological researchers (17 companies) than Brazil,

suggesting that the current stage of development of the Chilean biotechnology industry is proportional in terms of company numbers to the one in Brazil.

However, the small number of biotechnology companies present in the Chilean economy may reflect what Bustamante and Bowra (Bustamante and Bowra, 2002) argue as the main competitive weakness of the Chilean biotechnology industry. The authors suggest that based on a relative lack of ability to innovate and adapt technological change, Chilean biotechnology companies are serving modest domestic markets that are far from global investment centres, thereby, hindering their ability to grow and expand the industry.

Regarding research capacity in biotechnology, Chile stands third in South America after Brazil and Argentina (<http://sea.agr.ca/latin/e3346.htm>). Nevertheless, according to Table 1, Chile has virtually the same percentage of biological researchers as a proportion of the population than Brazil (119 researchers per million habitants) and a larger ratio of scientific publication identified *via* Medline per biological researcher than Brazil and Argentina. In fact, Chile presents practically the same number of scientific publication per biological researcher than USA (0.3 publication per biological researcher).

Nevertheless, as noted by the Chilean Commission for the Development of Biotechnology, Chile already has certain capabilities that may be useful to develop a biotechnology strategy aimed at expanding the competitive advantages of the country.

Characterisation of the Chilean biotechnology industry

At present, the Chilean biotechnology industry is comprised of 31 companies that accounted for approximately US\$ 10 million in sales in 2002 and employs nearly 600 people (www.biotechnologia.fia.gob.cl/comision). According to Dornberger (Dornberger, 1999), almost all Chilean biotechnology companies emerged from academic institutions; some were the result of research projects that were developed into companies, while others were literally designed as spin-off initiatives. In general, the main activities of these companies are related to chemical diagnostics, human and veterinary medicine, and enzyme production (www.biotechnologia.fia.gob.cl/comision).

Growth of the biotechnology industry in Chile

Table 2 shows that, on the whole, the Chilean biotechnology industry is at an early stage of development (small number of companies and relatively modest industry revenues). The biggest growth has been in the number of people employed (152 per cent of total growth from 1999 to 2002). However, according to the evidence provided in Table 2, it might be possible to infer that the industry is currently going through a phase of rapid growth were the industry revenue grew by approximately 41% and 10 new companies were founded in the last year.

Description of the Chilean biotechnology industry as of December 2002

As shown in Figure 1, most biotechnology companies are located in Santiago (capital city). On the other hand, it can

be inferred that the Chilean biotechnology industry is fairly new (only 1/3 of the companies are 10 years old), it has some academics and scientists involved with the entrepreneurial side of the business (13 companies were founded by scientists or academics) and, above all, it is an industry that lacks financial support and international collaborations (3 companies are endorsed by Venture Capital while 4 companies have established international collaborations with foreign biotechnology corporations).

Academic capacity to train human resources in biotechnology in Chile

According to the Chilean Commission for the Development of Biotechnology, the academic capacity to train people in biological sciences and related disciplines is considered sufficient to cope with the current demand of professionals in that area. In other words, the evidence shown in Table 3 suggests that the Chilean higher education system has properly developed biotechnology related degrees, consonant with the expectation that the biotechnology industry will grow in Chile. Figure 2 describes how the human resources are distributed across the Chilean biotechnology industry.

Distribution of human resources across the biotechnology industry in Chile

As can be seen in Figure 2, the Chilean biotechnology industry has a workforce of 600 employees. In other words, the biotechnology labour force available in Chile is 318 and 67 times smaller than those present in the US and the UK, respectively.

Furthermore, less than half of the industry's personnel (240 persons) work in Research and Development activities. In

Table 2. Growth of the biotechnology industry in Chile.

	1999	2000 ^ñ	2001	2002	Total Growth (1999-2002) %	Average growth per annum %
N° of biotechnology Companies ^a	19	20	21	31	63	19
N° of people employed ^b in the industry	238	341	444	600	152	36
Total industry revenues ^c (in US\$ million)	7.33	7.46	7.07	10	36	13

Source: National Commission for the Development of Biotechnology, Chile

ñ: For year 2000 the values were estimated.

a: Biotechnology company: a company that uses modern biological technologies (e.g. recombinant DNA, biochips, cell culture technology, tissue engineering, bioinformatics, genomics, proteomics, etc) to fabricate commercial products and/or provide services.

b: Employees: persons hired for a wage or fixed payment in exchange for personal services. Full-time equivalent identification has not been considered.

c: Revenue: total payment from sales of goods and services, minus the cost associated with returned or undeliverable merchandise.

- Limited financial support from venture capital and foreign investors.
- Scarce recognition from international biotechnology leaders in the form of partnerships or collaborations.
- Modest proportion of highly qualified employees that work in Research and Development.
- Small patent productivity of Chilean scientists and Chilean biotechnology companies.
- Scant technology transfer from university to companies.
- Biased regulatory environment towards the use of GMOs.

Figure 3. Summary of the key limitations that affect the biotechnology industry in Chile.

addition, just 40% of the people who work in Research and Development (96 persons) have Masters degrees (MPhil) or PhDs. As a result, this evidence suggests that the existing Research and Development capacity of the industry is relatively modest and implies that major scientific innovations may be unlikely to occur.

However, approximately 30 PhD students are currently engaged in PhD studies at several biotechnology companies (Gil et al. 2002). That situation can potentially increase the number of highly qualified personnel working in Research and Development provided that the candidates continue working for the companies after finishing their PhDs.

Nevertheless, according to the information available from the Chilean Commission for Scientific and Technological Research (CONICYT) and from the Iberoamerican Network of Science and Technology Indicators (RICYT), the distribution of people with PhDs or MPhil in biological sciences across different sectors of the Chilean economy is as follows: approximately 70% (1,303 persons) work as researchers in universities, 5.2% (96 persons) work in the biotechnology industry and 24.8% (461 persons) work in other activities or may be not currently living in Chile.

Biotechnology patents in Chile

As shown in Table 4, in the period 1999 to 2003, a modest number of biotechnology patents (33) have been granted in Chile. Moreover, nearly 90% of these patents (30 patents) were granted to non-residents, *i.e.* people or organisations that do not have Chile as their country of origin. Taking that into account, only three patents were granted to Chilean residents, suggesting that the patenting activity

related to the biotechnology industry in Chile is certainly minimal or grossly insufficient.

Regulations concerning biotechnology in Chile

According to the Chilean Commission for the Development of Biotechnology, there are a number of institutions that have established laws that cover aspects of biotechnology practice, but there is no coordinated effort to regulate this sector in line with the way this industry works.

It can be seen from Table 5 that the regulatory environment for biotechnology in Chile is mainly focused on the use of genetic engineering technologies. In addition, different regulatory instruments (laws, decrees, resolutions, etc) concerning biotechnology are distributed across a variety of legislations. Therefore, no regulatory framework that combines the different regulations in a meaningful way is currently available.

Strategic opportunities for the biotechnology industry in Chile

Based on the information summarised in Figure 3, the following strategic propositions represent an alternative approach to help develop the Chilean biotechnology industry. According to Collis and Montgomery (Collis and Montgomery, 1999), it is very good strategic practice to incorporate and develop new plans and resources constantly that complement the competitive advantages of the main strategy in place.

To begin with, Chile's reputation for mining (copper, gold, molybdenum, iron, silver and zinc), aquaculture (salmon

and trout), agriculture (in particular, wine and fruit production: grapes, apples, avocados, kiwis, plums, pears, nectarines and raisins) and forestry (cellulose and woods) can serve as the foundation upon which a biotechnology strategy can be implemented in order to differentiate the Chilean biotechnology industry from the general trend of biomedical or genomic biotechnology development. The idea is to support with a range of biotechnology tools and processes the productive sectors that have significant participation in global markets and represent competitive advantages for the Chilean economy. In that way, biotechnology may be used to reduce production costs or exploit new resources.

Secondly, an in-depth study of the productive needs of the most significant sectors of the Chilean economy might help to identify key elements from each industry that could be enhanced with biotechnology. Therefore, the uniqueness of the Chilean biotechnology industry should be built around those elements that take advantage of particular physical locations, exclusive rights of exploitation, robust patents or unique opportunities that can be translated into valuable solutions that tackle specific needs for each industry.

In other words, a successful biotechnology strategy is to do with taking advantage of the leading position and reputation that Chile enjoys in several global markets. Altogether, the idea is to showcase Chilean biotechnology as a scientific innovation that would be responsible for complementing the competitive advantages and improving the value of the most competitive industries of the Chilean economy.

Table 6 illustrates that; in general, the productive sectors of the Chilean economy mentioned in this report show significant market participation and account for considerable exports. Therefore, this situation represents an opportunity where the existing competitive advantages of such sectors could be complemented with biotechnology solutions in order to improve the value and competitiveness of these areas.

However, it is widely agreed that biotechnology development requires considerable financial resources, therefore, it may be expected that the more profitable

industries would be willing to invest in biotechnology solutions.

In that case, when considering the relative average revenue per firm ('profitability') of the Chilean productive sectors, Table 6 shows that the bigger areas in terms of revenue per company are: mining, forestry and aquaculture. Therefore, biotechnology companies and research institutions should consider these industries as the first potential consumers of their biotechnology tools and processes.

Nevertheless, taking into account the small proportion of biotechnology companies dedicated to serve these sectors in Chile, it may be inferred that the biotechnology industry has not seriously seized the opportunity to serve the mining, forestry and aquaculture industries with biotechnology solutions.

However, biotechnology companies and research institutions may complement their efforts in biotechnology development with the assistance of several Chilean institutions, where most of them are part of the science and technology development framework of the government.

In fact, institutional support for the development of biotechnology in Chile is distributed transversely across four estate ministers that have established development programmes where funds and infrastructure are available to encourage biotechnology initiatives. Namely, the major institutional supporters and their programmes available in Chile are the following: the Ministry of Economics with its Chilean Economic Development Agency (CORFO), the Ministry of Agriculture with its Foundation for Agrarian Innovation (FIA), the Ministry of Education with its National Commission for Scientific and Technological Research (CONICYT) and the Ministry of Planning and Cooperation with its Millennium Science Initiative (ICM).

Presently, the Chilean government has conceived a Biotechnology Policy named "Biotechnology as a Tool for Development and Well-being" (www.minecon.cl) that plans to leverage on the existing biotechnology development framework, concentrating its resources in achieving the following objectives:

Table 3. Academic capacity to train Human Resources in biotechnology in Chile.

Type of programme	Number of programmes
Undergraduate programmes that teach different aspects related to biotechnology	48
Undergraduate programmes directly related to biotechnology	4
Masters programmes particularly focused on biotechnology	17
PhD programmes particularly focused on biotechnology	13

Source: Current Vision about Biotechnology in Chile, (Gil et al. 2001).

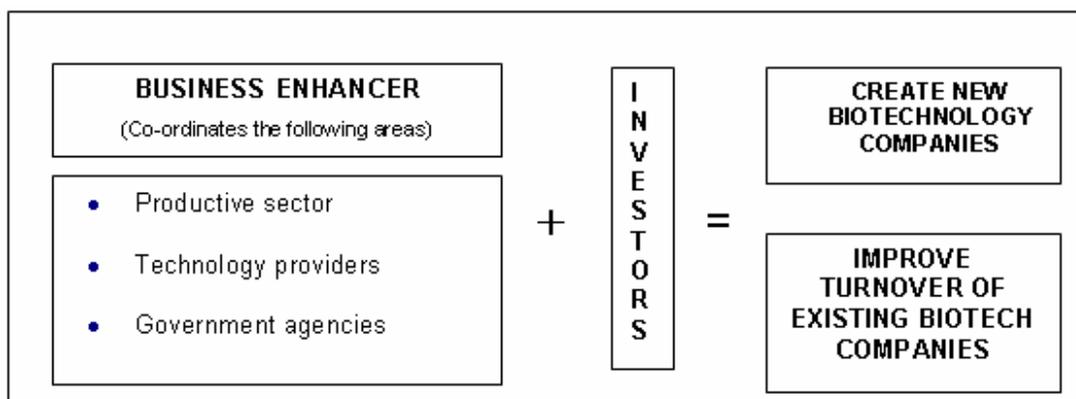


Figure 4. The Business Enhancer and its role in the creation of biotechnology companies.

1. Updating laws that concern biotechnological activities
2. Creating an overarching regulatory body
3. Developing scientific and technological capacity
4. Promoting entrepreneurial innovation in biotechnology

As can be seen in Table 7, the institutional infrastructure available in Chile for the development of biotechnology has been divided into three major groups: sources of funding, research and development programmes largely focused on biotechnology and support institutions.

From the first group, the Chilean Economic Development Agency (CORFO), through its varied financial instruments and support programmes, plays a major role in the development of scientific and technological initiatives that have direct impact on Chilean industry. However, it is sensible to notice that while CORFO supports a wide range of scientific and technological initiatives that include the industrial application of biotechnology tools and processes, the Foundation for Agrarian Innovation (FIA) commits a considerable proportion of its resources to distinctively support biotechnology projects related to forestry, agriculture-livestock and aquaculture.

With respect to the research and development programmes showed in Table 7, the three programmes, all together, have hold a substantial amount of biotechnology research projects that accounted for more than 250 research assignments during the last three years (www.genomachile.cl, www.mideplan.cl/milenio, www.inia.cl). In general, their research interests bring together bioinformatics, molecular genetics and cell biology to the health, environmental and productivity issues in Chilean industry.

On the other hand, the support institutions listed in Table 7, represent a group of organisations that may not have a direct match with biotechnology at first glance, but when considering biotechnology development as a complex

activity that involves the participation of several stakeholders, entities like the Industrial Property Department (DPI) or the Foreign Investment Committee (CINVER) may play an important role in the growth of this industry. For example, activities like filing biotechnology patents or placing Foreign Direct Investment (FDI) in a biotechnology company in Chile are part of the actions needed to foster the expansion of Chilean biotechnology.

In addition to the above, the Science for Life Foundation <http://www.cienciavida.cl/> and the Chile Foundation <http://www.fundacionchile.cl> are regarded as key non-governmental elements in the institutional infrastructure that supports biotechnology development in Chile. Both institutions were created to fill the gap between industry and science. In most cases, the Science for Life Foundation focuses on industry-biotechnology topics mainly from the research and development perspective, while the Chile Foundation tackles the biotechnology-industry interaction from the angle of commercialisation of technological innovations in an industrial environment.

On the whole, the institutional infrastructure available in Chile to promote biotechnology development may be considered sufficient to uphold this task. However, organic growth and guided expansions of the industry may not be expected in the country with its current dissemination of efforts. In other words, there is a somewhat efficient fund-allotment infrastructure in Chile; however, a coherent management programme that could extract real value from the biotechnology initiatives currently in development is actually missing.

Therefore, an overarching entity that would leverage upon and bring together, in a meaningful way, all the different biotechnology stakeholders that are available in Chile, may be seen as a realistic approach to maximise the value distributed across a number of government institutions towards the consolidation of the Chilean biotechnology industry.

Is in this direction where a strategy to foster biotechnology development would be desirable. Especially, if such initiative may set the appropriate incentives and financial supports in accordance with the industrial needs of the productive sectors of the Chilean economy.

Strategic propositions

Biotechnology development initiatives such as, the joint biotechnology venture established between the Chilean Copper Corporation (Codelco) and Nippon Mining and Metals (www.biosigma.cl), the plant genomic consortium set to combat fungal rot, improve quality and delay ripening in varieties of grape and nectarines (www.genomavegetal.cl, www.genoma-frutos.cl) as well as, the forestry biotechnology alliance (www.infor.cl) focused on using molecular genetic methods to improve forest plantations have served as inspiration to incorporate and develop new plans that may enhance, in a more structured and coherent way, the competitive advantages of the biotechnology development approaches going on in Chile.

Briefly, two general trends can be described from what is happening in biotechnology development in Chile.

First, big corporations like the Chilean Copper Corporation (Codelco) are recognising that some of their productive needs and competitive advantages must be optimised in order to keep their competitive fitness up to global market standards. Therefore, Codelco through its biotechnology company, BioSigma, is aiming at improving their current *in situ* bioleaching processes through the implementation of several biotechnology solutions. In this way, tailored solutions from the biotechnology arena are being developed to satisfy specific productive needs of a large business.

In contrast, in other productive sectors, such as agriculture and forestry, an alternative approach to include biotechnology as a tool for competitive improvement is being used. In this case, several stakeholders are grouped to form a cooperative consortium, where productive needs that generally affect the whole sector are being addressed. In this way, biotechnology development is seen as an

alternative route to optimise the performance of the productive companies that form the alliance. In fact, this cooperative approach gives medium and even small productive companies the privilege of benefiting from scientific and technological innovations developed under the consortium scheme, that otherwise, would have not been able to afford.

On the whole, based on the information provided above, biotechnology development in Chile is naturally evolving in two routes. The first one is to do with leveraging existing Research and Development resources from universities and research institutions to satisfy specific unmet needs of large businesses, while the other, is to follow the same principle but addressing unmet needs of productive sectors as a whole. In other words, the biotechnology development process that is currently going on in Chile, has a common structure shared across different productive sectors and companies. However, the main difference relies in how the existing biotechnology resources are being pulled (scope and focus) to achieve either company- or industry-specific performance goals.

The following propositions represent two complementary approaches that aim at developing the biotechnology industry in Chile. The models discussed are based on the assumption that Chilean biotechnology should focus its resources on improving the competitive advantages of the main productive sectors of the Chilean economy.

THE BUSINESS ENHANCER STRATEGY

This organisation should identify, structure and promote biotechnology business opportunities that could be transformed into new biotechnology companies or improve the turnover of existing biotechnology companies with the participation of investors.

As can be seen in Figure 4, the Business Enhancer should operate as an intermediary or facilitator entity that coordinates the stakeholders described below in order to serve company-specific unmet needs from the productive sectors previously mentioned.

Table 4. Profile of biotechnology patents in Chile (1999-2003).

Type of applicant	Nº of patent applications (1999-2003)	Nº of patents granted (1999-2003)
Residents	39 ^a	3 ^a
Non Residents	232 ^a	30 ^a
Total	271	33

Source: Department of Industrial Property, Chile.
a: Correspond to approximated values.

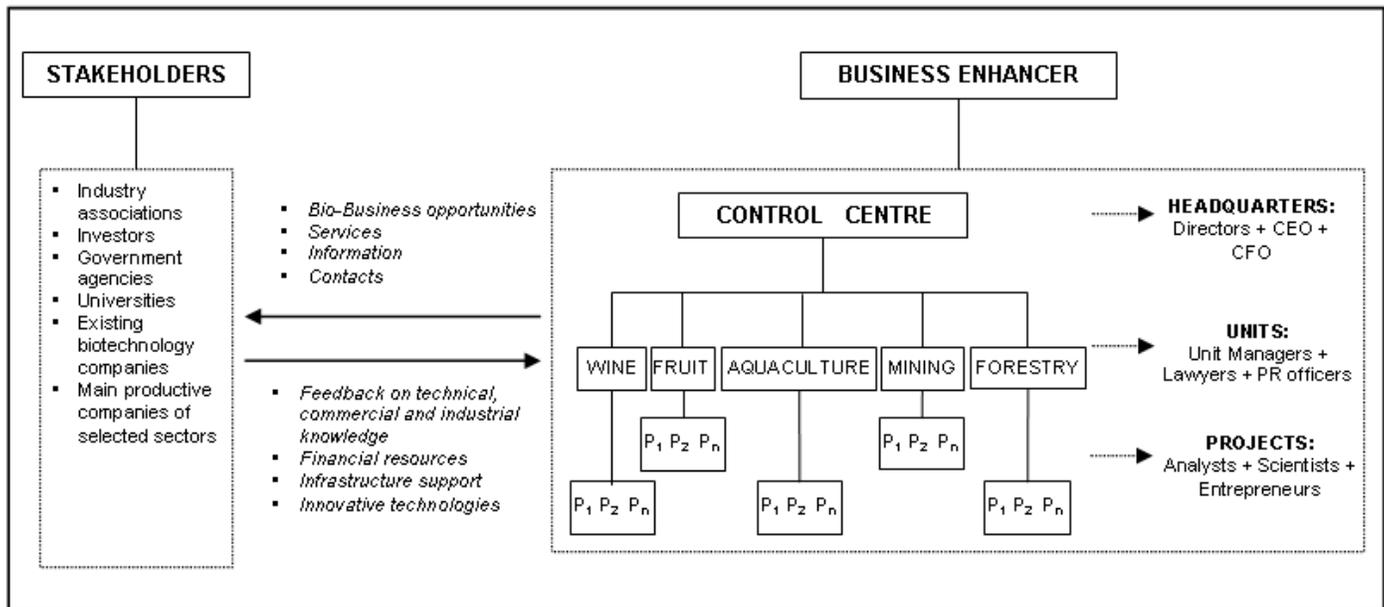


Figure 5. The business enhancer and its interactions with relevant stakeholders of the biotechnology industry.

Investors

They would be responsible for the actual implementation and development of biotechnology ventures. In other words, the Business Enhancer would provide them well-conceived business opportunities where global markets and relevant unmet needs have been addressed. Therefore, different types of investors might be interested in these opportunities. For example, existing biotechnology companies, venture capitalists, companies or industrial associations from the same productive sector than the solutions come from, international investors as well as institutional investors such as banks, investment funds, etc. should be considered as significant elements in this section of the strategy.

Productive sector

Chilean companies and industrial associations from the selected areas mentioned above should be included in this section. In this case, those elements may contribute valuable feedback to the Business Enhancer in terms of critical appraisals about the productive needs, resources and opportunities that can be transformed into profitable businesses by applying biotechnology.

Technology providers

Research institutions, universities and existing biotechnology companies should be part of this section. Therefore, these elements may provide the technological innovation needed to complement or materialise the business opportunities previously identified by the productive sector. In other words, the elements described in

this section should use their knowledge, technologies, know-how and science to deliver biotechnology solutions. Then, those solutions may be managed by the Business Enhancer to include them in a well-conceived bio-business proposition.

Government agencies

Regulatory and intellectual property departments, economic development agencies and international investment and foreign trade bureaus would be significant components in

this section of the strategy. In fact, those agencies might collaborate with the Business Enhancer in order to expand its capabilities. For example, the regulatory department may include its recommendations in the development of meaningful biotechnology regulations. In addition, the economic development agency might contribute financial resources to cooperate with the operations of the organisation. Furthermore, the intellectual property department might work in collaboration with the Business Enhancer in order to introduce an IP management programme across the industry, and finally, the international investment and foreign trade agency may support the Business Enhancer organisation by attracting investors and promoting Chilean biotechnology projects in international markets.

Regarding the Business Enhancer's structure, Figure 5 describes that it would be organised into three levels. First, the control centre would be represented by the headquarters where mainly the Chief Executive Officer (CEO), the Chief Financial Officer (CFO) and the Board of Directors would

guide and control the most relevant activities of the organisation. Secondly, five strategic units, one per competitive sector of the economy, would represent the core of the system. Here, primarily unit managers, lawyers and public relation (PR) officers would work together to assess and communicate the unmet needs or the biotechnology business opportunities that can be exploited in each productive area.

Finally, the third level represents the actual projects that would be currently in development. In other words, each unit, i.e. forestry, fruit, etc; would have a group of analysts, scientists and entrepreneurs that would be exclusively focused on assessing the real business potential of the biotechnology opportunities identified in the level above.

On the other hand, the Business Enhancer, as a whole, would be constantly interacting with relevant stakeholders of the biotechnology industry. Therefore, a two-way flow between the Business Enhancer, industry associations, government agencies, universities and existing biotechnology companies would be established. In fact, Figure 5 shows that some of these interactions would be in the form of information exchange, financial support and service provision.

On the whole, the Business Enhancer would be structured in a way where all its resources and capabilities may be used to extract value from the relevant stakeholders in order to complement, with biotechnology, the competitive advantages of the main productive sectors of the Chilean economy.

CONSORTIUM STRATEGY

It is widely agreed that technological development, especially when it is related to biological sciences, demands time and resources. In fact, it is estimated that around one thousand research and development biotechnology projects are needed to produce one blockbuster product or solution. However, if this blockbuster does come to fruition, substantial returns grossly outweigh the time and resources invested in producing such hit.

Therefore, a governmental strategy, focussed on reducing the risk of developing biotechnology at the private sector, is proposed. According to Valenzuela (Valenzuela, 2003), the Consortium Strategy is to do with the management and investment schemes that the government should use to ensure the effective involvement of the private sector in biotechnology development.

First, the Chilean Economic Development Agency (CORFO) or the Ministry of Economy would be in charge of selecting, in collaboration with industry leaders and technical experts, which industries of the Chilean economy would truly benefit from biotechnology applications. Once they have been identified, initial seed capital would be distributed across each selected area according to the type of projects each consortium is expected to develop. For example: strategic competitive advantages, commercialisation prospects and many other characteristics would be assessed to proportionally allocate the funds provided by the government among the selected consortiums.

Secondly, private companies, especially the ones that have major impact in Chile's economy, would be encouraged to actively participate in the consortiums. More specifically,

Table 5. Description of the main regulations concerning biotechnology in Chile.

Regulation	Year published	Topic	Regulatory aspects related to biotechnology
Law N° 19,039	1991	Intellectual Property	Patentability of biotechnology products and inventions ^a
Law N° 19,300	1994	Environment	Safe use of GMOs ^b
Decree N° 997	2000	Human Health	Labelling of food containing GM material
Resolution N° 1,523	2001	Agriculture	Seed multiplication of GM crops ^c
Decree N° 320	2001	Aquaculture	Use of GM fishes in aquaculture

Source: National Commission for the Development of Biotechnology, Chile.

a: The patent law is being amended at the national congress where international standards are being included to facilitate biotechnology patents;

b: The Cartagena's protocol of biotechnology safety has not yet been ratified by the national congress;

c: Chile supports the use of GM crops for research since 1992. It allows GM seeds to enter the country for multiplication propose but not for commercialisation as food or food ingredient.

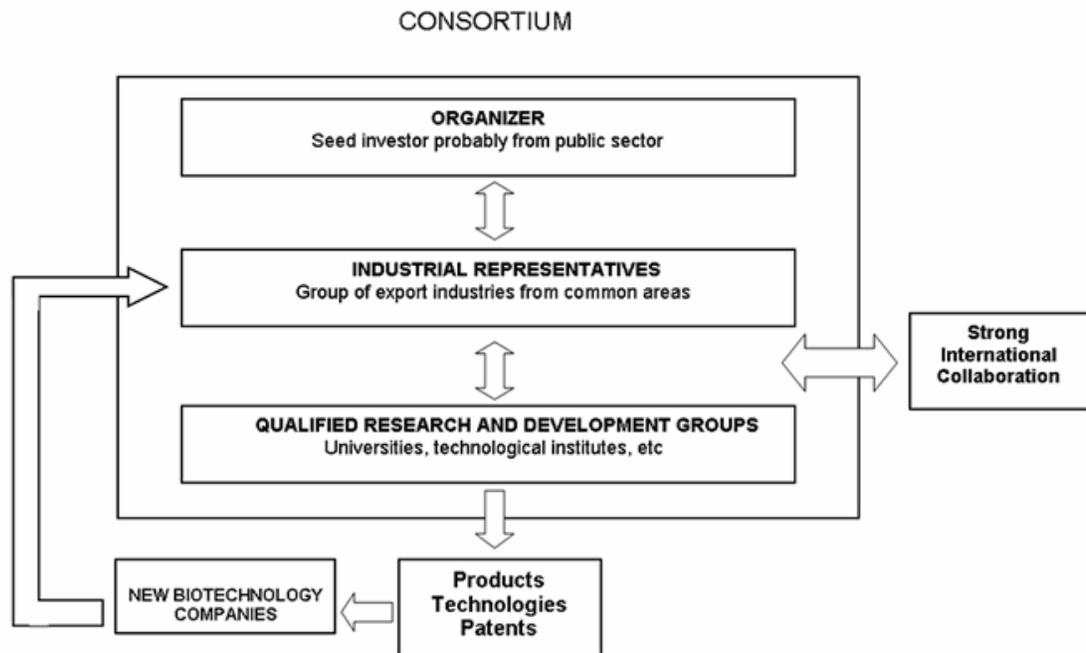


Figure 6. The consortium strategy and its role in the creation of biotechnology companies.

The Chilean Commission for the Development of Biotechnology was created by the current Chilean president Mr Ricardo Lagos, with the objective of identifying and proposing biotechnology actions that should have a positive impact in the development of both Chilean economy and society.

these private organisations would be economically as well as strategically bound to their consortium, contributing valuable feedback on their industry's needs and focusing the consortium's Research and Development efforts towards valuable and commercial solutions. However, to effectively start this initiative, the government should pay a larger proportion of this programme. Ideally, it should reduce its participation in comparison to the private sector as successive rounds occur, reaching almost virtual levels of participation in the long term.

Thirdly, technology developers such as universities, institutes and existing biotechnology companies, would tender for different vacancies as research and development collaborators of each consortium. As a result, a number of Research and Development activities would be outsourced to the best-qualified institutions in order to relieve the consortium from the bureaucratic burden of managing science and, at the same time, managing industry-academia interactions, IP management plans, business development activities, spin-off of companies and international collaborations.

Finally, as shown in Figure 6, each consortium would produce biotechnology solutions that would serve the main productive companies involved in this initiative. Therefore, scientific development would be funded and managed by the consortium but delivered by technology institutions. In

fact, every consortium would have strong business focus and would be set up to serve a well-defined market.

In other words, the technological solutions would be developed in academic institutions but would be under the control of the consortium's business mindset. In this way, the efforts would be focused on improving the capabilities and commercial activity of productive sectors, while at the same time, establishing meaningful industry-academia interactions that may take advantage of intellectual property assets, which may benefit the Chilean biotechnology industry as a whole.

Furthermore, the development of robust intellectual property rights around the technologies developed by the consortiums may have a positive impact in the development of Small and Medium Biotechnology Enterprises (SMBEs), which can be the entities responsible for delivering, in the long term, the biotechnology products or services to the big corporations of the different industries.

Altogether, the idea of this proposition is to position Chilean biotechnology under the umbrella of successful industries, similarly to what happened in USA with health related biotechnology organisations that initially served pharmaceutical companies or agricultural biotechnology companies that firstly worked for seed corporations. Consequently, the model presented in this section suggests that new industrial biotechnology companies would be

servicing the mining, aquaculture, agriculture (in particular, wine and fruit production) and forestry industries.

INTEGRATING THE PROPOSED MODELS WITH CURRENT INSTITUTIONAL INFRASTRUCTURE

First, the development propositions described above rely upon the essential assumption that all the resources that are being deployed to foster the expansion and consolidation of the biotechnology industry in Chile are driven by the market or productive needs of the most competitive industries of the Chilean economy.

Secondly, the research and development capacity in Chile is considered sufficient but by no means enough, to cope with a potential increase in the current demand of scientific innovation needed by the productive sectors. Therefore, biotechnology Research and Development projects, as showed in Table 7, play a vital role in maintaining a constant supply of industry-focused innovations and improvements.

Thirdly, it is widely agreed that in order to achieve high productivity and output yields, the research and development programmes require substantial resources, in particular cash. In this case, a number of government institutions in Chile, provide the financial instruments and support programmes needed to develop biotechnology.

Finally, it seems that the core elements needed to help develop the biotechnology industry in Chile are already in place, *i.e.* Market driven needs for biotechnology solutions, adequate Research and Development capacity and access to financial resources. However, it appears that is not enough to have those attributes if the consolidation of the biotechnology industry is expected in Chile.

In this context, the support institutions listed in Table 7

may complement a number of activities that are not easy to access through traditional individual biotechnology projects. Then, the establishment of facilitating entities such as the Business Enhancer or the Consortium Approach would effectively exploit the existing resources in Chile to cover all the issues related to a bio-industry development.

For example, depending on the scope of a biotechnology development project (company- or industry-focused) the Business Enhancer or the Biotechnology Consortium would leverage on Millennium Science Initiative (ICM), or National Agricultural Research Institute (INIA) research programmes to identify biotechnology tools and processes that could solve or optimise some industry or productive company requirements.

Then, after successfully identifying feasible technological solutions at the research institutes, the facilitator (Business Enhancer or Biotechnology Consortium) would approach funding organisations such as the Foundation for Agrarian Innovation (FIA) or the Chilean Economic Development Agency (CORFO) to secure funding for the development or adjustment of the technological solutions to industry standards.

In deed, some of these actions may include filing patents at the Industrial Property Department (DPI), developing a marketing strategy for a new product or creating a biotechnology company with the assistance of the Chile Foundation.

In addition, international cooperation in the development of this biotechnology solution may be provided through the International Cooperation Agency (AGCI) and the RedBio Network.

Moreover, it might be the case that the solution that would be developed could be incubated in a business incubator.

Table 6. Competitive industries of the Chilean economy and their global markets.

Productive sector	Competitive advantage	Number of firms	Exports (US\$ million 2002)	Revenue per firm (US\$ million 2002)	Market size worldwide (US\$ million 2001)	Market share %
Mining	Cost advantage, World's biggest reserves	37	7,025	189.86	20,646	34.03
Forestry	Cost advantage, Plantation management	35	2,104	60.11	17,027	12.36
Fruit	Cost advantage, Opposite seasonality	117	1,319	11.27	8,710	15.14
Aquaculture	Cost advantage, Quality	23	973	42.30	5,182	18.78
Wine	Cost advantage, Quality	76	600	7.89	12,666	4.74
Total	-	288	12,021	-	64,231	-

Source: Food and Agricultural Organisation, the Chilean Copper Commission and Chilean export database.

Table 7. Institutional infrastructure for biotechnology development available in Chile.

Sources of Funding	Description	Website
Foundation for Agrarian Innovation (FIA)	Supports biotechnology projects related to Forestry, Agriculture-Livestock and Aquaculture	www.fia.cl
Fund for Advanced Research in Priority Areas (FONDAP)	Provides infrastructural support for the development of Research and Development centres that would create a critical mass of researchers in key development areas	www.conicyt.cl/fondap
National Fund for Scientific and Technological Development (FONDECYT)	Funds Basic Research across several disciplines, from physics to philosophy, including biotechnology	www.fondecyt.cl
Technological Innovation Fund for Bio-Bio Region (INNOVA BIO-BIO)	Exclusively supports the development of biotechnology projects in the Bio-Bio region. Its priority areas are: Forestry, Agriculture-Livestock and Aquaculture	www.innovabiobio.cl
The Chilean Economic Development Agency (CORFO)	Main source of economic support for the development of scientific and technological initiatives that have direct impact on Chilean industry. It offers more than 40 different financial instruments	www.corfo.cl
Fund for the Promotion of Scientific and Technological Development (FONDEF)	Provides funds for the development of industry focused Research and Development activities that promote Academia and Industry interactions	www.fondef.cl
National Fund for Technological and Productive Development (FONTEC)	Supports technology transfer, technology development or adjustment of scientific innovations directly into operating productive companies	www.fontec.cl
Technical Cooperation Service (SERCOTEC)	Offers funds for the implementation of innovative scientific activities that enhance the competitiveness and management capabilities of micro and small enterprises	www.sercotec.cl
Research and Development programmes in Biotechnology	Description	Website
GenomaChile	Encourages the use of genomic, bioinformatic and proteomic tools to enhance Chile's economic activity. The projects that are currently in development tackle Natural Renewable Resources and Biomining opportunities	www.genomachile.cl
Millennium Science Initiative (ICM)	Initially supported by the World Bank, ICM aims at fostering Chilean Research and Development at the highest international standards. Its current activities are divided into three Research Institutes and more than 10 Science Nuclei, where most of which are involved in biotechnology research	www.mideplan.cl/milenio
National Agricultural Research Institute (INIA)	Provides technical and scientific solutions to the Agricultural sector in Chile, with special emphasis in plant biotechnology	www.inia.cl
Support Institutions	Description	Website
Chile Foreign Investment Committee (CINVER)	Presents several incentives for foreign shareholders to invest in High Tech projects in Chile	www.cinver.cl
Chilean Commission for the Development of Biotechnology	Aims at identifying and proposing biotechnology actions that should have a positive impact in the development of the Chilean economy and its society	www.bioteconologia.gob.cl/comision
Industrial Property Department (DPI)	Supplies a coherent database of biotechnological inventions that has been involved with patent applications in Chile, USA, EU and Japan	www.dpi.cl
Science for Life Foundation (non-governmental)	Offers guidance in Biotechnology-industry topics in Chile, including: Research and Development, technical education, intellectual property, international exchange and diffusion campaigns	www.cienciavida.cl
Chile Foundation (non-governmental)	Develops scientific innovations into biotechnology companies that, after proven successful, are offered for acquisitions or mergers in the main markets	www.fundacionchile.cl
Business Incubator Portal (part of Chile Foundation)	Presents a one-stop website of business incubation alternatives available in Chile	www.portalincubacion.cl

International Cooperation Agency (AGCI)	Provides useful information about international training opportunities in biotechnology, grants for continuing education and access to financial collaborations with foreign countries, including the European Union	www.agci.cl
RedBio Network (associated with FIA)	Supported by FAO, supplies access to information related to plant biotechnology development across Latin America	www.redbio.org
National Information System for Silviculture Biotechnology (SINABSI)	Introduces a detailed record of biotechnology projects that have been executed in the forestry sector	www.bioteconologia.gob.cl
Entrepreneurs and Business Start-up Website (SitioEmpresa)	Compiles useful information for entrepreneurs who are planning to start their businesses in Chile	www.sitioempresa.cl
National Commission for Scientific and Technological Research (CONICYT)	Backs from different angles the development of Science and Technology in Chile, including: defining policies, promoting research programs and increasing public awareness	www.conicyt.cl

Then, the Business Enhancer or the Biotechnology Consortium would interact with the Business Incubator Portal (part of Chile Foundation) to assess the best place where to grow the emerging company.

Finally, this solution may have a global market potential, where foreign investors may consider the opportunity to become shareholders in the company. Then, the Foreign Investment Committee (CINVER) may guide and inform foreign investors about the benefits Foreign Direct Investment in high technology projects can offer.

To sum up briefly, there are many alternative ways of interaction between the elements described in Figure 10 and the Business Enhancer and/or Biotechnology Consortium. The idea is to maximise the value of the institutional infrastructure currently available in Chile with virtual overarching and flexible entities that would master key capabilities in both, science and business.

CONCLUDING REMARKS

The strategies proposed represent a new way to help develop the biotechnology industry in Chile. First, they use unexploited resources (productive sectors, technology providers and government agencies) that are difficult to access through traditional biotechnology models. And second, they are exclusively focused on complementing competitive advantages of productive sectors with biotechnology solutions.

However, it is widely agreed that biotechnology is a costly and risky business in which few companies can achieve the major product breakthroughs needed for success. Therefore, these models are mainly proposed with the intention of reducing the risk of failure and the cost of establishing new biotechnology businesses.

With respect to the long-term sustainability of the strategies proposed, the models could be expanded to other productive sectors. Therefore, areas like biomedicine,

livestock and marine products could be included.

Nevertheless, the Consortium Strategy and the Business Enhancer proposition also differ in several important aspects:

First, instead of the Government, through its Consortium, being the one that mainly invest in the identification of unmet needs and biotechnology solutions for the main productive industries, the Business Enhancer could encourage private or foreign investors to adhere such biotechnology development.

In this way, the Business Enhancer would act as an intermediary between biotechnology developers and the productive sector. In other words, it would provide bio-business opportunities to investors who wish to satisfy with biotechnology solutions the unmet needs of the main productive areas of the Chilean economy.

However, the Business Enhancer model assumes that the potential biotechnology solutions are already available among research and academic institutions. Therefore, no substantial Research and Development expenses should be made by the investors in order to set up a company that provides such solutions.

On the other hand, the Consortium Strategy is mainly focused on developing from scratch the biotechnology solutions tailored to each industry. In this context, government participation, through economic development agencies, would play a major role in the plan by initially assuming the risk of researching and developing new biotechnology solutions. In other words, the government would take the first mover risk, while at the same time, including relevant stakeholders as counsellors and minor investors.

Finally, it is expected that the shareholders involved with the Consortium Strategy would receive benefits (financial or strategic) directly from their participation in the new

biotechnology ventures that would be established. Instead, the Business Enhancer would provide its “bio-business identification service” free of charge with the condition that if a project comes to fruition, it has the first option to provide management and consulting services to the ventures newly incorporated.

In other words, the Business Enhancer would forgo the potential revenue streams coming from bio-business identification, in return for long-term sustainable income related to management consulting services.

Altogether, both models present different ways of encouraging the engagement of relevant stakeholders to the strategies. For the Business Enhancer, industry engagement in biotechnology development may be improved because no economic burden would be borne by the productive sectors unless a ‘feasible’ biotechnology business opportunity is identified. In the case of Consortium Strategy, industry involvement may increase because the government would initially cover Research and Development expenses. Hence, a considerable risk reduction for other partners involved in this initiative may be achieved.

On the whole, both propositions could create or extract value from the elements they would be coordinating by:

- Educating the productive sector for the value biotechnology is to them.
- Engaging stakeholders to work together to bring about long-term sustainable growth of the industry.
- Identifying what mix of local and global leadership is required to foster business opportunities.
- Distributing relevant information (market information, technological trends, commercial opportunities, etc.) across the different units.
- Reducing bureaucracy or implementing more functional skills.
- Focusing the efforts (Research and Development, market research, IP management, etc.) of the units towards more aggressive bio-business goals.
- Recruiting or training project managers that could effectively turn particular business opportunities into biotechnology companies.
- Helping the units to establish the appropriate alliances and collaborations with relevant partners and institutions.
- Encouraging and supporting networking activities.
- Marketing and promoting the biotechnology projects that would be developed at the units.

Moreover, both strategies are based upon organisations that have been designed as flexible and bureaucratic-free

institutions. Therefore, quick implementation and termination as well as, virtual management are some of the key features that give them real value in terms of their ability to attract investment, in particular, tax incentives from private corporations through different tools like the university donation law.

Regarding the expected cost of implementing these Strategies, the financial analysis of the Business Enhancer proposition showed that with US\$1,750,000 this entity would be able to secure 5 years of operations including the assets and salaries needed to run an organisation with 30 to 50 employees.

For the Consortium Strategy, US\$ 5,000,000 would be needed per Consortium, *i.e.* Mining, Forestry, etc. to secure 5 years of operations including the assets, salaries and Research and Development budget needed to run an organisation that would outsource its research and development activities and would have 10 to 30 employees.

Essentially, such investments would support the assets and salaries required to create an institution that would be able to deliver new biotechnology companies and patents, increase the number of highly qualified personnel working in biotechnology, improve the scientific innovation of the industry, complement the competitive advantages of the main productive sectors of the Chilean economy and boost the turnover of the biotechnology companies that already exist in Chile.

Finally, it is recommended that government should triple both, the Research and Development budget for biotechnology initiatives and the grants available for PhD studies in Chile and in foreign countries. With such approach, Chile may be in a realistic position to develop, in the short term, a sound scientific base that would seize biotechnology opportunities turning them into businesses that may contribute innovation and wealth to the nation.

To conclude, strategic schemes for the development of the Chilean Biotechnology industry have been proposed. However, these plans may be the first step of a challenging road towards biotechnology development in Chile. Undoubtedly, bigger challenges would arise when the suggested recommendations have been implemented. Therefore, permanent effort, commitment, coordination, motivation and support, from a number of stakeholders involved with this sector, would be required to successfully ensure long lasting development of the Chilean biotechnology industry.

REFERENCES

BUSTAMANTE, P.I. and BOWRA, S. Biotechnology in developing countries: harnessing the potential of high-

TECH SMES in the face of global competition. *Electronic Journal of Biotechnology* [online]. 15 December 2002, vol. 5, no. 3 [cited 27 May 2003]. Available from Internet: <http://www.ejbiotechnology.info/content/vol5/issue3/issues/01/index.html>. ISSN: 0717 3458.

COLLIS, D.J. and MONTGOMERY, C.A. Competing on Resources, Strategy in the 1990s. In: *Harvard Business Review on Corporate Strategy*. 1999, p. 33-62. ISBN 1-57851-142-9.

DA SILVA, E.J.; BAYDOUN, E. and BADRAN, A. Biotechnology and the developing world. *Electronic Journal of Biotechnology* [online]. 15 April 2002, vol. 5, no. 1 [cited 1 June 2003] Available from Internet: <http://www.ejbiotechnology.info/content/vol5/issue1/full/1/index.html>. ISSN: 0717 3458.

DORNBERGER. U. Empresas Biotecnológicas en Chile (Estudio 1999). University of Leipzig, Small Enterprise Promotion and Training SEPT, Germany, 1999. 20 p.

GIL, L.; MARTINEZ, V. and DORNBERGER, U. Caracterización de la Industria Biotecnológica en Chile, 2002, CambioTec-Chile, 76 p.

GIL, L.; MARTINEZ, V. and DORNBERGER. U. Una Visión Actual de la Biotecnología en Chile, November 2001, CambioTec-Chile. 50 p.

HOLM-NIELSEN, L. and AGAPITOVA, N. Chile – Science, Technology and Innovation. *Department of Human Development, The World Bank Latin America and the Caribbean Regional Office*, December 2002. Portable Document Format. Available from Internet: <http://wbln0018.worldbank.org/lac/lacinfoclient.nsf/>.

ROTA, G. and IZQUIERDO, J. "Comics" as a tool for teaching biotechnology in primary schools. *Electronic Journal of Biotechnology* [online]. 15 August 2003, vol. 6, no. 2. [cited 10 April 2004]. Available from Internet: <http://www.ejbiotechnology.info/content/vol6/issue2/issues/2/index.html>. ISSN 0717-3458.

SOLLEIRO, J.L and CASTAÑON, R. Technological strategies of successful Latin American biotechnological firms. *Electronic Journal of Biotechnology* [online]. 15 April 1999, vol. 2, no. 1 [cited 27 May 2003]. Available from Internet: <http://www.ejbiotechnology.info/content/vol2/issue1/full/4/index.html>. ISSN: 0717-3458.

VALENZUELA, P.D.T. La estrategia de los consorcios. *Revista Universitaria Chile*, 2003, no. 81, p. 44-47. Portable Document Format. Available from Internet: http://www.puc.cl/ru/81/pdf/81_dossier_3.pdf.