Chapter 4

THE ROLE OF GOVERNMENT

For a long time, Chile's innovation system was rudimentary, having developed through a series of *ad hoc* decisions in the absence of a strategic vision for the role of innovation in economic development and for the role of government in its promotion. It consisted mainly of a funding agency which supported mostly academic research and financed scholarships and a set of publicly owned or funded technological institutes that performed public missions and provided some technological services to the industrial and agricultural sectors. A turning point occurred in the early 1990s, following the reestablishment of democracy, when policies explicitly aimed at strengthening capabilities in the areas of science, technology and innovation in the various sectors of production were first introduced. Chile is currently going through a new, probably more fundamental, transition. A growing political awareness of the importance of innovation for the country's further catching-up has motivated three bold decisions: the creation of an Innovation Council for Competitiveness entrusted with the mission of proposing guidelines for a long-term national innovation strategy; the introduction of a specific mining tax to increase resources available to implement this strategy; and the introduction of an R&D tax incentive to motivate private-sector participation.

This chapter first briefly reviews the evolution of Chile's innovation policy and then describes and assesses the support of innovation by Chile's government and government agencies.

4.1. The evolution of Chile's innovation policy

4.1.1. The initial phase

Chile's initial efforts in research and development (R&D) date from the 1960s, when the first public technological institutes were founded; the university system was strengthened through the creation of regional campuses; and CONICYT, the National Commission for Science and Technology research, was created. The aim was capacity building in the public sector through direct public funding but there were no mechanisms to gear such allocation to the needs of businesses.

A true research and innovation policy, which sought to address identified market and system failures, emerged at the beginning of the 1990s, with the creation of matching funds that were available to universities, companies and other public and private organisations. The most important new initiative was the Science and Technology Programme (PCT) (1992-95), set up with Inter-American Development Bank (IDB) resources.[36] The programme's main objective was to foster technological innovation in Chilean companies and strengthen R&D.

Two new entities were created: the Fondo Nacional de Desarrollo Tecnológico (FONTEC, National Technological Development Fund), part of CORFO (the Corporación de Fomento de la Producción, Chilean Economic Development Agency), whose purpose was to promote technological innovation in private enterprises by co-financing innovation projects carried out by the companies; and the Fondo de Fomento al Desarrollo Científico y Tecnológico (FONDEF, Scientific and Technological Development Promotion Fund) established under the Comisión Nacional de Investigación Científica y Tecnológica (CONICYT, National Commission for Scientific and Technological Research), whose purpose was to strengthen R&D capabilities and to improve technological infrastructure by co-financing pre-competitive projects carried out by universities and technological institutes jointly with private companies.[37]

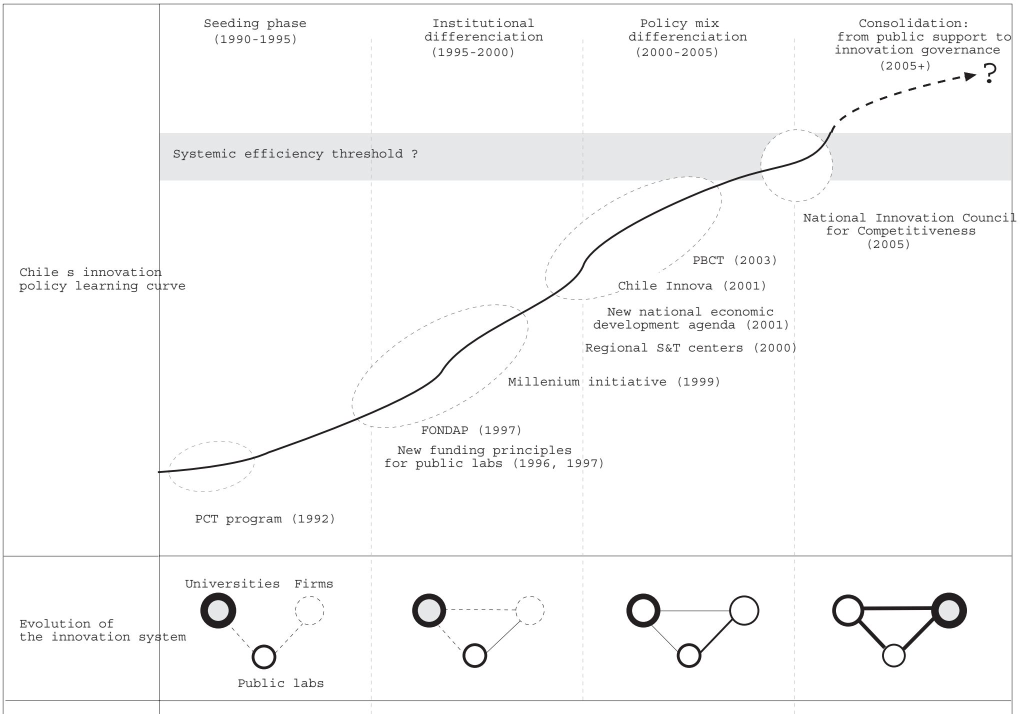
During that time, the funding model shifted from a direct type to a contestable one, based on competition among recipients without any discrimination between productive sectors or technology areas. The idea was to achieve an across-the-board increase in the number of companies participating in technology transfer, absorption and diffusion activities and to provide them with a supporting infrastructure (Teubal, 1998).

During this stage, which has been referred to as "a horizontal technology policy", the strategic objective was to create a critical mass of R&D and technological projects throughout the public and private sectors in order to initiate a collective, cumulative and multidisciplinary learning process.

36. The IDB approved a loan to the Chilean government of USD 67 million, which represented 36% of the total cost of the programme.

37. In addition, additional backing was given to the Fondo Nacional de Desarrollo Científico y Tecnológico (FONDECYT, the National Fund for Scientific and Technological Development, under CONICYT) which was geared toward basic research. This fund, created at the beginning of the 1980s, was, until that time, the only source of public financing for scientific and technological activity in the country.

Figure 4.1. Chile's innovation policy: the learning trajectory



	Seeding phase (1990-1995)	Institutional differenciation (1995-2000)	Policy mix differenciation (2000-2005)	Consolidation (2005+)
Trigger	First policy push	Growth of export-oriented industries		Second policy push
Type of learning	Assisted learning from foreign practices	Accelerated own learning from best practices in advanced countries plus elements of endogenous institutional learning		Endogenous national and institutional learning, including within the OECD community
Policy focus	Horizontal promotion of R&D projects through a pure bottom-up process	Engage firms; concentrate funding of scientific research on areas of excellence	Build stronger linkages between actors in targeted areas; improve specific framework conditions	Improve overall governance, streamline and prioritise
Funding instruments	Grants to individual projects; unconditional funding of public labs	Introduction of grants to research groups; new funding mechanisms for public labs	Development of consortia, emergence of a cluster-based approach	Introduction of a R&D tax incentive

The PCT ended in late 1995. It produced significant outcomes but also demonstrated several shortcomings. First, it failed to connect effectively activities carried out in the three main research spheres (universities, technological institutes and firms). Second, it had only a limited inducement power *vis-à-vis* the private sector; companies' innovation activities remained limited. Third, it failed to address the rapidly evolving needs of export industries which had to improve their competitiveness on increasingly dynamic and globalised markets, in order to derive more value added from the exploitation of Chile's natural resources.

Promoting what has been called a "second exporting stage" required policies to correct structural weaknesses in the industries concerned, notably the insufficient number of large, highly efficient world-class companies and the too large number of small and medium-sized enterprises (SMEs) that were not technologically oriented and unlikely to innovate.

4.1.2. First transition: institutional differentiation

During 1995-2000 various adjustments were made to R&D and innovation policy to improve its economic impact by increasing the participation of the private sector. Three goals were emphasised:

- To increase the involvement of private firms in research and innovation activities by: *i)* continuing to foster the emergence of a "critical mass" of innovative companies; and *ii)* articulating supply of and demand for innovation inputs by encouraging companies to become more active in co-operative activities, R&D contracts and purchase of technological services.
- To focus R&D on innovation, with three specific objectives: *i)* to encourage R&D projects that combine scientific excellence with economic relevance; *ii)* to promote pre-competitive R&D projects with a more immediate impact on productive sectors; *iii)* to support research with high spillovers, *i.e.* that would produce for economic players as well as for the public sector as a whole information that would be useful, reliable and up-to-date.
- To strengthen the national technology infrastructure by supporting the modernisation of public technological institutes, encouraging the creation of technological service companies, and promoting the formation of a network of public and private technological centres.

In line with the new objectives, the technological funds no longer took a purely horizontal approach. Competitive funding was organised by topic or sector in areas identified as particularly important for the country's development, such as underwater species, information and communication technologies (ICT), and biotechnology, among others.

One of the most important changes during this phase was the modification in 1996 of the criteria and mechanisms used to finance the public technological institutes run by CORFO. Such funding was made conditional on the achievement of specific goals ("performance contracts") and included a portion of self-financing. A new fund was created under CORFO, the Fondo Nacional de Interés Público (FONSIP, National Public Interest Fund), to implement these new principles. This fund later became the Fondo de Desarrollo e Innovación (FDI, Development and Innovation Fund) and was opened to other users, such as private technology institutes and companies, and later to universities. In 1997, two other technological institutes (INN and INFOR) ceased to receive core funding from the government and became mostly dependent on other sources of income, especially competitive funds and income from sale of services.[38]

The technology funds introduced new lines of financing aimed at improving the commercialisation of research results, including: the protection of industrial property, the development of business plans, product design, and marketing strategy in the case of FONDEF and the FDI's line of "entrepreneuriable" innovation projects.[39]

These efforts to increase the economic impact of public investment in R&D induced behavioural changes among beneficiaries, especially universities, which were encouraged to create or improve internal capabilities to manage research projects and to pay more attention to the economic value of research results, a dimension of academic research that had clearly been neglected.[40]

38. They continued to receive some government funding through an instrument called a Performance Agreement.

39. This line of support was introduced to correct a "technological novelty and feasibility" bias in the criteria used to select projects, emphasising more the commercial prospects and the managerial and entrepreneurial skills required to bring new technology to the market.

40. One of the historical causes of the very low level of patenting in Chile (one a year for every million inhabitants) is the restrictions set by FONDECYT which, in addition to giving priority to the number and quality of scientific publications over patents, imposed an obligation to return the funds awarded to the project if any of the results were patented. This has left its mark on the university culture even to today.

Box 4.1. Sector-specific R&D and innovation funds

The Fundación para la Innovación Agraria (FIA, Agrarian Innovation Foundation), is a private foundation created by the Ministry of Agriculture. Its primary goal is to promote changes in the country's agriculture and rural economy. It stimulates the development of competitive advantages in the agricultural production system by modernising productive systems, developing and implementing new technologies and products, diversifying production, helping in the commercialisation of forestry and agriculture production on domestic and international markets, increasing product quality, and ensuring the sustainability of productive processes.

The mission of the Fondo de Investigación Minera (FIM, Mining Research Fund), created in 1996 under the Centro de Investigaciones Minero Metalúrgicas (CIMM, Mining Metallurgy Research Centre), is to finance scientific research on copper and its by-products. It is funded by both public and private mining companies.

The Fondo de Investigación Pesquera (FIP, Fishery Research Fund) was created in 1991 under the General Fishing and Aquaculture Law. Its purpose is to finance fishing and aquaculture research projects whose results will help in the management of fisheries and aquaculture businesses and the conservation of hydro-biological resources. It is funded from the national budget and from fishery and aquaculture licences.

Another important new development during this stage was the recognition of the regional dimension. Thus, in 2000, CONICYT launched a new financing mechanism, the Programa Regional de Desarrollo Científico y Tecnológico (the Regional Programme for Scientific and Technological Development) to create scientific and technological centres throughout the country in conjunction with regional governments, universities and private enterprise. Another aspect of the institutional differentiation which characterised this period was the consolidation and creation of sector-specific innovation funds and the launch of two programmes to concentrate scientific research efforts in areas in which Chile showed the greatest potential. Under CONICYT was created the Programas de Investigación Avanzada en Areas Prioritarias (FONDAP, Programmes for Advanced Research in Priority Areas), which gave birth to the Centros de Excelencia (Centres of Excellence). Surprisingly to foreign eyes, this programme was complemented by the Iniciativa Científica Milenio (Millennium Scientific Project), placed under the Ministry of Planning (MIDEPLAN), which had quite similar rationale and goals.

4.1.3. Second transition: rebalancing the policy mix through further institutional differentiation

In 2001, the new national economic development agenda, which aims to transform the country into a developed economy within ten years, identified the reinforcement of science, technology and innovation capabilities as one of six priorities and therefore stimulated to several new developments in innovation policy.

As a result, CORFO's FDI underwent a major transformation which, following a merger with FONTEC, gave rise to the Innova Chile programme which was established to provide support to private enterprise's efforts in a wide range of activities: *i)* pre-competitive and public interest innovation; *ii)* business innovation; *iii)* technology diffusion and transfer; and *iv)* entrepreneurship. In addition, Innova Chile set up interconnected departments with a sectoral focus on mining, biotechnology, food industry, tourism, infrastructure and energy, and ICTs, with a view to promoting a shared strategic vision among stakeholders, screen new opportunities for technological innovation and development, activate demand for new projects, and monitor the achievements of relevant programmes.

Another new initiative was the launch under CONYCIT of the Programa Bicentenario de Ciencia y Tecnología (PBCT, Bicentennial Science and Technology Programme) financed in part by a World Bank loan. The purpose of this programme is to assist in the transition to a knowledge-based economy and society by developing an effective innovation system. It has three components: *i)* improve Chile's science, technology and innovation system so that it has a major impact on the development of policies and creates an environment conducive to innovation in Chile; *ii)* strengthen the science base, including the research infrastructure and the ability to access new findings in other countries; and *iii)* promote relationships between the public and private sectors at the national and international levels.

In 2001, the Technological Innovation and Development Programme (PDIT or Chile Innova) (2001-06) was set up. Its mission was to help increase competitiveness and support innovation and technological development in strategic areas of the national economy, especially among SMEs that produce goods or services. The PDIT has contributed significantly to creating spaces for inter-institutional interaction and dialogue among the agents through which the programme has operated (CORFO, CONICYT, FIA, INN and Fundación Chile). In addition, it has helped to set priorities for S&T policies. The programme has also contributed to the modernisation of Chilean companies, especially SMEs (mainly through quality improvements, environmentally clean production and the introduction of information technologies).

A shift gradually took place in the overall policy mix and instrument toolkit to make government support more responsive to the requirements of activities and sectors of strategic importance. This involved some re-balancing between horizontal, non-discriminatory support, and more selective approaches to leverage comparative advantages through joint development of sector-specific technological capacities and the diffusion of enabling technologies such as biotechnology, ICTs, clean production and quality management. This also involved complementing financial support by measures to foster human resource development and innovation management.

As a result, a cluster-based approach to innovation policy began to take shape, following a path successfully pioneered by Fundación Chile. Policy makers realised that a bottom-up, project-based approach to the selection of priorities was at odds with the productive structure in which dynamic "clusters" had arisen, such as the aquaculture industry in general and salmon fish-farming in particular, and the wine and fruit industries, to name the most famous. The main ensuing challenge was two-fold: devise ways to facilitate collective action on the part of companies and provide customised support "packages" from several funds. Some of them, particularly FONDEF, FDI, and FIA, began to work together to finance technology consortium types of projects.

There was also greater recognition of the importance of some framework conditions for innovation other than macroeconomic stability and competition, especially specialised financial markets and intellectual property rights (IPR). Realising that conventional CORFO and CONYCIT funding could no longer be considered a satisfactory mechanism for boosting technology-based entrepreneurship, the government initiated new measures, inspired by international best practices, to address the shortage of seed and risk capital (see Box 3.2 in Chapter 3). Chile's Industrial Property Law was adapted in 2005 to meet the requirements of the Agreement on Trade-related Intellectual Property Rights (TRIPS agreement) and an Industrial Property Court was created.

4.1.4. Ongoing transition: moving from public support to innovation governance

In spite of the considerable progress made during the last decade there is a wide consensus among stakeholders that Chile's innovation system has not yet reached a satisfactory level of efficiency, although opinions vary regarding some aspects of the diagnosis. Another consensual idea is that the root of the problem is the absence of coherent overall governance of the innovation system, which creates a "silo effect" whereby multiple funds and instruments both overlap and leave certain needs unanswered, while at the same time many may not have in any case the size necessary to have a real impact. Creating a proper institutional framework to design an overall strategy and to co-ordinate, monitor and evaluate its implementation is now considered a priority objective.

4.2. Governance and policy mix

4.2.1. Governance

Chile has not so far had a formal mechanism for defining an explicit strategy, translating it into priorities and guiding its implementation. The priorities have been defined in a relatively decentralised manner by agencies such as CORFO in the Ministry of Economy, CONICYT in the Ministry of Education and FIA in the Ministry of Agriculture. Other ministries such as Health and Planning have played a comparatively minor role. Of course, some degree of co-ordination does exist at the programme level and to a lesser extent across agencies but this is not a good substitute for high-level steering of the system.[41] It may even have perverse effects since individual agencies have a natural tendency to appropriate what they perceive as the national policy agenda to serve their constituency at the expense of others.

For example, the Ministry of Economy has played an important role in the co-ordination of multifaceted governmental initiatives to promote innovation in the business sector by means of three programmes established under its auspices during the last 15 years: the PCT (the Science and Technology Programme) (1992-95), the PIT (the Technology Innovation Programme)[42] (1996-2000) and the PDIT (2001-06) (The Technological Innovation and Development Programme, known since 2003 as Innova Chile).[43] However, none of these programmes has been really successful in inducing more R&D-based innovation by firms, partly because CORFO's culture mirrors the dominant business culture and its responsiveness to its "clients", at least those able to articulate their needs, can lead to some conservatism. Another example is the PBCT[44] (2003-10) which has been launched under CONICYT with the very broad ambition to "guide the country in the process of transforming itself into a knowledge economy".

41. The cross-presence of directors in the governing boards of various funds and other communication channels helps co-ordinate the operations of the various institutions.

42. Science and Technology Program.

43. The co-ordination scope of these programmes was reduced since they accounted for a small share (10% in the case of PDIT) of the funds assigned to CORFO and CONICYT.

44. Programa de Ciencia para la Economía del Conocimiento. Also known as Programa Bicentenario de Ciencia y Tecnología.

However, CONICYT is not necessarily well placed to implement the part of this agenda that requires serious participation by business firms, including the consortium component.

Box 4.2. The Science and Technology Policy Council of Finland

The Science and Technology Policy Council of Finland (STPC) was established in 1987 as "successor" to the Science Policy Council (established in 1963). It functions as a high-level political body for the formulation of Finnish science and technology policy guidelines and it is the main inter-ministerial body for co-ordinating and integrating science and technology activities. Its main tasks are to advise the government and the ministries, to prepare proposals and reviews for the Council of State and the ministries, to issue statements on the allocation of public funds to science and technology and to act as an expert body for questions relating to science and technology. Though it only participates in drafting science, technology and innovation policy and legislation by formulating guidelines and national strategies, as it formally has only an advisory capacity, the Council is mainly responsible for the strategic development of Finnish science, technology and innovation policy.

The members of the STPC, which is chaired by the Prime Minister, are the Minister of Education and Science, the Minister of Trade and Industry, the Minister of Finance, and up to four other ministers. Further, the membership includes ten other members with a stake in science, technology and innovation policy, including representatives from the Academy of Finland, the National Technology Agency of Finland, universities and industry as well as employers' and employees' organisations. They are appointed by the Council of State for three years. This corporatist structure is based on the Finnish tradition of decision making and consensus building and ensures broad-based discussion among stakeholders and thus support for policies, which not least ensures their smooth implementation. The STPC functions as a forum for discussion in which policy makers and main stakeholders develop a common political understanding and vision of the Finnish education and science, technology and innovation system. The STPC has two subcommittees with preparatory tasks: the science policy subcommittee, chaired by the Minister of Education and Science, and the technology policy subcommittee, chaired by the Minister of Trade and Industry. In addition the Council's subcommittees draw on the knowledge and the advice of two experts each.

The Council's strategic guidelines and issue statements are published in a science and technology policy review every three years. These policy papers analyse past developments, draw conclusions and make proposals for the future. For example, in its review of 1990 the STPC promoted the concept of a national innovation system, being understood as a complete set of public and private factors influencing the development and utilisation of new knowledge and know-how. Following several OECD recommendations, the concept of knowledge-based society was launched in 1996. In its review "Knowledge, Innovation and Internationalisation 2002" the Council stresses the importance of the rapidly internationalising innovation framework and the pressures for structural and operational change in Finland. Thus, the need for increased government R&D expenditures was urged. Public funding should increase faster than the estimated growth in GDP, which would mean an increase of EUR 300 million from the 2002 level until 2007. The money is to be allocated to promising Finnish research areas such as life sciences, environmental technologies, ICT and health and to knowledge-intensive service sectors.

Source: Berghell and Kiander (2003); European Commission (2004); Lemola (2002); SATW (2004); Seppälä (2002).

Devolving policy functions to funding agencies is not a good idea. Many OECD countries have struggled or are still struggling with the consequences of this confusion of roles. It is wise to rigorously separate policy from delivery. It is somewhat surprising that in Chile, where a strong economic culture is pervasive among public servants in charge of macroeconomic policy, thinking about innovation policy seems so far to have had little theoretical underpinning, such as agency theory, public choice theory and new public management concepts.

In this context, some recent decisions of the Chilean government are particularly opportune and in line with best international practices (see Box 4.2 for an example). At the end of 2005 a draft law was sent to Congress that creates two new components in the Chilean NIS: the Consejo Nacional de Innovación para la Competitividad (the National Innovation Council for Competitiveness) and the National Innovation Fund for Competitiveness. Pending Congress's approval, a temporary Innovation Council for Competitiveness was created by decree at the end of 2005.

The interim Council was given the mission to propose guidelines for a 12-year national innovation strategy for competitiveness; measures to strengthen the Chilean innovation system and the effectiveness of public policies or instruments; and some allocation criteria for resources in the 2006 budget that had not yet been allocated to specific expenses, notably the income from the mining tax (see Box 4.3). This mission was renewed in April 2006 by the new government.

Box 4.3. The mining tax

The law that establishes a specific tax on mining activities came in force on 1 January 2006. This tax is levied on mining companies whose sales are equal to or greater than the equivalent value of 12 000 metric tons of fine copper (MFT) in accordance with the following schedule.

Bracket of annual sales in MFT	Rate (%)
12 000 to 15 000	0.50
15 000 to 20 000	1
20 000 to 25 000	1.5
25 000 to 30 000	2
30 000 to 35 000	2.5
35 000 to 40 000	3
40 000 to 50 000	4.5
Over 50 000	5

MFT is determined according to London Metal Exchange Grade A copper cash quotation, which is published, in domestic currency, within the first 30 days of every year by the Chilean Copper Commission.

When officially established, the Council will be an advisory body to the President of the Republic for all aspects related to innovation policies, including science, the formation of specialised human resources and the development, transfer and diffusion of technology. It will also provide a forum for facilitating dialogue among key players.

The Council could be the catalyst of an accelerated maturation of Chile's innovation system (Figure 4.1), provided that it is properly composed, institutionally positioned and equipped. OECD countries' experience in this field suggests that:

- Its composition, in terms of the number and institutional affiliation of members, should balance representativity and efficacy, in order to avoid capture by vested interests and ensure productive deliberations. It should comprise representative of all "communities" (government, industry, financial sector, academia and technological institutes), but at least one-third of the members should not have any responsibility for the management of innovation policy. Among "independent" members at least one should be foreign or at least a Chilean expatriate with a proven record in science, technology or innovation.
- Its institutional positioning should maximise its policy impact and guarantees its reputation as an impartial body that acts in the public interest.
- Its mandate and mode of operation should safeguard against the "talking shop" syndrome and encourage evidence-based approaches to policy assessment and advice.
- It should be backed by an executive secretariat with sufficient resources, steered by a reduced-scale executive board with the skills and financial means to carry out or commission independent studies and evaluation and implement a permanent monitoring system.

Its role in evaluation should be two-fold: to set quality standards and a framework for the evaluation of individual institutions, programmes and measures and to carry out thematic evaluations from a systemic perspective. Regarding the latter, the following tasks stand out as particularly important:

- Assessing the role of technological institutes in the innovation system and their steering mechanisms. These have evolved over time, at different paces and according to variable motivations and guiding principles. It would be timely for the government to get a clearer overview of the current situation in order to decide whether reforms would be warranted to increase these institutes' contribution to national innovation performance.

- Assessing the combined efficiency of existing programmes and measures, including key framework conditions (*e.g.* IPR), to promote commercialisation of university research through mobility of researchers, patenting and licensing, research contracts and spin-offs.
- Assessing the supply of and demand for the specialised human resources needed for innovation, with a special focus on the role of engineering sciences, with a view in particular to determining a good model of more fruitful public-private co-operation in this area.
- Assessing the scope for a fully fledged cluster approach to innovation policies by: evaluating the current portfolio of programmes in order to promote consortia and firm networking; mapping existing and latent innovative clusters; extracting lessons from successful experience in Chile and abroad (Box 4.4); and determining how further decentralisation of innovation policy could be achieved.
- Assessing international linkages (from foreign direct investment to scholarships) to determine ways of intensifying those likely to make the greatest contribution to the whole innovation system.

A very important new tool for implementing a more coherent policy is the Innovation for Competitiveness Fund (FIC). In 2006 it received a very substantial CLP 43 432 million, which represents almost one-quarter of the total budget outlays for R&D four years earlier. Its budget for 2007 was increased to CLP 52 760 million (Table 4.1). This makes it possible to translate policy priorities into sizeable incremental changes in the allocation of funds among existing structures. More importantly, this fund has the potential to be an "agent of structural change" that could induce deeper, dynamic structural adjustments in the system, helping to provide the public support system a more strategic focus. To that purpose, one option might be for the FIC to absorb all public funds targeted at innovation. Another, which would preserve some degree of institutional differentiation, while taking advantage of experience accumulated by existing funding agencies in dealing with some stakeholders, would be to structure and manage FIC following the venture capital industry's model of a "Fund of Funds", with of course the adaptations required to comply with public finance regulations and to fulfil its public interest mission.

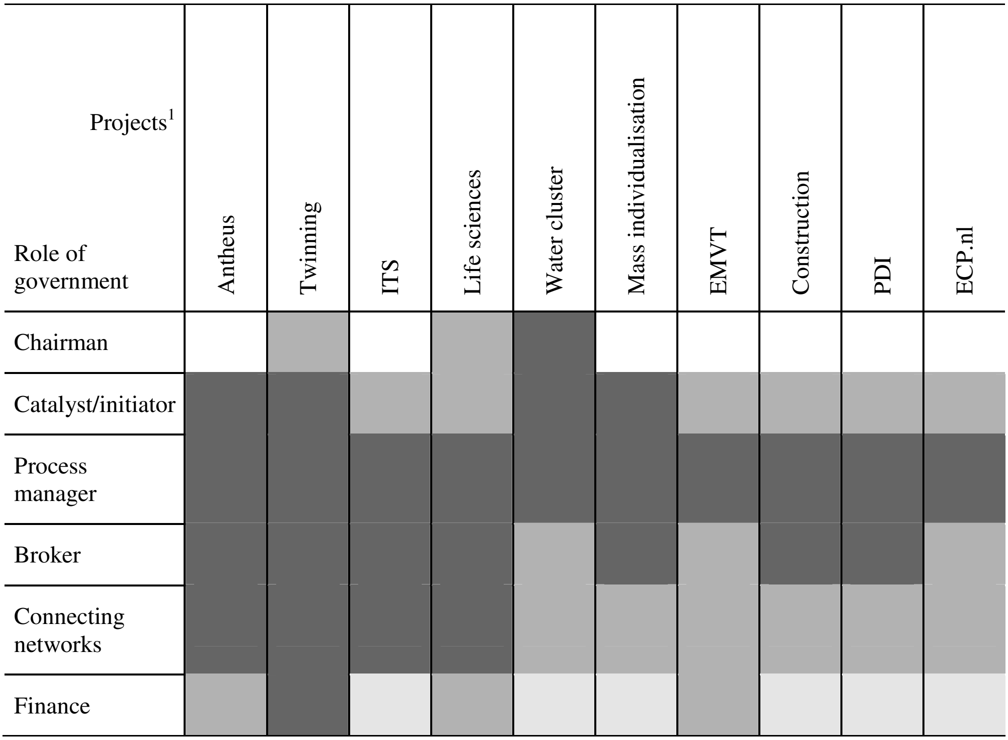
Box 4.4. Cluster-based innovation policy: some lessons from OECD countries' experience

Governments can nurture the development of innovative clusters primarily through regional and local policies and programmes to stimulate knowledge exchange, reduce information failures and strengthen co-operation among firms and between firms and knowledge institutions. More direct policy tools can be used at the national level to encourage cluster formation and development, such as public-private partnerships for R&D, public procurement and competition for government funding to provide incentives for firm networks to organise themselves on a regional basis. OECD work suggests that efficient cluster policies:

- Build a shared vision, based on a sound diagnosis of initial conditions, and ensure a vibrant dialogue between industry and government in defining and implementing the cluster development strategy.
- Catalyse rather than plan local development by bringing actors together and supplying enabling infrastructures and incentives.
- "Back and empower local leaders" instead of trying to "pick winners".
- Improve availability and access to key resources (skilled people, R&D, physical and "intangible" infrastructure, smart money).
- Avoid "high-technology" or "manufacturing" myopia by recognising the importance of knowledge-intensive services and of the technological upgrading of traditional industries for an innovation-led growth.
- Build on existing innovation networks, but keep incentive schemes open and attractive to outsiders, especially new firms.
- Customise policy approaches to fit the specific needs of different industry and technological fields. Depending on a cluster's characteristics, government plays a variable role in addressing the following problems: lack of interaction; information imperfections; mismatch between knowledge infrastructure and business needs; lack of demanding customers (see table below).
- Leverage regional resources through interregional co-operation and participation in national and international innovation initiatives.
- Allow experimentation and learning by doing in an area with a good deal of scope for improved international diffusion of good practices.

Box 4.4. Cluster-based innovation policy: some lessons from OECD countries' experience *(continued)*

A "customised" cluster policy in the Netherlands



Note: White = no role; grey = role.

1. Antheus is a regional cluster project at the micro level, aimed at increasing co-operation between a large aluminium plant and the smaller (aluminium-using) firms surrounding it. ITS stands for Intelligent Transport Systems. EMVT is the Dutch abbreviation for Electro Magnetic Power Technology. PDI stands for Product Data Interchange, a project mainly aimed at supporting this technology in the chemicals cluster.

Source: Gilsing in OECD (2001b).

Table 4.1. FIC 2007 budget

Budget line	CLP millions	Percentage of total
Public interest innovation	8 390	16%
Formation of human capital	8 961	17%
Fostering science and technology	19 168	36%
Business innovation	10 085	19%
Internationalisation of innovation	2 571	5%
Raising awareness of innovation	2 699	5%
Other	885	2%
Total	52 759	100%

Source: Consejo Nacional de Innovación para la Competitividad.

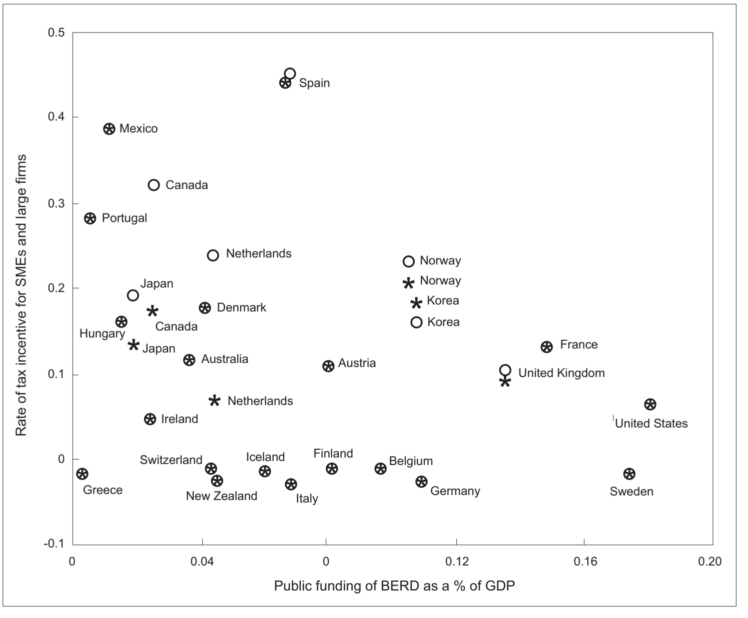
4.2.2. Policy mix

Chile's innovation policy mix shows quite strong disequilibria. These reflect structural features, notably the dominant role of universities in the performance of R&D, discussed in preceding chapters, but also policy choices regarding priority objectives and preferred instruments. Regarding the latter, two problematic features should be highlighted.

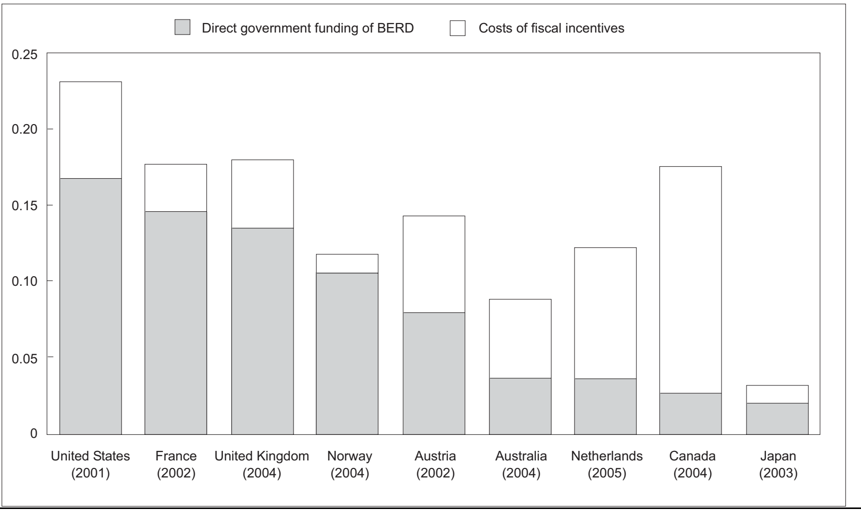
First, the emphasis has been on R&D rather than on knowledge diffusion and technology-based entrepreneurship, even if Innova Chile has recently been more active in these areas. Second, project-based schemes, as opposed to programme-based support, represent the lion's share of overall public expenditure for R&D. Third, compared to most OECD countries (Box 4.5) Chile's mix of instruments to promote business R&D in the business sector has been tilted towards direct government support. Currently R&D spending is deductible against corporate income tax liabilities, as is one-half of donations to universities. The bulk of public support takes the form of competitive grants through a multiplicity of funds (see section 4.3).

Box 4.5. OECD countries' policy mix to promote innovation in the business sector

Public financial support to firms' R&D, by instrument, 2004 or latest



Direct government funding of business R&D and tax incentives for R&D
As a % of GDP



Box 4.6. The new Chilean R&D tax incentive

The incentive consists of a corporate tax credit equal to 35% of the payments made to a "research centre" contracted to conduct R&D. The remaining 65% of the payment can be deducted as a cost for tax purposes. There is an upper limit to the size of the credit of 15% of the company's annual revenue. The incentive will be established for a period of ten years.

To obtain the tax benefit, CORFO, the Government's Development and Innovation Agency, has to certify the R&D contract. The certification will consist of a simplified process whereby CORFO only checks that the tasks in the contract are in fact R&D, as defined in the law, and that the research centre has the capability and resources to conduct the required activities.

Research centres may be part of a university, they may be part of a firm or they may also be private non-university stand-alone research centres. To conduct R&D subject to the tax benefit, the research centres must obtain an initial authorisation from CORFO. The tax benefit cannot be obtained by firms that contract with research centres that belong to them or to related parties. This restriction is established for two reasons: first, to avoid tax evasion, and second, to target the benefit to activities for which knowledge spillovers and externalities will be maximised.

The law requires biannual evaluations and a more complete one at the eighth year. These evaluations will provide information about the benefits and problems of the tax incentive so that it can be corrected, if necessary, and it will allow the government decide whether it should continue once the ten-year deadline has been reached.

This is about to change since, following a lengthy debate, the government has introduced a tax incentive for private R&D.

This decision, in its principle, conforms to practices in a majority of OECD countries. It sends a strong signal about government commitment to research and innovation to the business community since it implies overcoming the *Hacienda's* (Treasury) well-known reluctance to complicate further the overall tax system. The design of the proposed tax incentive (Box 4.6) is quite unusual by OECD country standard (Tables 4.2 and 4.3) and seems to reflect: *i)* a compromise between the "believers in tax credits" and the "sceptics" since the proposed scheme excludes own R&D and thus limits the possible extent of deadweight losses; *ii)* a willingness to promote interaction within the innovation system since the scheme supports R&D contracts; and *iii)* the immaturity of the business R&D culture since the scheme, in particular the certification procedure, is less straightforward than those applied in various OECD countries.

Table 4.2. Tax support to R&D – a decision tree

Policy choice		Practices (see Table 4.3)	Evaluation
Whether or not to use tax incentives for promoting R&D		Over two-thirds of total OECD business R&D expenditures benefit from tax incentives. Among the largest R&D performers, only Germany does not offer such incentives.	Tax incentives are cost-effective for increasing private R&D, but their inducement power is moderate and contingent on the level of corporate income tax. Their superiority over alternative uses of government resources is clear only with regard to non-selective subsidies. At an aggregate level the effectiveness of tax incentives tends to increase (decrease) with the decrease (increase) in R&D subsidies. For an R&D fiscal measure to induce substantial and worthwhile R&D at low cost to taxpayers, there must be high spillovers from the modest amount of induced R&D to generate net benefits. This is unlikely to be the case in countries where R&D activities are more concentrated in large firms operating in sectors where appropriability problems are less severe (*e.g.* oligopolistic industries).
If yes, choose between or combine	Volume-based scheme	Ten countries.	The most generous form of tax incentives. Appropriate as part of a catching-up strategy in terms of R&D intensity. But an effective inducement is achieved at high cost. The generosity of the scheme can be reduced as countries catch up. The generosity of support can be limited for large firms and eligible expenditure defined in a restrictive way (Netherlands). A switch to an incremental mechanism always needs to be given careful consideration.
	Incre-mental and mixed schemes	Ten countries.	More cost effective than volume-based schemes for increasing R&D. However, the effective rate of support varies considerably across industries and firms and the choice of the reference base for calculating eligible incremental R&D raises difficult problems. An incentive proportionate to the intensification of R&D efforts (as a % of turnover) is more cost-effective than one proportionate to the increase in R&D expenditure, unless the target is to favour fast-growing young SMEs.
Target or grant favourable treatment to certain types of research, sector or firm		Nine countries give preferential treatment to SMEs. Only a few offer specific tax incentives for basic research, "priority technology areas" or co-operative research.	Preferential treatment of SMEs might be justified on the grounds that small firms are more affected than large ones by liquidity constraints stemming from capital market failures. However, it is difficult to design a scheme which will meet the various needs of all types of SMEs, as demonstrated by a relatively low participation rate in some countries. The quality of the financial and infrastructural environment of SMEs varies greatly. R&D tax incentives can be seen as a transitory remedy which may become less effective as the business environment improves. Ceiling on benefits of general schemes can make them more generous to smaller firms. Superior targeted grant-based policy tools exist to provide capital to start-ups as well as to promote specific technologies or basic research.

Table 4.3. R&D tax incentives in OECD countries, 2005

	Large firms		Special treatment for SMEs	
	Tax credit	**Tax allowance**	**Tax credit**	**Tax allowance**
Volume	Canada (20%) Japan (8-10%) Mexico (20%) Netherlands (14%) **Norway** (18%)	Belgium (113.5%) Czech Republic (200%) Denmark (150%) **Poland** (130%)[1] **United Kingdom** (125%)	Canada (25%) Italy (30%) Japan (15%) Netherlands (42%) **Norway (20%)**	Belgium (118%) **Poland** (150%)* **United Kingdom** (150%)
Combination (volume/incremental)	France (5%-45%) Korea (7%-40%) Portugal (20%-50%) Spain (30%-50%)[1]	Australia (125%-175%) Austria (125%-135%) Hungary (100%-300%)	Korea (15%-50%)	
Incremental	Ireland (20%) United States (20%)			
None	Finland Iceland Switzerland Turkey	Germany Luxembourg Slovak Republic	Greece New Zealand (under consideration) Sweden	

Country in bold indicates incentive introduced after 2000.
1. Only for enterprises that obtain at least 50% of their income from the sale of their R&D results.

It should be noted that the introduction of an R&D tax incentive is part of a broader effort to make the tax system more innovation-friendly. Chile has recently reduced the tax rate on some goods and services that increase the knowledge base. Income generated in Chile by foreign residents is subject to the "additional tax" (a withholding tax). Although the general "additional tax" rate is 35%, there are other tax rates for some specific activities. For instance, software imports were subject to an "additional tax" rate of 30% if the product was standardised and 20% if it was custom-made. Since 1 January 2007, in order to promote the diffusion and adoption of new technologies, the additional tax rate charged for knowledge-related services was reduced to a uniform 15%. Table 4.4 shows the previous and the new tax rates for the types of activities considered very important for the country's development since they involve technology transfer from abroad that directly benefits Chilean companies' productivity and competitiveness.

Table 4.4. Tax treatment of knowledge-related services

Category	Former tax rate	New tax rate
Patents	30%	15%
Utility models	30%	15%
Industrial designs	30%	15%
Integrated circuit designs	30%	15%
Vegetable varieties	30%	15%
Standardised software	30%	15%
Technical consulting	20%	15%
Engineering work	20%	15%
Custom-made software	20%	15%

4.3. Portfolio of instruments

4.3.1. Funding agencies, funds and programmes

As already mentioned, innovation policy in Chile is implemented through a number of generally small funds and programmes managed by a few essentially independent agencies, mainly CONYCIT, under the Ministry of Education, and CORFO, under the Ministry of Economy. Access to all funds and programmes is through public tenders. Projects are selected according to criteria which are specific to each fund/programme. When applicable, eligibility requires private-sector partnership. The main funds and programmes are listed in Table 4.5. Box 4.7 briefly describes other related policies.

Table 4.5. Main funds and programmes to support R&D and innovation in Chile[1]

	Created	Ministry	Mission
Funds			
Innova Chile	2005	Economy	Contribute to increase the competitiveness of the Chilean economy by promoting and facilitating innovation in firms, promoting entrepreneurship, and strengthening the national system of innovation.
FONDECYT	1981	Education	Support basic scientific and technological research in all areas of knowledge.
FONDEF	1991	Education	Encourage universities and technological institutes to co-operate with industry in R&D projects.
FIA	1981 (reactivated in 1994)	Agriculture	Promote science and innovation processes relevant for the agricultural sector.
FIP	1991	Economy and Energy	Support scientific research and technical work relevant to the management of fishing resources.
INNOVA Bío-Bío	2002	Economy and Interior	Promote innovation and transfer of technology in the Bío-Bío region.
Science and technology programmes			
Technological Development and Innovation Programme	2001	Economy (with Education and Agriculture)	Increase competitiveness of SMEs by supporting innovation in ICT, biotechnology and new technologies. It aims to articulate and co-ordinate the various public innovation support mechanisms used by different institutions (CORFO, CONICYT, FIA, INN and Fundación Chile). It ended in 2005.
FONDAP	1997	Education	Support groups of researchers in centres of excellence with a view to achieving critical mass in some areas (seven ongoing centres)
Millennium Scientific Initiative	1999	Planning	Support scientific institutes and nuclei of excellence in various disciplines and areas (there are currently three institutes and 12 nuclei). Objectives very similar to FONDAP.
Science for the Knowledge Economy (PBCT)	2003	Education	Encourage interaction between public and private innovators and develop human capital directed at science and technology (supported by the World Bank).
Explora	1995	Education	Disseminate scientific and technological developments among children and youth.
Scholarships (CONICYT, President of the Republic,[2] and MECESUP)	..	Education and Planning[2]	Promote the development of Master's and PhD programmes. Foster specialisations abroad for Master's, PhD and specialisation studies for civil servants, academics and recent graduates of universities or professional institutes.

1. The newly created National Innovation Fund for Competitiveness (FIC) is not included, since its institutional positioning and precise mandate is not yet clear.

2. It is likely that the President of the Republic scholarships will be soon transferred to the Ministry of Education (CONICYT).

Box 4.7. Other innovation-related policies

Clean production policy

Clean production is a production and environmental strategy which has the double objective of increasing the competitiveness of companies and preventing emissions that can harm people's health and the environment. In 1997 the government announced a Clean Production Promotion Policy. A year later, the Ministry of Economy established a committee, composed of over 40 representatives from the public, private, academic and non-government sectors, which took part in the creation of the Clean Production Policy 2001-05. Chile thus took the lead in institutionalising clean production in Latin America. This policy is implemented within the framework of the Clean Production Programme of Chile Innova (PDIT) which promotes institutional strengthening, application of clean technologies within firms, and diffusion of good practices.

Biotechnology policy

Chile faces the challenge of advancing from traditional technology to modern uses of biotechnology: genetic engineering, bio-information technology and molecular biology, including with a view to creating new opportunities for production diversification and adding value in resource-based, export-oriented, industries.

The National Commission for Biotechnology Development was set up in June 2002. For ten months, over 200 players – public authorities, members of parliament, scientists and private-sector representatives – worked on defining the measures to be implemented to allow biotechnology to take off as a tool for production and social development. In addition, the ethical implications of transgenics and cloning were discussed, and the need to establish regulations was agreed. The Commission's report presented a complete diagnosis and a policy proposal which included a range of concrete initiatives.

On that basis, the government advanced a National Policy for Biotechnology Development. Its objective is to foster the development and application of biotechnology in Chile, especially in production sectors based on natural resources, with the goal of increasing the well-being and quality of life of citizens, contributing to the creation of wealth in the country, and ensuring the protection of health and environmental sustainability. During the two first years (2004-05) the focus was on structuring a sectoral innovation system tightly linking companies with universities to give the country leadership in certain niches of biotechnology in the medium term.

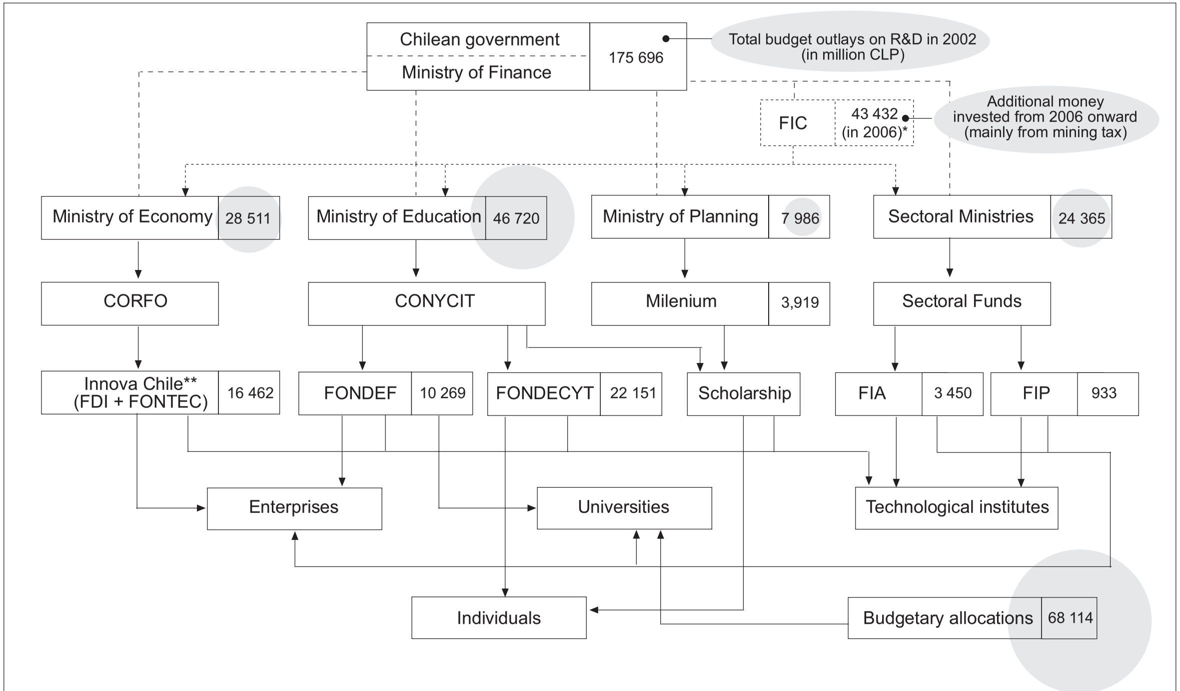
Digital Agenda (2004-06)

As a bicentennial objective, the government has stated its ambition to make Chile the Latin American leader in the use of ICTs for driving development. The connectivity figures for Chile were in this regard promising: at the end of 2003, 500 000 homes and 100 000 companies were connected to the Internet, as were almost the whole educational system and all of government, from La Moneda down to the municipalities.

At the beginning of 2003, representatives from the government, private and academic sectors formed the Digital Action Group to design proposals to reduce the poverty gap and promote the efficient use of ICTs in SMEs (Digital Action Group, 2004).

Today, Chile leads in digital development in Latin America. According to Harvard University's Networked Readiness Index (NRI), it rose at the global level from position 35 in 2005 to position 29 in 2006.

Figure 4.2. The institutional profile of Chile's innovation policy making



* FIC 2007 budget is 52 760. ** FDI and FONTEC were merged into *Innova Chile* in 2005.

Source: OECD, based on Ministry of Economy and CONICYT.

4.3.2. Agency co-ordination failures

Agency co-ordination, especially between CONICYT and CORFO, is a longstanding problem which has so far not received a satisfactory solution. It poses major challenges given that:

- Many funds and programmes are insufficiently differentiated in their objectives, rationale and desired types of outcomes. In fact, the tendency has been for each major agency to develop its own responses to all problems, resulting in a poor division of labour in the public support system.
- This existing division of labour is almost entirely based on the type of beneficiaries and does not reflect policy objectives and rationale.
- The form of incentives, rate of subsidisation and eligibility criteria are determined separately by each fund and their differences are often not justified on economic grounds.
- The internal capabilities, management style and culture are specific to each agency/fund.

Co-ordination through cross-cutting programmes, most notably the Technological Development and Innovation Programme, has largely failed. In fact, it has been limited to such functional aspects as systemising exchange of information on activities and projects, joint promotion of programmes, and sharing of information on results. Such an approach cannot by itself address all aspects of the problem.

Direct inter-agency co-ordination has also produced disappointing results:

- Top-down co-ordination through cross-participation in agency boards has not proven very effective.
- There are no established mechanisms for co-operation in designing programmes and mutual learning of best practices in their management; co-ordination remains spontaneous, voluntary and lacking in accountability.
- Funding mechanisms do not play their role in co-ordination since they are allocated through separate "pipelines".

Such shortcomings in inter-agency co-ordination are partly the result of the lack of a clear overall national innovation policy strategy, but they have also aggravated the consequences by creating various disequilibria in the policy instrument mix.

4.3.3. Fragmented, unbalanced and unfocused instrument mix

4.3.3.1. Lack of critical mass, duplication and blind spots

Public spending for R&D and innovation in Chile is important in relative terms, when compared to the level of private efforts, but limited in absolute terms. The multiplication of instruments unavoidably spreads resources too thin in every area of support, but particularly in the promotion of business innovation since a large fraction of public money for R&D is earmarked for basic research.

This fragmentation has been also encouraged by too hasty learning from good practices in advanced countries which encouraged the introduction of many measures in an institutional and policy context not entirely prepared to cope with the ensuing accelerated institutional differentiation. The period 1997-2005 was particularly "fertile" in new initiatives by the two main funding agencies (see Figure 4.1). The need to achieve critical mass in government support has consequently been neglected. This explains why many measures, evaluated positively in terms of individual projects' cost-benefit ratio, have had no significant impact on the competitiveness of firms, sectors or territories.

The problem has been compounded by duplication of effort owing to an uncertain division of labour among funding agencies. There are many cases of duplication, or at least unnecessary overlaps, such as the pre-competitive projects promoted in FONDEF (CONICYT) and FDI (now absorbed by CORFO's Innova Chile), or the promotion of centres of excellence in scientific research by the Millennium Initiative and FONDAP, to cite just two examples.

At the same time some of the most basic needs of numerous economic actors have largely not been met, as their satisfaction would have required actions which are: *i)* more difficult to articulate because they require inter-agency co-ordination, such as cluster-based policies; and/or *ii)* are less visible politically and less in demand by the usual clientele of funding agencies, such as measures to help the "silent majority" of SMEs to take the first step towards innovation; and/or *iii)* are less easy to handle by existing public agencies given their skills and "corporate culture".

Overall, one of the main problematic features of the current mix of instruments is that it offers uneven support to the different phases of innovation projects in different types of firms. The public system remains focused on the research stage of innovation in well-prepared companies. The early stage of capacity building in "could-be" innovative firms, and the obstacles encountered by "would-be" innovative firms in stages such as concept-to-prototype, industrialisation, and commercialisation are not sufficiently addressed.

4.3.3.2. Deficient articulation with sector-specific demand

Chile has a legacy of horizontal innovation policy approaches (see section 4.1.1 above), which was appropriate at a certain juncture in the development of its innovation system but may have been unduly prolonged under the influence of neo-classical economic thinking (the dissuasive "picking the winners" argument), and because of the limited ability of the current governance structure to devise and manage programmes with multiple objectives and stakeholders and involving different levels of government.

The question for Chile is not whether innovation policy should target some clusters of activities or firms' network, but rather how it can formulate and implement "clever selectivity" in practice. This does not of course preclude horizontal policies to capitalise on serendipity, to help firms from all sectors build on externalities from dynamic cluster developments and to upgrade innovation capabilities throughout the economy.

The connection between the innovation support system and the competitive development of productive sectors has been too weak for too long, even if institutions like Fundación Chile demonstrated quite early the feasibility of a cluster-based approach to the promotion of innovation, and even if public policy has been tilting in this direction in recent years: CORFO, CONICYT, the Ministry of Economy's efforts to identify strategic areas and the Programas Territoriales Integrados (Integrated Territorial Programmes). Such efforts are, and will remain for some time, constrained by the fact that regions are not well-equipped to play the role they should in the definition and implementation of relevant policies.

4.3.4. Evaluation and institutional learning

An evaluation culture is not lacking in Chile, but evaluation frameworks are underdeveloped and questions arise regarding the approach that should be taken to systemic evaluation.

Table 4.6. Evaluation of innovation policy instruments in the last decade

1997	Science and technology programme	Functioning of support funds
1998	CONICYT FDI FIA	FIP FONDECYT Scholarships of MIDEPLAN
1999	FDI	System of technological funds
2000	Millennium Initiatives	Technological Institutes
2001	Millennium	
2002	Explora of CONICYT	
2003	Millennium	Technological Innovation and Development Programme (mid-term evaluation)
2004	FDI FIP	High-technology Investment Programme of CORFO Institutes and nuclei of Millennium
2005	Chile Innova, sub-programme TIC FONTEC	Innova Bio Bio

Over the last ten years, a number of *ad hoc* evaluations have been carried out by national and foreign entities (Table 4.6). They analysed either the operation and effectiveness of public financing tools or the national innovation system as a whole. In general, they concluded that public funding has functioned properly in terms of quality of management, transparency and strictness of follow-up, and that it has yielded tangible benefits for the beneficiaries and for society as a whole. They also generally noted that public support to R&D and innovation has helped bring the research community and the productive sector into closer association, and more generally has increased awareness in Chile of the importance of science and technology. Some of these evaluations clearly pointed to the need for institutional reform in order to strengthen the government's ability to formulate and enforce a coherent national policy that would stimulate and guide science, technology, and innovation efforts more effectively towards the areas of greatest public interest.

Until now there has been no official permanent organisation in charge of monitoring and evaluating Chile's innovation policy, which is able to provide an overview of the system and assess progress towards increasing its overall consistency. Today, however, there is a consensus that such an evaluation body should be attached to the newly established National Council for Innovation for Competitiveness. The main question now is:

What approach should this future body take? The main observation to be made is that the evaluation of an innovation system still under construction, such as that of Chile, should not be carried out using simple international benchmarking methodologies since, from an evolutionary perspective, evolving institutional capabilities are a vitally important parameter. The level of such capabilities, in both the public and private spheres, determines at each point in time what can be expected from public policy and what cannot and, consequently, how to direct the search for international best practices. Dynamic learning processes increase these capabilities. The drivers of such processes should receive great attention (OECD, 2002).

4.3.4.1. Government agencies' capabilities

Chile is fortunate to have competent, dedicated and honest public servants. This social capital is a considerable asset which allows confidence about the responsibilities that can be entrusted to government bodies and the degree of sophistication with which these bodies can fulfil their tasks. There is only a small number of human resources with high-level technical expertise, experience and leadership but they are very mobile within the bureaucratic and political systems and they therefore act as efficient "learning vectors". Given this, while the capabilities of Chile's public organisations in charge of innovation policies lag behind those of many of their peers in OECD countries, they have in many respects reached a level of quality that others may envy.

Taking funding agencies as an example, one can highlight the following positive outcomes of successful learning:

- Good mastery of the basics of a transparent grant allocation process (project application, evaluation, selection, monitoring, follow-up and closure).
- A good record in achieving planned objectives and in fulfilling budget commitments.
- Relatively low administration costs.
- Increasing ability to reach deeper into the innovation system, notably to increase the participation of SMEs.

There are also limitations. In particular, evaluation of the financial aspects of projects remains problematic owing to a lack of skills. The procedures for processing and selecting applications are still slow and heavy. Responsiveness to feedback from beneficiaries is low. A bureaucratic culture, not only regulations, prevents outsourcing even when own competencies are limited.

4.3.4.2. Capacity building in the innovation system

Capacity building, as facilitated by public support, is heterogeneous. Its pace and content varies depending on players, economic sectors and regions (see Box 4.8 for an example). These discrepancies reduce the efficiency of the innovation system. It is therefore important for government to identify "capability gaps", to see what progress has been made towards eliminating them and what the contribution of public policy has been. Table 4.7 presents a few examples of the potential value of monitoring learning processes in different institutions.

Box 4.8. Successful publicly supported firm-level capacity building: the case of CINTAC

CINTAC S.A. is a company that manufactures steel profiles, tubes and pipes. It was founded in 1956 and has enjoyed a leadership position in Chile. It is a medium-sized company (392 employees) with subsidiaries in Argentina and Peru.

Overwhelmed by growing competition from PVC pipes and aluminium profiles, the company developed an innovative construction solution using steel. It hired an external expert and applied for help from FONTEC. The success of the project led the company to establish a new department, the Innovation Management Office, under the expert hired. CINTAC has subsequently continued to innovate. In 2001, 20% of its sales were products with the company's own technology and brand, and these sales have grown at a rate of nearly 50% since they went on the market in 1998.

CINTAC's Innovation Management Office consists of only one person, as products are developed by subcontracting different experts for each project. CINTAC has not returned to FONTEC for backing, since innovation is now an integral part of its business strategy.

Source: Rivas (2004).

Table 4.7. Progress and shortcomings in capacity building in different institutions

Institution	Progress	Shortcomings	Impact of public policies
Universities	Consolidation of traditional areas of strength in scientific research. Initial accumulation of new capabilities in promising research areas, such as biotechnology.	Low competencies and weak infrastructure for delivering technology-based services. Low capability for managing innovation (from formulating projects to commercialising results). Insufficient business-relevant engineering skills.	Project-based support does not encourage universities to take a strategic approach to relationships with industry and thus does not help the development of relevant capabilities. The centre of excellence approach has had a good effect on basic research capabilities.
Firms	Greater awareness of and experience in searching for external sources of knowledge and technology. Small-scale, still generally patchy inclusion of innovative processes and products into business processes. Some progress in collective action, *e.g.* sector-wide strategic vision and technology road mapping.	The number of truly innovation-oriented companies is still very low. Lack of human resources with appropriate skills limits firms' absorptive capacity. Managerial capabilities are generally insufficient to sustain active in-house innovation.	Given the average competency profile of Chilean companies some crowding out of private effort (subsidy redundancy) is likely for companies the participate recurrently in support schemes. Despite some success stories (Box 4.7), the capacity building power of the overall support system has been insufficient.
Technological Institutes (ITPs)	Growing heterogeneity of demonstrated capabilities. Improvement and broadening of capacities in some areas (*e.g.* mission-oriented R&D) and institutes (*e.g.* Fundación Chile).	Investment in building exclusive capabilities has been often insufficient. Ageing human resources. Low ability to develop and diffuse sector-specific strategic technologies.	Steering and funding modes have encouraged many ITPs to adopt short-sighted strategies regarding the provision of technological services while, at the same time, overlapping with universities in R&D activities.

continued…

Table 4.7. Progress and shortcomings in capacity building in different institutions ***(continued)***

Institution	Progress	Shortcomings	Impact of public policies
Knowledge-intensive services	Emergence of a critical mass of actors in some areas.	Still underdeveloped in many others (IPR, innovation management, business angels, etc.). Shortage of engineers with both a solid scientific background and business flair.	Low inducement of firms' demand for market-based services. Limited impact of recent initiatives (e.g. CORFO's promotion of seed capital). No perceptible "labellisation effect" (government-sponsored projects have no easier access to private financing).
Regions	Some regionally concentrated clusters are taking shape, with all the necessary ingredients. A model of regional-national co-operation in innovation policy is being experimented for the first time (Bio-Bio). A regional technological infrastructure is developing (CONICYT regional centres)	Lagging regions remains deprived of both private and public investment in innovation. Most regional governments show no interest in and no institutional capacity to develop their own innovation strategy.	The lack of co-ordination among agencies and government services complicates decentralisation. New conflicts of interest arise (it is more difficult at the regional level to distinguish clearly between beneficiaries and policy makers when allocating public support).

4.4. Strategic tasks of innovation policy: a functional assessment

As analysed so far, innovation is not yet a core element of the growth model. However, over the past 15 years different institutional approaches have been tried, several programmes have been implemented in diverse areas and a variety of policy instruments have been applied. As a result, Chile has accumulated a great deal of valuable experience and institutional learning regarding innovation activities and policies.

One example of this learning process is the acknowledgement that public funds committed to promoting innovation activities were not enough, followed by the decision to create an earmarked new tax levied on mining activity to provide more resources for promoting innovation. As a result, from 2006 the public budget allocation for innovation has risen considerably. Another example is the recent creation of the National Council of Innovation for Competitiveness to overcome the many co-ordination failures and overlapping initiatives of different players, as well as the perceived lack of a strategic leadership to set the main goals and priorities of the innovation process.

While these initiatives are quite recent and it is too early to measure their impact, they certainly indicate the government's commitment to strengthening and streamlining Chile's innovation system so that it can become one of the most effective springboards for sustained and sustainable growth in the not so distant future.

Previous sections have provided some elements of answers to such questions as:

- Is the strategic guidance of innovation policy adequate?
- Are institutions well positioned in the system to fulfil their tasks efficiently?
- Is the overall policy mix and portfolio of instruments adequately balanced?
- Are instruments well adapted to their objectives?
- Does the approach to innovation policy encourage "clever selectivity"?
- How developed are the learning capabilities of the NIS institutions?

Keeping these questions in mind, this final section undertakes a synthetic assessment of public support by adopting a functional perspective: how effective have innovation-related policies been collectively in performing the following tasks?

- Providing the business sector the right incentives for increased R&D and innovation.
- Promoting the emergence and consolidation of a critical mass of scientists that fulfils the criteria of excellence and relevance in their research work.
- Fostering synergy among the different players and institutions within the system.
- Providing the basic infrastructure needed for efficient diffusion of knowledge, know-how and technology.
- Securing the supply of qualified human resources.
- Keeping the Chilean national innovation system (NIS) well connected to dynamic global innovation networks.

4.4.1. Providing the business sector the right incentives for increased R&D and innovation efforts

In spite of significant public efforts, in terms of both financial and institutional resources, to improve the performance of the business component of the NIS, aggregate results have been rather poor. Table 4.8 shows some indicators taken from three of the four innovation surveys made so far in Chile.[45]

45. The results of the last one, conducted in 2005, were not yet fully available at the time of the OECD review. Preliminary results point to the possibility of an underestimation of private R&D efforts in former innovation surveys.

Table 4.8. Selected innovation indicators at firm level

	1995	1998	2002
Number of firms investing in R&D	1235	497	697
R&D per worker (thousand CLP)	80.6	54.4	103.6
R&D per worker in firms investing in R&D (thousand CLP)	293.3	420.3	518.5
Public support to R&D (as % of total financing)	1.04	0.38	2.93
Firms with product innovations (%)	65.1	53.3	59.3
Firms with process innovations (%)	70.8	54.2	56.0

Source: based on Benavente (2004).

These figures show a sharp decline in almost every indicator between 1995 and 1998 and, notwithstanding the recovery in 2002, they remain far below initial levels. This shows the influence of the economic cycle and is an indication that innovation activities are not deeply rooted in firms' strategies (Benavente, 2005).

A first observation is therefore that, although public support to R&D has grown in importance as a source of financing for Chilean firms, it has not had a significant impact on performance indicators, if one considers that more than 1 000 Chilean companies regularly carry out innovation activities. A second important observation is that companies that have received public funding have subsequently increased their own spending on R&D, have introduced more process innovations, and have increased their productivity in comparison with companies that have not benefited from public support.

This is only an apparent paradox. The explanation is probably that individual innovation policy instruments have been reasonably[46] efficient in stimulating innovation-related investment in "prepared" firms but, taken together, have failed to induce more widespread changes in the behaviour of the vast majority of firms.

Since the beginning of the 1990s the cornerstone of public policy has been the system of technological funds. The diagnosis that led to the creation of these funds was, rightly so, that excessive emphasis had been put

46. For example, Benavente (2002) estimated, based on the results of a survey of 450 firms, that every public dollar invested through FONTEC induced a private investment in R&D projects of $1.3. This is not bad, especially since FONTEC mainly supported adoption rather than development of technology. More recent empirical studies produced more ambiguous results (Benavente, 2007).

on the supply side (financing universities and research centres, mainly through FONDECYT), without enough connection to the needs of firms and of society at large. The idea has been to devise instruments – notably FDI, FONDEF, FONTEC and sectoral funds like FIA – that could strengthen that connection and, at the same time, increase private companies' investment in R&D.

These funds were based on a rigorous policy rationale (clearly identified market failures). They were operated following good practices and in a transparent manner: open calls for proposals and selection based on criteria in line with the mission of each fund. A strong horizontal, bottom-up approach to the selection of beneficiaries ensured against the risk of capture by specific groups, although lately some elements of top-down selectivity were introduced by some funds to the benefit of priority areas, such as ICTs and biotechnology, with a view to increasing economic impacts through spillovers.

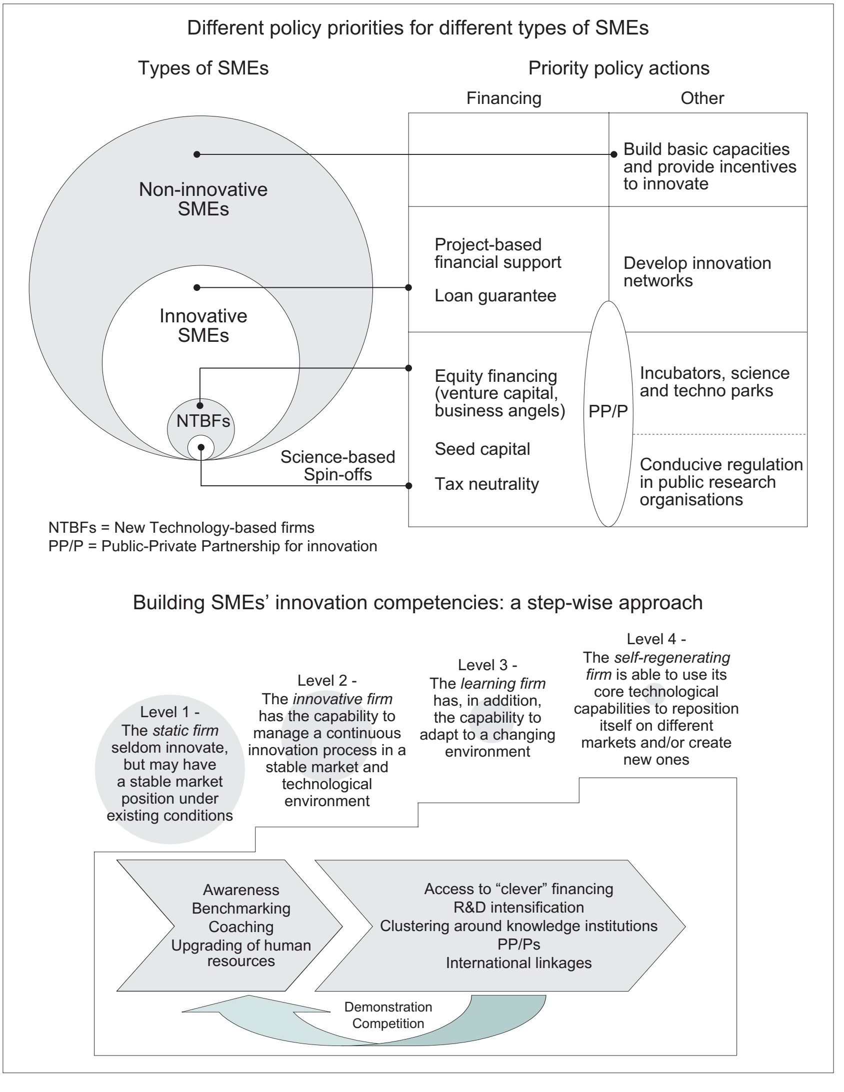
A reasonable hypothesis is that the fund-based approach did not bring about the desired results for two main reasons. First, it addressed piecemeal a series of market failures but failed to address underlying system failures, such as obstacles to the commercialisation and diffusion of new technologies, bottlenecks in the human resource "pipeline", lack of supportive public infrastructures, etc. Second, the portfolio of instruments (funds) did not sufficiently address "capability gaps". Chile should in particular take a more comprehensive but differentiated approach to the promotion of innovation in SMEs, following international best practices (Figure 4.3, Box 4.9).

In particular, for years the emphasis has been on technological innovation, rather than on diffusion, and on technological projects rather than technological entrepreneurship. However, a number of initiatives have tried more or less recently to correct this bias, for example:

- The Business Innovation programme of Innova Chile now supports more strongly business management schemes that foster company competitiveness.
- Innova Chile provides companies with co-funding for technology missions or internships abroad, to hire international level experts or specialised consultancy services, among others.
- The "entrepreneurship line" of Innova Chile helps companies introduce innovative results or products to the market.
- The Bicentennial Science and Technology Programme (PBCT) of CONICYT, through the co-operative research consortia, supports the recruitment of young scientists in industry.

- FIA supports initiatives and projects to commercialise innovation in the areas of agriculture, forestry and water.
- Recently, both CORFO and CONICYT have introduced instruments to encourage patenting by alleviating the cost of the local and international patenting process.

Figure 4.3. Promoting innovation in SMEs: the need for a comprehensive but differentiated approach



Box 4.9. Promoting innovation in SMEs: OECD countries' experience

When placing greater emphasis on innovation in their SME policies, governments face two challenges. First, given the variety of factors that influence firms' capabilities and incentives to innovate, they need to co-ordinate their actions in a variety of areas of government policy on the basis of a clear-cut strategy. Second, the heterogeneity of the population of small firms precludes any "one-size-fits-all" approach. In some sectors the bulk of innovations are due to new entrants or start-ups that challenge incumbents' market shares. But in most industries, SMEs contribute to the innovative process in a very different way. They operate in medium- to low-technology environments and innovate without engaging in formal R&D activities. They focus on improving production processes through the use of codified knowledge embedded in up-to-date equipment and on improving product design and marketing techniques through the use of tacit knowledge embedded in human resources.

OECD countries' experience demonstrates the importance of finding the right balance between measures addressing generic problems related to firms' size or newness and more targeted actions to solve problems that are specific to particular types of firms. Best practice policies include the following main components:

- *Conducive framework conditions*. The first responsibility of government is to provide a favourable climate in which entrepreneurs can easily create firms, have incentives to innovate and grow, and can access the necessary resources at a reasonable and predictable cost.
- *Measures to build innovation capacities.* Up to the early 1990s government promotion of innovation in SMEs was almost equated with support to technology diffusion. It focused on supply-led technology transfer and was biased in favour of manufacturing. However, mixed experience with supply-driven programmes, improved understanding of the role of new firms in increasingly interactive innovation processes, as well as growing evidence that the obstacles to innovation in most SMEs were internal to the firm and stemmed from deficiencies in labour skills and in organisational and managerial capacities prompted the emergence of a new generation of policies that put more emphasis on: *i)* fostering an entrepreneurial culture; *ii)* building the "innovative and absorptive capacity" of firms through skills development and improved management; and *iii)* promoting e-business and developing other business infrastructure for small innovative firms.
- *Measures to facilitate financing of innovation*. Insufficient access to financing is a persistent obstacle to the creation, survival and growth of innovative SMEs. Policies to reduce financing gaps broadly fall into three categories: *i)* subsidised loans and loan guarantees; *ii)* provision of seed financing and support for the development of venture capital; and *iii)* tax incentives and/or grants to correct market failures that lead to under-investment in R&D.
- *Measures to promote networking and partnerships.* Even more than larger firms, SMEs depend on external sources of information, knowledge, know-how and technologies in order to build their own innovative capability and to reach their markets. For complementary knowledge and know-how, innovative firms increasingly rely on collaborative arrangements in addition to market-mediated relations (*e.g.* purchase of equipment, licensing of technology). Inter-firm collaboration within networks is now by far the most important channel for the sharing and exchange of knowledge. Interactions are also intensifying between firms and a number of other institutions involved in the innovation process: universities and other institutions of higher education, private and public research labs, providers of consultancy and technical services, regulatory bodies, etc. In OECD countries, public programmes and initiatives that explicitly address networking are a rather new phenomenon. They address market failures at different stages of the networking process through SME-specific or less targeted measures (see the table below): *i)* raising awareness of networking opportunities and helping search for partners; *ii)* organising, financing and operating networks; *iii)* interfacing scientific and innovation networks through public-private partnerships (PP/Ps); and *iv)* creating international linkages and building global networks.

These trends do not solve all problems, and they raise new ones, particularly because they make the support system more complex, blurring further the division of labour among institutions. The system of funds cannot create by itself all the conditions for its efficiency; this is obviously even truer for any individual fund. For example, the public-partnership approach, which is being tested in the framework of PBCT, has a great potential for helping to close an institutional gap in the innovation system. However, as the experience of OECD countries suggests (OECD, 2007b), realising this potential may require more than additional "lines" in existing funds' portfolios (see also section 4.4.3).

Existing funds should probably continue to carry out the tasks for which they are best equipped. This raises the issue of the type of complementary actions needed to ensure better "behavioural and not only resource additionality" (Box 4.10) in beneficiary firms and to extend the pool of the latter at a minimum cost to the budget.

**Box 4.10. Measuring behavioural additionality:
A new focus of OECD countries' evaluation of public support to business R&D**

Do recipient firms pursue different types of R&D, or collaborate more with others? Do they improve their R&D management capabilities and introduce enduring changes in their R&D strategy and performance? Such issues are not typically addressed in traditional evaluations, and there have been relatively few efforts to explicitly measure changes in the ways firms conduct R&D as a result of government policy, the so-called "behavioural additionality" effects.

This OECD has explored the concept of behavioural additionality and promoted a multinational effort to develop better ways of measuring it. A recent publication summarises the results of a series of studies undertaken in Australia, Austria, Belgium, Finland, Germany, Ireland, Japan, Korea, Norway, the United Kingdom, the United States and the European Union. These studies reveal a number of qualitative changes in the types of R&D conducted by firms and the way in which they carry out R&D as a result of their participation in government R&D funding programmes.

Source: OECD (2006c).

The question of the tax treatment of R&D arises in this context. Unlike the majority of OECD countries, Chile has not yet used such an instrument. Recently, however, the government decided to take a first step in this direction by proposing some tax relief on some business R&D expenditures. As pointed out in section 4.2.2, which describes the proposed scheme, its main merit will be to send a powerful signal about the public sector's commitment to innovation and to boost the market for contract R&D. It is doubtful that it will fundamentally change the average Chilean firm's propensity to innovate.

4.4.2. Ensuring critical mass, excellence and relevance in scientific research

A vibrant innovation system requires a strong science base which is able to perform three vitally important functions: *i)* increase the quality of training in higher education and ensure that a minimum number of highly skilled personnel have research experience before entering the labour market; *ii)* provide a platform for ambitious science-based innovation; and *iii)* monitor worldwide progress in scientific knowledge and help domestic actors access relevant new knowledge produced in other countries.

In the last two decades Chile has made great efforts to gain a critical mass of highly skilled human resources and excellent scientific research institutions. It has been less successful in the admittedly more difficult task of making its science system more responsive to evolving economic and social needs, largely because of the absence of mechanisms to articulate and translate these needs into a scientific agenda.

In addition to direct funding of universities, Chile now uses a whole set of instruments to fund scientific research projects on a competitive basis. The diversification of this policy toolkit over the last decade reflects a political will to concentrate more resources in areas of excellence and to encourage links between academia and industry.

Over the last 25 years FONDECYT has consistently supported scientific researchers and small research groups in all areas of knowledge. It has been very well evaluated in terms of the transparency and independence with which it performs its mission. Established more recently, FONDAP has promoted with undeniable success the establishment of centres of excellence in advanced research and has sought to better articulate the work of research groups in areas in which Chilean science has reached a sufficient level of development and a critical mass of researchers with accredited productivity. The Millennium Science Initiative has created a number of institutes and nuclei of excellence in various disciplines and areas. The obvious overlap between this initiative and FONDAP is another example of a Chilean institutional disease: fragmentation instead of warranted differentiation.

Other programmes have also played a role in increasing Chile's capabilities in scientific research in connection with foreign partners, notably several scholarship programmes. In addition one component of the PBCT programme is aimed at strengthening the scientific base of Chile through the increase in manpower for scientific and technological research, in research infrastructure and in the ability to acquire knowledge produced in other countries in a timely manner. Although the "Higher Education Quality and Equity Improvement Program (MECESUP)" is not specifically targeted at improving universities' research capabilities, the issue has been tackled indirectly through actions that improve the universities' capabilities and the quality of their education programmes, especially at doctorate levels.

In the absence of significant demand from industry and of any, if only soft, top-down guidelines regarding research priorities, the Chilean science system is, as in many other countries, strongly path-dependent in terms of the allocation of resources among disciplines, and shaped by bottom-up demand from researchers, in terms of the allocation of resources among projects within disciplines. The only focusing devices, FONDAP and the Millennium Science Initiative, have a qualitatively important but quantitatively limited impact since their combined budget is less than one-sixth of the direct budget allocation to university R&D by FONDECYT, and they do not use economic relevance as a criterion to support research groups.

4.4.3. Strengthening the knowledge infrastructure through appropriate steering of technological institutes

Technological institutes (ITPs) were created to be the backbone of Chile's infrastructure for technology diffusion. As discussed in Chapter 3 many of those in fields of relevance to the private sector have had difficulties adjusting to the changing economic environment. Their contribution to the innovation system has been is a subject of debate for some time.

The way they are steered through funding has changed in the last decade. Initially, ITP funding derived almost exclusively from the public budget. In 1995 a dedicated competitive fund was set up to induce ITPs to respond better to the requirements of the productive sector. In addition, some ITPs also signed "performance contracts" with various ministries by virtue of which, in exchange for specific commitments, they received funding to invest in capacity building. The funds transferred through these performance agreements have rarely exceeded 10% of the total ITP budget.

The direct funding of ITPs has therefore been progressively reduced and has now been eliminated for the majority. A notable exception is the National Institute of Agricultural Research (INIA), the largest of the ITPs, which still receives significant direct funding from the public budget.

In 2000 an international evaluation of a group of ITPs was carried out. Its terms of reference were to assess their organisation and the relevance of their lines of activity, as well as to recommend adjustments – in light of international experience – which could improve their contribution to the innovation system. As a result some reforms have been implemented. In particular, there have been regulatory changes to give the ITPs more flexibility and a rationalisation that has involved the fusion of two institutes, with INTEC (which had belonged to CORFO) becoming an integral part of Fundación Chile.

However, there is not yet an overall coherent policy for the ITP sector. Its formulation would require an assessment of the performance and capabilities of all ITPs, from a truly systemic perspective, in order to reaffirm or redefine missions, operating modes, technological focus, etc., without excluding any option, reorganisation, merger, privatisation or closure.

4.4.4. Promoting industry-science relationships

The weakness of the linkages between public research and business innovation is acknowledged by all stakeholders in Chile. Initiatives to remedy this situation have recently been taken.

4.4.4.1. Public-private partnerships

FONDEF was created precisely to promote relationships between companies and research institutions, especially universities. It supports R&D projects in universities and research centres that have a clear application in production activities. Matching resources from at least one company is a pre-condition for project approval. This programme helps to encourage research interest in companies' problems, but its project-based approach has inherent limitations, as it is unlikely to generate projects with sizeable economic impact. It should be seen as a networking tool and be managed in that spirit.

A few true public-private research partnerships have appeared in Chile in the last decade, but until recently they were dispersed bottom-up entrepreneurial initiatives in which policy had a minor role. For example, Fundación Chile promoted several focused co-operative technological undertakings. In 2002, under the auspices of the Genoma-Chile Programme, BioSigma S.A. was created as a public-private partnership between Codelco and Nippon Mining & Metals Co. to incorporate the latest developments in biotechnology in the processes of biomining.

The first structured public initiative in this area is the recent creation of 19 technological research business consortia, a joint initiative between CONICYT (through PBCT), CORFO and FIA. This is the largest government effort to date to generate leading-edge scientific and technological knowledge by bringing together various players of a single value chain, include participation by potential business end users. These consortia have been established in a variety of areas, most of them within resource-based industries: applied biotechnology for new varieties of fruit; improved wood production through the use of forestry genomics; development of new technologies in fisheries; development of a cluster or alliance between producers and milk researchers in the Los Lagos region; strengthening of the wine industry through new technologies; development of new products with added value based on waste from traditional export industries; technological innovation in cancer research; launch of an aeronautical technology programme; and creation of a development pole around applied biomedicine.

It should also be noted that under the CONICYT's Regional Programme, co-operative research and development consortia have recently been established in all regions of the country.

4.4.4.2. Innovative clusters

CORFO's Integrated Territorial Programme (PTI) is aimed at fostering the development and improving the economy of a given territory or geographic zone. Its objective goes beyond technological development and innovation. It funds a range of activities, for example to improve company management, especially in SMEs. Recently, the PTI channelled additional resources to consolidate the development of the salmon cluster in the regions of Los Lagos and Aysén. This public-private programme promotes research and innovation as part of an overall development plan. Earlier initiatives to foster innovative clusters include: the mining cluster in the region of Antofagasta and the Colchagua Tierra Premium, for the wine industry, in the Region of O'Higgins. The latter initiative included the creation of the Colchagua Technological Management Centre as an R&D platform for the region's wine industry.

Overall, despite these successful or promising initiatives, Chile has not implemented a fully articulated cluster-based approach to innovation policy. This is surprising given that such an approach would have the potential to help achieve several of the government's priority objectives: *i)* better articulation between public research efforts and market dynamics; *ii)* rationalisation of the public knowledge infrastructure; and *iii)* acceleration of economic diversification by building around or creating bridges between poles of strength. However, there are new initiatives in this area. The Consejo de Innovación is currently undertaking a cluster analysis to be carried out by the Boston Consulting Group. So far eight clusters have been prioritised and policy instruments to promote their development are being designed. The clusters are: offshoring, fish farming, tourism, copper mining and sub-products, pork and chicken farming, processed food for human consumption, primary fruit industry and financial services.

4.4.4.3. Mobility of researchers, patenting and spin-offs

As pointed out in Chapter 2 there is very low researcher mobility in Chile, although mobility is an important vector of knowledge transfer and dissemination, including between public research and the business sector.

There have recently been specific initiatives to reduce this important bottleneck, especially through Chile Innova and the PBCT. Chile Innova funds scholarships for doctoral candidates in ICT and biotechnology and internships in world-class companies and research centres. One component of the PBCT (Researchers in Industry) seeks to expand the stock of high-quality research personnel in Chilean industry by awarding scholarships to doctoral students who undertake a substantial part of their thesis work in industry. A staff member of the company functions as the student's associate supervisor and the company is required to contribute a small supplement to the scholarship. It also awards partial scholarships to post-doctoral or other researchers early in their careers who undertake research in industry. These scholarships are temporary and their amount diminishes over time, with the company paying for an increasing share of the researchers' salary.

Another initiative, which can help increase the flows of highly skilled personnel within the innovation system, is Innova Chile's Programme for the Hiring of International Level Experts or Consultancy. This programme co-funds the hiring of experts in technology and highly specialised production processes for companies that require it. Finally, some national universities have placement programmes for their graduates in the private sector, through joint agreements with companies interested in receiving the new professionals.

So far the impact of these initiatives has been quite modest, but it is too soon to jump to conclusions. If demand-side complementary measures succeed, notably those aimed at increasing R&D and innovation activities in the private sector, they can play a significant role in helping increase researcher mobility.

Patenting and licensing is another channel of knowledge transfer from public research to the business sector which has increased in importance in the OECD area, with many countries, following the example of the United States, implementing policies to encourage their universities to adopt a more strategic approach to the management of their intellectual assets. This has usually involved a combination of regulatory reforms (*e.g.* in the field of IPR) and institutional innovations (*e.g.* establishment of technology licensing offices), together with the provision of incentives that can gradually change the academic research culture. The results have been uneven, and many countries are still struggling with the problem. Chile obviously belongs to the group of countries in which universities have a very low propensity to patent for cultural reasons and because of their modest production of patentable work, but also because of the underdevelopment of the domestic market for knowledge.

The same basic reasons, plus the lack of seed and risk capital, explain the very small number of spin-offs in Chile. Promotion of this type of venture is very recent and faces cultural barriers that can only be removed with an appropriate combination of incentives for researchers and the institutions that house them, and the encouragement of networking among researchers, entrepreneurs and sources of finance (seed and venture capital). The experience of Innova Chile's seed capital programme, although small in scale and not exclusively oriented towards science-based spin-offs, seems to be a good first step. However it is too early to evaluate its impact.

In countries like Chile, where the knowledge market is very immature, it may be important to promote the development of knowledge brokers/ translators that can create a bridge between communities with different values, visions, objectives and languages. As in other countries, most SMEs do not have full-time researchers in house or even highly skilled engineers. In contrast with the situation in most OECD countries, however, if a Chilean SME wants to buy research it most often must turn to universities, which are practically the only institutions able to provide this type of service. However, communication between them is not good. They work at such different paces and with such different perspectives that they have difficulties adapting to each other's needs.

Intermediaries can help mitigate this problem. They can either be individuals (as technological brokers or technological counsellors) or institutions (even specialised departments of universities or research centres), with clear mandates and an understanding of business. They might well become business entities themselves as the system reaches sufficient maturity. The mere existence of financing mechanisms has proven not to be enough to promote industry-science relationships. Organisational innovation and institution building may be necessary to lift them to the level required for innovation-led growth.

4.4.5. Securing the supply of qualified human resources

Chile's huge effort in terms of public investment in education in the last decades has led to a significant increase in the system's coverage. Despite these achievements in terms of coverage, public discussion has been dominated in the last years by a growing concern about the quality of education (Eyzaguirre *et al.*, 2005).

This concern has arisen, among other reasons, from an analysis of the standardised international tests in which Chile participates: the International Study of Tendencies in Mathematics and Sciences (TIMSS), and the Programme for the International Evaluation of Students (STEPS). In both, Chilean students ranked among the lowest in the respective samples. Chile is surpassed by countries with a higher level of development, in particular the most innovative ones. However, Chilean students have even poorer results than would be expected for a country with Chile's level of spending per student, when controlled for its level of development.[47] To improve the quality of its education, it is critical to identify the main problems and to clearly focus efforts on resolving them.

To meet the challenge of the knowledge economy, quality, coverage and equal access to higher education matter a lot. In these areas, Chile lags the most innovative countries. However, demand for higher education is expected to rise in the coming years. This will help reduce the shortage of technicians and professionals in the Chilean labour market. It may also help diminish the shortage of professionals with doctorates in the active population.[48]

The main source of concern regarding higher education is inequity in terms of access. Although the share of the poorest 40% of the population benefiting from higher education has tripled since 1990,[49] the access gap between this group and the richest 20% has not decreased. In light of the high private profitability of education, this means that the development of the higher education system is not improving social equity.

As regards doctoral programmes, the supply has expanded notably, with a total of 91 in 2003. At the same time, there is a growing flow of graduates to doctoral programmes abroad, particularly in the United States and Europe. However, there are some weaknesses in this area. Each doctoral programme generates on average only 1.3 PhDs a year. This is not only quite low by international standards, it is also a sub-optimal use of resources given the financial and qualified human resources that are diverted from other uses to run these programmes. Moreover, there is probably an

47. Additionally, the OECD's International Adult Literacy Survey (IALS) showed that only 20% of the adult Chilean population has the minimum level of reading comprehension necessary for self management in a modern society.

48. Tokman and Zahler (2004) show that in the period 1996-99 Chile only incorporated three science PhDs per million inhabitants in the labour force, while Sweden and Finland incorporated 197 and 177, respectively.

49. It has passed from 4.4% to 14.5% in the first quintile of revenues and of 7.8% to 21.2% in the second.

excessive thematic diversity and very little co-operation among the different institutions.

While the number of graduate research scholarships has increased dramatically in recent years, the actual funding of advanced training is still insufficient. No more than 500 PhD scholarships are awarded each year, a number that should be at least 1 000 given the population and the need to renew staff levels in the higher education sector and in other institutions and companies. One of CONICYT's new priorities is to significantly increase specialised training; this organisation needs to become a central source for this type of funding since the Ministry of Education and the Ministry of Planning also have scholarship programmes, and this dispersal results in inefficiencies.

At the same time, however, certain limitations in the graduate education system need to be addressed, as the problems will become more acute if not corrected given the increased numbers of students entering Master's and PhD programmes and the short-term expansion plans. One of the problems students face is the difficulty of completing their theses owing to the lack of well-equipped laboratories and of teams of active researchers to ensure the quality of this level of education.

To improve quality and relevance it would be necessary to balance the PhD-Master's programme mix, to focus on some strategic areas and concentrate scarce resources on them, and to develop incentives to achieve more co-operation among institutions in the design and implementation of joint programmes. Recruiting foreign PhDs and post-doctorates in Chilean universities, which would help strengthen the accumulation of qualified human resources, is not easy for various reasons, and should be facilitated by means of regulatory reforms and additional financial support.

The lack of focus in graduate degree programmes, which are frequently ill-adapted to the needs of companies, explains why businesses are reluctant to hire scientists on a permanent basis. In fact, fewer than 6% of scientists working in R&D in Chile work in businesses, compared with over 30% in Finland. This situation potentially poses problems for the country since the ever higher number of students finishing PhD programmes will not all be able to work in the university system. With this in mind and as indicated earlier, CONICYT through its Programa Bicentenario de Ciencia y Tecnología (Bicentennial Science and Technology Programme) recently created an instrument to subsidise the hiring of PhDs in industry for well-identified innovation projects. While it is too soon to evaluate this instrument, early indications are that companies currently show limited interest in using it to hire highly qualified personnel.

4.4.6. Keeping the Chilean NIS well connected to global innovation networks

Chile lags significantly behind comparable countries in terms of the number of foreign students received and of Chilean students who study abroad. In other words, there is little internationalisation of the educational process.

The postgraduate programmes available abroad include the DAAD/CONICYT Agreement, the Fulbright/CONICYT Agreement, the ECOS/CONICYT Agreement (France), the Virginia University of Wellington/CONICYT Agreement, the President of the Republic Scholarship of the Ministry of Planning, and the International Master and Doctorate Scholarships of MECESUP of the Ministry of Education. Doctoral and postdoctoral scholarship financing lines have also been included in recent and ongoing support programmes, such as Chile Innova and PBCT.

The Technology Transfer Programme of the Innova Chile Committee of CORFO is dedicated to fostering initiatives for prospecting, dissemination, procurement and adaptation of management or production technologies to Chilean firms. It uses a range of mechanisms to allow regional and national firms to gain access to technologies in more developed countries. These mechanisms include bringing international experts to Chile, sending Chilean businessmen on technology trade missions abroad, sending local company experts to study in technology centres abroad, organising technology transfer centres and technology dissemination programmes with research centres and universities.

Chile has signed many science and technology co-operation agreements with OECD countries, including Germany, the United States, Spain, France, the United Kingdom, Italy, Japan, Mexico and Portugal. However, not all have been equally productive. According to the National Academy of Sciences, Chile has not in most cases committed the resources needed to become a "real counterpart" in those agreements. The agreement with France, which has so far been the most productive in terms of new projects, is aimed at researcher mobility based on submitting joint projects by both countries.

Acronyms and Abbreviations

BERD	Business enterprise expenditure on research and development
CCHEN	Chilean Nuclear Energy Commission
Codelco	Corporación Nacional del Cobre (National Copper Corporation)
CONICYT	National Commission for Scientific and Technological Research)
CORFO	Foundation for Promoting Development)
CIREN	Natural Resources Research Centre
CIMM	Mining and Metallurgy Research Centre
CIS	Community Innovation Survey
CLP	Chilean peso
CRUCH	Council of University Rectors
DEEM	Design, engineering, entrepreneurial and management
EFTA	European Free Trade Association
ESO	European Southern Observatory
EU	European Union
FDI	Foreign direct investment
FDI	Development and Innovation Fund
FONDAP	Fund for Advanced Research in Priority Areas
FIA	Agrarian Innovation Foundation
FIC	Innovation for Competitiveness Fund
FIDES	Investment Fund for Enterprise Development
FIP	Fisheries Research Fund
FONDECYT	National Fund for Scientific and Technological Development
FONDEF	Scientific and Technological Development Promotion Fund
FONSIP	National Public Interest Fund
FONTEC	National Fund for Technological Development
FTE	Full-time equivalent
GDP	Gross domestic product
GERD	Gross domestic expenditure on research and development
HRST	Human resources in science and technology
ICM	Millennium Science Initiative Programme
IDB	Inter-American Development Bank

IFOP	Institute for Fishing Development
IGM	Military Geographic Institute
INACH	Chilean Antarctic Institute
INFOR	Forestry Institute
INIA	Agriculture and Livestock Research Institute
INN	National Institute for Standardization
IP	Intellectual property
IPRs	Intellectual property rights
ISI	Institute for Scientific Information
ISRs	Industry-science relationships
ITPs	Technological institutes
MECESUP	Higher Education Quality and Equity Improvement Programme
MIDEPLAN	Ministry of Planning
MNE	Multinational enterprise
NIS	National innovation system
NTBFs	New technology-based firms
PAA	Academic aptitude test
PBCT	Bicentennial Science and Technology Programme
PCT	Science and Technology Programme
PDIT	Technological Innovation and Development Programme
PIT	Technological Innovation Programme
PPP	Purchasing power parity
PSU	University admission exam
R&D	Research and development
SERNAGEOMÍN	National Geology and Mining Service
SENCE	National Training and Employment Service
SHOA	Hydrography and Oceanography Service of the Chilean Navy
SMEs	Small and medium-sized enterprises
TFP	Total factor productivity
WTO	World Trade Organisation

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