

FONTEC and FONDEF: Driving Chilean technological development

In 1991, the Chilean government created two programs to provide funding for local firms collaborating with research organizations to develop product and process innovations. The National Productivity and Technological Development Fund (FONTEC), managed by the Chilean National Development Agency (CORFO), was focused on supporting private research and development (R&D). The Science and Technology Development Fund (FONDEF), managed by the Chilean National Research Council (CONICYT), is focused on promoting public–private research collaboration. Both FONTEC and FONDEF have successfully contributed to an increase in private R&D expenditures, productivity and the competitiveness of Chilean industries.

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Introduction

In 1990, the Chilean government began adopting trade liberalization policies that forced domestic businesses to compete with global imports. In light of this, international organizations including the World Bank and the Inter-American Development Bank (IDB) advised the government of Chile to promote innovation within domestic industry, in order to make it more competitive. In the newly opened economy, they viewed a more innovative domestic industry as a key input for driving economic development and improving social welfare. To create that more innovative industry, they advised the Chilean government to strengthen national research institutions and promote private investment in research and development (R&D). Accordingly, the IDB provided a loan to Chile to finance the creation of a suite of science and technology (S&T) programs and participate actively in its design and implementation.

The main goals of the S&T programs were the creation of a national science and technology infrastructure and the funding and management of its own programs. The first S&T program was



the National Productivity and Technological Development Fund (FONTEC),¹ developed by the Chilean National Development Agency (CORFO),² a government agency dedicated to promoting entrepreneurship, innovation, and economic growth in Chile since 1939. The FONTEC program, launched in 1991, aimed to help increase economic competitiveness in the local industrial sector by investing in technological innovation and development in strategic areas of the national economy.

The second program was the Science and Technology Development Fund (FONDEF),³ managed by the Chilean National Research Council (CONICYT),⁴ the agency under the Chilean Ministry of Education that provides science and technology funding. This agency had played a key role in promoting scientific and technology research since 1967. The FONDEF program, still in operation, focuses on encouraging public–private partnerships between public research organizations and companies. These partnerships allow collaboration on R&D projects which are partially funded by government subsidies.

These two agencies, CORFO and CONICYT had severe internal problems that required closer attention from the national authorities to guarantee success in implementing the new S&T policy. The main issue that CORFO faced was financial difficulty due to a large number of unrecoverable loans which required an urgent restructuring. CORFO carried this out, transferring its loan portfolio to the private banking system. During this restructuring phase, the Ministry of the Economy established the Industrial Advisory Technical Unit (UTADI⁵) formed by economists and engineers with international postgraduate education. They advocated for strong public support of institutions such as CORFO to reduce market failures that impede economic development.

The situation in CONICYT in the 1990s, in turn, was unstable due primarily to a limited budget for its scientific research fund (FONDECYT⁶), which at the time financed no more than 400 research projects. CONICYT's strategic goals were focused mainly on the support of basic research. The scientific community was small and poorly funded, depending almost exclusively on grants from FONDECYT and no private sector support. The lack of private R&D funding of academic research isolated the work of public research institutions from the productive sector. In 1990, private R&D investment in Chile amounted to about US\$23 million. Although it increased fourfold in the following decade, during that same period it represented only 21.5 percent of the total Chilean R&D expenditures (Holm-Nielsen 2002). Moreover, only 3.7 percent

¹ Fondo Nacional de Desarrollo Tecnológico y Productivo.

² Corporación de Fomento de la Producción de Chile (see www.corfo.cl).

³ Fondo de Fomento al Desarrollo Científico y Tecnológico.

⁴ Comisión Nacional de Investigación Científica y Tecnológica (see www.conicyt.cl).

⁵ Unidad Técnica de Asesoría Industrial.

⁶ Fondo Nacional de Ciencia y Tecnología.



of the total expenditures were for in-house R&D activities of the private sector (Corvera 2004). The underperformance of companies' R&D reduced the chances of fostering innovation processes that would lead to greater productivity and improve their competitiveness. Policy makers viewed this as a market failure that required public intervention—an argument used by the Chilean government to establish its innovation policy and create FONDEF and FONTEC.

The use of the market failure argument to justify public support of R&D is well known and used widely, beyond just the Chilean context. Innovation activities are highly uncertain, with a high risk of failure. If successful, their results are not fully appropriated, and spillovers allow competitors to profit from the innovators' risky investments. Firm managers, loath to invest in R&D under these conditions, are more inclined to invest in equipment and incremental improvements to known processes and products. FONTEC was to address this specific sort of market failure in Chile with direct financial support of private R&D.

An additional problem undermining Chilean firms' R&D performance was their lack of collaboration with public research organizations. Industry can use technological knowledge produced in collaboration with public research organizations to develop innovations that make companies more competitive. Researchers, however, tend to focus primarily on basic research (aimed at understanding) rather than the applied research (aimed at problem solving) that is generally more useful to industry. The FONDEF program was created to address this problem by subsidizing collaborative projects between firms and public research organizations.

A company applying to FONDEF for a grant was required to propose an R&D project for creating technological solutions in collaboration with a Chilean research organization. Collaboration was to be a vehicle for affecting industry performance, improving competitiveness, and benefiting the economy by providing more and better jobs for workers and a supply of better-quality goods and services for local consumers.

Program design

The FONTEC and FONDEF programs were separate but complementary tools within the same overall R&D policy framework, so each had some specific design features that the other did not.

FONTEC sought to support private R&D activities that would not otherwise be conducted by Chilean companies alone. It aimed to join a handful other programs involved in promoting a culture of innovation in Chilean industry; these efforts included co-financing international missions to learn how R&D expenditures in other countries had increased firm performance as well as acquiring technologies used overseas that could be applied in Chile in the short term.

FONDEF, in turn, was designed to promote collaboration between public research organizations and firms. Collaboration with industry, so the assumption went, would help broaden the agendas of university and public laboratories to include more applied research that could affect firm productivity and competitiveness. FONDEF's goal was to increase the supply of scientific and technological knowledge needed to promote innovation—the creation of new products and processes—especially in the industrial sectors at the core of Chile's economy. It also expected



to improve the absorptive capacity⁷ of the country's firms. To do so, FONDEF included funding for the development of human resources and sought to strengthen science and technology infrastructure with grants for laboratory equipment, especially the high-tech instruments required for advanced research.

Both programs were designed in response to the fact that Chilean science and technology performance indicators in the 1990s showed several weaknesses compared to other countries in terms of producing applied research that could positively affect industry. Government policymakers and the scientific community shared the opinion that this situation was largely due to limited expenditures on R&D. For instance, total R&D expenditures in Chile during the 1990s were less than 0.51 percent of gross domestic product (GDP), with less than one-third of that attributed to the private sector. Meanwhile, other countries were more successful in producing and applying such research (De Gregorio 2004). Korea, for example, invested 1.87 percent of GDP in R&D, with its private sector contributing about two-thirds of that; the higher proportion of R&D funding in the private sector indicated a prioritization of applied over basic research. In Chile, R&D expenditures for basic research in 2001 were 57 percent of total R&D expenditures, and applied research accounted for less than 30 percent. In Korea, that distribution was reversed, with 75 percent of R&D funding going to applied research. (Benavente 2005)

In general terms, the Chilean scientific community performed well on the scale of scientific publication productivity, placing it in the top four countries in Latin America after Brazil, Argentina, and Mexico. It was small, however, with 5,571 researchers in 1995 and fewer than 50 new PhDs each year. Most worked in public research institutions, so their contribution was of minimal value to the innovation system. They were almost exclusively focused on basic research and on educating new generations of the Chilean professional work force. This also lends credence to the idea that academics are typically more risk-averse than industry-focused innovators, who are immersed in an environment in which science and technology play a key role in competitiveness.

Despite this, Chile's scientific community had a significant role to play. To address the shortage of innovation-driving R&D, the Chilean government needed to create an environment favorable to conducting applied R&D in a way that would affect the national innovation system. This required the active participation of public universities, with their potential to be sources of creativity and knowledge transferrable to the productive sector. To be innovative and competitive, industry also needed access to a pool of highly qualified people. With the appropriate curricula, universities could train the highly skilled workers, scientists, and professionals in science, technology, and engineering (STE) who are so important to promoting an innovative environment.

⁷ Absorptive capacity is the ability of organizations to understand and apply knowledge created by others and acquired from publications or reports or by inspecting existing products. Human resources and infrastructure are keys to increasing absorptive capacity.



The science and technology program which launched FONTEC and FONDEF was funded by a loan of US\$100 million from the IDB in 1992 to establish a national innovation system that would put science and technology institutions, such as CORFO and CONICYT, in a position to catalyze accelerated technological innovation. The program was carried out by the Ministry of the Economy and had five specific goals:

1. Identify and establish priorities for long-term technological development
2. Accelerate and encourage the introduction of information and communications technologies in the private sector
3. Promote increased competitiveness in the forestry, agricultural, and aquacultural sectors through the use of biotechnology
4. Support the development of cleaner production processes
5. Encourage the introduction of quality and productivity management systems

FONTEC and FONDEF were key pieces of the IDB-funded program, which was in operation until 1995. In 1996 the S&T program was replaced by the Technological Innovation Program (PIT),⁸ which operated until 2000. Under PIT, the funding structure changed; rather than exclusively using public funding for science and technology in support of innovation, it now worked with participating firms to co-finance the R&D projects. Then, in 2001, PIT was superseded by the Technological Development and Innovation Program (PDIT).⁹ The new program was established with a second loan from the IDB, now combined with funding from the Chilean government; project funding rules also kept the co-financing requirement. PDIT lasted until 2006. Throughout these changes, both FONTEC and FONDEF continued to operate under each initiative.

Projects funded by FONTEC were of low- to medium-level technological risk and yielded relatively fast returns on investment. The application process was designed to take into consideration firms' own decision-making patterns and timing concerning the types of R&D activities they wanted to pursue. A continuous application system allowed them to apply for funding at any time with no specific deadlines, so they could decide when to pursue the activities based on market information and business opportunity rather than bureaucratic constraints.

To guarantee transparency in the evaluation of project proposals and reduce bias that might occur if assessment were dominated by public sector panels, a public-private council was set up. Council members received monetary compensation for time served to ensure their commitment to their role as evaluators. The frequency of the council's meetings depended on the number of projects submitted to authorized CORFO agents, who supervised the preparation of the proposals and supported the projects from their formulation to their final council

⁸ Programa de Innovación Tecnológica.

⁹ Programa de Desarrollo e Innovación Tecnológica.



presentation. If a project were approved, its agent was charged with following it during the implementation stage. CORFO agents were selected for their expertise and qualifications and generally enjoyed great prestige (Rivas 2012).

FONDEF was designed to address weaknesses in public research organizations, such as universities and government research and technology institutes, whose financial resources, personnel with advanced training, and infrastructure were insufficient for conducting high-quality applied research in fruitful collaboration with the private sector. Managed by CONICYT, the organizations submitted proposals through competitive rounds of requests for public–private collaborative projects of an applied nature with potential to have an impact on industry and improve its competitiveness.

FONDEF was designed to consider four types of projects suitable for receiving financial support:

1. R&D projects with high chances of being transferred to industry in less than four years, defined by the program as the “short term”
2. R&D projects with high chances of being successfully transferred to industry after more than four years, defined as “medium to long term”
3. Scientific and technological service projects in areas supportive of R&D activities and the transfer of scientific and technological knowledge for practical uses, such as metrology and quality control
4. Scientific infrastructure projects aiming to improve research and development capacity by focusing on, for example, laboratory equipment, information networks, or documentation data centers

Among the expected results from the program were the following:

- Quantitative and qualitative increase of R&D activities with positive effects on the production processes of Chilean industry
- Improvement in the transfer of knowledge from public research organizations to industry, with more public–private collaborative R&D activities
- A focusing of R&D activities on strategic productive sectors, such as agriculture, forestry, energy, health, information technologies, manufacturing, mining, and aquaculture

Implementation

The FONTEC program defined five lines of actions:

Line 1—technology innovation projects—would subsidize 50 percent of R&D costs for product and process innovation projects, covering the development of prototypes and market testing.

Line 2—technological infrastructure—would cover 20 to 30 percent of investment costs for the physical infrastructure needed to set up a technology development unit serving a firm



or group of firms to carry out product and process improvement and innovation. For example, if a company needed to set up a laboratory for research on salmon vaccines, the line could support up to 30 percent of the investment costs.

Line 3—associative technology transfer—would cover 50 percent of the costs (to a maximum of US\$100,000) of technology adaptation activities. This line included international “technology capture” missions, training, and technical assistance provided by international experts to groups of at least five firms. For example, in several instances, groups of company managers participated in international industrial business fairs to learn about new technologies available overseas that might be adopted by their companies.

Line 4—technology transfer centers (CTT)¹⁰—would cover 50 percent of the costs (to a maximum of US\$400,000) to set up a center. A collaboration of at least five firms was required to set up a CTT.

Line 5—productive scale pre-investment studies—would finance up to 50 percent of the costs (to a maximum of US\$15,000) of studies to bring to market the results of R&D activities.

From 1992 to 2003, more than 2,400 FONTEC projects were funded in the five lines, with line 1 the most important in terms of number of projects and funding amounts (see table 1).

Table 1: Number and Type of FONTEC Projects, 1992–2003

Line	Number of Projects	Total Costs (US\$1,000)	Private Contribution (%)
Line 1	1,784	208,683	62.2
Line 2	41	12,258	75.5
Line 2 individual	36	8,090	74.3
Line 2 associative	5	4,168	77.9
Line 3	508	26,436	58.3
Line 3 missions	460	23,634	57.7
Line 3 consultancies	48	2,802	63.6

¹⁰ Centros de Transferencia Tecnológica.



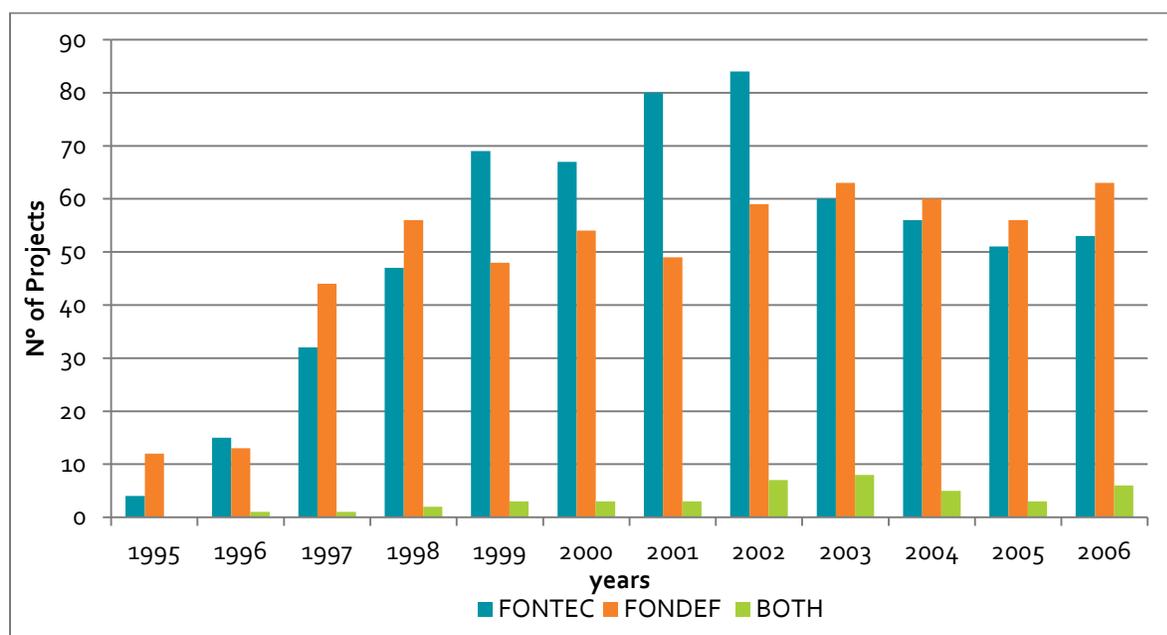
Line 4	10	4,945	51.9
Total	2,892	291,015	

Source: Benavente and Price 2009.

The FONDEF program started in 1991 with a competitive submission system to subsidize directly up to 55 percent of the total cost of technology transfer projects, with a maximum of US\$900,000 per project lasting 36 months. The program required firms to collaborate with public research institutions, such as universities and other nonprofit research organizations. The public–private partnership had to co-finance the project, covering 20 percent and 25 percent of total costs, respectively. The contribution of each partner could be in kind, such as hours of human resources, infrastructure, equipment, and other inputs used in the project. A few projects that demonstrated they needed more time for their R&D activities were given an extension of 36 months, with a maximum grant amount of US\$1.5 million.

During its first years of operation (1991–96), FONDEF funded 56 projects with a total expenditure of US\$36 million. It funded an average of 11 projects a year. After 1997 the number of FONDEF projects doubled compared to the previous year, reaching 44 projects underway. This surpassed CORFO’s FONTEC program, which had only 32 projects in the same year. Beginning in 1996, a few firms had simultaneous projects in both programs; by 2006 these firms represented 10 percent of program participants (see figure 1).

Figure 1: Number of FONTEC and FONDEF Projects by Year, 1995–2006



Source: Alvarez, Crespi, and Cuevas 2012.



In March 2005, FONTEC was merged with another CORFO program called the Innovation Development Fund (FDI) to form a new agency, Innova Chile, intended to improve the institutional linkages of the public organization. This was accomplished by creating an advisory council with 21 members from public and private sectors who were distributed into four subcommittees—public R&D and innovation, individual business innovation, entrepreneurs innovation, and technology transfer and diffusion—to make the most efficient use of public financial resources. The subcommittees met regularly to define the priority areas for program support. Later, in 2012, the program was replaced by the new “IDeA” program, which focused on projects that could show results in the short term. Its simplified application process used shorter application forms and eliminated economic evaluations, and the maximum project time was reduced to 24 months.

Results

FONTEC and FONDEF were well received by both the scientific community and industry (Asesoría para el Desarrollo 2012; Invertec 1995). They addressed the need to develop Chile’s scientific and technological capacity by improving the supply of highly skilled workers and S&T infrastructure and providing R&D subsidies for public–private collaboration in applied research. The open window project application system chosen by FONTEC took into consideration specific local firm behavior. This ability to adapt to the local context was appreciated by company managers at a time when R&D activities were not always popular or relevant to them.

FONDEF was valued by the Chilean scientific community and industry because it offered a competitive program with high transparency in how funds were allocated to projects that met high quality standards. It demonstrated strong ties with private partners willing to co-finance the projects, which meant participants shared both the benefits and the potential risks of failure. The CONICYT program strengthened national scientific and technological capacities and helped build links between two main sectors of the innovation system that did not have a culture of collaboration in place before.

Both programs were evaluated several times, using different methodologies; these included measures of economic impacts (Invertec 1995) and social benefits impacts (Gerens 1996), qualitative assessments (Montero 1997; Asesorías para el Desarrollo 2012), and expert panels (CONICYT 2013).

The first independent evaluation was conducted in 1995 by INVERTEC.¹¹ This consulting company conducted surveys and interviews with FONTEC and FONDEF program users, authors of declined proposals, and potential applicants. The study covered the period 1991–95 and mainly analyzed FONTEC’s line 1 projects and FONDEF’s R&D services and scientific infrastructure projects. The study showed that for each Chilean peso invested in FONTEC, the

¹¹ INVERTEC is a Chilean consulting company founded in 1989.



state received a net benefit of eight Chilean pesos in tax revenues; for FONDEF, the benefit was a return of five pesos per one invested. Analysis by company size showed that the larger firms had twice the profit of the smaller ones.

A 1996 study by Gerens¹² evaluated the socioeconomic impacts of both programs, looking at 15 promising FONTEC projects out of a total of 400 and 10 promising FONDEF projects out of a total of 56 and calculating their economic benefits relative to the total project costs. The size of a positive difference between the former and the latter was the social benefit from the program. The methodology used in this study distinguished the social benefits from innovation from the social benefits from the program itself. The first calculation of social benefit represented the present value of the net social benefit related to a particular innovation project and was obtained by comparing scenarios both with and without the innovation.¹³ The second was a similar comparison of scenarios with and without public financial support of the program. This methodology assumed that in the absence of the program, another economic agent – say, the private sector – could have financed the project in the long term. In that case, however, the positive social and economic benefits might have occurred later than they did with early public sector funding.

Both of Gerens analyses showed positive economic and social impacts. In the 15 FONTEC projects evaluated, the innovations generated a total of US\$217 million in present social value benefits, with US\$55 million in social benefits directly related to the FONTEC program. The FONDEF evaluation revealed a total of US\$1.745 million in social benefits obtained from innovation, of which US\$429 million was directly related to the program. These positive FONDEF results, however, were based on 99 percent of the benefits coming from only one project called REUNA, which sought to strengthen the national university system. The remaining FONDEF projects provided only marginal benefits.

In 2004, CORFO asked the Economics Department of the Universidad de Chile to evaluate the performance of the FONTEC program (U Chile 2004). This study considered FONTEC projects begun between 1991 and 2002 that were finished between 1999 and 2002. A total of 485 projects meeting this criterion were surveyed to evaluate their innovation performance, and information on the companies' sales was analyzed to measure their economic impacts against those of a control group of companies that did not participate in the program. This study confirmed the positive impacts obtained by the previous ones. Two-thirds of FONTEC participating companies conducted product innovations and brought them to market, and half introduced new technological processes to their operations. The economic impact analysis of FONTEC showed that sales for participating companies were 16.9 percent higher than for the

¹² Gerens is a Chilean consulting company in areas such as economics, finance, and management, founded in 1994.

¹³ The counterfactual “without” was assessed from the socioeconomic impacts of financing the S&T infrastructure of universities and research centers with funding sources other than those two programs.



control group. A positive and statistically significant increase of 18.9 percent in jobs created was also observed for FONTEC participant companies compared with the control group.

The most recent evaluation of the FONTEC and FONDEF programs was conducted by the IDB in 2012 (see Alvarez and Crespi 2012) and looked at the performance of firms participating in the program during 1995–2006. It selected firms for a control group based on information provided directly by the managing organizations CORFO and CONICYT and the national annual manufacturing survey (ENIA).¹⁴ In collaboration with the National Office of Statistics (INE),¹⁵ the authors measured and compared the economic performance of each group using propensity score matching (PSM)¹⁶ and differences in differences (DID). Because the proportion of firms that participated in both programs during the period of the study was small (around 5 percent), a multiple-treatment methodology was applied to establish whether these programs had a reinforcing effect on each other. The results were coincident with previous ones that confirmed the success of both programs in terms of increasing sales, improving employment, and generating productivity growth in the beneficiary companies. The study also found evidence of an important reinforcement effect for companies that utilized both programs, showing a 6 percent increase in labor productivity for those companies that participated only in FONTEC, a 10 percent increase for those that participated only in FONDEF, and a 24 percent increase for those that were in both programs (Alvarez and Crespi 2012).

In sum, these two programs were successful because their design was grounded on an accurate diagnosis of the weaknesses of the national innovation system in the 1990s. Both programs focused on specific sectors. While the CORFO program was mainly oriented to the private sector, the CONICYT program focused on supporting public research institutions in collaboration with the private sector. Analysis showed that a small overlap in participating firms was not redundant. The programs, which were evaluated several times, strengthened the national innovation system and scientific infrastructure and were stable over time. They helped improve the management of participating companies and ensured the fulfillment of their own program objectives. The programs also improved private participation in R&D activities, not only raising the number of firms conducting R&D activities but also promoting an increase in the co-funding of them. Between the 1990s and 2010, the private sector's contribution to national R&D funding increased from an average of 21.5 percent to 41 percent.¹⁷

¹⁴ Encuesta Nacional Industrial Anual, which is a annual survey conducted by the national office of statistics (see http://www.ine.cl/canales/chile_estadistico/estadisticas_economicas/industria/enia/enia.php).

¹⁵ Instituto Nacional de Estadísticas (see www.ine.cl).

¹⁶ PSM is a statistical matching technique that attempts to estimate the effect of a treatment, policy, or other intervention by accounting for the covariates that predict receiving the treatment.

¹⁷ Based on the National R&D Survey. Chilean Economy Ministry 2012. (See <http://www.economia.gob.cl/estudios-y-encuestas/encuestas/encuestas-de-innovacion-e-id/segunda-encuesta-nacional-sobre-gasto-y-personal-en-id/>)



Lessons learned

The most important lesson learned from the FONTEC and FONDEF programs is that accurate situational evaluation at an early stage of a program's design makes a significant difference in whether it achieves its goals. These programs were successful because several independent evaluations conducted over the last 20 years helped obtain a clear picture of their performance. This information served as valuable input for the adjustments and modifications made to the programs over time in terms of the amounts of subsidies and private contributions to the projects, among other things. For example, since the beginning of the first S&T program, FONDEF was strongly oriented toward funding research infrastructure. This funding ended in 1997 as an independent line but subsequently became one of the permanent priority areas for all projects presented in the regular R&D solicitations.

Another example of fine tuning to the program was the change in the total amount of the subsidies. While the number of FONDEF projects selected remained relatively constant—approximately 40 projects per year from 2006 to 2009—the total amount of the subsidies provided to them increased by 22 percent during that period. The constant increase in R&D public funding allocated by the two national programs helped support research activities in traditional public research organizations (mainly located in the metropolitan area of Santiago, which at that time had a sufficiently advanced workforce to support them). Furthermore, it also generated incentives for educational organizations elsewhere in the country, previously focused primarily on teaching activities, to strengthen their research capabilities. The programs helped these organizations to achieve a progressive integration into research activities and explore the establishment of R&D collaborations with the local industrial sector to solve productivity challenges. For the government, the programs were a tool to bring more support to productive activities in regions that had abundant natural resources to exploit but had lagged in their use of updated technology to improve their competitiveness in the global market.

The flexibility with which both FONTEC and FONDEF were redesigned also created interest on the part of the private sector in joining in collaborative R&D activities with public research organizations. Companies that had avoided working with these institutions perceived them as very bureaucratic and inefficient and not focused on solving problems. The two programs helped promote an environment of greater trust.

Program administration also improved over time. Experience played a key role in the learning process and in improving the capacity of the agencies' administrative staff. For instance, in the case of FONTEC, the council that decided which projects were approved remained practically the same for more than 13 years. This helped the council members share a common vision with respect to program aims and to persist in achieving program goals. Professional staff supporting each project also remained stable and learned how to deal with companies and offer better advice on how to succeed in R&D activities. The close involvement of the agencies' staff in the program also contributed to a better understanding of the differences among the 13 regional districts, not only with respect to productive characteristics, but also in terms of their local business environments, the characteristics of local pools of human resources, scientific



capabilities, and so forth. This learning process helped in the effective allocation of the programs' financial resources toward improving the deficiencies specific to each region and closing gaps in human resources, infrastructure, and technological development.

Finally, an important issue that still requires attention by Chilean policymakers is the coordination between the current iterations of FONTEC and FONDEF. The revised versions of the programs under INNOVA in CORFO and IDEA in CONICYT are not very differentiated in terms of goals and target groups. A duplication of efforts can occur, resulting in a reduction in efficiency and the impacts expected from each program.

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