

Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin-America

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Abstract

Latin-American Governments have frequently adopted Technology Development Funds (TDF) to financially support firms' innovation activities. This paper shows that TDF effectiveness depends on the adopted financing mechanism, on the presence of non-financial constraints and on the characteristics of the target beneficiaries. In general, the TDF that promote the interaction firm-university seem to be more effective. This paper includes impact evolutions of TDF in Argentina, Brazil, Chile, Colombia and Panama. This unique set of micro-econometric works has been conducted using data drawn from innovation and industrial surveys combined with the administrative records of the TDF executing units. In the absence of randomized experiments, the study estimates the TDF impact through quasi-experimental techniques aimed at identifying comparables treated and no-treated firms and at minimizing the effect of the potential "selection bias". The empirical analysis considers four levels of potential impact: input additionality, behavioural additionality, firm's innovative output, and firm's performance. In terms of input additionality, the evidence suggests that TDF do not crowd out private investment and that they positively affect the R&D intensity. The results also suggest that different financing mechanism have different impacts on beneficiary groups. Matching-grants, in particular, seem to be more effective for new innovators and small firms. In terms of behavioural additionality, the empirical results suggest that the participation to TDF induces a more proactive attitude of beneficiary firms towards innovation activities. In terms of innovative output the analysis does not find statistically significant impact on patent. Once again the interaction firm-university seems to play a relevant role. In terms of firm performance the evidence is mixed. There are positive results in terms of firm growth, but there is no corresponding positive impact on measures of firm productivity.

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1. Introduction

In recent years the role of Science and Technology in growth has gained preeminence in the public policy dialogue of Latin American and Caribbean (LAC) Countries and it has become a central topic competitiveness agenda of the Multilateral Organizations. During the 1990s, LAC policy makers promoted several S&T programs aimed at supporting the effort of regain competitiveness. These programs were generally built around a demand-driven model.

Given the topic's increasing relevance for the Region, the Office Of Evaluation and Oversight (OVE) of the Inter-American Development Bank (IDB) decided to evaluate the impact of a sample of IDB's Science and Technology Programs within the 2005 ex post evaluation cycle. The aim of this evaluation project was to assess the impact of two policy instruments most frequently financed by the IDB: i) the Competitive Research Grants (CRG), aimed at financing basic research activities, usually carried out by academia ii) the Technology Development Funds (TDF), aimed at fostering innovation activities of the productive sector.

This paper summarizes the findings of the evaluation of the Technology Development Funds (TDF). The paper shows that TDF effectiveness depends on the adopted financing mechanism, on the presence of non-financial constraints and on the characteristics of the target beneficiaries.

The paper includes impact evaluations of TDF in Argentina, Brazil, Chile, Colombia and Panama.¹ This unique set of micro-econometric works has been conducted using data drawn from innovation and industrial surveys combined with the administrative records of the TDF executing units. In the absence of randomized experiments, the study estimates the TDF impact through quasi-experimental techniques aimed at identifying comparables treated and no-treated firms and at minimizing the effect of the potential "selection bias".

The empirical analysis considers four levels of potential impact: input additionality, behavioural additionality, firm's innovative output, and firm's performance.

In terms of input additionality, the evidence suggests that TDF do not crowd out private investment and that they positively affect the R&D intensity. In two cases (Argentina and Brazil), the TDF even produce multiplier effects on R&D by facilitating the completion of innovation projects and, eventually, by generating the financial conditions for additional projects. The results also suggest that different financing mechanisms have different impacts on beneficiary groups. Of the three programs that contain matching-grants, the evaluation finds clear positive multiplier effects only in the case of the Brazilian FNDCT, which promotes the cooperation firm-university. In contrast, the evaluation finds positive impacts for both the TDF that use credit. Although limited in scope, these results suggest that credit may be less exposed to firms' opportunistic behavior than matching-grants. A corollary to this finding is that for some groups of beneficiaries - notably new innovators and small firms - matching-grants seem to be more effective.

In terms of behavioral additionality, the empirical results suggest that the participation to TDF induces a more proactive attitude of beneficiary firms towards innovation activities. Although in this case data are available only for Chile and Panama, the evidence suggests that the TDF positively affect firm capability to interact with external sources of knowledge and financing, which are proxies for changes in the firms' innovation strategy.

¹ For detail on the individual studies see: Binelli and Maffioli (2006), Benavente and Maffioli (2007) Chudnovsky *et al.* (2006), De Negri *et al.* (2006a and 2006b), Maffioli and Ubfal (2007) and OCyT (2007). This paper includes some preliminary and incomplete results of the Colombia evaluation. Complete and revised results of the Colombian case will be included in a forthcoming revised version.

In terms of promotion of innovative output, the paper shows more disappointing results. In almost all the cases the analysis does not find statistically significant impact on conventional measures of innovative output, such as patents and new product sales. Results are more encouraging when more proximate indicators of innovative output are considered, such as patent applications. Once again the interaction firm-university seems to play a relevant role, since only the Brazilian FNDCT produces a positive significant impact on patent applications.

In terms of firm performance the evidence is mixed. There are positive results in terms of firm growth, but there is no corresponding positive impact on measures of firm productivity. In any case, the lack of results on innovative output, coupled with mixed results in firm performance should be interpreted with caution, given that this finding seems to contradict what theory would predict.

Although this paper has to be considered as a first step in a wider and more intense effort of understanding the TDF effectiveness, the results suggest the need for a more accurate targeting of this instrument. The TDF design and implementation have to be based on a more tailored assessment of the country specific market failures and of firms' constraints. In addition, the evidence suggests that financial support should be complemented with technological services and infrastructure, such as those provided by universities and research centers.

This paper is structured into seven sections. After this brief introduction, section 2 assesses the recent evolution of S&T sector and policy framework in Latin American and the Caribbean (LAC). Section 3 briefly describes the main feature of the TDF supported by the IDB. Section 4 brings into discussion the rationale behind the TDF and the conceptual framework on the theme discussed by the literature. Section 5 summarizes the evaluative framework, presenting the questions of interest, the indicators and data sources and the methodological approach followed. Finally, section 6 presents the empirical results and section 7 gives some concluding remarks.

2. S&T Sector and Innovation Policy in Latin America and Caribbean

This section briefly assesses the recent evolution of S&T sector and policy framework in Latin American and the Caribbean (LAC). The discussion focuses, in particular, on the specific constraints that affect the Region's performance in comparison to other geographical areas, and on the policies put in place by the LAC governments in order to respond to these challenges.

Recent evidence suggests that the S&T sector in Latin America has been progressing in absolute terms but falling behind in relative terms.² This statement certainly holds when input variables such as R&D investment levels are observed: according to the last UNESCO science report (UNESCO 2005), LAC economies account for just a small fraction of the world expenditure in R&D and this share has even contracted between 1997 and 2003 (from 3.1% to 2.6%).

The overall investment in R&D has always been low in the Region and it has not significantly improved over time. Between 1991 and 2003 the R&D investment only slightly increased (from 0.49% to 0.57% of the GDP). Consequently, not only has the gap with highly developed economies not narrowed,³ but also the Region has fallen behind other emerging areas

² Many surveys on this topic have been recently produced. For a detailed discussion see, among others: IDB 2001, ECLAC 2004, Velho 2004 and Hall 2005.

³ In 2003, R&D accounted for 2.62% and 1.7% of the GDP in the US and Europe respectively (Sources: RICYT, 2006 and UNESCO, 2005).

such as East Asia and eastern Europe, where in 2003 the ratio R&D/GDP reached 1.2% and 0.97% respectively.

In particular, the LAC economies have historically experienced a low participation of the productive sector in R&D investment. The limited innovative effort of firms became particularly concerning when many regional economies shifted their development strategy from the traditional “import-substitution industrialization” (ISI) to an open-market approach at the beginning of the 90s. Although the LAC governments expected an overall net-benefit of the opening up, they also acknowledged that the potential cost of adjustment depended on the firms’ capability to adapt to a completely new business environment.

Why do the LAC economies and, in particular, LAC firms tend to under-invest in R&D? Recent studies clearly discard that the low expenditure level in R&D and the limited participation of the productive sector in innovation activities are the consequence of low rates of returns to this type of investments (Laderman and Moloney 2003, De Ferranti 2003 and Benavente *et al.* 2005). Lederman and Maloney (2003), in particular, find rates of return that are higher for developing countries – principally in LAC and Asia – than those of the advanced countries⁴. They then observe that since these returns far exceed those of physical capital, LAC economies should be investing over twice what they presently do.⁵ Therefore, evidence suggests that the low private R&D investment in the LAC countries depends on other factors: (i) short planning horizon brought on by persistent macro volatility; (ii) financial constraints; (iii) weak intellectual property rights; (iv) low quality of research institutions; (v) incapability to mobilize government resources; and (vi) *rentier* mentality due to a long history of passive natural resource exploitation (Lederman and Maloney 2003 and De Ferranti 2004).

Still with regard to inputs, the lack of skilled human resources has always imposed serious constraints on LAC innovation systems. In spite of some general achievements in terms of literacy, enrollment and tertiary education, recent studies (De Ferranti et al 2003, Velho 2004, and Hall 2005) point out that the average educational attainment in many LAC Countries is still low and that education is distributed less equitably than in other emerging regions. In addition, in many LAC countries tertiary and secondary education are unbalanced, the latter being too low, and LAC students still perform poorly in international comparison tests, especially in math. This unbalanced education system partially explains the limited Latin-American capacity of absorbing new technology. In fact, although the tertiary education generated a stock of scientists and engineers in line with the income level of LAC economies, the secondary education failed to provide the workforce with up-to-date technical knowledge. To make this problem even worse, only a marginal part of researchers and scientists works in the productive sector (around 11% in most countries) while the majority works in the public and academic sectors.

The regional performance in terms of R&D outputs is consistent with the previously mentioned limitations at the input level. On one hand, the Region has experienced non negligible improvements in the productivity of scientists and researchers. Figure 1 in the appendix clearly shows that a partial catching up has occurred in terms of scientific production (both when publications are weighted by number of researchers and by the country GDP). On the other hand, the results in terms of outputs related to the productive sector are much more disappointing: the number of patent applications by LAC residents per year increased at very slow rate between 1991 and 2003 (2% per year according to RICYT data) and the gap with developed economies increased.

⁴ The estimated social return rate of R&D in Latin America approaches 60% for medium income countries such as Chile and Mexico, and 100% for relatively poor countries such as Nicaragua.

⁵ At global interest rates of 7 percent, the number is closer to 10 times.

The World Bank's "knowledge for development" indicators provide further evidence of the relative worsening of the LAC context. Table 1 in Appendix shows that the overall "knowledge divide" between the Region and the G7 economies widened between 1995 and 2003. LAC is the only emerging area that experienced an increasing gap in the innovation indicator, while it has slightly improved in terms of education and information technology. Obviously enough, the cross country heterogeneity is strong: among the upper middle income economies of the Region, only Chile reduced the gap in all the indicators, even overcoming the benchmark in terms of economic incentive and institutional regime (EIR). Brazil was the most dynamic lower middle income country, even though its catching up process was limited by the worsening of EIR.

What has been the policy response of LAC governments? Over time emerging and developed economies have experimented with a rich menu of policies aimed at fostering research and innovation activities. This policy mix is usually defined around three pillars: (i) the education system; (ii) the intellectual property system; and (iii) the public subsidy system (Hall 2005). The specific policy choice can then vary according to the development level of each country and to the specific constraints that hamper innovation and research activities. Although there is no clear consensus on what should be the optimal policy mix in the preliminary stages of S&T development,⁶ it is widely acknowledged that an adequate educational system need to be in place in order to guarantee the long run sustainability of all the other interventions. Indeed, it would be almost impossible to create high quality institutions or a supply of skilled labor without a good secondary and tertiary schooling (Hall 2005).

During the import substitution industrialization stage, LAC governments attempted to expand their innovation capacity by focusing on the supply side of the research and innovation processes. Assuming a linear model of innovation, governments focused on the promotion of scientific research activities. According to this model, a critical mass of high quality researchers, labs and universities should result in codified knowledge to be transferred in a linear, one-way manner from public research organizations to the productive sector. In this context, public administrators and representatives of the scientific community decided on the allocation of public resources on the basis of national development priorities, with little or no consideration of the technology demand. (Velho 2004 and ECLAC 2004). Therefore, public investments were concentrated in public research infrastructures and in sectors dominated by State owned enterprises - such as energy, telecommunications, transport and aeronautics - or those connected to public technology institutes – such as agriculture, nuclear, mining and forestry (ECLAC 2004).

At this very first stage, the organizational structure adopted by most of the LAC countries provided for the central role of Research Councils and National Research institutes. These organizations, usually controlled by the scientific and academic community, were responsible for both the political planning and implementation of the S&T policy.⁷ The research was then performed by public research centers, universities and national technology institutes. The absence of a rigorous inter-agency coordination effort severely limited this organizational setting and usually led to fragmentation, duplication and overlapping of initiatives (ECLAC 2004 and Velho 2004).

From the end of the 80s, the majority of LAC governments adopted a new approach, based on horizontal policies to be guided by the actual demand of the production system. The supply side

⁶ For example, Hall (2005) argues that although it is natural to look at the successful East Asian tigers for hints on how to manage innovation policy, it has to be considered that under the new trade agreements and TRIPS these strategies are probably no longer acceptable by the WTO and, therefore, probably no longer replicable.

⁷ In cases such as the Argentinean CONICET, the Council was not only responsible for the definition of political guidelines and the allocation of resources, but it also directly carried out research activities.

approach began to be replaced by market incentives and the policy focus shifted towards the needs of the productive sector. To avoid interference with the market incentives, more horizontal and neutral policies began to be promoted. Priority has been given to foster the demand of knowledge by final users and to support the transfer of technological know-how to the production sector. The allocation of public resources shifted significantly towards the instruments aimed at supporting innovation activities that had to be driven by the firms' proposals. The structure and size of financing of the scientific community changed dramatically: resources devoted to research infrastructure were significantly reduced for the benefit of those allocated to innovation. The remaining resources were mainly channeled towards support to scientists through the use of mechanisms aimed at rewarding the quality of research and, to some extent, at promoting linkages with the production sector.

To support this new approach, governments introduced many changes to the organizational structure of the S&T sectors. Many countries undertook a significant process of reorganization with the purpose of more efficiently dividing responsibilities and tasks among public institutions. In particular, the new structure should have been based on a clear separation of the political planning functions from the execution and implementation functions and, within the latter, the financing from performing activities.⁸ At the top of the organizational pyramid, central government agencies were empowered to articulate the S&T policies, while the national research councils became responsible for the implementation through the coordination of the funding mechanisms. The emphasis in the former arrangement led to the creation of Ministries of Science and Technology in three countries (Brazil, Costa Rica and Venezuela), while in others, the policymaking authority was assigned to special divisions within other ministries⁹. Alternatively, the National Research Councils, usually under the direct supervision of the Presidency of the republic, have maintained their original role (Bolivia, Ecuador, Guatemala, Guyana, Honduras, Jamaica, Panama and Paraguay).

Within this context, technology funds emerged as the key instrument of the new S&T policy. Although this instrument varies significantly in terms of targeting, operational mechanisms and administration rules, recent reviews identify two main technology fund systems in Latin-America (ECLAC 2004). The first system (implemented in Argentina, Chile, Colombia, Costa Rica and Mexico) allocates resources exclusively on the basis of the firm technology demand. The second system (adopted by Brazil, Chile and Colombia) requires the coordination between supply (academic institution and research centers) and demand (enterprises). In any case, the competition among project proposals of potential beneficiaries plays a central role in determining priorities and resource allocation of the TDF, in line with a horizontal and demand drive approach.

Only a few of the LAC economies (Argentina, Colombia, Brazil and Mexico) have adopted fiscal incentives for technological innovation. This incentive usually includes: (i) reduction in the corporate income tax; (ii) reduction in the value-added tax; (iii) accelerated depreciation of capital goods and equipment acquired in the context of an innovation project and (iv) fiscal credit for expenses in R&D. According to Hall (2005), the scarce utilization of this policy has to be ascribed to some specific features of both the instrument and the Latin American context. First, fiscal incentives tend to be expensive unless they are incremental, and an incremental fiscal credit

⁸ According to the IPES 2001 (IDB 2001), LAC governments aimed at setting up an organizational structure that should have included: "(i) a central government agency in charge of defining S&T policy; (ii) a set of executing agencies; (iii) institutions (including public and private universities) in charge of basic and applied research; (iv) institutions responsible for defining technical norms, standards, quality control and certification; (v) institutions in charge of technical and vocational education as well as short term training of the labor force; and (vi) financial institutions and funding agencies".

⁹ The Ministry of Planning in Colombia, the Ministry of Education in Argentina, Mexico, Peru and Uruguay, and the Ministry of Economics in Chile, El Salvador and Nicaragua.

is very complex to design. Second, to be effective they require sufficient corporate tax bills and an efficient tax enforcement system.

The LAC governments' attitude towards the strengthening of the intellectual property rights (IPR) systems, as required by the TRIPS agreement, has been much more controversial. This is probably due to the own nature of this institution. Although the importance of the IPR system is widely acknowledged, scholars and policy makers are still debating on how strong the system should be and how it should evolve in developing countries. Advocating stronger intellectual property rights presumes that the combined positive impact of the appropriability incentive for the innovator and the disclosure element for peers (resulting in greater innovation) outweighs the negative impact of temporary market distortions (resulting in higher prices for consumers and slower technology diffusion for producers). Therefore, timing becomes the key factor for the IPR policy: protecting IPR very early in the technological catch-up process can discourage an important channel for technological learning. Failing to protect IPR when private firms are launching R&D programs could weaken the incentives to innovate. This only partially explains why LAC economies have not yet developed IPR system in line with the TRIPS agreement. Some institutional weaknesses could have contributed to this situation as well. Indeed, efficient IPR systems require strong institutional capacity and credible enforcement.

LAC governments have implemented some complementary instruments to strengthen the S&T policy tools. Brazil has used governmental procurement to support the national software industries. Chile and Brazil has also introduced some pilot attempts of promoting venture capital for innovation projects. Many countries (Brazil, Chile, Mexico, Nicaragua) implemented networking and clusters policies to support the technological upgrade of SMEs. Chile, Costa Rica and Mexico have implemented instruments aimed at attracting Multinational Enterprises (MNEs) and at promoting linkages with local suppliers.

3. The Technology Development Funds Supported by the IDB

On the basis of the experience gained through the years of lending to the Region, and especially during the period extended from the late eighties until 2000, the IDB developed a specific S&T approach in a sort of ad-hoc basis. This section aims at identifying the IDB approach or "model" on the theme, as it emerges from a desk review of the sample of operations approved since the 90s.

During the ISI stage, the IDB supported the traditional linear model of innovation policy. The IDB operations mainly focused on building institutional capacity in universities and public research institutions, on extension services for agricultural technology and, on technical education.

In the 1990s the Bank's approach shifted towards horizontal and demand driven policies. With the S&T operations of the 90s the Bank responded to the increasing LAC need to maintain or regain competitiveness in a new economic environment. In this context, the exposure to international competition should have allowed a more efficient allocation of resources among sectors and fostered firms' competitiveness, eventually generating an export-led process. For this to happen, the productive sector needed to respond to the new commercial opportunities and to adjust to the increased competitive pressure. Therefore, the real demand for technology of the productive sector became one of the main criteria for defining the Bank's priorities and resource allocation. The transition from a supply side approach to a demand driven one occurred with the implementation of programs such as the Chilean Science and Technology Program (1991), and the Colombian Science and Technology Research Promotion Program (1989). Indeed, FONTEC

of Chile and COLCIENCIAS of Colombia rapidly became points of reference to following IDB operations.¹⁰

These and other programs supported a model of intervention that included the establishment of technology funds for innovation and research projects. As previously pointed out, these funds operated under certain features and modalities that varied across the countries and the Region over time. A brief review of the funds supported by the IDB reveals six main features of this instrument: (i) demand driven approach; (ii) subsidy modality; (iii) co-financing; (iv) evolution from neutral to targeted; (v) competitive allocation of resources and (vi) execution by a specialized agency.

- (i) Demand-driven approach: the early '90s IDB operations supported funds that exclusively finance projects designed and submitted by final users. Therefore, the beneficiary demand determined the policy priorities and the resource allocation. More recent IDB operations slightly reduced this emphasis on the demand by financing service providers, such as technology service centres.
- (ii) Subsidy modality: grants and matching-grants have progressively become the common financing modality of the IDB funds. Over time the Bank's operation have abandoned other modality of subsidizing innovation projects, such as the conditional credit lines.¹¹
- (iii) Co-financing: the funds never cover all costs of the financed projects. They always require the beneficiaries to participate in the financing of the initiative, often on the basis of *pari-passu* conditions.
- (iv) Evolution from neutral to targeted: although in the early 90s' IDB funds were designed on a principle of non-discrimination of public intervention, later on the funds adopted more targeted or approaches. Different justifications supported the initial preference for neutrality. In a free market perspective, neutrality aimed at not interfering with the market resource allocation. In a more evolutionistic perspective, the initial neutrality aimed at facilitating a policy adjustment process. In a first phase, the governments needed to identify the industry-specific externalities and market failures. This exploratory neutral approach should have allowed developing more targeted policies in a second stage. Further, in the early stages the massive and flexible support to innovation activities aimed at facilitating the "endogenization and routinization" of R&D in the productive sector (Teubal 1996, 1998, 2002).
- (v) Competition in the allocation of resources: the early 90s IDB funds operated on the basis of an "open-window" mechanism. Later the funds adopted competitive mechanism such as call for innovation project proposals.
- (vi) Execution by specialized public agency: although the institutional setting for the funds' execution differs on a across countries and operations basis, many funds are operated by an independent specialized organization. Over time, this tendency has generated some concerns about the coordination between different agencies and the definition of roles within the sector.

¹⁰ The IDB projects frequently mention the FONTEC and COLCIENCIAS as benchmarks for other operations in the Region (see, for example, the loan proposal of the operations in Argentina, Panama, Uruguay and Venezuela).

¹¹ In this modality, the loans could be partially or even totally condoned on the basis of three criteria: the success or failure of the project; the nature of the beneficiary; and, the level of the project technological risk.

Table 1 summarizes the TDF studied in this evaluation. It is worth noticing that the FNDCT is the only TDF that directly promote partnership between firms and research institutions (i.e. University and Research Centers).

Table 1: TDF Evaluated

Country	Name	Tools	Mechanism	Beneficiaries
AR	FONTAR-TMP I	Targeted Credit	Open Window	Firms
AR	FONTAR ANR	Matching Grants	Call for Proposals	Firms
BR	ADTEN	Targeted Credit	Open Window	Firms
BR	FNDCT	Matching Grants	Open Window / Call for proposal	Firms and Research centers
CH	FONTEC –Line 1	Matching Grants	Open Window	Firms
CO	PNDCT	Targeted Credit and Matching Grants	Open Window	Firms and Research centers
PN	FOMOTEC	Matching Grants	Open Window	Firms

Source: Author's elaboration

4. The Rationale for Promoting Innovation through TDF

The prime justification for promoting firm investments in R&D through public financing is related to the need of correcting market failures financial constraints and lack of appropriability reduce the firm innovative effort.¹² In addition, evolutionary scholars argue that public intervention is also justified by the need of addressing issues related to the dynamic, collective and uncertain nature of the innovation process, such the linkages and absorptive capacity of the agents of the National Innovation System (NIS).

The TDF mainly address market failures related to financial constraints. Under these constraints, firms cannot undertake certain potentially profitable innovation projects because asymmetric information and moral hazard problems affect the cost of credit and make the projects unfeasible or unattractive. In addition, the TDF financing could reduce the financial risk of innovation activities, by reducing the cost of innovation.

Although the provision of subsidized financial resource generally help firms to overcome financial constraints, the effectiveness of this policy can be limited by the presence of rent seekers. When the firm's preferences are not observable, the provision of subsidized financial resources can incur the risk of attracting and financing firms that have already reached their desired level of R&D investment and seek low-cost public resources for other type of investments.¹³ In this case, the potential positive effect of the public financing is compensated by an internal transfer of resources, producing a displacement of private funds. As Wallsten (2000) states, if R&D investment has short-run diminishing returns and the firm has an equilibrium level of R&D investment funded with its own funds, the public funding will cause the firm to reduce its own expenditure in the whole amount of the subsidy, thus the total R&D investment would remain unchanged.

¹² As first described by Nelson (1959) and Arrow (1962), to the extent that knowledge cannot be kept secret, the returns from investing in the production of science and technology cannot be fully appropriated by the investor; the private returns associated with an investment in S&T are therefore much lower than the social ones.

¹³ On the so-called crowding out effect see David *et al.* 2000, Klette *et al.* 2000 and Chudnovsky *et al.*

To tackle information and adverse selection problems, the TDF institutional setting usually includes a public agency responsible for selecting the innovation projects. The role of this agency is at least three-fold: first, the agency acts as a screener, conveying the technical knowledge that the financial markets lack or are not willing to develop. This process aims at reducing the usual asymmetry of information between the financial sector and the innovative firms. Second, the agency has the possibility and the authority of monitoring and supervising the firm investment. This function could diminish the risk of financing rent seekers. Third, the agency aims at selecting those projects that being profitable for the firm have the highest social returns. Under these assumptions, the agency selects projects that would be rarely financed otherwise. In the extreme, the funds may be financing projects with the aim of making available public goods, ensuring that firms undertake projects with very high social returns but low private appropriability.

The presence of the specialized agency marks one of the most important differences between TDF and fiscal incentives. In the latter case the firms receive the public financing in the form of tax exceptions calculated on predefined accounting categories. Governments usually adopt fiscal incentives because they are automatic and, thus, minimize the public interference with the firm decisions. Fiscal incentives, indeed, do not imply any quality assessment of the firm's R&D expenditure, nor distinguish (at least explicitly, since they usually favor larger firms) sectors or specific areas of financing. In addition, automatic incentives allow avoiding the costs of establishing an S&T agency. These costs could be particularly high when a country lacks the technical expertise for innovation project assessment.

As previously pointed out, over time the TDF have adopted matching-grants as the common financing modality, abandoning the use of credit lines.¹⁴ The advantage matching-grants with respect to credit is that they reduce the administrative costs, since they do not require the collection of repayments. In addition, matching-grants do not require collaterals, making this option particularly suited for SMEs and new firms. The disadvantages of matching-grants are firstly related to the fact that the financial resources are not recovered, at least in the short-medium run.¹⁵ Further, this instrument does not help the firm build up a credit reputation in the financial markets. Finally, matching-grants potentially attract more rent seekers and increase the risk of producing crowding out effects.

Some TDF include specific lines of financing aim at promoting the linkages between research institutions and firms. In this case the TDF aim at affecting not only the cost, but also the of project technical risk, as it is perceived by the firm. In fact, a firm could decide to not undertake a project even when is not financially constrained because believes that it require some technical capability or infrastructure that has the nature of public or semi-public good (such as highly specialized laboratory and equipment). In addition, firms may discover new investment opportunities thanks to the interaction with scientific institutes and research centers. In this case, the public financing mainly aims at making research infrastructure available and at reducing the costs of acceding to highly specialized researchers.

Other TDF specific lines aim at promoting joint ventures and alliances for the execution of innovation and research projects. In this case, the rationale of intervention is threefold: first the TDF aims at taking advantage of potential economies of scale and scope of the research activities. Second, the TDF aims reducing the typical duplication problem of the private investment in R&D

¹⁴ Another alternative could be public procurement (public contracts). This instrument produces more or less the same effect of a subsidy but it has the additional advantage of signaling the market that the innovation projects undertaken by the firm do have a market.

¹⁵ In the long run, the TDF being successful, the public financial resources should be recovered through higher income from corporate taxes.

(Martin and Scott 2000). Although cooperation could degenerate into collusion, it could also significantly mitigate the negative effect of both free-riding and duplication of research effort. To deal with this trade-off, the public programs usually promote firms' cooperation in the first stages of the R&D activities and foster competition in a second stage (Martin and Scott 2000).¹⁶ Third, the promotion of firm-level research agreements aims at fostering interactive learning processes. The interaction with other firms allows a firm to expand its knowledge base beyond its own endowment. In this case systemic failures due to coordination costs and limited absorptive capacity justify the public financing of firms' networking activities (Maffioli 2005).

5. Evaluation Strategy, Data Source and Methodology

The TDF impact evaluation strategy makes reference to a simple structural model inspired by the work of Crepón on the relationship between firms' investment in R&D, productivity and competitiveness (see Box 1). Needless to say, the aim of the evaluations is not to estimate the entire model. The model just synthetically represents the causality chain that lead from the provision of the subsidy to the R&D investment, then to the innovative outputs and finally to the performance outcomes. Figure 1 synthetically summarizes the temporal sequence of events that are involved in the assessment of the impact of the TDF.

Box 1 – TDF impact evaluation structural model

The likelihood that a firm introduces an innovation that can significantly affect its performance strongly depends not only on the participation to the program, but also on its own history of cumulative learning and on other endogenous factors. In addition, we have already seen that the public financing does not automatically imply an increase in the research effort of the firm. Therefore, following Crepón *et al.* (1998), the structural model of the TDF can be defined as follow:

$$\bar{Q} = f(\bar{Y}, \bar{I}) \quad (1)$$

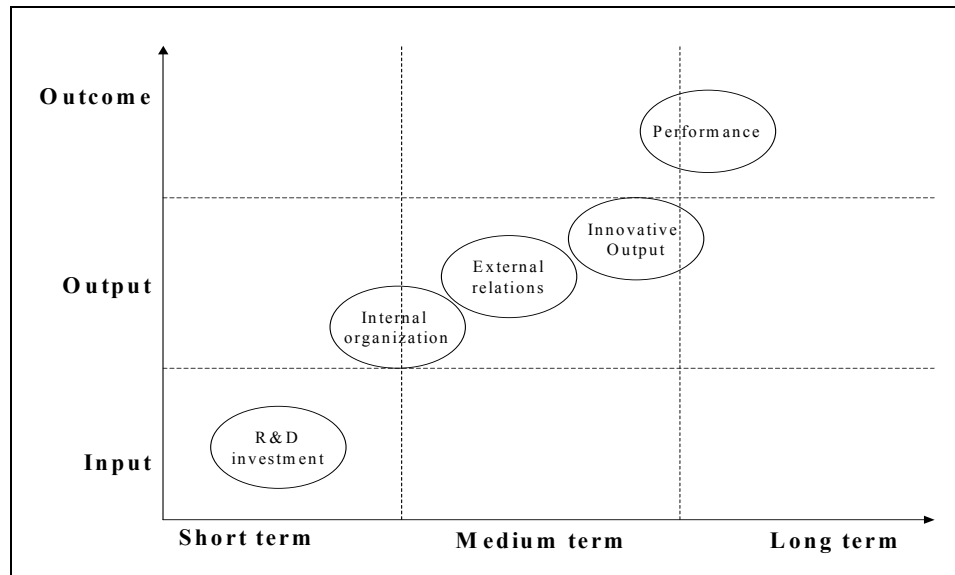
$$\bar{I}^* = g(\bar{Z}, K^*) \quad (2)$$

$$K^* = \gamma(\bar{X}, P | \bar{C}) \quad (3)$$

In the first correspondence (1), the vector Q includes the firm's performances (for example sales, export, productivity and wages); the vector of Ys includes exogenous determinants of the firm performances and context variables. The vector I includes the innovative outputs of the firm (such as number of patent, changes in the firm organization, introduction of new production process and new product, changes in the external relationships). In the second equation, which describes the determinants of the innovative output, the vector Zs includes the exogenous determinants of the innovative outputs (sectoral effects, demand pull and technology push effects) and the K is the firm investment in R&D. Finally, in the third equation the vector X represent the exogenous determinant of the investment in R&D (age, size, sector and number of plants); P is the public subsidy. In addition, we consider the firm decision on the optimal level of investment as conditional to a set of constraint C.

¹⁶ For instance, In the case of R&D cooperatives and Research Joint Ventures (RJVs), where firms are allowed and encouraged to coordinate their R&D investment in a first stage and then put into the condition of engaging in Cournot or Bertrand competition in a second stage.

Figure 1: Evaluation Model



Source: Author's elaboration

More in detail, the TDF evaluation considers four levels of results. First, the TDF should impact the firm expenditure in R&D. This leads to the analysis of the relationship between public and privately financed R&D investments, with the aims of determining whether they are complements or substitutes.

Nevertheless, an increase in R&D expenditures does not necessarily reflect the success of R&D efforts (Patel and Pavitt, 1995). Therefore, the evaluations consider the impact at the level of firm behavioural changes and innovative output. The innovative output indicators usually employed in the literature are patents, sales of new products and the introduction of a new or improved product or process. Although patents can be appropriate for developed countries, they are not always relevant for measuring innovative outputs in developing countries.

Recent studies point out that as long as the impact is formulated in terms of input and output measures the firm is largely treated as a black box (OECD 2005). Therefore, the evaluation complements the analysis at input level analysis with the analysis of the TDF impact on the firm behavioural changes. In particular, the evaluation considers: (i) process innovation and organizational changes; and (ii) access to external resources.

Lastly, since innovation is not an end by itself, the evaluation includes assessment of the TDF effects on firm performance. Sales, employment, productivity and profitability measure this level of impact.

On the basis of this framework, the impact evaluation of the TDF instrument was performed on four levels of outcomes (data permitting), all in comparison with the “control” or non-beneficiary group:

- (i) Input additionality: the impact on the firms' investment in R&D.
- (ii) Behavioural additionality: the capability of the program of inducing changes in the internal and external organization of the firms;
- (iii) Innovative outputs: the impact on the development of new products and patents;

(iv) Performance: the impact on firms' productivity and competitiveness –as measured by change in sales, employment, productivity and share of sales exported.

Box 2 summarizes the research questions for each of the four levels of the potential TDF impact.

Box 2: Evaluative Questions

1. Input additionality: (i) Does the public financing crowd out private resources? The evaluation addresses the impact of the TDF on the beneficiaries' own financial resources devoted to R&D and innovation activities, as a test for the potential crowding out effect of the public financing.

2. Behavioural additionality: (ii) What is the impact of the TDF on the innovative behaviour of beneficiaries? The evaluation assesses the effectiveness of the public financing in inducing a change in the behaviour of the beneficiaries and increasing their capability of developing process and product innovations and allowing them to be more connected to the NIS.

3. Innovative Outputs: (iii) What is the impact on innovation capacity of beneficiaries? Was a significant product or process innovation introduced? Was a patent requested?

4. Performance: (iv) What is the impact on competitiveness of beneficiaries - change in sales, employment, productivity and a share of sales exported? An innovative and efficient firm is expected to be able to improve its competitiveness in relation to non-beneficiaries.

Indicators and Data Sources

It is worthy to briefly assess the issue of how to measure both innovation activities and scientific production. Objective criteria of innovativeness consider the introduction of absolute innovations in certain industry or quantify the efforts of firms in developing innovations. The first could be the case of the demand for patents; the second could be the case of R&D expenditure. Considering the limitations of indicators such as the intensity of R&D expenditure and the number of patents registered in economic context largely based on small firms, these criteria could underestimate innovativeness of firms and could lead to a misleading perception of the innovation process.

On the other hand, subjective criteria are based on arbitrary judgment and therefore reflect a more personal perception of innovation capabilities. Such criteria usually rely on qualitative information collected via direct surveys. Interviewees are asked to provide information regarding particular events such as the introduction of innovations in the firm, which is not based on quantitative, measurable information but on the interviewees' perception of the issue.¹⁷ Nevertheless, despite this bias, subjective criteria may provide a valuable source of in-depth information on firms' innovation activities, especially in some contexts in which the overview of R&D efforts and patent activities do not provide a complete view of the innovation phenomenon.¹⁸ For this purpose many efforts have been devoted to the attempt of standardizing

¹⁷ For instance, subjective criteria may refer to the provision of information on the introduction by firms of products and processes substantially different from the previously adopted or the introduction of industry specific innovations, which are otherwise difficult to identify. This does not imply that the invention of products/processes can be considered innovative for the whole industry, but evidences some incremental efforts of the firm in improving competitiveness.

¹⁸ This is especially true for industries in which patent activity is low or for SMEs, in which R&D activity is normally not formalized.

the collection of information based on both objective and subjective criteria. The most successful achievement is the methodology proposed and adopted by the OECD.¹⁹

Table 2 – Indicators and Data Sources for TDF Impact Evaluation

	Indicator	Sources	Type	Term
Input Additionality	(i) Amount invested by beneficiaries in R&D	(i) firm balance sheet; (ii) Innovation surveys (iii) industrial surveys	Direct	Short term
Behavioral Additionality & Innovative Outputs	(ii) Subjective indicators about: Product innovation, process innovation, linkages with other agents in the NIS. (iii) Patents	Innovation surveys Patents Databases	Direct	Short term
Performance	(iv) Total Factor Productivity Labor productivity (v) Sales Exports Profits	(i) firm balance sheet; (ii) Innovation surveys (iii) industrial surveys (iv) labor surveys	Indirect	Short/ medium term Long term

Source: Author's elaboration

In order to address the evaluation questions previously defined, and taking into account the above-mentioned considerations about subjective and objective indicators, the indicators defined in Tables 2 were explored, with varied degree of availability across cases and countries.

Evaluation Methodology

To measure the impact of TDF on outcome indicators, each individual evaluation followed the basic program-evaluation techniques developed in the econometrics literature. To the best possible extent, each instrument have to be analyzed using a counterfactual perspective in order to reduce potential selection bias (see Box 3). These techniques provide for a rigorous strategy for identifying a statistically robust control group of non-beneficiaries, and following both over time. The ideal evaluation design is the one that creates a valid comparison group by randomly allocating treatment prior to the beginning of the program, which more closely guarantees that on average the characteristics of both groups are the same.

The TDF evaluations follow quasi-experimental designs in all the cases, given that no randomized design has been implemented for any project in the sample reviewed. In the absence of randomization, the evaluations aim at identifying comparables treated and no-treated individuals and, thus, at minimizing the effect of potential “selection biases” on the evaluation results. The identification strategies are consistent with the recent policy evaluation standards. The evolutions identify a counterfactual scenario (control group) by using techniques that allow removing most of the potential sources of bias within a quasi-experimental design (propensity

¹⁹ In 2000 this methodology was adapted to the LAC context by a group of scholars and experts, producing the Bogotá Manual.

scores matching procedures, difference in differences estimations, fixed effect panel estimations and instrumental variable estimations).²⁰

Box 3: The Evaluation Problem

The measurement of programs' effectiveness poses the well known "evaluation problem". Let us call Y_{it}^T the average expenses in innovation by firm i in year t if the firm participates to TDF and Y_{it}^C the average expenses by the same firm if it does not participate to the program. The impact evaluation is interested in the difference $Y_{it}^T - Y_{it}^C$, which is the effect of having participated to the program for firm i . Computing $Y_{it}^T - Y_{it}^C$ requires knowledge of the counterfactual outcome Y_{it}^C that is not empirically observable since a firm can not be observed among participants and non-participants at the same time. The evaluation will not be able to compute the program impact for an individual firm but we can evaluate an *average* effect of program participation, $E[Y_{it}^T - Y_{it}^C]$, comparing data on participating and non-participating firms. Defining D as the dummy variable for program participation, the average treatment effect will be given by:

$$\delta = E[Y_{it}^T | D = 1] - E[Y_{it}^C | D = 0] \quad (1)$$

Subtracting and adding $E[Y_{it}^C | D = 1]$, we obtain:

$$\begin{aligned} \delta &= E[Y_{it}^T | D = 1] - E[Y_{it}^C | D = 0] = E[Y_{it}^T | D = 1] - E[Y_{it}^C | D = 1] - E[Y_{it}^C | D = 0] + E[Y_{it}^C | D = 1] = \\ &= E[Y_{it}^T - Y_{it}^C | D = 1] + E[Y_{it}^C | D = 1] - E[Y_{it}^C | D = 0] \end{aligned} \quad (2)$$

The term $E[Y_{it}^T - Y_{it}^C | D = 1]$ in (2) is the average effect of the treatment on the treated that we try to isolate. The difference $E[Y_{it}^C | D = 1] - E[Y_{it}^C | D = 0]$ is the selection bias: besides the effect of the program there may be systematic differences between participating and non-participating firms that affect program's impact.

A simple estimator of δ using the sample analogue $E[Y_{it}^T | D = 1] - E[Y_{it}^C | D = 0]$ will give an unbiased estimate of the program impact only if there is no selection bias, that is only if $E[Y_{it}^C | D = 1] - E[Y_{it}^C | D = 0] = 0$. However, participating and non-participating firms differ in a number of dimensions (e.g. size) that are likely to affect both the level of innovation expenditures and the probability of getting financed through the TDF. Therefore, the simple difference in mean outcomes between participants and non-participants is capturing the effect of program participation together with the impact of third factors affecting both the decision to invest in innovative activities and to participate to the program.

6. Empirical Results

The results presented in this section offer an unprecedented opportunity to open a discussion on the effectiveness of relevant components of the S&T policy implemented in Latin America in

²⁰ On these techniques see among the others: Heckman *et al.* (2000), Blundell and Costa-Dias (2002), Jaffe (2002), Smith and Todd (2003).

the last 15 years.²¹ This section reports the four level of the TDF impact evaluation. First, the TDF impact on R&D investment (input additionality); second the program impact firms innovative behavior (behavioral additionality); third the impact on patents and innovation outputs (innovative output); and fourth the program impact on sales, employment, productivity and exports (firm performance).

The evidence suggests that TDF do not crowd out investment and that they significantly impact firms' investment in R&D (see Table 3). In all evaluated programs, results seem to rule out a crowding out effect; that is, public financing do not produce any displacement of other internal or external financing sources. In addition, participation in the TDF programs have a positive impact on R&D intensity, as measured by the ratio of total R&D expenditures to total sales.²²

In some cases the evidence shows that TDF have multiplier effects. These multiplier effects occur in the cases of ADTEN, FNDCT and FONTAR-TMP I, where beneficiaries see an increase in investment in R&D beyond the amount financed by program funds. This result is consistent with what was expected from the literature: by providing the opportunity to overcome liquidity and credit constraints, TDF programs should allow beneficiary firms to undertake projects at the margin of their portfolio and, eventually, to generate the technical conditions for undertaking *additional* innovation projects. In the above-mentioned cases it appears that this actually took place.

The results also suggest that different financing mechanisms are associated with different impacts. Among the four programs that contain matching-grants, the evaluation finds evidence of a positive multiplier effect only in one case (FNDCT). In this case, the matching grant finances cooperation between research centers and firms.²³ In contrast, the evaluation finds positive impacts for the two cases for which interventions contained targeted credit components (i.e. ADTEN and FONTAR-TMP I).

Although this partial results are insufficient to draw broad inferences regarding the effectiveness of matching-grants vs. credits based instruments, the findings are based on a rigorous estimation methodology and are broadly consistent with the existing empirical and theoretical literature. The weaker impact of matching-grants as opposed to targeted credit may be revealing a misjudgment of the real (or main) market failure that is hampering private investment in R&D. Matching-grants are more likely to produce a significant increase in R&D when the firms are financially constrained. Nevertheless, if the firm difficulties are more related to technical capabilities or risk aversion, the provision of subsidies is much less likely to produce a significant impact and could result into a substitution of private resources. In contrast, the use of targeted credit potentially reduces the risk of firms' adverse selection. The clear positive impact of the FNDCT seems to confirm this hypothesis. The FNDCT is the only evaluated TDF that requires the cooperation between firms and research institutes. This particular modality could have contributed to simultaneously address financial and technical constraints (lack of human

²¹ Unfortunately, the heterogeneity of available information and data sources did not allow to adopt the same estimation techniques for all impact evaluations. As a consequence, results are not fully comparable, and in some cases not even available, for all countries.

²² This also implies that the financial constraints faced by potentially innovative firms are truly a major obstacle to a significant increase of private investment in R&D.

²³ In the FONTEC and FONTAR cases, the program participation had a positive impact on the overall firm investment in R&D (reported in table 3), but once the impact is calculated on the R&D investment without including the public subsidy the results are not significantly different from zero. In the case of FOMOTEC the impact on overall R&D investment was also positive and significant, but it was not possible to estimate the impact on private R&D investment due to data unavailability. In the FNDCT case, the program had a positive impact also when only private investment in R&D is taken into consideration.

resources, lack of own specialized research infrastructure and lack of technical knowledge, for instance).

Table 3: Input Additionality - Testing for Crowding in / Crowding out Effects

	Indicator	Impact	Signif.	Conclusion
FONTEC (CH)	R&D intensity *	0.74%	10%	No crowding out, but no multiplier effect
FONTAR-ANR (AR)	R&D intensity *	0.18%	5%	No crowding out, but no multiplier effect
ADTEN (BR)	R&D intensity **	0.66%	5%	Positive and significant impact
FNDCT (BR)	R&D intensity **	1.63%	5%	Positive and significant impact
FOMOTEC (PN)	R&D elasticity ***	0.28%	5%	No crowding out
FONTAR-TMP I (AR)	R&D elasticity ****	0.15%	5%	Positive and significant impact

* Double difference [(Treated After-Treated Before) - (Control After – Control Before)] with Propensity Score Matching

** Single difference [Treated After - Control After] with Propensity Score Matching

*** Panel Data Fixed Effects. Available data do not allow us to test for the presence of a multiplier effect.

**** Panel Data Fixed Effects and Instrumental Variable

Source: Author's elaboration

Despite the limited evidence of matching-grants effectiveness, the data shows that this instrument may be effective for new innovators. In the case of the FONTAR-ANR program, although the analysis does not provide evidence of multiplier effect at the aggregate level, the data indicates that new innovators have seen a substantial increase in their private investment in R&D. On the other hand, the effect of matching grants is smaller for experienced innovators, for which some evidence of displacement of resources has been found. Although some caution is called for, the result is not surprising and is consistent with the rationale that led to the implementation of the matching-grant scheme.²⁴

As opinion surveys reflect, it appears that the project beneficiaries are using TDF as a signal of firm technical capacity and ability to innovate. Qualitative information collected from the beneficiaries in both the Chilean and Argentinean cases reveals that firms may be using the programs as a signaling mechanism in order to obtain complementary financing from the financial sector. In particular, in the Chilean case the majority of the beneficiaries consider the public subsidy an important complementary source of financing (50%), probably associated to a helpful signal of the quality of the project to get other sources of financing (28%).²⁵ However, this result should be interpreted with caution since it was derived from beneficiaries' opinion.

Opinion surveys also suggest that human resource constraints may be mitigating TDF effects. When asked to identify the main difficulties faced during the execution of the subsidized project, the majority of the beneficiaries mentioned the lack of skilled labor force. This suggests that some sort of underestimation of the human resources required to carry out the subsidized project could have displaced other R&D activities originally included in the firms' work plan. The fact that the participation in the program did not show an effect on physical capital investment is quite consistent with the hypothesis that the limited impact on R&D intensity is more due to a temporary adjustment in the investment decisions rather than to some sort of resource displacement.

²⁴ As previously pointed out, one of the main motivations for introducing the matching-grants scheme was to offer to those firms with a limited experience in R&D activities a more accessible support than targeted credit.

²⁵ Furthermore, thirty percent of the beneficiaries applied to the program because they believed the project could not receive any financing from the private sector.

For the Chilean and the Panamanian the evaluation considers a set of indicators (Table 4) to measure behavioural changes in firms related to innovation. In this sense, it was possible to demonstrate that the FONTEC and FOMOTEC programs had a positive impact on variables such as the firms' capability to interact with external sources of knowledge and financing, which are proxies for significant changes in the firms' innovation strategy. A positive impact of the programs on the introduction of process and product innovations was also found. This provides further evidence of the impact on short run measures of innovation activity.

Table 5: Innovative Output and Behavioral Changes.

Indicator	Impact FONTEC (CH)*	Signif.	Impact FOMOTEC (PN)**	Signif.
Product innovation	- 1.45	NS	0.081	5%
Process innovation	0.46	10%	0.099	5%
Financial access	0.13	10%	0.148	1%
Human Capital	- 0.06	10%	0.047	NS
External relationships-knowledge	0.10	5%	0.07	5%

* Double difference [(Treated After-Treated Before) - (Control After – Control Before)] with Propensity Score Matching
** Single difference [Treated After – Non Treated After] with Propensity Score Matching. Gaussian kernel function with a bandwidth parameter of 0.16

Source: Author's elaboration

In terms of promotion of innovative output (patents and sales of new products) the evaluation's results are more disappointing (Table 5). In almost all the cases the evaluation does not find any statistically significant positive impact. It is worth noticing that there could be a considerable time lag between the program participation and a significant change in the traditional measure of innovative output, such as patents' registration and sales of new products. To deal with this problem, the evaluation took into consideration the program impact on indicators related to a more immediate change in the innovative outputs of the firms.

Table 5: Innovative Output

	Indicator	Impact	Signif.	Conclusion
FONTEC (CH)	Number of Patents*	0.15	NS	Positive but not significant impact
	Number of new products*	-1.15	NS	Negative but not significant impact
FONTAR-ANR (AR)	Sales of new Products*	1013	NS	Positive but not significant impact
ADTEN (BR)	Number of Patents**	0.87	NS	Positive but not significant impact
FOMOTEC (PN)	Ratio of sales of new products on total sales***	0.0001	1%	Positive and significant impact
FNDCT (BR)	Number of Patents**	-1.35	NS	Negative but not significant impact
	Patents' applications****	14.6	5%	Positive and significant impact

* Double difference [(Treated After-Treated Before) - (Control After – Control Before)] with Propensity Score Matching
** Single difference [Treated After – Non Treated After] with Propensity Score Matching
*** Panel Data Fixed Effects.
**** Double difference [(Treated Before-Treated After) - (Control Before - Control After)]

Source: Author's elaboration

The evaluation finds significant impacts on short run measures of innovation activity. For example, the Brazilian FNDCT fund shows a clear positive and significant impact on patent application, although there is no evidence of a positive impact on patent registration. The application for a patent could be considered a much more immediate proxy for the firms innovative output than the one of obtaining a patent.

In terms of firms' performance the evidence is mixed (Table 6). The evaluation shows some positive results on sales and employment growth, but no corresponding impact on firm productivity. On the one hand, the FONTEC, FONTAR, ADTEN and PNDCyT programs positively affect firms' growth in terms of employment and sales. On the other hand, there is no evidence of a significant impact of the FNDCT program. In addition, the FONTEC program seems to be effective in promoting firm exports. Only the Colombian program results significantly effective in fostering participants' productivity in the short run. In addition, some estimates for the FOMOTEC program bring evidence of a significant impact on productivity two years after the granting of the subsidy. In general the pattern, which was also observed for other programs, is one of a negative impact on productivity in the year of the reception of the funds and the year following that reception, while a significant positive effect begins to be appreciated afterwards.

Table 6: Performance

	Indicator	Impact	Signif.	Conclusion
FONTEC (CH)	Employment ($\Delta\%$)*	10.8%	10%	Positive and significant impact
	Sales ($\Delta\%$)*	16.2%	NS	Positive, but not significant impact
	Productivity ($\Delta\%$)*	-0.3%	10%	Negative and significant impact
	Exports (% of sales)*	2.7%	10%	Positive and significant impact
FONTAR-ANR (AR)	Employment ($\Delta\%$)*	1.5%	NS	Positive, but not significant impact
	Sales ($\Delta\%$)*	11.5%	NS	Positive, but not significant impact
	Productivity ($\Delta\%$)*	-11.7%	NS	Negative, but not significant impact
	Exports (% of sales)*	-0.1%	NS	Negative, but not significant impact
ADTEN (BR)	Employment ($\Delta\%$)*	79.0%	1%	Positive and significant impact
	Sales ($\Delta\%$)*	64.0%	5%	Positive and significant impact
	Productivity ($\Delta\%$)*	- 1.0%	NS	Negative, but not significant impact
	Exports	--	--	--
FOMOTEC (PN)	Sales**	0.007%	NS	Positive, but not significant impact
	Productivity ($\Delta\%$)**	-0.037%	NS	Negative, but not significant impact
	Exports**	-0.011%	NS	Negative, but not significant impact
PNDCyT (CO) (1)	Employment (log)*	1.533	1%	Positive and significant impact
	Sales (log)*	TBC		
	Productivity (log)*	1.22	1%	Positive and significant impact
	Exports (log)*	TBC		
FNDCT (BR)	Employment ($\Delta\%$)*	18.0%	NS	Positive, but not significant impact
	Sales ($\Delta\%$)*	20.0%	NS	Positive, but not significant impact
	Productivity ($\Delta\%$)*	27.5%	NS	Positive, but not significant impact
	Exports	--	--	--

* Double difference [(Treated Before-Treated After) - (Control Before - Control After)] with Propensity Score Matching

** Panel fixed effects.

*** Single difference [Treated After – Control After] with Propensity Score Matching

(1) Preliminary results to be revised

Source: Author's elaboration

7. Conclusion and Recommendations

The potential crowding in/out of private resources has to be monitored more carefully, in particular when non-reimbursable resources are granted. This would not imply any additional burden for the execution of the programs. The present evaluation demonstrates that it would be enough to collect some basic economic and financial information on a relevant group of beneficiaries and non-beneficiaries firms in order to monitor the potential occurrence of this phenomenon. Since opportunistic behaviour may arise as a consequence of changes in the NIS specific conditions, this activity has to be conducted periodically.

There is no clear evidence that the TDF can significantly affect firms' productivity and competitiveness within a five-year period. The evaluation does not provide any strong evidence of a clear impact on firms' productivity and competitiveness. These outcomes, which are often the general objective of the programs, are more likely related to a long run impact of policy. Although it is possible that TDF programs do not produce productivity and competitiveness gains, it is also possible that these impacts occur over a time frame longer than the five years for which the evaluations have data. For this reason, the long run impact of the TDF has to be carefully monitored. Follow up evaluations, allowing for larger time lags to analyze the same groups of treated and non-treated firms, is strongly recommended. In addition, this result should be carefully taken into consideration in the ex-ante estimation of the program's internal rate of return.

Governments should always consider the inclusion of services that can complement the financial support of innovation activities and should be more accurate in defining firms' constraints beyond those of financial nature. Shortage of skilled labour could significantly affect firms' innovation strategy and plan (as it could have happened, to some extent, in Chile). The provision of financial support should be complemented by measures aimed at tackling other relevant constraints. Governments should promote access to highly educated human capital, in particular for those firms that have limited possibility of directly hiring these specialists. The FNDCT results suggest how the interaction between firms and universities can be an effective response to this need.

This study has to be considered as first step in a wider and more intense effort of understanding the effectiveness of the evaluated instruments. For this reason it is highly recommended that an evaluation design similar to the one adopted for this exercise be applied to supervise the activities of the TDF. In particular, the evaluation design should clearly identify: (i) a detailed assessment of the rationale behind the particular policy tool adopted, including a description of the country's specific market failures that the instrument would be addressing, and the rationale of the specific selection mechanism adopted (i.e. the targeting of the instrument); (ii) the identification of the short, medium and long run expected outcomes; (iii) the periodic collection of primary data on the programs' beneficiaries and on a group of comparable non-beneficiaries; (iv) the repetition of the impact evaluation on the same sample of beneficiaries and non-beneficiaries so that long run impacts can be clearly identified; and (v) the periodic repetition of the impact evaluation on new samples of beneficiaries and non-beneficiaries in order to identify potential needs of re-targeting of policy tools.

For the purposes of the TDF impact evaluation governments should promote a more systematic cooperation between the authorities responsible for the TDF and National Institutes of Statistics. A significant part of the information needed for a rigorous impact evaluation can be generated at a low cost and without any additional organizational effort by simply including specific "policy evaluation" sections in the industrial and innovation surveys periodically collected in many LAC countries.

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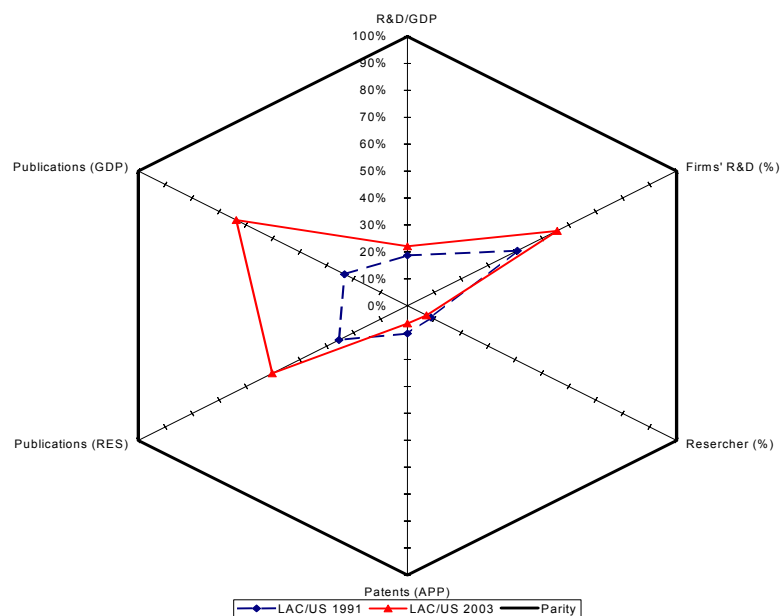
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Appendix

Figure 1 – R&D input and output: evolution of the gap between LAC and US (1991-2003)



Source: OVE's calculations on the basis RICYT 2006

Table xx – Knowledge divide between emerging countries and G7 (2003 and variation 1995-2003)

	KEI (1)		EIR (2)		INN (3)		EDU (4)		ICT (5)	
	GAP*	Δ^{**}	GAP*	Δ^{**}	GAP*	Δ^{**}	GAP*	Δ^{**}	GAP*	Δ^{**}
Latin America	52.5	-2.7	50.4	-9.6	48.9	-3.4	49.5	1.3	61.2	0.1
Argentina	64.1	-4.7	35.4	-36.5	68.8	2.5	87.3	15.8	63.0	-2.7
Barbados	70.8	14.3	72.0	32.3	36.5	-2.6	91.2	11.0	85.1	19.6
Bolivia	42.3	-1.1	54.3	-23.1	18.3	4.5	64.0	18.1	34.8	-5.3
Brazil	60.8	7.7	54.5	-4.5	57.3	6.4	65.9	22.9	65.4	5.6
Chile	80.8	9.7	112.4	24.2	64.6	3.0	73.6	7.9	75.4	4.6
Colombia	45.7	-5.6	40.2	-17.8	37.4	1.8	51.9	1.2	53.3	-8.7
Costa Rica	65.1	-2.4	77.3	3.8	61.1	1.0	49.4	-10.3	73.8	-3.8
Dominican Rep.	36.3	-2.6	42.4	12.4	3.5	-28.7	47.3	-0.4	53.4	8.5
Ecuador	38.0	-1.5	30.4	-15.9	29.1	15.5	44.5	-4.8	48.1	-1.7
El Salvador	42.8	-0.4	66.9	4.0	19.4	-2.5	36.7	-1.9	50.8	-0.3
Guatemala	28.6	9.1	46.5	20.0	5.8	-2.2	25.5	0.5	38.6	19.2
Haiti	17.6	7.7	26.0	22.4	0.9	0.0	13.9	0.7	30.4	8.8
Honduras	26.1	-7.5	39.4	7.6	10.7	-25.5	28.3	-1.2	27.3	-9.4
Jamaica	58.2	-0.3	51.8	-13.6	55.3	-15.0	50.8	6.3	74.2	20.3
Mexico	59.7	0.4	68.1	-7.2	55.3	3.0	51.5	2.3	64.7	2.4
Nicaragua	30.5	5.6	51.4	31.5	8.4	2.1	33.6	-0.1	30.7	-8.6
Paraguay	31.9	-4.5	30.9	-28.4	8.4	3.6	49.1	6.8	40.3	-1.2
Peru	49.4	1.9	46.7	3.4	38.0	-0.3	59.9	-0.4	53.2	5.9
Uruguay	64.1	-7.6	72.4	-13.8	35.2	-21.1	82.8	8.1	67.9	-3.0