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Abstract[*]

In contrast to the limited impact of aggregate-level productive development policies (PDPs) in Argentina, micro-level PDPs in several sectors have proven highly successful. This study seeks to understand how these PDPs succeeded in a challenging environment, what kinds of mechanisms were generated to ensure adaptation and learning, and how these PDPs evolved. Of importance is not only policy design and implementation, but also the policymaking. Following a historical overview of PDP in Argentina, the paper presents three case studies: i) the Argentine Technology Fund (FONTAR), a horizontal PDP; ii) the National Institute of Agricultural Technology (INTA), a vertical PDP; and iii) the application of both horizontal and vertical PDPs to the biotechnology sector. Lessons learned and conclusions are presented in a final section.

JEL Classifications: O25, O43
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Acronyms

ANPCyT	National Agency on Scientific and Technological Promotion
ANR	Non-reimbursable grant
ARAI	Reimbursable grants to institutions
AT	Technological assistance
BF	Biotechnology applied to food
BHH	Biotechnology applied to human health
BNA	Banco Nación Argentina
BPA	Biotechnology applied to plants and animals
CAE	Credits for the technological modernization of firms
CAEFIPP	Credits to firms for the financing of pre-competitive projects
CAI	Credits to institutions
CIDETER	Cluster of farm machinery manufacturers in Southern Santa Fe
CIMMYT	International Center for the Improvement of Corn and Wheat
CNVT	National Coordination of Technological Liaison
CONABIA	National Commission on Agricultural Biotechnology
CONICET	National Council of Scientific and Technological Research
CT	Technology consultancies
CVT	Technological liaison agreements
EBT	Technologically based firm
EEA	Agricultural experimental stations
FAT	Technical Assistance Fund
FDI	Foreign direct investment
FONTAR	Argentine Technology Fund
FVT	Technological Value Upgrading Fund
GACTEC	Scientific and Technological Cabinet
GDP	Gross domestic product
GMO	Genetically modified organism
IDB	Inter-American Development Bank
INDEAR	Institute of Agrobiotechnology of Rosario
INPI	National Institute of Intellectual Protection
INTA	National Institute of Agricultural Technology
INTI	National Institute of Industrial Technology
IPR	Intellectual property rights
ISI	Import substitution industrialization
ISPG	Industry-specific public good
LTPG	Local technological public goods
MERCOSUR	Southern Cone Common Market
MNC	Multinational corporation
PA	Precision agriculture
PDP	Productive development policies

PIT	Innovation technology parks
PITEC	Technological Innovation Projects
PMT	Technological Modernization Program
PNBA	National Program of Advanced Biotechnology
R&D	Research and development
S&T	Science and technology
SICAR	System of venture capital investment
SME	Small and medium enterprises
SOE	State-owned enterprise
UVT	Technological liaison units
VAT	Value-added tax

1. Introduction

Argentina's lackluster productivity growth performance in the past decades (total factor productivity has grown less than 1 percent per year on average since the mid-1970s) suggests that productive development policies (PDPs) failed to make a difference at the aggregate level. However there are several cases of PDPs that appear to succeed at the micro level.

This study seeks to understand how these PDPs succeeded against the odds (macro and political stress, rapidly changing institutional environment and priorities), what kinds of mechanisms were generated to ensure adaptation and learning, and how they evolved. The case study analysis focuses on understanding the extent to which these PDPs enable the emergence of platforms, defined as channels for enabling different possibilities for the technological modernization of different sectors and for the development of new goods and processes.

We are concerned not only with the policy design and implementation and the matching of market and government failures with policy instruments, but also with the actual process of policymaking: a) who the stakeholders are, how they interact and how much weight each one brings to shaping the PDP, and b) whether the interests of the private and public sectors are aligned and what facilitates or hinders this alignment.

In order to shed light on these issues, we present the results of case study analysis of the Argentine Technology Fund (FONTAR), a horizontal PDP; the National Institute of Agricultural Technology (INTA), a vertical PDP; and the biotechnology sector, specifically how it successfully makes use of market interventions and public inputs.

FONTAR is in charge of designing and implementing financial instruments and subsidies that support business-oriented technological innovation and the acquisition of larger technological capabilities, especially by small and medium enterprises (SMEs), and the provision of technological infrastructure and services by public sector institutions.

INTA provides public inputs in the form of technological assistance and technology transfers. Most of its interventions result from a close interaction with the private sector, which facilitates coordination. We analyze both its general functioning and two specific success stories: a) the development of new varieties of genetically improved rice, and b) the key role of INTA in the introduction of precision agriculture technologies in Argentina through its extension activities, which contributed not only to technological modernization but also to the creation of a platform for continuous introduction of new technology arrivals.

Biotechnology is a success story in Argentina. The emergence of these sectors has benefitted from horizontal support from FONTAR and from the vertical provision of public inputs by INTA.

The methodology employed in this research involves a case study analysis of each set of PDPs. We interviewed relevant actors from the private and public sectors that participate in each sector and activity supported, and we analyzed relevant information from secondary sources.

Section 2 provides a historical overview of PDP in Argentina. The analyses of the case studies on FONTAR and INTA are respectively presented in sections 3 and 4. Section 5 briefly illustrates the use of different horizontal and vertical PDPs by biotechnological firms. The conclusions are presented in Section 6.

2. Historical Overview of Productive Development Policies in Argentina

Between the end of World War II and the mid-1970s, PDPs took the form of import substitution industrialization (ISI). The main policies were tariff and non-tariff barriers to imports, explicit and implicit agricultural export taxes (through marketing boards), multiple exchange rate regimes, and subsidies and tax credits for investment in the manufacturing sector. Although protection was granted across the board, certain industries like machinery, automobiles, and shipbuilding were targeted.

In the initial stage, which lasted until the late 1950s, protectionist policies focused on light, labor-intensive industries. The heavy reliance of these industries on imports of intermediate inputs, together with the discrimination of agricultural exports, led to frequent shortages of foreign exchange and to the introduction of barriers to imports of capital goods (to prioritize imports of intermediate goods), which considerably increased the price of these goods and hurt investment.[1] In a second stage, emphasis was placed on the development of heavy industries through foreign direct investment (FDI) and state-owned enterprises (SOEs), which produced intermediate inputs to substitute the imports of petrochemicals, steel, aluminum, pulp and paper, energy, transportation, and others.

ISI was deemed to have both positive and negative effects (see Chudnovsky and López, 2007). Its pros included productive diversification, some technological learning, and the

[1] Taylor (2003) estimated that the distortions in the price of capital had an annual growth cost of 2 percentage points per year between 1945 and 1990.

emergence of an urban middle class. Its cons included: a) the inherent tendency to cause macroeconomic and external instability, b) the poor quality and high costs of local goods (because of small market size, as well as insufficient competitive pressure and technology flows towards the country), c) exacerbation of income inequality, d) the discouragement of and/or lack of incentives for exports, and e) the embedded incentives to engage in rent-seeking activities rather than innovation.

The creation of SOEs improved the availability of critical inputs, reduced but did not eliminate the shortage of foreign exchange, solved some coordination failures, and generated some technological learning. However, the prevalence of political criteria to manage these companies led to bloated payrolls and political pricing which contributed to growing fiscal deficits and to low investment in these firms, together with misallocation of investment.

Tariff protection and other PDPs attracted multinational corporations (MNCs) to some strategic sectors. These firms acted as providers of technology and capital and contributed to some development of specialized inputs and training of the labor force of local suppliers, but not to an extent that generated large spillovers to local companies. Multinational corporations were mostly attracted by the possibility of avoiding the tariff, usually working at suboptimal scales with large unit costs.

Import substitution industrialization fell apart in the mid-1970s, mostly because of the considerable macroeconomic and external instability associated with it, together with the accumulation of large deadweight losses. In the late 1970s and early 1980s, the military government initially liberalized imports of final goods but continued to protect critical inputs produced by SOEs. It introduced a negative effective rate of protection for manufacturing activities which, together with a large real exchange rate appreciation, was highly detrimental to manufacturing firms. The military also introduced a national industrial promotion program that subsidized projects to produce intermediate inputs in large capital-intensive plants (Kosacoff, 2000). These projects, implemented between 1976 and 1990 but mostly while the military government was in power, would have made more sense under the previous ISI regime. The military also implemented a regime that fostered investments in less developed provinces, largely specialized in the final stages of the production process in order to maximize tax deductions (Chudnovsky and López, 2007). These schemes, which had large fiscal costs, lacked transparency and did not include performance requirements, were eventually discontinued.

During the 1980s, the isolation from the world economy caused by the debt crisis of 1982 forced a new closure of the economy, while the chronic fiscal imbalances, largely associated with SOEs, left very little room to finance PDPs.

The early 1990s saw a shift towards financial and trade liberalization, deregulation, privatization, and attraction of FDI. PDPs were not abandoned, but there was less emphasis on them, and now they were geared towards enhancing competitiveness vis-à-vis imports in a more open environment, albeit with more faith placed on giving the right market signals. There were both horizontal and vertical PDPs, and a more demand-driven approach prevailed in the latter. The formation of MERCOSUR in 1995 provided a boost to the manufacturing sector, leading to fast-growing intra-industry trade with Brazil (with horizontal specialization) until 1998.

During the 1990s, the manufacturing sector shed less efficient firms and jobs in order to gain international competitiveness and compensate real exchange rate appreciation with higher labor productivity, leading to large-scale destruction of manufacturing jobs.

Productivity gains and technological improvements were attained but were not enough, together with the existing PDPs, to compensate for the devaluations in the currencies of Argentina's trading partners in the late 1990s (especially Brazil), and the costlier and scarcer credit associated with private capital outflows. Industrial relocation towards Brazil, together with a sizable firm exit process in many sectors characterized by sequential production processes, also weakened the competitiveness of surviving firms. The agricultural and service sectors underwent significant technological modernization, due both to FDI and the provision of important public inputs. Macroeconomic and regulatory stability and improved access to public utilities were important horizontal public goods until 1997, but deteriorated thereafter.

Throughout the 2000s, there has a been a greater emphasis on PDPs, geared towards enhancing competitiveness with an eye to competing in global markets and targeting more sectors and clusters than in the past. However, the overall policy environment has not favored targeting global markets. Manufacturing exports have grown significantly because of a competitive real exchange rate and world trade growth, but they have also lost sizable world market share (the opposite of Brazil). The attitude toward FDI has not been very favorable (and the debt arrears with the Paris Club do not help either), causing FDI flows to Argentina to fall significantly, losing its sizable share of FDI flows toward Latin America and the world.

The most important PDPs, in terms of the number of specific programs and the allocated budgets, are those that horizontally target SMEs, investment, and exports. The most common instruments used to support SMEs are subsidized credits to finance investment, working capital, and exports. The Ministry of Production also has a Guarantee Fund that supplies collateral for SMEs.[2] The second most commonly used instruments are subsidies or tax credits for the purchase of capital goods.

The most common policies used to support investment are subsidized loans and tax breaks. The main instrument is Law 25.924, which introduces several subsidies, such as the immediate reimbursement of the value-added tax (VAT) on investment, the possibility of an accelerated amortization of investment (to reduce income taxes), and the reimbursement of the technical credit on VAT.[3]

There are about 26 export promotion programs, most of which are horizontal, although some of them focus on certain regions and others on SMEs. More than half use market interventions, such as subsidized loans, non-reimbursable grants, export processing zones, export drawbacks, VAT reimbursement, temporary admission regimes, long-term post-shipment loans, and other tax break and financing programs. About one-third provide public inputs in the form of marketing information, training of managers for exporting, assistance of managerial re-organization for exporting, organization of trade fairs, and so on.[4] There are no relevant PDPs to compensate for the information and coordination externalities that may hinder self-discovery, which is reflected in the stagnant export sophistication and scant diffusion of new exports during the past two decades (see Sánchez et al., 2008, and Sánchez and Butler, 2008). Other relevant

[2] Support to SMEs receives a large amount of resources. Almost US$100 million were allocated in the 2008 national budget to this end. Most of the support programs are implemented by the SSPEPyME, which runs 22 programs. Most of the PDPs are horizontal, although there are a few vertical programs for SMEs, in the software, tourism, and agriculture sectors. There are also several other government offices (both at the national and provincial levels) that have programs to support SMEs. This is a very large set of PDPs from a budgetary point of view. Just to give one example, the *Régimen de Bonificación de Tasa de SSEPyME* has a budget of AR$700 million.

[3] There are other accompanying regimes (such as Law 25.988 and Decree379/2005), which introduce additional tax breaks on investment. The Secretary of Industry at the Ministry of Economy is in charge of designing and implementing these programs. Then there are several programs that subsidize credit to investment, mostly targeted to SMEs (discussed above). Most of these programs are horizontal in nature. There are vertical programs that promote sectoral and/or regional investment.

[4] About 15 percent of the export-related PDPs offer a combination of market interventions and public inputs, such as the Exporters Group program, run by the export promotion agency and a private foundation. There are some special export-support programs that specifically target: a) exporting SMEs b) regional exports, c) some sectoral exports (domestic SMEs that export software), c) some specific activities (like the turnkey export regime), and d) the formation of export consortia that share some fixed costs of exporting (logistics, etc.).

horizontal PDPs support technological innovation and promote cluster formation, mostly through market interventions in both cases.

There are a small but growing number of vertical PDPs that provide market incentives or public inputs depending on the sectoral needs. The National Institute of Agricultural Technology (INTA), analyzed in this paper, has provided public inputs in the form of technology transfers to agriculture and to biotechnology applied to plants and animals for more than 50 years. INTA transfers some technology to manufacturing firms and certifies compliance with technical regulations. The National Commission on Biotechnology provides key public inputs by certifying the safety of new genetically modified organisms that have led to vast technological modernization of agriculture during the past two decades. There are a number of recent sector-specific PDPs that seek to provide subsidies and financing to sectors such as software and biotechnology, but that have not yet had a significant impact. FONTAR is also moving in the direction of creating several sector-specific technology funds. Finally, non-tariff barriers (anti-dumping policies, import licenses, technical barriers, etc.) continue to be used as defensive PDPs in a number of sectors.

The historical vacillation in attitudes toward PDPs and their rationales, coupled with a large turnover of public officials and lack of coordination in among relevant areas, has led to very little accumulation of learning for formulating the adequate PDPs, and to the lack of an adequate assessment and corresponding strategy behind the PDPs. Interviews with tenured public officials in areas related to PDPs reveal that during the past 20 years there has been an apparent deterioration in the institutional setting, which has resulted in poor capacity to identify priorities and design and implement adequate policy instruments.

3. PDPs for Technological Innovation: The Case of FONTAR

Technological innovation and research and development (R&D) are relatively scarce in Argentina. Total spending on R&D in 2007 amounted to 0.5 percent of GDP, significantly less than relevant comparators. Additionally, a disproportionately large share of the total research effort in Argentina is undertaken by the public sector.[5]

[5] R&D spending relative to GDP is 0.7 percent in Chile, 0.9 percent in Brazil, 1.1 percent in Spain, and 2.7 percent in the United States. Private sector participation in total R&D spending in Argentina never exceeded 25 percent, whereas in countries like the United States, private sector participation is around 60 percent.

The dearth of innovation appears to be especially important in the manufacturing sector.[6] Nevertheless, some sectors, such as biotechnology, farm machinery, and chemistry, display high intensity of technological innovation and are close to the world technology frontier. Innovation appears to be more widespread in the agriculture sector and the services sector, particularly software.

The Scientific and Technological Cabinet (GACTEC) is in charge of defining science and technology (S&T) policies and national priorities.[7] It proposes the budget for support to this activity and evaluates the accomplishment of the multi-year S&T plans. Most of the instruments used fall in the category of financing, although some PDPs provide public inputs (testing and calibration laboratories, technological counselling, IPR counselling, etc.) as well.

The public institution most directly related to technological innovation is the Ministry of Science, Technology, and Productive Innovation, created in 2007. This Ministry includes the National Agency on Scientific and Technological Promotion (ANPCyT), which manages two technology funds, the FONCYT and the FONTAR.

The Fund for Scientific and Technological Research (FONCYT) provides grants to non-commercial basic and applied S&T projects. Its beneficiaries are mostly universities and the National Council of Scientific and Technological Research (CONICET) and, to a lesser extent, INTA and the National Institute of Industrial Technology (INTI). The grants are allocated to competing research projects, research equipment and infrastructure upgrading projects, organizational projects that generate more synergies within the national system of innovation, human capital accumulation in S&T, and research consortia.

The direct provision of public inputs to innovation is done by INTA and INTI. INTI is an industrial research institute attached to the Secretary of Industry at the Ministry of Production and whose main lines of work are technology transfers and technological assistance for the manufacturing sector. However, because of budgetary incentives and human resource limitations, INTI is more inclined to provide testing and calibration services for the private sector

[6] Sánchez, Nahirñak and Ruffo (2006) find that the average amount spent on innovative activities by Argentine firms relative to sales was 1.7 percent in 2001, much less than in Brazil (4 percent). The maximum amount spent by Argentine innovative firms was 2.15 percent of sales, much less than the maximum amount spent in Brazil, which reached 7.8 percent of sales.

[7] The GACTEC was created in 1996 and is coordinated by the Chief of Staff. It was established by all of the ministries and secretaries that control activities linked to S&T.

rather than undertaking technology transfers and technological assistance. The latter occur only in some of the Institute's regional offices.

3.1 The Financing of Innovation in Argentina

The difficulties faced by private firms in obtaining access to adequate financing have been singled out in the National Innovation Surveys as the main obstacle to innovation by manufacturing firms. Most of the innovation done by manufacturing firms is self-financed.[8]

Funding by ANPCyT funds (FONTAR and FONCYT) financed only 2 percent of all the innovation activities performed by manufacturing firms in 2004 (AR$57 million). The ANPCyT financed 8 percent of the spending in technological innovation by small firms, 4 percent in the case of medium-sized firms, and 1 percent in the case of large firms. If we focus solely on R&D by private manufacturing firms, ANPCyT funds financed 8 percent of these outlays in 2004. This survey also revealed that FONTAR was the second source, after banks, of external financing for innovation activities of small firms. FONTAR participated 25 percent of all loans granted by financial institutions to innovation activities. FONTAR was also the second source of financing of innovation by medium-sized firms, ranking behind suppliers and doubling the participation of banks, which ranked third.

3.2 The Argentine Technology Fund

The Argentine Technology Fund (FONTAR) is charged with designing and implementing PDPs that support business-oriented technological innovation and R&D. These PDPs deal mostly through financing and subsidizing technological modernization, R&D, the provision of technological services to private firms, and the provision of local technological public goods that enhance the technological capabilities of SMEs.

The Fund, established in 1995, is the first Argentine program aimed at financing technological innovation by private firms. It has managed to sustain itself over time despite threats posed by macroeconomic instability since its inception.

[8] Self-financing represented 72 percent of all the innovation funding for the private sector between 1998 and 2001, rising to 83 percent in 2004. Most of this funding came from the reinvestment of profits. According to the 2004 National Innovation Survey, between 2002 and 2004, 74 percent of the self-financing came from the reinvestment of profits.

3.2.1 Governance Structure and Institutional Capacity

FONTAR has a staff of 40, including experienced engineers, young engineers and economists, and administrative staff. It has relatively little turnover, save for the young technical staff.[9]

Most of the staff have one-year contracts, which must be renewed annually. The renewal is conditioned on the continuation of funding from the Inter-American Development Bank (IDB), which has financed FONTAR since the outset. A few senior positions (at the director and president levels) are tenured, and appointments are based on public competitions.

FONTAR's governance structure includes a president and a board of directors. It relies on ad hoc commissions that advise them on specific issues and that evaluate the technical aspects of the supported projects. Project financing is managed by experienced tenured technical staff, who advise on the project approval process.

FONTAR is autonomous with respect to defining the support instruments. Its budget (U$S200 million in 2008) is financed mostly by multilateral organizations. The funding originating in the public sector represents only 25 percent of the total budget.

3.2.2 What Policy Instruments Are Being Used?

The first set of PDPs was implemented in 1995-1999 with financing from the IDB of U$S190 million (Technological Modernization Program I, PMT I). There were two sub-programs, one run by FONTAR and another run by SECyT-CONICET. The instruments included the following:

- Loans to established, relatively old firms that financed mostly the acquisition of capital goods with embodied technological knowledge (Line 1). These loans were co-financed with Banco Nación Argentina (BNA), which bore all the credit risk. They targeted established firms that had tangible collateral.
- Financing of the development of technological services for business firms by technological and scientific institutions in the public sector (Line 3). These services usually entail the provision of local technological public goods (LTPG), such as laboratories, metrology services, and so on. These credits

[9] The experienced engineers usually have retired from jobs in large private firms and bring valuable evaluation experience. Young technical staff are difficult to hire and retain because of low public sector wages compared to salaries in the private sector.

were financed only by FONTAR, which reduced the collateral required and facilitated their granting.

- Loans with contingent repayment run by SECyT-CONICET, which targeted more innovative and technologically riskier projects (development of products or processes, construction of prototypes, etc.). If the project failed on technical grounds, the beneficiary only had to repay the residual value of acquired research equipment (Line 4). This instrument was also financed by FONTAR only.
- Small subsidies for the management of technological projects, technical assistance, and elaboration of business plans by SMEs.

The PMT I tended to promote the acquisition of capital goods with embodied technological knowledge and to provide LPTG that would enhance technological capabilities in the private sector. It allocated 44 percent of its funds to modernization loans, 31 percent to credits to institutions, and the remaining 25 percent to contingent repayment loans.[10] Contingent repayment loans were subject to important moral hazard and were eventually abandoned. The financing counterpart by firms and institutions was significant, as FONTAR financed only 45 percent of the total cost of the supported projects.

FONTAR was consolidated when the ANPCyT was created in 1996, which granted it access to managing the budgetary funds established by Law 23877 on Promotion and Support to Technological Innovation. This allowed it to design new lines of support that better accommodated the different types of projects and actors involved in technological innovation. FONTAR could lend itself these funds, increasing access to innovative projects by firms and institutions that lacked the collateral required by commercial banks. The larger pool of funds and greater flexibility obtained as a result of these moves greatly increased the number of projects approved (from 22 to 350). Access to all of these instruments was granted on a non-competitive basis (open-window system).

At different times between 1998 and 2007, FONTAR also financed the creation of "technology consultancies" (CTs), which serve as institutions that provide technological

[10] The Line 4 instrument, which targeted technological spillovers and lack of venture capital, received much less funding per project than the others, probably reflecting the involved risk. The programs financed 172 projects; the average financing was approximately US$400,000 per project. The total amount devoted to these programs was US$68 million.

consulting and guidance to SMEs with the ultimate goal of enhancing the ability and inclination of the latter to undertake innovative projects and to secure IPR. The initial CTs supported involved technological liaison units advising groups of SMEs mostly in the areas of technical assistance for quality assurance and certification, organization of production, productivity improvements, and business administration. In a second stage the CT program was extended to agricultural SMEs. The support to CTs reflects the concern of FONTAR regarding what they perceive as the absence of "a culture of innovation" in private firms (a public input).

Between 1998 and 2007, FONTAR introduced a program of tax credits that could be applied to projects involving: a) research applied to production activities, b) pre-competitive technological research, and c) adapting and improving existing technologies. The beneficiaries of these programs were manufacturing and service firms. The maximum tax credit allotted could not exceed 50 percent of the project's budget. At least half of the tax credits had to be allocated to SMEs.[11] One interesting feature of the program is that it entailed a system of matching grants, which required more information to be revealed, thus diminishing the scope for moral hazard. Starting in 2003, the tax credit program was tailored to four different types of projects: a) R&D projects by SMEs and large firms, b) technological modernization projects by SMEs, c) technological service projects that firms contract with public research institutions, d) technological consultancies in which a large firm was granted a tax credit to finance different types of technical assistance to its network of suppliers or of customers.

A new program to finance technological modernization, known as PMT II, was launched in 2000. It was jointly funded by the IDB and by the Argentine government and included the following instruments:

- Credits for the technological modernization of firms (CAE), which were intermediated through financial institutions.

[11] This program was held annually since 1998 (except in2001). Tax credits were allocated on a competitive basis (there is a call for projects every year). An ad hoc commission created by the Board of Directors of ANPCyT monitors the evaluation of the applications for support and analyzes the appeals for reconsideration of projects rejected in the first round. The total budget remained constant between 1998 and 2006, and more than doubled (in AR$) since 2007. However, this budget fell significantly when measured in real and dollar terms. The program financed 952 projects between 1998 and 2007. Total funding was US$104 million during this period (US$11.5 million per year), and the average funding per sponsored project was US$109,000. Whenever the number of approved projects exceeded the availability of funds, priority was given to those projects demanding a lower proportional subsidy and to those that allow preserving a targeted distribution of projects among provinces.

- Credits to institutions (CAI), which continued financing the generation of technological services for the private sector.
- A new line of credit to firms for the financing of pre-competitive projects (CAEFIPP). The CAEFIPP could be granted directly by FONTAR after the PMT II regulations were modified with the consent of the IDB.[12]
- A new line of non-reimbursable grants (ANR) or subsidies. The ANR targeted projects seeking to improve the capacities for R&D, engineering, and design of SMEs.[13]

The goal of the ANRs was to improve the R&D, design, and engineering capabilities of SMEs through research units that could be located inside the firm or contracted to public research institutions. The ANRs were in high demand by SMEs.[14]

In contrast to the PMT I, the PMT II tended to promote R&D and improvement of the technological capacity of the smallest firms. The total amount allocated by the PMT II was AR$350 million, 1 percent of which went to the modernization loans to firms, 15 percent to the credits to institutions, 48 percent to pre-competitive projects, and the remaining 36 percent to ANR.[15]

There remains a relatively large emphasis on financing the provision of LPTG by institutions. The use of the ANR appears to correct for the PMT I bias toward financing innovation by larger firms with collateral. The PMT II additionally had more funds, although it distributed them to a larger number of projects. The CAEFIPP represented a response to the

[12] These credits were aimed at the production/development of new materials, products and services; the establishment of new processes, services and systems; and the construction of prototypes and the performance of pilot tests and essays. The CAEFIPP replaced the CAE in 2003, which were discontinued because of the inability of banks to act as financial agents during the 2002 crisis. The CAEFIPP could not exceed US$750,000 and had subsidized interest rates and longer maturities than the CAE. They were initially granted on a non-competitive basis, but the growth in demand prompted FONTAR to allocate them on a competitive basis.

[13] The ANR could grant up to US$300,000 per firm (which became smaller with the 2002 devaluation), and up to 50 percent of the total cost of the supported project.

[14] The excess demand forced FONTAR to generate merit rankings to allocate them. There was a preference for financing highly innovative projects of firms that were smaller and located in less developed regions, generated more jobs, and involved collaboration with public research institutions. The demand for ANR declined in 2002 with the economic crisis but quickly recovered after 2003. The ANR also were used to support technological consultancies, business incubators, technology parks and patents. Some specific financing was allocated to innovative agriculture-based manufactures innovative projects in the Northwest and Northeast regions in 2002 and to ITC projects by SME in 2004.

[15] Between 2000 and 2006, the PMT II financed nine technological modernization loans to firms for an average of AR$433,000, 46 loans to institutions for an average of AR$1.1 million, 201 CAEFIPP credits for pre-competitive projects for an average of AR$840,000, and 1297 ANR for an average of AR$96,000.

crisis by making the system for financing firms more flexible. These were very successful financing instruments (75 percent of the PMT II funds were used in these loans), which supported a large variety of new technological developments. The growth of credits to institutions reveals that FONTAR appeared to be prioritizing the creation of a "culture of innovation" and/or compensating for the lack of an adequate technological infrastructure for SMEs.

PMT III was launched in mid-2008, with resources available to finance technological innovation amounting to U$S280 million. These resources enabled FONTAR to continuing offering its existing instruments as well as offer new ones. The ANR now included the financing of R&D capabilities of SME (ANR-I+D), and the provision of technological services (ANR-CT) by public and private institutions that train technological start-ups on the relevance of, and processes for, patenting their technological developments. FONTAR also runs the ANR-Patentes program, which finances the costs of patenting for SMEs. The loans to firms (CAE) can now be fully granted by FONTAR without having to resort to financial intermediation. The loans to institutions (CAI) for the provision of technological services have been relabeled ARAI (reimbursable grants to institutions). Institutions charge fees to users for their technological services, which they use to repay the grant.[16] The ARAI are being used by municipal governments seeing to provide LPTGs and by local business associations.

Other recent PDPs implemented by FONTAR include the PITEC program for financing technological modernization and R&D activities of groups of firms, research centers, local governments, and business chambers that form ad hoc associations to jointly pursue these projects. These instruments seek to promote synergy and spillovers among the participating actors.

The World Bank is providing funding for programs that will support the creation of new technological start-ups that spin off from research projects developed in public institutions. It will be a flexible program that uses the instruments that support several classes of projects.[17] The World Bank will also finance a venture capital fund that will seek to leverage the funding

[16] The ARAI are covert credits that require no repayment during the first four years and that are repaid over a period of 10 years.

[17] It seeks to finance the start-up from inception to the break-even point, when it can be financed by venture capital (VC) funds or other financing vehicles.

provided by private financiers.[18] This fund will also finance the creation of consortia involving public institutions that assist SME in the analysis and demonstration of technical feasibility of the projects and business and financial institutions that assist SMEs in the analysis of the economic and financial feasibility of the project.

3.2.3 What is the Underlying Assessment?

The main goal of FONTAR is to support R&D and strengthen the technological capacity of SMEs. FONTAR believes that this will help SMEs create linkages with public research institutions (universities, INTA, INTI, etc.), which will in turn enable the emergence of platforms.[19]

The provision of LPTG, which is vulnerable to coordination failures, is supported in order to enable and stimulate SMEs to move from more traditional technologies to modern, R&D-intensive technologies. These LTPG also help firms comply with product and process standards and technical regulations and to compete internationally, hence justifying investment in R&D. The provision of these technological services also contributes to interaction among the institutions and the beneficiary firms. The typical LPTG promoted is the creation of a modern laboratory in a region that provides technological services to firms in that region. These include, for example, testing and calibration labs, clinical analysis labs, and metrology services.[20] Providing these technological services is considered the first step for SMEs to start developing ready-to-finance projects.

Technological liaison units (UVT) were formed to facilitate, together with universities and business associations, the formulation of ready-to-finance projects and access to FONTAR's support. The UVT should facilitate technology transfers from public institutions to private firms.

3.2.4 Is There a Policy Learning Process?

FONTAR learns about the need to adapt and upgrade policies mostly from observing the response of private firms and public research institutions to the launching of the different

[18] The MINCYT will add U$S10 million to finance seed/angel capital.
[19] R&D and technological modernization by large firms is supported through tax credits and through CAEFIPP.
[20] Examples of these types of LTPGs include the installation of wine chromatographers in Mendoza, the metrology center of Universidad Austral and the labs for firms in the CIDETER cluster. The ARAI for the CIDETER cluster finances not only the installation of labs for the cluster firms, but also the undertaking of prospective efforts by the cluster coordinator. It is worth highlighting that for instance the installation of the metrology service by Universidad Austral was promoted by Volkswagen, with the intention of providing an LPTG for its suppliers of car parts (although the metrology service can also sell its services to other firms in the metal-mechanics sector).

instruments and also from the ex-post detection of possible inadequacies in the conditions established in each call for projects. We now provide two examples of this policy learning process, as reported by FONTAR.

Tax credits. The first batch of fiscal credits, which were rather generic (one size fits all), were not too in demand, until they were tailored to different activities (R&D, technological modernization, etc.). This tailoring was done after learning from the initial lack of response.[21] FONTAR now analyzes how the demand for different instruments evolves and what types of projects are presented by firms. Based on this information they organize different types of tax credits by activity. However, they always give priority to R&D.

PITEC. PITECs were created in response to an ad hoc request of support for a joint innovative project by CIDETER (a cluster of farm machinery manufacturers from Southern Santa Fe). FONTAR saw an opportunity for financing innovative projects by clusters that included interaction with R&D activities and the provision of LPTG and technological services by the involved firms and public research institutions. This instrument was very complex to design; it was set up in 2006 and has only now begun functioning.[22]

Other examples of policy learning include the creation of technological consultancies for IPR after funding with generic ARAI a technological consultancy by CETRI (a technological liaison unit at the Universdidad Nacional del Litoral that provided this type of service to some local SMEs), and the introduction of the ANR-I+D in response to demands by private firms for ANR that supported the installation of R&D labs within the firm that exceeded the requirements for the specific project. Another example is the abandonment of the contingent repayment loans of the PMT I because of the moral hazard involved. This problem made FONTAR replace the contingent repayment loans with tax credits based on matching grants.[23]

[21] For instance, they have now introduced a new tax credit for technological consultancies (CT) that supports the formation of CT by large firms that provide technological services in the form of advising and assistance to suppliers and customers (that are SMEs) for compliance with technical regulations and product and process standards. They are doing this because they have learned that a starting point for SMEs to engage in innovative activities is that they have standardized processes and that they are able to target international markets.

[22] At present, FONTAR is moving in the direction of adapting the PITEC to support joint endeavors that serve as technological platforms for generating broad classes of innovative projects (rather than one specific project), like the INDEAR in Rosario (which includes joint ventures by Bioceres, Biosidus AG, and Polo Tecnológico de Rosario in biotech research for plants). They are also moving in the direction of supporting the provision of club goods, such as LPTGs, by associations of firms and public institutions.

[23] These instruments demanded a very complex evaluation of the results of the projects supported, i.e., to the extent to which the project had actually succeeded or failed. There was a general trend to formulate the projects in such a

3.2.5 Has the PDP Succeeded Partially or Completely?

Aseries of quantitative and qualitative indicators suggest that FONTAR did make a difference at the microeconomic level, especially for highly innovative sectors. FONTAR's own assessment highlights that, through the ANR, it had a direct impact on the creation of new technologically based firms.[24] Between 2004 and 2006, at least 75 percent of approved projects were classified as having medium-high or high technological content and were financed via ANR and loans for pre-competitive projects, thus meeting one of the avowed priorities of the fund.

FONTAR also noted that the emphasis given to the promotion of a larger liaison between firms and scientific and technological institutions is one of the biggest impacts.[25] Almost 40 percent of the institutional loans involved public universities, and 20 percent involved INTA and INTI.[26] The technological liaison units (UVT), especially those belonging to public universities, played an important role in the institutional projects.

At first, FONTAR approved only 10 percent of the projects that applied for support. Now, it approves 50 percent of the projects presented. This increase is attributed to the actions taken by UVT, business associations, and universities. It is also the case that a good part of the projects supported is presented by firms that got support in the past and that have learned how to formulate innovative projects with adequate financial feasibility.

Incremental Impact on Technological Innovation. FONTAR considers that its support to technological innovation is not substituting for private spending, but rather complementing and strengthening its effect. There have been some exceptional cases where a firm has sought to substitute FONTAR's support for private spending, especially in the case of credits to large firms. But generally they have avoided this type of deviation through an adequate design of the conditions required to receive support and an adequate monitoring process. In this vein, econometric studies by Chudnosky et al. (2006a) show that the ANR had an incremental effect

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way that the results could be interpreted as failures even when, under reasonable R&D parameters, they are actually successes, so as to avoid repaying the loan.

[24] Out of 924 firms that applied for ANR in 2003, 71 were created at the time of the call for projects and 352 of them were less than 5 years old and had minimal or nil sales.

[25] More than half of the 695 projects that were evaluated in 2003 sought to link firms with S&T institutions. FONTAR supported institutional projects of very high technological content, such as the production of radioisotopes by the National Atomic Energy Commission, developments in animal virology by INTA, biotechnological developments by INTI, and genetics developments by the agricultural experimentation station of INTA in Obispo Colombres, among others.

[26] In order to strengthen technology transfers to private firms, FONTAR allows firms to include the cost of subcontracting public research institutions in the budget of the projects it supports.

on the innovation intensity of the SMEs supported.[27] Another study by Chudnosky et al. (2006b) estimates the social and private rates of return of ten supported projects and found that the social rate of return was larger. Finally, a study by Carullo et al. (2003) found that the technological consultancies supported by FONTAR had a positive impact on the beneficiary SMEs in terms of business and technological planning.

An econometric analysis performed by Sanguinetti (2005) found that FONTAR appears to have an incremental effect on R&D spending by the supported firms, but no incremental effect on total spending on innovation. This analysis focused on all manufacturing firms supported and not just on SMEs, which may help explain the result. Additionally, FONTAR's support is skewed towards supporting R&D activities rather than all types of innovative activities.

Perception of Supported Firms. The perception of the officials interviewed at the firms that received support from FONTAR is very favorable, especially those who, after receiving initial support, benefitted from a learning process on how to formulate financeable projects and were able to obtain additional financing from FONTAR. Some of the SMEs that received support consider that, while the support policies were well designed and implemented and very helpful to their initial development and growth, it would have been necessary to complement them with policies that support the growth and consolidation of young firms, for instance by transferring to the Ministry of Production the cases of young, successful firms that would need further support in other areas to continue growing.

Large firms in the biotechnology applied to the human health (BHH) sector that have repeatedly used FONTAR instruments such as contingent repayment loans, tax credits, and CAEFIPP loans are satisfied with this support, which helped accelerate their projects (partial crowding-out of private spending). However they complain that the support is normally not sufficient to finance all of the innovation projects through the final development stages.

Government Failures. FONTAR considers that there is insufficient coordination with other related public agencies, and improvement in this area is slow. Lack of coordination hinders the growth of innovative firms after they graduate from the technological start-up phase with the support of FONTAR. The gaps in policy coordination include the promotion of the

[27] These authors also found that 55 percent of the SMEs supported would not have undertaken the project without the support of FONTAR. Forty percent of them asserted that the ANR support allowed them to accelerate project implementation (partial crowding-out of private spending). On the other hand, 28 percent of the firms supported stated that the amount of the subsidy was not large enough.

venture capital industry, adequate tax and labor regulation treatment to these firms, and the creation of trade capacities that facilitate the targeting of export markets.

FONTAR highlights the lack of long-term planning in the formulation of public policies as a whole, which reduces the effectiveness of innovation policies. It notes, however, that there has been significant improvement in terms of long-term planning at the local government level.[28] FONTAR also complains about the insufficient formality of many of the firms seeking support, which suggests that policy and regulatory incentives designed to bring SMES into the formal sector are a barrier to the provision of more extensive support to innovation.

3.2.6 Sources and Allocation of Funding

The national budget has funded FONTAR's tax credits and a few tenured positions (25 percent of FONTAR's budget in recent years) since 1998. The Inter-American Development Bank, which has funded FONTAR since its inception, pays for the short-term contracts of most of the staff and all of the instruments that are not tax credits. Additional funding from the World Bank finances new programs. Other funds are authorized by Law 23877. Loans from international organizations are granted to the Ministry of Economy, which is responsible for repaying them. Hence, all loan amortizations and interest payments made by firms and institutions are an extra source of funding for FONTAR.

FONTAR allocates 66 percent of its funds in the form of credits.[29] FONTAR enjoys a high rate of repayment. It covers its financing gaps with its own savings (the Recovery Fund), which allows it to continue making unlimited calls for new projects to support and to sustain itself during the periods between IDB loans, such as during the 2002 crisis. One reason that beneficiaries do not default on FONTAR credits is that they do not want to be denied future funding. Nevertheless, both FONTAR and the ANPCyT have had to rely on credible sanctioning mechanisms to prevent beneficiaries from defaulting.[30]

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[28] One example cited was the creation of the Ministry of Science and Technology in the Province of Córdoba, which has an undersecretary of technological liaison and which is working very well with a UVT created by the Unión Industrial Córdoba, the local stock market and the National University of Córdoba, helping private SMEs in the formulation of a large number of attractive ready-to-finance innovative projects. They are also working very well with the technological liaison office of Unión Industrial Argentina.

[29] In 2008, AR$175 million were allocated, of which AR$20 million were subsidies. While the number of projects supported by credits is relatively smaller, the amount financed per project is larger than for the other instruments.

[30] For instance, there was the case of one university that tried to renege on the repayment of an ARAI (or CAI), and the ANPCyT had to cut FONCYT funding to researchers in that university, which forced the university to comply. These mechanisms force universities and other institutions that apply for ARAI to come up with profitable business

The sectoral allocation arises purely from the demand side. Some sectors present a larger proportion of ready-to-finance projects. However, the creation of sectoral funds financed by the World Bank reflects the growth of certain high-tech sectors, such as biotechnology, nanotechnology, and ICT, which have traditionally demanded more support. These sectors have also benefited from recent legislation designed to promote them. The IDB has directed some of its recent funding toward the creation of four sectoral technology funds in the areas of health, clean energy, manufactures of agricultural origin, and social sectors.[31] FONTAR is currently moving in the direction of adding vertical components to facilitate the emergence of sectoral venture capital funds. It is also supporting the growth of innovative SMEs that have graduated from their seed-capital stages.

Between 1995 and 2006, 58 percent of FONTAR's funding was allocated to manufacturing firms, 30 percent to the business services sector, and only 5.9 percent to agriculture.[32] The chemical industry (especially BHH) absorbed 31 percent of the funding allotted to manufacturing, which is consistent with the high R&D intensity of this sector and the technological and bureaucratic sophistication of the entrepreneurs.[33] Next comes the machinery and equipment industry, especially farm machinery (which is in the technological frontier), which absorbed 15.7 percent of all the funding for manufactures, followed by the food and beverage industry (15.3 percent).[34]

The largest share of the support to the business services sector was allocated to information and telecommunications technologies projects, especially those related to software

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plans for the supported projects. This means that the technological services generated with the ARAI and sold to private firms must generate sufficient revenues. The projects that apply for ARAI's support are evaluated from a technical and financial point of view using the same parameters as the projects presented by private firms (that apply for credits to support R&D or technological modernization projects).

[31] The IDB has now extended the maturity of the loans to FONTAR to a period of 6-7 years, distributed in several stages. In the first stage, sectoral funds are to be used as catalysts for the creation of sectoral venture capital funds by the private sector.

[32] Although there is significant innovative activity in agriculture, there is a dearth of projects that are adequately formulated by private firms in the sector. This is improving with new firms like Bioceres, which exclusively seek to promote R&D in the agricultural sector.

[33] A sizable share of this support went to BHH, especially to projects linked to biopharmaceutical products and to the development of systems and techniques for the diagnosis of diseases.

[34] The relatively large participation of farm machinery is consistent with Argentina's leading position in precision agriculture and the development of direct seeding machines. Argentina is currently exporting both technological know-how on direct seeding and the seeding machines. Additionally, FONTAR is supporting the formation of innovative clusters of manufacturers of farm machinery (the CIDETER cluster) through the PITEC instruments.

development, followed by the development of management and telecommunications systems.[35] Within agriculture, the activity that received the most support is biotechnology applied to plants and animals.

3.2.7 Enduring Macroeconomic and Political Stress

FONTAR's programs survived macroeconomic stress by making use of its Recovery Fund. Nevertheless, the economic depression of 1999-2002 put the brakes on its expansion at that time, as many SMEs did not use the approved subsidies not only because of the inability to provide the 50 percent financing counterpart, but also because of the negative effect of uncertainty on long-term investment. The loans to firms (CAE) had to be discontinued because of the inability of banks to continue acting as financial agents during the crisis. FONTAR reacted by negotiating with the IDB a change in the regulations of the PMT II, which enabled it to act as a direct lender. Hence, macroeconomic stress reduced the demand for FONTAR's support.

FONTAR survived political stress by creating external technical evaluation commissions that are fully independent from the government, and whose members work in research institutes and in the private sector and are highly respected on technical matters.[36] The commissions send their evaluations to the Board of Directors of ANPCyPT. If the Board agrees with the evaluations, they are published online. This technical and financial scrutiny and transparency shelters FONTAR from political manipulation. These commissions ensure the continuity of FONTAR regardless of staff turnover.[37]

FONTAR's prestige and commitment compensates for a bureaucratic environment that is not very favorable for pursuing a career as a government official. The technical staff at FONTAR has remained in office since the creation of the fund in 1992.

[35] This is another technologically "hot" sector of Argentina. It is one of the successful new export activities and has recently obtained a sector-specific law that provides PDPs for the sector. It is also closely linked to the universities and made up of technologically and bureaucratically sophisticated entrepreneurs.

[36] The commissions evaluate FONTAR's work from a technical point of view, looking at all of the supported projects. The commission members include university professors, the president of the Argentine Biotechnology Fund (FOARBI), technical staff from UIA, CONICET researchers, etc.

[37] They ensure that there are standardized procedures to be followed in policy design and implementation, and contribute to the policy learning process with their appraisals. The commissions renew two or three members each year, but there is a nucleus that is maintained.

4. The Case of INTA

The National Institute of Agricultural Technology (INTA) operates under the aegis of the Secretary of Agriculture of Argentina, but it functions autonomously. It is decentralized in a number of regional centers that interact closely with local producers and that conduct research focused on regional production needs. It has been quite successful in generating and disseminating new technology that is adopted by private firms and that has improved agricultural productivity.

4.1 How Are the PDPs Used?

INTA's research is largely driven by the needs of the private sector. This demand is channeled through Technological Liaison Agreements (CVTs) that formalize technology transfer and R&D agreements and technological assistance programs (ATs).

In the case of technology transfer agreements, INTA completes an innovative project that generates a technological innovation on a certain product or process. Then it transfers the technology to one or more firms for a certain period of time and to a certain region through a licensing agreement and earns royalties from this transfer.

The R&D agreements entail a joint venture between INTA and a firm or group of firms to generate a new technology and market the product into which this technology is incorporated. The firms and INTA share their research capabilities, the costs of knowledge generation and dissemination, and the underlying technological and commercial risks. These agreements involve the participation of private firms, which participate in the financing and commercial orientation of the product, its adaptation to market needs, and industrial scaling up. Once the innovation is attained, the firm manufactures, reproduces, and markets the product through licensing agreements, compensating INTA through previously agreed royalties. INTA can then participate in post-transfer services to the customers through technological assistance services. It can also participate in the dissemination of the technological advantages of the innovation and in the detection of opportunities for deepening the agreement. This type of agreement also encompasses strategic partnerships formed with other science and technology public institutions and with NGOs that conduct agricultural research.

The technological assistance services enable the transfer of pre-existing tacit knowledge on the use of technologies to producers, which helps them solve specific problems that they face. They generally help solve problems of high scientific and technological complexity.[38]

Other PDPs include the creation of technologically based firms (EBTs). INTA may sign agreements with entrepreneurs to support the creation of EBTs. These EBTs must be located within innovation technology parks (PIT) promoted by INTA. The supported EBT may cede a certain capital stock share as compensation for INTA's support for the technological development done by the firm being incubated within the PIT.

Finally, INTA also sells products and provides specialized technical services. In this case, INTA transfers codified knowledge, which is already incorporated in the product or service it sells. The specialized technical services involve solving technical problems such as the repair, assembly and operationalization of a plant, repetitive tests, quality control tests, and so on.

4.2 Governance Structure

INTA is governed by a board of directors, charged with designing institutional policies pertaining to INTA's external relations and internal functioning. It has a normative responsibility. The board approves the signing of the R&D and Technology Transfer Agreements, the licensing agreements, and the technology liaison policies and regulations.

The board's resolutions are then implemented by the National Directorate, which is the top managerial echelon within INTA. The National Directorate also has a say in the design of internal institutional policies. It approves the AT agreements at the national level and the location of firms at the industrial and technology parks (PIT from now on). The National Directorate also decides on the allocation of the overheads arising from the CVT, AT and royalties, to projects that are not as easily financed through CVT but that are deemed to offer high social return. It also implements the system of monetary incentives granted to researchers participating in the CVT and AT (the FAT). The National Directorate also decides which technologies are subject to obtaining commercial value (through patenting and licensing agreements), and the mechanisms and resources used to this end.

[38] These services can be divided in two groups according to the scope and the degree of involvement of INTA: a) national technological assistances, which involve the participation of several INTA operational units (see below) and/or demand a large institutional commitment and/or entail a very large budget and/or a high contractual complexity that demand the approval and contracting at a national level, and b) regional technological assistances, which are of regional interest and which do not require the participation of other INTA units.

The National Coordination of Technological Liaison (CNVT) coordinates the relationship between INTA and private firms and public institutions. It is in charge of proposing the types of liaisons that can apply for associations with private firms and public institutions.[39]

Next come the regional centers and the research centers. The directors of the centers approve and sign agreements that regional in scope. They participate in the definition of the terms of the agreements and allocate the revenues from royalties and private sector financing to CVT and AT generated by the centers' technological liaison activities. They also sign confidentiality agreements and materials transfer agreements that do not involve licensing commitments. They propose agreements on R&D, technical assistance, and technology transfer. There are also Center Councils, which approve each center's participation in technology liaison agreements.

Finally there are operational units, where the research is actually done, which include agricultural experimental stations (EEA) and research institutes. These operational units initiate discussions with the firms and institutions with which they will cooperate through CVT and AT. They participate in the commercial value creation groups for the outcomes of the CVT. They also help define the technical aspects of the project and its costs. The director of an operational unit may sign confidentiality agreements and materials transfer that do not entail licensing commitments. The director also proposes the development of the transfer strategy, the confidentiality terms of the project, the strategy for registering the IPRs, and the definition of the institutional benefits arising from the outcomes of the research.

INTA's governing bodies are made up of government officials and representatives of academia and the private sector. This institutional design, together with the fact that INTA depends both on public and private financing, increases the degree of control over the institution and its accountability.

Two other important actors within the governance structure of INTA are Fundación ArgenINTA and INTEA S.A., public institutions subject to private law created by INTA to support it in the areas of knowledge generation and transfer, the administration of non-budgetary

[39] It also creates the commercial value creation group and proposes who will be in charge of it. The CNVT manages the database that enables the monitoring of the implementation, advances and outcomes of the CVT, from both a technical and economic and financial standpoint, including the royalties obtained. The CNVT proposes the allocation of the overhead (FVT) and the technologies subject to obtaining commercial value, and the mechanisms and resources used to this end. It also defines how the technologies will be registered in the different IPR registries and coordinates the surveillance of the contractual and managerial aspects of the CVT.

resources, and the development of technological endeavors where the risk is shared with the private sector.[40]

4.3 What Is the Goal of the PDP?

The most prevalent failures that INTA seeks to compensate for are technological spillovers and coordination failures to provide local public goods or inputs. The choice of instruments (technological transfers, R&D agreements, technological assistance, and even the promotion of coordination among private firms at the local level) appears to be adequate to compensate for these failures. It must be mentioned that public research institutions play a key role in agricultural research across the world.

INTA has been increasingly moving in the direction of creating platforms to implement CVT. To this end, it focuses on generating and structuring innovative groups, or "nuclei," made up of technicians from INTA and the private sector, which generate new knowledge through technological liaison agreements. The new knowledge must be directly applicable to production activities. Technological liaisons favor an efficient transfer of technology and have a positive impact on the accumulation of human capital and improvement of the research teams. The liaison activities are seen to be crucial for avoiding ossification, by leading to a continuous upgrading of skills and directing research toward areas close to the frontier.

In the past decade, INTA's platform creation strategy has been based on joint R&D projects with the private sector and strategic partnerships with other public research institutions, and on the integration of INTA's technicians with national and international R&D networks. It is also based on support to business incubators and technological innovation parks.

INTA seeks decentralization of technology management as way to meet the specific technological demands of the regions. This decentralization has led to the emergence of some very successful regional research centers, although other centers are lagging. The difference in performance across centers reflects differences in local skills and motivation and in the ability to

[40] INTA is responsible for the implementation of the technological liaison policies and the management and negotiation of the CVT. It does not participate directly in the commercialization of products and services. The commercialization of its own production is done through the Asociaciones Cooperadoras. The management of production and commercialization of primary and technological products and services is done by INTEA S.A. The latter also manages the revenues coming from royalties generated by the CVT. Fundación ArgenINTA is the technological liaison unit of INTA. It cooperates in all of the activities related to the management of INTA's funds (the Fondo de Asistencia Técnica and the CVT budget), and the preparation and presentation of applications for support of FONTAR, the ANPCyT and the funds provided by Law 23,877. It also manages the provision of services that facilitate the management of technological liaison projects.

cooperate with the private sector, which is in turn affected by the technological capabilities of the latter and its ability to coordinate to cooperate with INTA.

The move toward promoting the creation of technological base firms seeks to generate private sector counterparts with technological capabilities that may interact with INTA in the generation and transfer of new technologies to regional economies. The EBT may originate from technological frontier developments done at INTA operational units, from the incubations of entrepreneurs that received specialized services from INTA, and from spin-offs of INTA technicians and researchers that developed a new technology or provided specialized services. The promotion of EBT is still incipient and needs substantial improvements in allowing and stimulating the mobility of public sector researchers towards the EBT, the generation of more public funds that finance venture capital, and subsidies and loans for the creation of new firms, together with tax deductions, subsidizing of consulting services, and so on.

INTA is attempting to compensate for these failures, particularly the lack of availability of private financing for EBT, by making use of the technical and financial resources and financial support instruments that are available at INTEA S.A., Fundación ArgenINTA, and the Cooperative Associations of the EEA.

INTA periodically updates its rules, procedures, and instruments in response to global changes in the areas of technology generation, transfer and management and to its own institutional learning.

INTA is keen to lead many developments which in some cases could be developed by the private sector. The reason is that it can behave differently from a private monopolist and more effectively disseminate the new technology at lower prices or even for free. This way, it becomes a more powerful tool for coordinating the adoption of modern technologies by private firms. INTA also considers that technology licensing agreements encourage private sector financing of INTA's R&D.

The motivation for private firms to participate in CVT with INTA financing the latter's research is two-pronged: a) they may benefit from the licensing rights and b) they gain access to technologies that are specific to their regions that the private sector may fail to provide because of coordination failures to provide public goods and/or insufficient research capabilities.

4.4 History of the Evolution of the PDP

INTA was created in the mid-1950s. Initially, it generated, adapted, and disseminated non-appropriable technologies (public goods).[41] This activity demanded the production, adaptation, and application of knowledge and the development of technologies that were disseminated to agricultural producers via rural extension programs.

The technological changes in agriculture in the 1960s, together with the emergence of new techniques that used agricultural inputs with embodied technological knowledge produced and commercialized by private firms, prompted INTA to shift toward the development of appropriable technologies (private goods).[42] INTA also moved toward the transfer of know-how to the industry that supplies agricultural inputs and to the agricultural based manufactures.

INTA started out by adopting foreign technologies. Then it began conducting its own research, while at the same time pushing for adaptation of the IPR law to the requirements of technological innovation in agriculture. Its initial research focused on producing seeds that were appropriate for local weather and soil conditions through informal agreements with local producer cooperatives. These producer cooperatives commercialized the seeds through informal contractual arrangements.

This changed in the mid-1980s when the then-President of INTA, Ing. López Saubidet, created the technological liaison units (UVT) to serve as INTA's vehicles for technology transfer to the private sector. These arrangements preceded the enactment of a law that gave them a more formal status.[43] The technological liaisons enabled the move toward research that had direct application in production activities.

In order for the UVTs to advance, INTA had to overcome serious internal infighting and conflicts with the universities. The debate centered on the advisability of moving toward developing and transferring (at a cost) appropriable technologies as opposed to the then-prevalent mode of free transfers of non-appropriable technologies through extension activities.

[41] These non-appropriable technologies include management of cultivations; efficient techniques for planting and harvesting, soil; climate and water studies; studies on plagues, immunology, and plague control; management of cattle, cultivation improvements, usage of farm machinery, and management of water irrigations and fertilizers, among others.

[42] These appropriable technologies included vaccines, vegetable varieties, farm machinery, and various biological products.

[43] The first agreement was held with San Jorge/Bagó in 1984-1985. In 1987, an agreement on soy was reached between INTA and the Federación Agraria Argentina (a union of small farmers).

The debate also revolved around the adequacy of providing monetary incentives to researchers participating in CVT, and the bureaucratic impediments to moving in this direction.

The rationale for INTA's moving to CVT and UVT was the rapid obsolescence of technological knowledge in agriculture. Hence, for their research to make sense, they needed to proceed quickly, ensure adequate IPRs (before competitors copied the development) and rapid technology transfer to the private sector so that the developments could be commercialized.

The law regulating the UVT and CVT appeared only in 1990, five years after being promoted by López Saubidet. Before that, INTA had been licensing technology to the private sector without the protection of an adequate legal framework.

In the 1990s, INTA was subject to budgetary constraints caused by a redefinition of the central government's budget priorities. In 1995, INTA lost its financial autonomy when the central government eliminated taxes that were specifically established to finance INTA. Since then, INTA became subject to financing by the Treasury through budgeted funds. Hence, between 1990 and 2002, a large amount of INTA's researchers and technicians at the regional centers focused on the provision of services and consulting as a source of non-budgetary funding, which distorted the primary goals of the CVT and generated deficiencies in the addition of commercial value to technological developments and in the registry of IPRs. There was an incentive to engage in projects and provide services that did not necessarily jibe with INTA's research and technology and knowledge transfer agenda. This period nevertheless yielded important lessons on how to engage in CVT. There was a late process of learning and institutional adaptation. The funding needs intensified the move toward developing competitive, appropriable technologies, which generated important institutional learning.

The crisis in the development of technological liaison policies in the 1990s also reflected changes in the stakeholders within INTA. Between 1987 and 1992, the technological liaison was a response to the enthusiasm of its initial promoters (both at the technical and bureaucratic level), who understood the reach and conditions for these policies. The changes in political and managerial authorities over time introduced new stakeholders who did not understand technological liaison as well as the initial promoters, and hence did not share their commitment to CVTs. During this period there was greater emphasis on analyzing the financial advantages of the signed CVTs rather than their social benefits.

The first institutional response to the state of affairs prevailing in the 1990s arrived in 1997-1998, when INTA generated a "white paper" on the administration of extra-budgetary resources, bringing administrative and institutional order to the management of these resources. At this time, the National Directorate of the Institute also undertook a critical review of the experiences, including the rules and procedures applied by the institutional policy of technological liaison.

INTA's technological liaison policy became institutionalized in 2002. This policy provided institutional order to decisions heretofore taken via ad hoc internal resolutions. The policy regulated the allocation of funds for research and other uses, the provision of incentives to researchers, and the fiscal treatment of this funding, and it centralized the signing of CVTs agreed between regional centers and local producers, although CVTs were managed by the regional center involved. During this period, greater emphasis was placed on increasing the quantity and quality of the generation and transfer of technologies, and a clear institutional and policy distinction was made between the sale of services (which had exacerbated during the crisis), R&D agreements, and technology transfer agreements. Contractual arrangements were updated to facilitate long-term cooperation with private firms and the technological and commercial risk sharing with the private sector. The mechanisms enacted enabled the development of innovative nuclei comprising of all the actors participating in the CVT.

These models were highly successful and had positive impacts on other firms in the agricultural sector, who sought to enter into CVT with other INTA units. The technological liaison also created demand for of knowledge generation and adaptation from other public research institutions. There were also failures arising from the application of CVT to certain types of frontier technologies which, because of their nature and scope, could not be transferred via licenses to private firms.

The move toward technological liaison agreements in the late 1980s established a clear distinction between the free transfers of non-appropriable technologies to agricultural producers through extension services (akin to the traditional linear model of innovation, or a supply model) and the development of appropriable technologies, which is done at a cost via CVT (closer to a demand model).

Since 2000, INTA has moved toward an intermediate system, which is neither supply-driven nor demand-driven. It works through the "early management" of the liaison with private

firms, via the maturation of ideas and conceptual sketches and the development of the technological business.

Since 2005 INTA has been implementing a strategic plan (Plan Estratégico Institucional 2005-2015) to enable institutional innovation and to place INTA at the knowledge frontier, generating and transferring strategic technologies.

The move towards CVT and AT thus reflected both the goal to generate mechanisms of transmission of private sector needs, and to ensure non-budgetary financing for long-term research that is not vulnerable to macroeconomic fluctuations.

4.5 Has the PDP Succeeded?

4.5.1 Observed Results

INTA has had a number of significant successes, including the development of new varieties of different grains, inoculants, and farm machinery. The first remarkable case was the genetic improvement of wheat, which resulted in higher yields and quality. It was done by the EEAs Pergamino and Marcos Juárez. The research began in the 1960s through an interaction with the International Center for Improvement of Corn and Wheat (CIMMYT), based in Mexico. CIMMYT is charged with transferring "intermediate international public goods" to local agricultural research institutions in wheat-producing countries. The local institutions then adapt the received technologies to local conditions.

New varieties were developed over time and later adopted for direct seeding techniques. The use of new herbicides and transgenic materials facilitated the great technological revolution in agriculture of the past 20 years. The program also included the creation of a new private firm for the production and dissemination of the new seed varieties. This firm, PRODUSEM, had a pioneering participation in the technological liaison policy of INTA since 1987, and it engaged in long-term CVT with INTA that supported the wheat R&D done by INTA and the dissemination of the newly created varieties. Eventually more private firms signed CVT agreements in the area of wheat.

Other successes include the development of the following:

- Mutagenic rice that is resistant to herbicides
- New technologies for the cultivation of beans in the Northwest region

- The elimination of “bovine spongiform encephalopathy” (also known as “mad cow disease”)
- A self-maceration vat for improving wine quality
- New horticultural varieties for the industrialization of dehydrated vegetables
- New inoculants for soy and alfalfa
- New varieties of alfalfa to be used in cattle feed
- A machine for inter-seeding of fodder
- Advanced biologic insecticide for the control of the Mediterranean fruit fly in apples and pears
- A cotton seeding machine.

INTA did not participate in some of the most important technological developments in the sector. For instance, it did not play a role in the development of transgenic soy, the production of which is quite dispersed in terms of regions and number of producers. There was no coordination between the INTA regional centers that were involved with this crop, which prevented INTA from moving at the same pace as private developers.

Although the success stories were facilitated by INTA’s institutional design favoring CVT, some of the successes preceded the emergence of this institutional design. Successes appear to have occurred in regional and research centers where there was a larger geographic and production concentration (which favored coordination of the private sector), where there was more research capacity, and where there was a greater concentration of motivated and capable stakeholders.

INTA has only vertical policies, which work well because of the coordination failures of the private sector to provide public inputs and because of INTA’s greater ability to disseminate new technologies by preserving IPRs.

Another reason that INTA is an interesting case is that it fosters the alignment of interests of the public and private sectors thanks to the technological liaison policies. These policies facilitate the emergence of new technologies through a co-movement of the public and private sectors based on mechanism design leading to the emergence of platforms.

4.5.2 Perceptions of Some of the Firms Interviewed

INTA's technological assistance in the area of biotechnology applied to plants and animals (BPA) is highly valued by the private firms that we interviewed. They consider that INTA is very well endowed in terms of the technical capabilities of its researchers and technicians and the physical and technological infrastructure to undertake different tests. Many private and public research projects in the area of BPA currently have AT agreements with INTA.

4.6 What Are INTA's Sources of Funding and How Are its Funds Allocated?

INTA has a system of incentives to retain researchers and to generate further research through funding allocation mechanisms of the CVT and the royalties obtained from the successful projects. While these incentives are deemed to be appropriate, they are not sufficient, especially in view of the absence of tenured positions and tenure track paths.

The institutional benefits of INTA come from the sale of products and services generated by the CVT, AT, the sale of specialized technical services, and revenues from royalties. These benefits are allocated in a way that contributes to the financing of research activities of INTA as a whole, while at the same time providing incentives and rewards to the originating units and researchers.

A Technological Value Upgrading Fund (FVT) was created to finance INTA's research. The Fund's resources come from a portion of the net benefits arising from the CVTs and ATs. The FVT finances autonomous research that is less likely to be financed through CVTs and which is deemed to have high social return.[44] The FVT finances the following activities:

- Research deemed to be strategic or a priority of technological liaisons.
- Enhancing the capacity to manage the technological liaisons.
- Adding commercial value to projects that are close to being transferred and which may increase the net institutional benefits.
- The costs of registering and maintaining IPRs for vegetables, patents, trademarks, and other IPRs related to the transfer and dissemination of INTA's knowledge and technologies.

[44] The technical assistance agreements (AT) must provide the following contributions to the FVT: a) 20 percent of the total budget for the agreement, when the counterpart is a private sector firm or entity, b) 10 percent of the total budget for the agreement, when the counterpart is a public institution or a NGO, and c) 0 percent when the liaison pursues a "social goal."

Net Institutional Benefits				
Type of liaison	CVT	AT	Specialized technical services	Routine technological and agricultural services
Goals	Technology transfer	Tacit knowledge transfer	Information transfer	Supply of products and services
Revenues	Royalties	Institutional remuneration	Institutional remuneration	Profit

There is a regulatory framework for providing incentives to participating researchers and units. INTA promotes the participation of its researchers in technological endeavors by providing additional payments received from the Technical Assistance Fund (FAT) and compensation for the generation of royalties.

INTA recognizes the right of researchers to non-wage compensation for their participation in projects that generate royalties. Researchers are in turn compensated with wages for their regular activities at INTA.[45]

The FAT for each CVT and AT is agreed upon between INTA and the associated firms. It reflects the opportunity cost for the firm of gaining access to this type of technical service. In the cases of R&D agreements that will generate royalties, the FAT paid by the private firms is considered to be an advance of the royalties to be obtained.

Distribution of Institutional Benefits				
Types of liaisons	Participating actors			
	Researchers	Work group	Operational unit	FVT
CVT agreements	30%	20%	20%	30%
National and regional AT		35%	35%	30%
Specialized technical services		30%	40%	30%
Sales of publications and specialized material	30% (copyright)	20%	20%	30% (Fondo Nacional de Publicaciones)

The researchers interviewed at INTA consider that this system of incentives is adequate, but that it is not sufficient to retain researchers. The biggest disincentive is the lack of tenured positions at INTA that provide researchers a medium-term horizon for their research activities. As a result, most of the young researchers at INTA's operational units are working under short-term contracts, which leads to a high turnover rate. The permanence of the young researchers in the different centers is a function of idiosyncratic factors, such as prestige, the collegial

[45] The unit's participation in royalties also helps finance the temporary job contracts granted to the non-tenured researchers at the unit (which tend to be the majority).

environment, and the reputation of each center. The lack of tenure tracks hinders the creation innovative research groups and eliminates the risk of ossification. This shortcoming has led to the emergence of a widening generation gap over the past 20 years. Some research centers rely on "importing" researchers from CONICET.

In the early 1980s, INTA promoted and financed graduate studies abroad for several of its researchers. The repatriation of these researchers was crucial for the movement towards technological liaison agreements and the other institutional changes observed in the 1980s. This policy of sending researchers abroad has been discontinued.

In 2007, the central government decided to allocate some of its fiscal resources to the opening of new tenured positions at the public sector. Priority was given to incorporating the personnel working under temporary contracts and internships. Those INTA centers and EEA that had a large number of interns and other non-tenured staff benefited more from this opening. Since those centers that were more active in research were the ones that had the largest number of researchers to incorporate, this job opening may have widened the research gap between different regional centers and EEA. All of these constraints matter, but they have not generated an ossification thus far.

4.7 The Development of Genetically Modified Rice

Rice is produced in the Northeast region of Argentina and is mostly exported. Until 1998, the variety being produced was the one developed by IRGA, the public agricultural research center of Rio Grande in Brazil. This variety was of low quality, had little resistance to herbicides and low productivity, and demand for it was limited to Brazil. The large Brazilian devaluation of 1999 rendered local rice production uncompetitive and forced 50 percent of the local producers out of business, or caused them to shift to soybeans.

Starting in 1990, the INTA EEA of Concepción del Uruguay (Entre Ríos) had been developing , through a CVT with Fundación Pro-Arroz (a foundation of local rice producers), a new variety called Cambá, that had higher quality and productivity and that could be sold in other markets at higher prices than in Brazil. This allowed a large diversification of markets and greater competitiveness of local production. Fundación Pro-Arroz not only financed the research but also interacted with INTA in the research process. The benefits for Fundación Pro-Arroz were having access to this better variety and improving the competitiveness of local rice

producers. It did not obtain profits because of its non-profit status. INTA retained the IPRs over the new variety and the rights for licensing the commercialization, which is done through local seed traders.

INTA additionally developed a new mutagenic variety of rice called Puitá, which is resistant to imidazoline, a herbicide that is required to eradicate a disease called *arroz colorado* (red rice), which shares the genetic characteristics of the good rice. The resulting rice has a higher quality and is more productive, as eradicating this disease enables better use to be made of cultivation techniques. This research was financed by INTA, although there was a CVT with BASF-Cyanamid, a private company that provided the imidazolines that were deemed to be more appropriate for the rice in different locations. Once the effort was successful, INTA licensed the external commercialization of the seed to BASF, which is responsible for patenting it on behalf of INTA in each market where it is sold. INTA retains the commercialization rights in Argentina and in Uruguay. This mechanism has a twofold impact. First, it further raises the competitiveness of local production (especially in the sub-tropical regions) by allowing an optimization of cultivation practices (use of better fertilizers, irrigation, etc.). Second, it places INTA as a worldwide leader in the development of new rice varieties of vast applications together with Louisiana State University in the United States.

4.7.1 "Policies" of INTA-Concepción del Uruguay (Provision of Public Inputs)

The origin of these policies in 1988 coincided with the return to INTA of technicians that had been trained abroad, which favored INTA's involvement in technology transfer activities. This was the case of Alberto Lívore, a rice breeder who is one of the major public sector stakeholders for the rice-specific PDP. Lívore brought from the United States the blueprint for a model of public-private interaction for improving the competitiveness of rice production. In each rice-producing state of the United States, there are private research foundations that associate with universities to conduct rice-specific research.[46] Lívore promoted the creation of Fundación Pro-

[46] These foundations, which are run by firms operating at different stages of the rice chain (production of seeds, commercialization, rice production, etc.), solve coordination failures by promoting laws that introduce a mandatory contribution to the foundation by all firms in the rice chain. The foundations' goals are to finance R&D, technology transfers and the advertising required for selling the product. This financing is complemented with funding from other sources, such as the U.S. Department of Agriculture. This continuous funding enabled the pursuit of medium-term research projects. The foundations additionally allow producers to engage in research agreements with non-governmental agencies and institutions.

Arroz, which would be an exclusive supplier of funds for the research that buffer large budgetary fluctuations and enable engagement in useful medium-term research.

The Fundación Pro-Arroz was created in 1990, thanks to a common view shared by key private and public actors in the rice chain (researchers, agronomic engineers, rice producers, and especially the industrial sector that elaborates and sells the refined rice, as they have a greater awareness of the importance of investing in technology). This alignment of interests was facilitated by the geographic concentration of production and the relatively small number of producers involved, together with the fact that INTA-Concepción was organized in accordance with the same vertical PDP that the private sector wanted. The high degree of vertical integration in the industrialization and production of rice also facilitated this coordination. This foundation solved an important coordination problem, as individual producers were hesitant to invest in research on the genetics of grains that yielded results only in the medium and long term.

This joint effort did not yield immediate results, but it was consolidated over the years, as the research done by INTA under the foundation's sponsorship started to yield incremental technical results that revealed adequate capacity and built confidence.[47]

The foundation's legal status and ability to coordinate became more solid with the enacting of a provincial law in 1998-99 that introduced a specific tax on all the firms operating in the rice chain. This tax would finance the foundation's activities, including the development of a new, appropriable variety and research on cultivation practices. The foundation itself collects this tax.[48]

The funding secured by the 1998-99 law was added to INTA's own budgetary resources, to other projects with external funding, and to CONICET's funds to supply the necessary resources for medium-term research. The steady financing of the foundation provided a buffer to cover the eventual troughs in the other financing sources, ensuring that the fixed costs of research would always be covered.

[47] The foundation has a technical committee made up of agronomic engineers that chose the projects and evaluated the results. While advances in the research were being attained, it still demanded a lot of creativity to show that improvements were being attained without having yet reached the development of the new variety.

[48] The rice refiners withhold the taxes charged on producers. The tax rates are 0.1 percent for refiners and 0.2 percent for rice producers.

The foundation's first major achievement was the development of the Cambá rice variety.[49] Once this appropriable knowledge was generated, INTA sought to ensure the seed quality, broad distribution, and the IPRs. To this end, it signed a CVT with the foundation stipulating that INTA would produce and commercialize the original seeds (production was done in fields chosen by foundation members).[50] This mechanism ensured the quality and broad distribution of the seeds while preserving the IPRs.[51]

In 2005, INTA completed the development of the Pituá rice variety, which was not the result of an agreement with Fundación Pro-Arroz. It was financed with INTA's own funds because INTA wanted to retain full IPRs over the new variety. This variety is resistant to herbicides without being transgenic (transgenic rice is not allowed for consumption). The research process began in 1996. It became successful in 2000, and the new variety was registered in 2005 following two years of discussion with BASF over licensing and patenting issues.[52] In this case, the research orientation was set by INTA itself, as the foundation would never have financed such an ambitious project.

Once the variety was developed, INTA had to negotiate with BASF over licensing the gene. This agreement has allowed INTA to have commercial and technological presence worldwide and to earn sizable royalties through BASF.[53] The royalties coming from the sales of the Puitá variety provided the largest royalties during the last agricultural campaign.

[49] The R&D for this variety was done by INTA, while the field tests took place in producers' plots, as well as all the validation efforts done in coordination with producers and the industry.
[50] The seed traders buy these original seeds, multiply them and sell them to producers.
[51] Still there is room for producers to try to generate their own non-IP seeds and commercialize them in informal channels. To avoid this, the industrial firms pre-finance the inputs of its suppliers on the condition that they use original seeds. This control is facilitated by the relatively small number of actors involved.
[52] INTA developed rice mutations that were resistant to the imidazoline herbicides produced by BASF. These herbicides were chosen because they had certain attributes that allowed working with mutant rice. This research process was parallel to what BASF/Cyanamid was doing with Louisiana State University in the United States, which fed into INTA's own research.
[53] First INTA had to ensure that the gene was different from the one developed in the United States (BASF helped with the sequencing of the gene). Then it had to negotiate that the worldwide patent belonged exclusively to INTA, while BASF held the exclusive license to commercialize the original seed (on the condition that BASF must patent it everywhere it sells it on INTA's behalf, except for Argentina and Uruguay). The original or legal seed is originated in Argentina and sold to seed traders abroad. The original seeds then undergo successive multiplications by authorized traders (or seeders).

4.7.2 Determinants of Success of PDPs. Is it replicable?

The keys for success of PDPs were the following:

- The presence of public and private stakeholders who had enough control over the required policies.
- The presence of highly committed and motivated public sector stakeholders, who had the institutional knowledge on how to ensure funding for long-term research.
- The adoption of best international practices, which ensured coordination between private actors in financing research and in transmitting their needs to INTA.
- The relatively small number of actors involved and their geographic concentration, which facilitated coordination and lobbying for a law that made this coordination permanent.
- The existence of a public agency organized in accordance with some vertical PDPs (this is not usually the case with other public agencies) with a private sector that organized itself according to the same PDP.
- The fact that INTA-Concepción was able to maintain the IPRs, which increased the public-good nature of the knowledge generated and appropriated.

These actually turn out to be rather stringent conditions that are not met in many other agricultural activities.[54]

The rice law was relatively easy to pass because it was a provincial law.[55] The role of foundations that coordinate the actions of private actors is underscored by the lackluster experience of IRGA, the public rice research institute in Rio Grande, Brazil, that has some

[54] In the area of cereals and oilseeds there are private associations that transmit research demands to INTA, but that are unwilling to finance this research because they expect to get it for free from the government. In the case of some strategic grains, the private sector simply lobbies for INTA to tilt its research programs in this direction, without contributing to finance the research. This not only reduces the chances of success of the research, but also diminishes the quality of the information transmission process. As a result, INTA lost the race with private companies that moved faster. In the case of wheat there is a competition between the associations among INTA and local seeders and the multinational companies.

[55] INTA is currently promoting laws to create and finance rice foundations in Corrientes, Formosa, Misiones and Santa Fe (the other rice producing provinces). Fundación Pro-Arroz from Entre Ríos is complaining that it is subsidizing INTA's research, which has an impact on the other provinces, which free-ride on the foundation's effort.

private support but is not structured around a rice foundation. It only developed one variety in 1979 (the one that Argentina produced until 1998) and another in 1988. IRGA's research effort failed because of its spasmodic behavior.

INTA has installed a system of incentives and a policy of technological liaison agreements that facilitates the activities of motivated stakeholders at the operational unit level that may generate successful PDPs. However, the continuation of each specific PDP is largely tied to idiosyncratic stakeholders.

4.8 The Role of INTA in the Adoption and Development of Precision Agriculture in Argentina

Precision agriculture (PA) involves adjusting the use of agricultural inputs to changes in the environment (soils, humidity, etc.) with the help of electronic devices. It entails two clearly differentiated activities that are closely linked: a) the development of precision instruments and machines and agricultural inputs of high complexity, and b) the development and efficient application of PA techniques in the production of crops.

Precision agriculture enables a reduction in the cost of producing crops, increasing productivity and making a more efficient use of inputs. Using precision agriculture, the use of inputs can be managed at different times and in different places. Production logistics in the field can be optimized, agricultural labor can be supervised, production risks can be managed, differentiated products can be segregated, products used in human consumption can be traced, and the use of inputs and compliance with environmental protection norms can be monitored.[56]

This technology includes the use of key tools such as GPS and electronic devices to gather real-time data on what is happening with different crops.

4.8.1 "Policies" of INTA-Manfredi

INTA introduced PA in Argentina. The Precision Agriculture Project was started in 1994-95. This PDP took the form of an extension activity (non-onerous technology transfers) conducted by INTA, which solved coordination failures in the provision of key industry-specific public goods. This development took place because these technicians had the capacity and commitment

[56] It is not always profitable to adopt PA techniques. The profitability will depend on the size and characteristics of the parcels. Additionally, the productivity improvements (savings on inputs) are not immediate. It may take several years until the investment in adoption and implementation of PA technologies begins to yield positive profits.

to push this agenda. INTA's PDP accelerated the introduction of this technology. Without its intervention, the private sector would probably have adopted it, although much later and in a more disorderly fashion. Thus, INTA's PDP led to the early adoption of modern production technologies, allowing INTA to gain a competitive edge vis-à-vis regional competitors.

This extension activity has been fully funded by INTA. The project's general aim is to develop a technological platform and a functional network devoted to improving and facilitating the application of technology to modern agriculture.[57] The Executive Unit for the project is the experimental station (EEA) of INTA at Manfredi.[58]

The Beginning of INTA's PA-PDP. In the early 1990s, a group of technicians at INTA Manfredi started making annual technological exploration trips to the United States, to the Farm Progress Show, and several universities. They discovered that the latest innovation was satellite yield monitoring.[59] The INTA technicians saw the opportunity and the need to introduce the new technology in Argentina as soon as possible. The initial project budget was rather limited ($35,000 in 1997), and financing the project required a reallocation of funds from other projects.[60]

INTA had to intervene to provide this industry-specific public good (ISPG) because universities and research centers in the United States were willing to reveal and transfer the new technologies to institutions like INTA, but not to private firms. Additionally, it was difficult for the private sector to grasp the full potential of the new technology, which was revealed by INTA's field demonstrations. INTA also helped producers with the calibration of the instruments to be used. Finally, INTA solved a coordination failure, as the individual investment in satellite yield monitors is only profitable if there is a large enough number of monitors and satellite

[57] The stated goal of the project was to "improve the productivity, quality, and consistency of the production of crops, oilseeds, pasture and fodder used both for final consumption and as agro-industrial inputs." The project promoted the development and utilization of highly complex tools that involve different branches of science such as electronics, electro-mechanics, robotics, telecommunications, systems engineering and software, applied to the design and implementation of production technologies that are based on adjusting techniques to the environment and to the development of precision agriculture machines.

[58] The project coordinator is the Agronomic Engineer Mario Bragachini of EEA-Manfredi. The project includes the participation of the INTA EEAs at Paraná, Marcos Juárez, Rafaela, Anguil, Salta, Faimallá, Sáenz Peña, Pergamino, the INTA Institute of Rural Engineering at Castelar, and the INTA headquarters.

[59] This monitoring allowed identifying environmental differences (climate, soil conditions, humidity) within a same production unit or parcel, and using that information to adjust the use of variable inputs to the conditions prevailing in each part of the plot.

[60] There were only five agronomic engineers from INTA working on the project at the beginning, but the private sector's growing demand for access to the new technology has led INTA to start incorporating more technicians into the project.

correction towers installed by other producers. The technicians at INTA-Manfredi undertook this PDP without relying on a technological assistance agreement because they were convinced of the role leading of INTA in the provision of ISPG for agriculture.

4.8.2 Characteristics of Public-Private interaction around the PDP

INTA introduced the new technology with the logistic support of private sector firms that were linked to INTA-Manfredi, such as D&E, Tecnocampo, Agrometal, A&T, Agrimax and Acopio Arequito, among others. These firms include crop producers, suppliers of agricultural services, and manufacturers of farm machinery. The cooperation in the introduction of PA was facilitated by the long-standing public-private interaction through INTA extension activities.

The first important cooperation was done with technicians from the D&E firm, using technology imported from the US to draw the first satellite map.[61] Subsequently, PA started to develop quickly. D&E used technologies and financial backing from Trimble in the United States to install a GPS satellite correction tower at a reasonable cost in the Province of Santa Fe, which is located in a strategic position within the Pampa Húmeda, and covers a 300km radius. This enabled the diffusion of satellite flaggers, which in turn facilitated the diffusion of PA technologies. In 1996, two new towers were installed in the Provinces of Buenos Aires and Tucuman, which enabled the application of GPS to agriculture.

The first satellite maps were done in 1995. In that year, the first seeding machines with variable dosage were used. These machines were initially imported. The diffusion of the technology later on created a market for the local production of this type of machine. INTA's diffusion strategy includes the organization of three-day training courses every year that included technological exhibitions by participating firms.

4.8.3 Advantages of Early Adoption: a Measure of the PDP's Success

Early adoption gave Argentine producers a competitive edge vis-à-vis their Brazilian counterparts, which it retains to this day. In 2008, the rate of adoption of PA in Argentina was substantially higher than in the rest of the countries of the region, and it was also quite high relative to the rest of the world. In Argentina, 5 percent of all producers are currently using PA

[61] D&E is a firm devoted to the development, manufacturing and adaptation of top technology for the production of agricultural and agro-industrial products and foodstuff, and which represents in Argentina the US technology suppliers Trimble and AgLeader firms.

(satellite yield monitors), and the capacity exists to raise the adoption rate to 40 percent of all producers in five years. Argentina is ranked second in the world in terms of the rate of adoption of PA, behind the United States, where 35-40 percent of producers are using PA.[62]

Adoption of PA tools, Latin American countries (2008)						
Country	**Manual Guidance Systems**	**Crop sensors**	**Yield Monitors GPS**	**Variable Dosis (seeds and fertilizers)**	**Automatic guidance systems**	**Liquid variable dosis**
Brazil	18.000	6.000	2.000	1.300	1.200	10
Argentina	9.000	8.000	4.500	1.000	400	300
Other Countries	2.000	1.200	1.000	50	50	25
Total	29.000	15.200	8.000	2.350	1.650	335

Source: Proyecto Agricultura de Precisión, INTA, D&E.

4.8.4 Diffusion of Precision Agriculture in Argentina

The adoption of PA tools has grown exponentially in recent years. The growth in adoption is measured by the diffusion in the acquisition and use of the different machines and equipment required by PA. The following table shows the evolution of the Argentine market for equipment and agricultural inputs used in PA.

Evolution of the Argentine market for equipment and agricultural inputs used in PA												
Equipment	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008*
Yield Monitors	50	200	300	450	560	600	850	1300	1600	2500	3600	4500
Yield Monitors with GPS	25	75	155	270	400	420	600	900	1300	2200	3300	4200
Yield Monitors without GPS	25	125	145	180	160	180	250	400	300	300	300	300
Variable rate seeding and fertilizing applicator	3	4	5	6	10	12	25	40	80	420	700	1000
Variable rate fertilizing applicator (liquid)	0	0	0	0	0	0	0	0	50	80	215	335
Interactive Seeding monitors	400	500	700	1000	1300	1500	1800	2200	3000	4200	6500	8000
Satellite guidance systems in planes	35	60	100	160	200	230	300	450	480	550	680	690
Satellite guidance systems in pullverizing	0	10	70	200	400	500	2000	3000	4000	5000	7600	9000
Automatic Guidance Systems in pulverizing machines	0	0	0	0	0	0	0	3	25	50	185	400
Actual time sensors	0	0	2	2	4	5	6	7	7	12	15	15
Electroconductivity sensors	0	0	0	0	0	0	0	0	0	2	4	5

*Until September 2008

Source: INTA Manfredi – Proyecto Agricultura de Precisión

[62] If we measure the rate of adoption by the number of yield monitors per area planted, Argentina ranks fifth after the United States, Denmark, Sweden, and Great Britain, and it has a higher rate than Australia and Holland. The leading positions of Denmark, Sweden, and Great Britain can be explained by their smaller surface areas and more intensive agricultural practices.

The average growth rate in the stock of PA machines and high complexity components was above 20 percent per year between 2003 and 2007, leading to a cumulative 290 percent growth during that period.[63]

Increase in PA equipment

Equipment	Change 2008/2007 (%)
Yield monitor	27%
Variable rate applicator for seeds and fertilizers (solid)	42%
Variable rate fertilizer applicator (liquid)	56%
Monitores de siembra	33%
Banderilleros satelitales en aviones	2%
Banderilleros satelitales en pulverizadoras	19%
Automatic Guidance	116%

Fuente: INTA Manfredi – Proyecto Agricultura de Precisión

4.8.5 Determinants of Success of PDPs

This non-appropriable technology transfer was facilitated by the fact that INTA-Manfredi, through its previous extension activities, had established a network of public-private cooperation. The regional concentration of the firms involved in Southern Santa Fe and Southern Cordoba also contributed to the transfer.

The creation of a platform through extension activities facilitated the adoption of the new technology and may lead to the generation of other classes of solutions for the sector in the future. The extension activity of INTA-Manfredi set it apart from EMBRASA, its Brazilian counterpart, which only does basic research and lacks the practical technological knowledge that results from experimentation on how to use the new technologies. Without extension activities by public institutions, the development and adoption of PA in Brazil occurred five years later than in Argentina.

[63] The first technological innovations adopted were the satellite flaggers, both for pulverizers and airplanes, and the yield monitors. The application of variable dosage in seeding machines and fertilizing machines gathered strength starting in 2006. The acquisition and use of yield monitors and satellite flaggers in pulverizers respectively accounted for 25 and 42 percent of the total investment in PA equipment in 2007, which reached U$S31 million. On average, 50 percent of the PA equipment introduced was made in Argentina (Bragachini, 2008). However, the highest yearly rates of growth in the acquisition of PA equipment and components between 2003 and 2007 corresponded to automatic guides (116 percent), and to the equipment used to administer variable doses in seeding machines and fertilizing machines (42 percent in the case of solid doses and 56 percent in the case of liquid doses).

This PDP is a vertical policy that provides a public input, facilitated by alignment of the public and private sector along this vertical interest. The private sector has formed an informal network that is embedded in the platform generated by INTA.

4.8.6 The Role of INTA in the Emergence of a Local Industry of Precision Machines

By diffusing PA, INTA generated a strong demand for precision machines and instruments. Nowadays, 50 percent of the equipment is produced domestically.[64] INTA also provided important technical information for the local development of axial harvesting machines that facilitated the development of the required sensors by the private sector. In this case, the private sector could have eventually acquired the needed information by itself, but there are fixed costs in the acquisition of this information, which then becomes a public good.[65]

5. The Case of Biotechnology PDPs

Biotechnology is the application of science and technology to living beings and to their parts, products, and models, with the goal of altering materials (either dead or alive) and using them to produce knowledge, goods, and/or services. Biotechnology involves the interaction of biology, genetics, biochemistry, virology, agronomy, engineering, chemistry, medicine, and veterinary medicine, among other disciplines.

This sector includes biotech applied to human health (BHH), biotech applied to plants and animals (BPA) and biotechnology applied to food (BF). These activities entail a substantial

[64] The first local developments included satellite flaggers, pulverizing machines, variable dose seeding machines and computers for pulverizers. The local production of flaggers was the first one to offer rapid positive profits, as they gave producers an instant improvement in their returns, which generated a large demand for this type of equipment. There currently are in operation 9,000 pulverizing equipments with satellite flaggers.

[65] One important factor when deciding whether to invest in PA machines is the availability of adequate mechanical, electronic, and agronomic service and assistance, which is often better supplied by local producers. Additionally INTA provides further assistance on these matters to local suppliers, reinforcing the attractiveness of investing in the adoption of these machines and technologies by agricultural producers.

The local production of PA equipment got a boost from the 2002 devaluation, which favored import substitution. During this period, the firms that developed electronic and hydraulic equipment and highly complex machinery undertook important developments and gained substantial knowledge and competitiveness in the areas of control technologies and PA machines. As a result, many SMEs gained (technological) competitiveness in the development of controlling systems, which include seeding monitors, recorders of events or activities (speed map, harvest day, time of the day at which this activity is undertake), satellite flaggers, and others. In 2007, import substitution reached an estimated 60 percent of the available stock of PA equipment.

amount of R&D, especially BHH.[66] They require highly skilled personnel with research skills adequate for commercial labs and long-term financing for risky ventures.

Biotechnology in Argentina is a relatively big success story. It is the result of an entrepreneurial effort of the private sector that exploits the combination of comparative advantages and accumulated capacity with a few very important public inputs. There were no vertical PDPs to support this sector, but private firms were able to exploit horizontal PDPs such as FONTAR and the provision of relevant public inputs by INTA and CONABIA to accelerate the growth of the sector and to move toward the creation of platforms.

The market and government failures that hurt the sector differ by biotech branches. Thus, the different branches sometimes need different policies and public inputs, and sometimes their needs conflict with each other. Even within each branch the PDP's needs are different.

The branch with the greatest innovative intensity is BHH (R&D spending represents 16 percent of sales of biotech products), followed by transgenic seeds (6 percent of sales), animal health (3 percent), inoculants (2 percent), and food ingredients for bioprocessing (1.5 percent). The overall innovation intensity for all biotech branches is 5.3 percent of sales of biotech products, much larger than the average for the manufacturing sector (0.3 percent).

5.1 Biotechnology Applied to Human Health

Argentina is currently one of the leaders among developing countries in the area of BHH. Its leadership emerged through the pioneering research activities of a large national pharmaceutical laboratory. Technological know-how is highly proprietary, and there has been relatively little diffusion of this activity, which is concentrated in a few big labs (see Sánchez et al., 2008).

New developments are done by a few large local firms. Foreign firms commercialize products developed abroad. There are a large number of small firms, many of which still do not produce BHH goods but have shown important advances in R&D. However, they face serious difficulties in taking these developments to the production and commercialization stage.

In the United States, SME labs do projects for large consolidated firms, who finance them. In Argentina, very few of the BHH SMEs had any prior or systematic interaction with large firms, although they can still sell them their discoveries at any stage of development. Large

[66] In the case of BHH products, there is no possibility of copying. Each lab that wants to replicate a pre-existing product only knows the characteristics of that product, but must do its own R&D to develop it. In this case, imitation only avoids the commercial and clinical risk, but the technological risk is unavoidable.

and small firms are linked mostly through the outsourcing of some processes that large firms do not undertake themselves. This scant interaction is due to the relatively small number of large firms interested in doing new projects, and to the scarce supply of capable smaller research groups or labs that can undertake systematic research.

The largest market failure that hurts this sector is the scarcity of financing, although the sector has also required the provision of some relevant public inputs such as establishing the right standards and control mechanisms for different BHH products and the availability of life scientists in the public sector that could be redeployed to commercial labs.

5.2 Biotechnology Applied to Plants and Animals

BPA was introduced in Argentina by multinational corporations in some branches and by local firms in others. Food biotech was started by a joint venture between one of the largest food producers in Argentina and an American firm, which got involved in the production of recombinant enzymes for the food industry. Local firms pioneered the application of micro-propagation techniques (cloning) in the area of vegetables. Two multinational firms introduced a gene for local varieties of soy that is resistant to glyphosate (a strong herbicide), which allowed the commercial launching of transgenic RR soy in the mid-1990s (Bisang, 2007). These developments were facilitated by the existence of institutions specialized in R&D activities for the agricultural sector, such as INTA, and by the availability of geneticists and agronomic engineers.

The majority of national firms who do biotechnological research work in the area of animal health. In the area of micro-propagation, a subsidiary of a multinational corporation coexists with a small number of small firms, which are mostly spinoffs of universities or public research agencies. Most of the work is done by the national firms. The production of transgenic seeds includes two groups of players: the local firms that develop new varieties and the firms that have genomic knowledge and the technologies for incorporating the genomes into seeds. The generation of new varieties that are adapted to local soils and climates is done by domestic firms, whereas the development of genes tends to be done by all players. The genetically modified organisms (GMO) approved in Argentina are developed abroad and transferred to Argentina.[67]

[67] The interaction among local firms is low, but there is a certain complementarity between national and foreign firms. The majority of domestic firms are stronger in the area of phyto-improvements, while the multinational firms specialize in developing genomic knowledge and incorporating the external genes to the seed. Firms that develop

This sector is relatively less intensive in financing than BHH, but it is more intensive in the use of public inputs in the forms of technological transfers and assistance provided by INTA and other public institutions and universities, and it is also more dependent on having the right regulatory framework and IPR, as knowledge is much less proprietary than in BHH.

5.3 The Role of Financing

The financing constraint hurts because of the long horizon and risk of the R&D projects until the new product or process is fully developed (a typical R&D project in BHH may last up to seven years). It also hurts because of the relatively large costs to do the industrial scaling up and commercial implementation, which prevents the completion of many developments. In the United States, SMEs are financed through systematic contracting of R&D services by large firms and to a lesser extent by venture capital funds. These financing channels are absent in Argentina.[68]

FONTAR and FONCYT compensate for this partially through their past contingent repayment loans, the tax credits and the CAEFIPP loans of FONTAR and a batch of FONCYT instruments. Biotech projects captured 13 percent of the FONCYT grants to finance research between 1997 and 2003. Between 2000 and 2003, 67 percent of the FONCYT biotech funding was applied to BPA projects and 33 percent to BHH. This distribution was reversed for FONTAR funding, which allocated 67 percent of the biotech funds to BHH projects. This allocation makes sense, as BPA is more intensive in public inputs and research that is not commercially driven, which are typically financed by FONCYT, while BHH is more intensive in research and technological innovation that is directly applicable to production and commercial activities. However, this support is not sufficient. Additionally, large firms also demand a large amount of credit that is not readily available.

The main source of financing for large firms comes from the reinvestment of profits or from capitalization by their owners. Nevertheless, large firms use FONTAR funding as a complement to their own funding.[69] While the ANPCyT grants relatively large loans per project,

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and commercialize the different GMOs also commercialize production inputs such as agrochemicals and fertilizers, which is important to ensure the loyalty of customers.

[68] In Argentina the most conspicuous exit options when the project cannot be scaled up by the SME are to sell the projects to large traditional laboratories, which limits the scope for bigger diffusion of this activity.

[69] Some large BHH and BPA firms get additional funding from issuing private equity, but this mechanism is not yet well developed and promoted. One of these firms has highlighted that it would be highly convenient to allow tax

in the majority of cases this funding is not sufficient to finance the final stages of many research projects.

The Ministry of Science and Technology has a program that aims at creating a system of venture capital investment (SICAR), which is based on allowing investors to take a 50 percent tax credit on their contributions to the venture capital fund. The goal is to make the investors partners of the different projects, especially technological start-ups, through the provision of upside incentives. However, the shallow capital market of Argentina may prevent SICAR from becoming a true alleviation of this constraint.

5.4 The Provision of Public Inputs for BPA

Genetically modified (GM) crops were introduced in Argentina in 1996, when the National Commission on Agricultural Biotechnology (CONABIA) authorized the release of transgenic soy that is resistant to the herbicide glyphosate.[70] The creation of CONABIA in 1991 in response to the application by a multinational corporation for the approval of the release of transgenic soy, cotton, and corn was an important institutional innovation that allowed an evaluation of the GMO almost simultaneously with the United States, and permitted the early adoption of this type of technology. This approval set in motion a large growth in the development, testing, and approval of new varieties. The most disseminated GM crops are corn, soy, sunflower and cotton. After the approval of these GM crops, there was an intense dissemination campaign that accelerated the adoption of these technologies in Argentina. The technological change was huge, both in terms of its impact on yields and the adoption of the new technologies. Genetically modified crops now represent 90 percent of all soy plantations, 70 percent of the corn planted area and 60 percent of the cotton planted area. This large technological change was facilitated by the institutional capabilities to undertake thorough analyses of the risk and biosafety issues linked to the release of these GMOs.[71]

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deductions on the capitalizations of the firm done by shareholders as a way to provide bigger incentives to capitalization.

[70] The CONABIA advises the Secretary of Agriculture on technical requirements and biosafety conditions that must be met by the genetic materials obtained by biotech methods. CONABIA is staffed by representatives from the public and private sectors involved in agricultural biotech.

[71] The Secretary of Agriculture has a Biotechnology Office, created in 2004, that assists private firms in the management of matters related to biotechnology and biosafety, especially regarding authorizations to release and commercialize vegetable organisms and/or animals that have been genetically modified, and which originate in the agricultural sector. The biotech office organizes activities of communication, training and technical assistance.

There is intense private-public interaction for the provision of other relevant ISPG. This interaction, led by the private sector, started with private projects that received technological assistance from INTA, which is highly valued by the private firms that we interviewed that do research in these areas. They consider that INTA is relatively well endowed in terms of the technical capabilities of its researchers and technicians and the physical and technological infrastructure to undertake different tests. Many private and public research projects in the area of BPA currently have AT agreements with INTA.

All of the firms that do research in BPA interact with public research institutes and regulatory agencies in different ways, ranging from broad, formal research cooperation agreements to cooperation on specific projects and to the hiring of public sector researchers for specific projects. There are no formal, well oiled mechanisms for enabling this interaction. It is done by appealing to individuals who interface with firms and public research groups. There are many other relevant cases of cooperation between private firms and public research institutes.[72]

The Emergence of Platforms in the Bioagricultural Sector
The most important platform is represented by the Institute of Agrobiotechnology of Rosario (INDEAR), which is a private endeavor partnered by Bioceres and Biosidus, leading private firms in BPA. The project also includes the participation of CONICET, which allowed the construction of the INDEAR building in its Regional Center for R&D Rosario (CERIDER). This partnership facilitates the generation of spillovers between INDEAR and CERIDER. CONICET will also contribute with the participation of its biotechnology researchers through its externship program. The goal of INDEAR is to become an institution of reference in the fields of molecular biology, functional genomics and proteomics applied to technological innovation in the local agricultural sector (in this they would compete with MNCs). The foreseen products will be GMO of vegetal origin, to be transferred to start-up firms. INDEAR will also develop a technological platform in the area of services such as bio-informatics, DNA sequencing, microbiology, and cultivation of vegetable knits, among others. INDEAR received support from the ANPCyT, which classified it as a strategic association between the private and public sectors. Through an ARAI of FONTAR the Agency loaned INDEAR AR$5 million for the construction of the building and AR$600,000 through five ANR. The Agency also chose INDEAR to participate in Strategic Areas Project (PAE) of FONCYT, which will allow it to interact with public research institutions in the area of soils metagenomics, and to lend its last generation DNA sequencing equipment to the public sector. INDEAR was expected to start working in early 2009, and to employ 100 staff.

[72] These cases include the different AT and CVT agreements with INTA, the Instituto Cerela, and the César Milstein Research Center, among others. We can also highlight the cooperation between Biosidus and: a) Fundación Favaloro (an NGO) in research on gene therapy for angiogenesis, b) INVAP and the Dirección Nacional de la Antártida to find microorganisms that adapt to cold temperatures and which can be applied to different industries such as textiles, chemistry and biofuels, among others.

The Cooperative Innovative Efforts of Bioceres

Bioceres is a private firm that focuses on the development, production, and commercialization of seeds, acting as a nexus between the public and the private sector. It currently has 150 shareholders, mostly agricultural producers. The firm has a small staff that is focused on bringing together the research efforts of the private and public sectors.

One example of this articulation is the joint venture between Bioceres and INTA in developing transgenic corn that is resistant to certain local viruses.[73] Another important project of Bioceres is the development of varieties of wheat, corn, and soy that are resistant to drought. This research is being done through an agreement with the National University of Litoral (based in Rosario) and the CONICET.[74] It cooperates with these two institutions in the design of new genetic tools for plants. It also participates in three strategic area programs promoted by the ANPCyT that seek to promote the interaction of knowledge-generating institutions in the cultivation of wheat and sunflower and in the genomic exploration of soils. Finally, Bioceres has the joint venture with Biosidus, with the participation of CONICET, in the creation of the Instituto de Agrobiotecnología Rosario (INDEAR).

In addition to the research joint-ventures with the private sector, INTA offers technical assistance in the area of BPA. Since 1994, it has run the National Program of Advanced Biotechnology (PNBA), where research on genomics, proteomics and bio-informatics is undertaken.

The Polo de Biotecnología de Rosario coordinates the actions of public and private sector actors in this geographic area, including private firms, the local, provincial, and national governments, international agencies, and the ANPCyT. The relevant stakeholders of this institution include the Instituto Biotecnológico de Rosario (which is part of CONICET), INDEAR, and an incubator of biotech firms. This effort concentrates, together with INTA, the largest amount of financial and human resources for research in the vegetable area of biotech.

5.5 The Role of IPR

During the 1990s, Argentina modified its legal patent system with the aim of strengthening the rights of inventors and the scope of protection. However there are still important restrictions on the patentability of living beings. As distinct from the United States, in Argentina industrial

[73] The project is being undertaken in the Instituto de Biotecnología and the Instituto de Genética de INTA Castelar. It is being financed by private investors in the form of venture capital. These investors will participate in the future profits generated by this effort. Field tests are currently underway. The agreement between Bioceres and INTA grants the former the exclusive commercialization rights, which can then be sub-licensed to other firms that commercialize seeds.

[74] Thus far they have developed a gene of sunflower seeds that is resistant to drought and salinity. The financing of the first two stages of this process was done by Bioceres, while the continuation to stages 3 and 4 in September 2003 required the establishment of a specific investment fund of U$S1.6 million, which was in the form of private equity.

protection is denied to plants, animals, and biological processes and to discoveries in this area.[75] Hence, biotech patents do not reflect the universe of innovations and inventions in this area, but only a relatively small subset of them, especially in the case of vegetable varieties, which receive only weaker IPRs.

The acquisition of technological knowledge through R&D in BHH remains highly proprietary, and local developments are more process innovations (replication through R&D) than patentable product innovations. Additionally, most Argentine exports have targeted non-IP countries. Hence, innovative activity in BHH is less sensitive to IPRs. In the case of BPA, technological spillovers are much larger and there is a greater possibility of copying, both for supplying the domestic market and for exporting. Thus, INTA strives to strengthen the IPRs for BPA inventions.

Since the change in the patent laws, only 6 percent of the patent applications presented to the National Institute of Intellectual Protection (INPI) corresponded to biotech (which is one of the most inventive and innovative industries), and only 1.7 percent of these applications were approved. The rest were either denied, or the applicant abandoned its pursuit, or they are still under technical evaluation. Local residents account for 15 percent of the biotech patents granted, while the rest belong to foreigners. Besides the restrictions placed by the Argentine patent law, local innovators and inventors are not accustomed to patenting their inventions or discoveries. Many small firms are not aware of the scope of the law and of the importance of patenting newly developed knowledge. FONTAR attempts to compensate partially for these shortcomings by offering non-reimbursable grants to finance the cost of patenting. Additionally, INPI lacks competent evaluators for biotech patents, thanks to the relatively few applications, which in turn are the result of the law and the shortcomings of INPI.[76]

The insufficient protection of IPRs in the BPA area is highly detrimental to further innovation in the sector. For instance, there is a large "white bag market" that commercializes seeds that are not provided by licensed seed traders but rather by agricultural producers that sell their own harvested seeds without respecting IPRs. According to members of CONABIA, there

[75] There are sizable differences across countries regarding the criteria for patenting, which are related to novelty, degree of invention and industrial application. In the case of biotech these differences are exacerbated by the diverging views regarding the limits that should be placed on the private appropriation of goods that are part of nature and/or human life, and hence should be public.

[76] According to the present law, the rights over the invention are not valid until the patent is approved. This may leave the inventor unprotected for a period of up to four years between the patent application and the time of its approval, which is long enough for the invention to be copied.

are currently many products that are not commercialized because of the absence of patent protection.

5.6 The Law on Promotion of Modern Biotechnology

The success of this sector, the proactive behavior of private sector stakeholders, the growing number of platforms and public-private cooperation, and the receptivity of the government have led to the enactment of a law that creates biotech-specific PDPs. This 2007 law will be valid for 15 years and will be implemented by the Ministry of Economy.

The benefits granted include subsidies/tax breaks for R&D and acquisition of capital goods and hiring of research personnel for specific biotech projects. The law also creates a fund that will finance (at a subsidized cost) the start-up capital for new entrepreneurs whose projects are at the research or production stages and which are candidates to qualify for the benefits of this law.[77] It also includes a Fiduciary Promotion Fund that will finance research activities and which is funded with taxes paid by the participating firms.

The law has been considered by existing firms as having introduced a good set of instruments to promote both the emergence of new developments and the consolidation of existing ones.

5.7 Human Capital

Argentina is relatively well endowed with highly qualified R&D personnel and technicians that meet the requirements of private firms. However, there is still a shortage of scientists capable of working for private firms, and of technology managers.[78] There is still a gap between the more autonomous research activities in the public sector and the needs of biotech SMEs. Despite CONICET's externship programs, this gap has not been eliminated. The Ministry of Science and Technology is supporting a project to develop managers in the private sector who are both technically knowledgeable and trained in business administration in important universities abroad.

[77] This fund will be financed with resources coming from: a) the national budget, b) donations, c) non-reimbursable funds provided by multilateral organizations, foreign governments or NGOs, and d) reimbursements from the beneficiaries of this law. The law additionally creates a Consulting Commission which will include representatives of the public and private sectors.

[78] Scientists that moved from academia to the private sector remarked on the difficulties in adapting to the corporate world and in finding compatibility between the two ways of working, which are completely different.

5.8 Relevance of PDPs for Biotechnology

There is no vertical policy for the sector, except for the recent biotechnology law. Instead, there is a collection of horizontal policies that were used by private firms to accelerate the growth of their sectors. There are a few important public inputs that were crucial for the takeoff of these sectors, such as the emergence of a regulatory agency in the early 1990s that was adept at evaluating the risks and approving the release of genetically modified seeds, and a number of public sector researchers in the area of life sciences. Financing by FONTAR and technology transfers by INTA have helped, although they are still insufficient. A very interesting feature is the emerging interaction between private firms and public institutions in research, most often led by the private sector and occurring mostly in BPA. This is leading to the creation of technological platforms in the sector and to growing cooperation in the design of new PDPs. The design and implementation of an appropriate intellectual property regime is still needed.

6. Conclusions

The PDPs analyzed here (FONTAR and INTA) are relatively small vis-à-vis the dominant PDP programs in Argentina (financing to SMEs, export promotion programs, financing of investment, etc.), but they are more successful. They managed to survive macroeconomic distress, to display important policy learning, and to achieve their goals. However their impacts are often limited by the lack of coordination with other public agencies that matter for the supported sector or activity, and by government failures. They also facilitate the emergence of platforms for the continuous technological modernization of different sectors rather than the expansion or survival of traditional activities. These PDPs also display important degrees of public-private cooperation and transmission of private sector needs regarding public inputs and market interventions. The successful emergence of biotechnology in Argentina was based on private sector initiative (especially in biopharmaceuticals) and on the use of both vertical and horizontal PDPs, which it has used to create and consolidate platforms (especially in the case of biotechnology applied to plants and animals).

These PDPs yield the following lessons:

- "Small and local" PDPs are good for solving coordination failures and for an adequate matching of instruments and failures.
- The PDPs are likelier to succeed when they are flexible and varied enough to adapt to the needs of different types of firms and different classes of projects, as in the case of FONTAR's instruments, which also facilitates the formation of platforms.
- In many cases the presence of committed stakeholders that break the status quo or that manage to maintain and upgrade policies in an unstable policymaking scenario was crucial.
- PDPs often times have to compensate for government failures (as in the case of innovation), which limit them to obtaining only some micro success.
- The dearth of tenured positions in intervening agencies conspires against the success of the PDPs. Idiosyncratic factors such as commitment and prestige of the agency have to compensate for the precariousness of employment.
- The relative impact of market interventions vis-à-vis public inputs depends on the characteristics of the supported sector and activities. For instance, in biotech applied to plants and animals the provision of public inputs (technology transfers) is more important than in the case of biotech applied to human health, where financing is more important.

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