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Institutions and Technological Learning:

Public-Private Linkages in Agricultural Research in Brazil and Argentina

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Abstract

The article discusses the institutional arrangements and forms of organization of agricultural research in Brazil and Argentina. The analysis focuses on Embrapa in the Brazilian case and INTA in the Argentinian case. Emphasis is laid on the two institutions' policies regarding intellectual property and technology transfer. The aim is to contribute to the debate about how to conceptualize the co-evolution of organizations considering the technical, scientific, legal, regulatory, economic and other contexts in which they operate, reinforcing the idea of learning and that economic institutions do not just evolve but co-evolve.

Keywords: co-evolution; learning; institutional arrangements; agricultural research.

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Introduction

The evolutionary economics literature has highlighted the role played by institutions and policies in industrial development processes and in the strengthening of national production and innovation systems. According to this approach, the development process is affected by a number of variables, most of which cannot be properly understood by an analysis that focuses solely on conventional economic transactions. Technological learning, for example, takes place in the framework of a complex process of institutional embeddedness, in which policies and institutions co-evolve with the environment (with the legal and regulatory framework, with consumer tastes and preferences, with technological trajectories, and with multiple forms of interaction among actors in the innovation process, among other elements) and also play an important role in influencing this context (Cimolli et al., 2007; Nelson, 1994 and 2008; Dosi & Malerba, 1996).

Like other segments, agricultural research is undergoing major changes. The development of new knowledge, competitive strategies on a global scale, the emergence of new players, and technological and institutional change are some of the factors that affect the evolution of research and innovation. In the midst of these ongoing changes, the key players are seeking new ways to interact with other participants in the process, both in the public and in the private sector.

In this new phase, public research institutions (PRIs) should constantly extend their capabilities via learning processes, so as to adapt to the institutional context (Perez & Vargas, 2007), anticipate changes in the sphere of science and technology (and even try to influence them), and contribute to building the capacities of their local partners, thus maintaining their legitimacy in the eyes of society. This should also entail a proactive attitude on the part of these institutions toward protecting the knowledge created and managing IP to capture investment in R&D (López & Rebolledo, 2007). For Rojas (2007), research institutions should establish coherent policies to capture the value created by execution of their R&D projects.

Brazil and Argentina stand out on the international agricultural stage as major food producers and exporters. This leading position results from a research structure created in the course of the 20th century, a structure that is mostly public but also to some extent private. Public-sector financial crises and investment by transnational seed companies and producers of chemical inputs had a severely impact on the agricultural research structure, especially in the 1990s. Private-sector investment was favored by expectations of profitability due to institutional changes such as the strengthening of IP rights in plant breeding activities, and technological changes such as progress in the production of genetically modified seeds, which represent an important market for the leading companies, particularly in light of the fact that in addition to seeds these companies develop complementary assets required for their use.

The article discusses the ways in which Embrapa, *Empresa Brasileira de Pesquisa Agropecuária* (Brazilian Agricultural Research Corporation), and INTA, *Instituto Nacional de Tecnología Agropecuaria* (Argentina's National Institute of Agricultural Technology), have built linkages with other public and private players in research and seed production. The authors set out to understand how the two institutions concerned interact with other players, especially in the private sector, including both domestic and transnational firms. Given the significance of their position in the agricultural production and innovation systems, it is posited that these two institutions may have different impacts on technological learning from other participants in the seed research and production system.

The aim of the article is to discuss the differences and similarities between the institutional arrangements entered into by Embrapa and INTA in conducting research on important crops. Special attention is paid to the policies regarding IP rights and technology transfer pursued by the two institutions. The authors believe the arguments discussed will contribute significantly to the debate about how to conceptualize the co-evolution of organizations considering the technical, scientific, legal, regulatory, economic and other contexts in which they operate, reinforcing the idea of learning and that economic institutions do not just evolve but co-evolve, and

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about the role public research institutions can play in developing "frontier" technologies such as biotechnology, in diffusing this knowledge, and in building local capacity based on linkages with other players in the research and production process.

Characteristics of the agricultural innovation systems in Brazil and Argentina

Brazil and Argentina have similar characteristics in several areas. Examples include the importance of agriculture to the national economy, the industrialization model, and the resulting formation of the innovation system. These systems relate to the set of public and private institutions that contribute in the macroeconomic and microeconomic spheres to the development, execution, support, financing and diffusion of new technologies (Sbicca & Pelaez, 2006).

Until the 1930s Brazil and Argentina were considered agro-exporting economies although at that time Argentina already exported processed primary goods (Katz & Bercovich, 1993). Both are late-industrializing countries which at a crucial stage in their development opted for import substitution industrialization. This model of industrialization focuses on prioritizing the domestic market and is dependent on public investment in major projects but also requires foreign direct investment to develop heavy industry. In both cases domestic industry enjoyed protection without any real reciprocity requirements. This contrasts with South Korea, for example, where the government prioritized the creation of large conglomerates, or *chaebols*, but also disciplined and controlled their performance with a view to promoting production for export (Amsden, 1989; Kim, 1993).

In both South American countries the science and technology (S&T) system was molded by economic development policies introduced mainly from the 1950s onwards. In Argentina all the organizations that comprise the foundation of the S&T complex (except for some important universities such as the University of Buenos Aires) were set up in that period: *Comisión Nacional de Energia Atómica* (CNEA, 1955-6), INTA (1956), *Instituto Nacional de Tecnología Industrial* (INTI, 1957), and *Consejo Nacional de Investigaciones Científicas y Técnicas* (Conicet, 1958). According to Morel (1979), between 1950 and 1967 the Brazilian state's main imperatives were industrial development and "national security". In this period Brazil laid the institutional basis for the scientific and technological development that was to be launched in the 1970s. For example, both of the main academic research funding institutions – *Coordenadoria de Aperfeiçoamento de Pessoal de Ensino Superior* (Capes) and *Conselho Nacional de Pesquisas* (CNPq) – were set up in 1951 (and it should not be forgotten that the institutionalization of higher education in Brazil had already begun with the creation of the University of São Paulo in the 1930s).

Another feature common to Brazil and Argentina (as well as other Latin American countries) and extremely important to the organization of the context for S&T is the fact that the S&T system has little connection to the productive system, according to some experts because of the industrialization model, based on import substitution and the attraction of large multinational corporations, which imported the technology packages they needed for the production process in these countries and thus did not place strong demands on the local S&T systems. In both countries the public sector accounts for a large proportion of investment in S&T, mainly owing to the role of universities, research centers attached to state-owned enterprises or former SOEs, and research institutes. As a result, scientific activities perform better than technological activities.[3] This gap between the two areas in performance terms is largely due to the profile of adaptive research activities developed by private enterprise in the shape of local and multinational firms. Local technology production has been low and imported technology predominates, leading to an industrial dynamism dependent on transfers from abroad, as noted earlier.

In both countries the weak integration between S&T and the productive sector derives mostly from the adoption of a linear conception of the innovation process as regards public policy for S&T, according to which scientific development is done by research institutions and, after a process of adaptive research, transferred to users. This conception also influenced the

[3] It is worth stressing that Argentina has produced three Nobel Laureates in science, an unusually high number for a developing country (Bernardo Houssay, 1947; Luis Leloir, 1970; César Milstein, 1984).

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organization of research institutions by leaving little space for interdisciplinary activities.

Although Argentina's Agricultural Innovation System was organized within this same framework, according to Parellada & Ekboir (2003) a number of factors contributed to dynamic processes of technology adoption: (i) the macroeconomic policies pursued from 1930 on were biased against the agricultural sector, obliging it to seek technologies that could offset this bias; (ii) many technology developments are not science-intensive (e.g. crop management), so that farmers with more resources have an incentive to form associations to develop such technologies; (iii) science-intensive developments, such as agrochemicals, could be introduced via imports of knowledge and/or technology from other countries thanks to ecological and structural similarities between the Pampas region, Argentina's agricultural heartland, and the main agricultural regions of the northern hemisphere, which favored the early installation of multinational companies that produce hybrid seeds; (iv) interaction between wheat improvement by Argentinian institutions (Buck and Klein, both important private seed companies, and INTA) and *Centro Internacional de Mejoramiento de Maíz y Trigo* (the International Maize and Wheat Improvement Center, known by its Spanish-language acronym CIMMYT), which favored the introduction of Mexican germplasm into seeds adapted to the wheat-growing regions of Argentina; and (v) the establishment by INTA from its inception of an agricultural extension system that partly compensated for the isolation of its researchers.

INTA was created in 1956, as stated earlier, in the context of the Green Revolution. As occurred in other Latin American countries, the idea was to supply agricultural technologies developed in international centers of innovation to local producers after adapting them to the regional conditions. INTA completed several projects designed to facilitate the adoption and adaptation of new technology by producers via its extension service. It also created new technological products in strategic areas through agreements with the private sector, as discussed in the next section.

According to Rossini (2004), in the mid-1970s subsidiaries of multinationals began marketing packages developed entirely abroad, leaving adaptation and other relatively less complex tasks to local firms. In addition to selling seeds, these companies also distributed and marketed phytosanitary products, intensifying competition with locally owned firms that specialized in farm inputs. The author also highlights the changes in official policy for the sector introduced under the military dictatorship that seized power in 1976. Following these changes INTA lost its leading position in agricultural technology development and transfer. There were two main reasons for this: political and ideological persecution by the military dictatorship, forcing many of INTA's technicians and scientists to leave the organization and, in numerous cases, the country; and prioritization by the military government of a division of labor whereby "INTA was to focus on basic research, population improvement and germplasm supply, while the ensuing stages of a competitive nature were to be left to private enterprise." This mistaken vision of the innovation process diminished INTA's research capabilities, especially in crops such as soy, where competition with the private sector is more intense.

According to Bisang & Varela (2006), until the mid-1980s there was a degree of balance among the various players in the seed markets, who were as follows: the public sector represented mainly by INTA and some universities; and the private sector represented by local firms, some with a long history in Argentina, such as Buck and Klein, and by multinationals that introduced into Argentina technologies developed in their countries of origin. There was also a parallel market for seeds, supplied by unauthorized seed firms or from seed reserves held by growers themselves or third parties, especially in the case of non-hybrid seeds such as soy and wheat.

INTA's presence in the market was therefore decisive at that time, which preceded the commercial launching of transgenics, as the authors point out. During the 1990s, however, trade liberalization and deregulation in Argentina favored local reproduction of the process seen internationally of concentration among companies producing farm inputs. In addition to concentration at the international level (with a local impact due to the fact that many of these corporations already operated in Argentina), acquisition of some important Argentinian firms by these multinationals further contributed to concentration. Thus Monsanto, Dow Agro Science, Dupont, Syngenta, Bayer Crop Science and BASF began

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to play an enormously significant role in supplying the new technology package organized around genetically modified seeds.

The market for GM seeds is important to the multinationals not only because of the gains from the technology present in the seeds but also because they supply the agrochemical inputs required while the crop is growing. In other words, these are complementary assets. Bisang & Varela (2006) argue that the large technical and economic scale required to develop new biotechnology puts developing countries in the position of being mere recipients and adapters of this technology. Moreover, the need to adapt the technology embedded in GM seeds to local weather and soil conditions created linkages between multinationals and local seed firms. The importance of these local firms in the Argentinian market due to their long experience in plant breeding positioned them favorably when the moment came to enter into alliances with the multinationals.

As in Argentina, in Brazil too the current structure of agricultural research "is the result of an evolutionary process which reflects, to a lesser or greater extent, the agricultural and development policies implemented at each moment in the history of the country" (Salles Filho & Mendes, 2009). Even though Brazil stands out among developing countries for its strong tradition in agricultural research, private-sector participation in the research process is relatively recent. This reflects the longstanding importance of public research, as exemplified by institutions such as Instituto Agronômico (IAC), founded in 1887 in the interior of São Paulo State, Instituto de Pesquisas Agronômicas (IPA), founded in 1935 in Pernambuco, Instituto Riograndense do Arroz (IRGA), founded in 1939 in Rio Grande do Sul, and other agricultural research institutions controlled by state governments, university departments of agrarian science and agronomy, and of course Embrapa (Beintema et al., 2001).

The current organizational structure of agricultural research in Brazil was greatly influenced by policies implemented in the 1970s, a time when public policy was geared to five-year industrialization plans, modernization of government structures, and modernization of agriculture, science and technology. Law 5851, dated December 7, 1972, laid the legal foundation for the creation of Embrapa, which took place in April 1973. The creation of Embrapa was an initiative of the federal government designed to centralize and focus agricultural technology policy by defining a single institutional trajectory. Embrapa's role was to coordinate the hitherto diffuse system of research centers and experiment stations scattered around the country. In contrast with INTA, rural extension was not Embrapa's focus but was the responsibility of another federal organization, Embrater, which was closed in 1991. Embrater operated in collaboration with state technical assistance and extension services still in existence today.

At the time of its creation, Embrapa attempted to impose a division of labor in the public sector whereby basic research would be the responsibility of universities and applied research would be conducted by Embrapa itself and by *Serviço Nacional de Pesquisa Agropecuária*, later renamed *Sistema Cooperativo de Pesquisa Agropecuária* or SCPA. On one hand, this weakened the state institutions that did basic research and, owing to a severe financial crisis caused by tax concentration imposed by the military government, depended on research funding and investment budgets centralized by Embrapa. On the other hand, the plan extended the coverage of agricultural research by establishing Embrapa's own research centers and units, and fostered the creation of new state research agencies technically subordinated to Embrapa. According to Carvalho (1992), the distancing of basic research was offset by the use of technologies created by international research centers, adapted to Brazilian conditions by Embrapa's "national product centers", and made viable under local conditions by state research units, which were either attached to Embrapa itself or controlled by state governments.

Thus the execution of research was the responsibility of Embrapa's national and regional centers. The state research system was in charge of adapting the technologies created by Embrapa's centers and working in areas not covered by those centers (it was realized that this division of labor could not be rigidly observed in states with a tradition in research and knowledge creation). Embrapa was also responsible for coordinating, programming and funding research activities.

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Embrapa[4] is the lead institution in and coordinator of *Sistema Nacional de Pesquisa Agropecuária* or SNPA (National Agricultural Research System), which also includes state agricultural research organizations, federal and state universities and research institutions, and other public and private organizations directly or indirectly linked to the agricultural research sector.[5] An analysis of the main institutions in the SNPA and their linkages highlights the need to reorganize the system so as to enable work to be done in an articulated and complementary manner, and so as to foster economies of scale and scope in the execution of projects, among other issues raised by the dynamics of the innovation process.

In the case of private agricultural research activities in Brazil, hybrid corn breeding was one of the milestones in early private research activities. The private firm that performed best in these activities was Agroceres, founded in 1945 (Castro, 1988). Generally speaking, however, most locally owned or multinational firms started their research activities in the 1960s and 1970s. Today Brazil has an active and growing private sector, which supplies technologies and technical assistance mainly in farm inputs and food processing (Beintema et al., 2001).

As was the case with Argentina's seed market, so too in Brazil there has been an intense process of concentration and transnationalization, especially since the 1990s. This is closely related to the strategies of multinationals in highly profitable markets such as those for soy and corn, the main Brazilian grain crops. Multinationals have acquired important local firms with a long tradition, Agroceres among them. In an increasingly competitive market, smaller firms have labored to remain open (Wilkinson & Castelli, 2000).

The next section discusses the linkages between INTA and Embrapa, key institutions in the agricultural innovation system in Argentina and Brazil respectively, and the wide array of actors who participate in the agricultural research process. Special attention is paid to linkages in the markets for grain seeds because these are markets in which the institutions have ample capabilities and which have been strongly affected by the changes that have occurred since the 1990s.

INTA, Embrapa and plant breeding research linkages

The late 1980s marked the beginning of closer ties between INTA and the private sector in Argentina. INTA had already worked with the private sector on the development of technologies for breeding new plant varieties, but these agreements were practically confined to private nonprofit institutions such as co-ops, growers' associations etc.

According to Moscardi (2007), in the mid-1980s three circumstances favored the creation of a Technological Linkage Policy by INTA known as *Vinculación Tecnológica* or VT: the emerging phenomenon of the privatization of science; the crisis of the linear innovation model in S&T; and low investment of public funds in agricultural research activities. To promote greater participation by the domestic private sector in the process of technological innovation in the agricultural sector, INTA launched its VT policy in late 1986 and in the following year created a Technological Linkage Unit to execute the policy. The first VT agreement was signed between INTA and Federación Agraria Argentina (FAA). An early cause of controversy in regard to VT arose from a clause requiring INTA to enter into agreements only with locally owned firms for technologies commercialized in Argentina. In 1990 the clause was revised to take advantage of an opportunity to enter into an agreement with the multinational corporation Pioneer.

The VT policy pursued by INTA can be divided into four stages (INTA, 2007). The first, lasting from 1986 until the mid-1990s, corresponded to the creation of the policy and the establishment of the first agreements. The second stage, between the mid-1990s and early 2000, was characterized by a reduction in the S&T budget for Argentina's national research institutes, with "negative effects on the quality and quantity of VT." The third stage lasted from 2001 to 2004 and began with a critical review of the early experiences and with the introduction of a new form of VT "in which the management of innovation played a more important role." The fourth stage, which began in 2005, is governed by the 2005-2015 Institutional Strategic Plan. Its key feature is a more

[4] Embrapa currently comprises research and service units, and administrative units.
[5] Information obtained from http://www.embrapa.br/a_embrapa/snpa. Accessed April, 01, 2009.

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integrated vision for VT policy as far as INTA's activities in the various regions of Argentina are concerned. The main types of technological linkage currently used by INTA are technology transfer with or without royalties; shared R&D, usually with licensing clauses; technical and scientific assistance; agreements with entrepreneurs to create technology-based start-ups; and the sale of products and specialized technical services.

As noted earlier, before the institutionalization of its VT policy INTA already had important linkages with the private sector. In 1972, for example, it contributed to the creation of a seed firm, Cooperativa Produsem, with which it had seed multiplication and distribution agreements. In 1987 the two organizations signed an agreement based on the VT policy that permitted an important advance in the development of wheat varieties. In 2001 the agreement was terminated owing to the macroeconomic crisis then under way in Argentina. In 2003 INTA entered into a wheat research cooperation agreement with Bioceres (Gutierrez and Penna, 2004).

Bioceres is an entity set up by more than 170 agricultural entrepreneurs to facilitate public-private interaction. Under the agreement with INTA, Bioceres will finance INTA's Wheat Breeding Program for ten years and hold an exclusive license to all the varieties developed while the agreement is in force, with the right to multiply the varieties and commercialize them in Argentina and neighboring countries. Bioceres will multiply and commercialize the varieties through its members, while INTA will hold the property rights to the germplasm (Rapela, 2006).

Another interesting linkage in the Argentinian seed market is an agreement between INTA and BASF to develop a non-transgenic rice variety resistant to herbicides in the imidazolinone class. The technique used to obtain imidazolinone-resistant genes entailed creating variability by inducing mutations. Research began in 1996, and potentially resistant plants with high yields were obtained in 2000. After a long process of negotiation involving technical as well as intellectual property issues, the agreement with BASF was signed in May 2005. BASF is responsible under the agreement for obtaining patents worldwide in INTA's name and in exchange has been exclusively licensed to use the gene worldwide except in Argentina and in Uruguay, where INTA administrates its property rights to the patented gene directly (Moscardi, 2007).

An analysis of these two examples highlights important points relating to public-private linkages in agricultural research in Argentina. INTA succeeded in expanding its research activities and achieving greater visibility in the local market for wheat seeds thanks to the agreements with Produsem and Bioceres. The agreement with BASF enabled it to assume a leading position in international research on non-transgenic herbicide-tolerant rice. Its partners also benefited, in the case of wheat by access to the cultivars developed by INTA. In the case of rice, the multinational extended its control over the technology package comprised by the herbicide-tolerant seed and the herbicide itself. Benefits to farmers related to the enhanced productivity derived from plant breeding, due both to activities conducted by INTA and its partners and indirectly to increased investment in R&D in recent decades by private wheat seed firms such as Buck and Klein, among others,[6] as a way of remaining competitive with the seeds developed by INTA (Moscardi, 2007).

In Brazil, Embrapa adopted an institutional policy for intellectual property management in 1996, whereby the organization actively seeks legal protection for the results of its research and maximizes the use of IP rights by licensing processes and products, provided its social mission is not compromised. This policy became the main regulatory framework for Embrapa's relations with external partners.

At the same time a number of laws were passed in Brazil to establish protection in practically all areas of IP, including Law 9279 (May 14, 1996), known as the Industrial Property Law, covering patents and utility models, trademarks and service marks, industrial designs and geographical indications; and Law 9456 (April 25, 1997), known as the Plant Variety Protection Law.

[6] In addition to Buck and Klein, both of which are longstanding private-sector plant breeding firms in Argentina, founded in 1930 and 1919 respectively, other important private-sector players in the wheat seed market include Nidera, Argentinian Cooperatives Association (ACA), Relmó and Don Mario (Rapela, 2006). For more information on the history of wheat and soy seed production in Argentina, see Brieva (2006).

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In 2000 Embrapa established mandatory rules for all research units in accordance with the principles of its IT management policy, and these were later extended to regulate relations with public and private partners. In the next four years many other rules and standards were introduced to regulate technology transfer to the private sector and "avoid the trap of affording preferential treatment to companies or business groups." (Cunha & Botelho Filho, 2007)

Embrapa takes a proactive position in the soy seed market, partnering with major private-sector multinationals to develop GM varieties, such as glyphosate-resistant soy developed with Monsanto, and imidazolinone-resistant soy developed with BASF. It also develops research in partnership with Japan International Research Center for Agricultural Sciences (JIRCAS) on a drought-tolerant GM variety of soy. Adaptation of these materials to different soy-growing regions in Brazil is possible through partnerships with seed producers' foundations. In all these partnerships Embrapa imposes agreements giving it the right to maintain ownership of its germplasm bank while at the same time offering growers seeds with different characteristics, such as transgenic and conventional, for example.

Embrapa's participation in the corn seed market is less significant. The organization is currently reviewing its approach to linkages with seed companies (Cota Júnior, 2008). Under the previous model seed companies acted as franchisees of Embrapa through a consortium called União dos Produtores de Sementes de Milho da Pesquisa Nacional (Unimilho). The end of Unimilho, due mainly to acquisition of several seed companies that belonged to the consortium by multinationals, has led to discussion of a new model between Embrapa and the seed industry. As is already the case in the soy seed market, seed producers organized in foundations provide information about market demands, collaborate with the final stages of research, contribute funding to cover the costs of these activities, and supply unskilled labor, land etc. In exchange the foundations have exclusive rights for a limited period to multiply and sell the materials developed by the partnership.

According to Cunha & Botelho Filho (2007), the implementation of this system of partnerships between Embrapa and farmers, wholly disciplined by technical and financial cooperation agreements, has greatly extended Embrapa's outreach by enabling genetic materials to be tested in many different parts of the country. Besides ownership of the materials created, "these agreements define the rights to commercialization, the regime for production of basic seeds, the parameters for determining percentage royalties, and the respective basis for calculation." In the case of plant varieties developed solely by Embrapa, transfer to the private sector is by public offering. The process, which is described in an Embrapa standard procedure, consists basically of offering varieties to registered producers. In these cases, too, of course there is an obligation to pay Embrapa royalties for the right to multiply its materials.

Embrapa's partnerships with the private sector are strongly monitored, as noted by Carvalho et al. (2007), in accordance with rules issued by Embrapa establishing that partners in its plant breeding programs may not have their own research programs in this area or work with other organizations that do. Embrapa also no longer shares ownership of IP rights with private partners. This important decision was taken at a time when multinationals were acquiring major local seed firms and staking out an ever-growing proportion of the Brazilian market. It enabled Embrapa to increase its control over its own germplasm bank. Another key event in the period was termination of the partnership between Embrapa and *Fundação Mato Grosso*, which refused to comply with Embrapa's new rules on IP rights and the sharing of royalties. In response to the new rules, the foundation decided to set up its own plant breeding program for soy and cotton (De Carli, 2005).

Thus while on the one hand Embrapa's policy favors linkages with growers' associations that do not have their own research programs, on the other hand its partnerships with larger institutions have been adversely affected. In the case of INTA, the policy adopted is less restrictive but partnerships are also constantly monitored to prevent appropriation of its germplasm bank by private partners. This is a strategic matter where public-private linkages in agricultural research are concerned. A germplasm bank is a key asset in plant breeding activities, especially in the context of fast-moving changes in biotechnology, and monitoring between the parties must therefore be constant. The analysis also shows that both institutions are pursuing capabilities in new

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technology, as indicated by the examples relating to GM seed research. With regard to linkages with multinationals, besides capabilities in plant breeding the importance of contractual provisions covering IP rights to the products developed is clear if the institutions are to succeed not only in developing new products but also in occupying important strategic spaces in a market that is increasingly limited to a few players worldwide.

Conclusions

Changes in science and technology, and in the institutional framework and competition, entail changes in the ways in which agricultural research is organized and in the linkages between the key players in the process. This co-evolution is an important dynamic that needs to be taken into account and internalized in the activities and decisions of PRIs, so that they can operate proactively in their main markets of choice. Embrapa and INTA are good examples of forms of public-private linkages in research and commercialization of newly created materials. Both have established policies designed to increase the appropriation of the results of their research, especially in respect of IP management and technology transfer. Beyond their importance for a policy to underpin relations with external partners, these changes entail a process of organizational learning that supports the new ways in which these institutions value the knowledge they create as their key asset.

Rausser et al. (2000) argue that PRIs in developing countries should adopt creative new approaches to the process of negotiating with their potential private partners, seeking to leverage complementarities and potential synergies between the public and private sectors. For Fischer & Byerlee (2001), IP and technology transfer management by PRIs involves a range of different institutional and political strategies, such as capacity building in legal practices relating to participation in germplasm exchange networks, and the establishment of strategies to enable access tools and technologies related to biotechnology, among others. The same authors also stress that the public sector should understand the investment and marketing strategy of the private sector in order to develop its own strategy to supply public goods in terms of crops, regions and technologies in which the private sector is not interested, thus avoiding duplication and undue competition between the two sectors.

PRIs need to pursue complementarities and synergies with the private sector in research and in commercializing their products. Hence the paramount importance of capacity building in IP management and technology transfer. However, a comparison between Brazil and Argentina highlights the importance of capacity building and strong action by PRIs in markets that are also of interest to the private sector. In other words there is no a priori division between markets based on whether they are of greater or lesser interest to private enterprise. What should be taken into account by both the public and the private sector is the strategic importance of these markets, or the occupation of strategic spaces in them, in respect of a number of factors. This is the case with the soy seed market, the most significant seed market in both countries. In the Brazilian case, Embrapa's leading position in seed research and in the seed market offers increased options to growers and enables it to compete with private firms, especially multinationals. In Argentina, INTA was a major player in the soy market in the past but currently plays a discreet role, which significantly limits its capacity to intervene in the market for this crop, the most important in Argentina's present agricultural model.

Given the importance of both institutions to scientific and technological research in their respective countries, a proactive approach in this new phase of agricultural research is fundamental for the future not only of the institutions themselves but also of food security and agricultural competitiveness in both countries. Positions that neglect the importance of capacity building in new technologies and in the practices of IP and technology transfer management, and that fail to take into account the importance of occupying strategic spaces in relevant markets, are not adequate for the formulation and execution of science and technology policies or agricultural policies in countries such as Brazil and Argentina.

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