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Analyzing the interactions between emerging technologies and institutional environments in developing countries: The case of GM maize in Argentina

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1. Introduction

This work is aimed at advancing the understanding of the interactions and dynamics between emerging technologies, and the institutional environments in national settings. Interactions and coevolution of technologies and institutions are fundamental drivers of social change (Nelson 1994a), and this is particularly the triggering question for this analysis. How and up to what extent have the institutional environments co-evolved with the emergence of agricultural genetic engineering within specific national settings? What types of interacting paths have they shaped, what actors have been involved and in what roles, and what have been the outcomes of these processes in terms of production, utilization, appropriation and commercialization of the technology? Furthermore it aims at tracing and tracking back and forth the connections and disconnections between institutional and technological change, and ultimately identifying and analyzing the outcomes of these processes and the role of policy in terms of who gets what, when and how[3].

These interactions are analyzed in the context of agricultural genetic engineering in the second country with GM planted area, with a tradition of crises and where policy environments' functionality and responsiveness are often at odds with innovation and change, and policy anticipation might be weak. This paper reviews this relationship in the context of an emerging technology such as agricultural GE in Argentina.

At the institutional end, it traces the 'critical junctures' as indicators of institutional innovation, and feedback effects, as indicators of their reproduction (Thelen 2003). The focus on the institutional environment refers to policy objectives, policy instruments and agendas, the timing of the interventions, and the regulatory framework. At the technological end, it traces the specific context of introduction of the

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technology, its production and utilization, the related set of capabilities developed, and the actors involved. The links and gaps between these two are analyzed, connecting the dots, tracing the trajectories and signaling the missing links, problems and bottlenecks over time.

At the broader level, this analysis intends to contribute with the discussion on the systemic character of innovations, focusing on the interaction mechanisms between technologies and institutions and a more precise understanding of the structure of these interactions, and the causal mechanisms supporting differential patterns of change.

This study fundamentally draws on work conducted in the context of the RESULTAR[4] research project, on the distributional consequences of emerging technologies. In depth interviews were conducted in Argentina in November 2007, and were complemented with government reports, bills and regulatory documents, and academic articles, among others.

2. Emerging technologies and institutional environments: some brief characteristics

2.1. Emerging biotechnology[5]

Biotechnology[6] cannot be defined as a singular, discrete technology. It is a set of interlocked technologies that cut across a wide range of sectors and industries. Thus, its analysis requires a combination of perspectives: it entails features of ‘technological systems’ (Carlsson and Stankiewicz 1991) as well as some of ‘sectoral systems’ (Malerba 2002, Mowery and Nelson 1999). In the former the boundaries of the system are defined by the technology; the technology is the unit of analysis and it is traced throughout the system, beyond the sectoral and/or national levels. Thus, a technological system is “…a network of agents interacting in a particular area of technology to generate, diffuse and utilize technology” (Carlsson and Stankiewicz, 1991). The latter in turn is defined as “a set of activities that are unified by some related product group for a given or emerging demand and that share some basic knowledge” (Malerba 2004) (pp.9-10), and comprises three building blocks: knowledge and technology, actors and networks, and institutions.

Furthermore, the complexity that underlies biotechnology is not unique to it. Emerging technologies are increasingly more complex, and inter-related with other technologies turning into technological systems that permeates across different sectors and industries. Thus, technologies’ interactions might lead to competition and/or complementarities, making it necessary to analyze emerging technologies in relation to others. As Rosenberg (1982) points out, “[S]ometimes a particular innovation has to await the availability of a specific complementary input or component; sometimes the evident need for the input is sufficient to lead to its invention; and sometimes the input, when it is fully develop, is found to have uses and applications of a totally unanticipated –or at least unintended- sort.” (Rosenberg 1982) (p.61).

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[4] RESULTAR is supported by a NSF Grant 0726919, and coordinated by Susan Cozzens, Georgia Institute of Technology. For more details see Cozzens, S. 2007. Distributional Assessment of Emerging Technologies: Case Studies in the Americas. In *Research proposal*. National Science Foundation.

[5] This section draws partially on Bortagaray (2007)

[6] The ethical, economic and political arguments and debate around GMOs exceed the scope of this paper.

2.2. The institutional environment

Not only technologies interact among them, but throughout that process, transformations are also triggered along sectoral structures and systems, and in the broader institutional environment[7]. Adaptation is at the core of evolutionary processes, as organisms adapt to better fit the environment[8].

Firms or technologies do not establish a one-way relationship with the environment; their interaction leads to transformations that often result in co-evolutionary paths in which industries, technologies and institutions jointly evolve (Nelson 1994b). Co-evolutionary processes imply learning and the development of organizational and technological capabilities (Coriat and Dosi 1998, Nelson 1994a, Nelson 1994b, Murmann 2003, Nelson and Winter 1982).

Nelson points out that "various features of the institutional environment themselves tend to adapt and change in response to pushes and pulls exerted by the development of a new industry. The processes involved here are not market processes, at least not of the standard variety, but involve the forming of collective bodies, decisions of voluntary organizations, government agencies and political action" (Nelson 1994b)(p.26).

Still the type of institutional response should not be taken for granted: the original 'optimal' institutional response to changes in economic circumstances proposed by the 'new institutional economics' has been abandoned (Nelson 1994b, Nelson 1994). This constitutes an empirical question, moreover when taking into account the socio-historical specificities at the country level. In that same work, the author highlights this issue: "…countries clearly differ in the ease with which new firms can form and get funding and in the degree to which markets are open to new sources of supply. They also differ in the speed with which universities are able to adopt new sciences, in how adaptable legal structures are to changing demands put on them by new technologies, in how supportive public sector programmes are of the new as contrasted with protective of the old, and so on" (Nelson 1994) (p.30).

Change of existing institutions could take two main avenues (Thelen 2003): change by *layering* and change by *conversion*. While the former entails partial change, some elements are renegotiated and others remain in place, the latter is about existing institutions that get reoriented to new purposes, changing the roles and/or the functions (Thelen 2003). As noted by the author "The dual notion of layering and conversion open the door for a more nuanced analysis of *which specific elements* of a given institutional arrangement are (or are not) renegotiable, and why some aspects are more amenable to change than others. As such, these conceptualizations provide a way of thinking about institutional reproduction and change that steers a course between deterministic "lock-in" models on one hand, and overly fluid "one damn thing after another" models on the other hand" (Thelen 2003). The reproduction of institutions and their transformation are intertwined processes.

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[7] Institutional environments in this study refer to the complex of organizations (players of the game), institutions (rules of the game), and policies (Bortagaray 2007).

[8] This is the core idea of evolutionary arguments in Biology. For a detailed discussion of the extent of the theory in that field see Gould, S. J. 2004. *La Estructura de la Teoría de la Evolución: El gran debate de las ciencias de la vida. La obra definitiva de un pensador crucial*. Barcelona: Tusquets.

Furthermore, institutions responsiveness and change could be triggered by external and/or internal factors. In the former the drivers of change come from the environment (including relationships with other institutions, social behavior, etc.), while in the latter change is triggered from within (Thelen 2003). Nonetheless, the shape of those changes as well as the resulting outcome cannot be anticipated and require tracing them back, in a dialogue between technologies and institutions. That is the discussion attempted in the next section.

3. National trends and technological patterns

3.1. Brief historical background

Throughout its history and since its independence in the 1820s, Argentina has had both wealth and poverty with frequent doses of crises; political and economic crises have left an imprint in Argentineans memories as well as in their attitudes. In the period 1930-1976 the country had seven dictatorships. Even its origins are marked by a long lasting dictatorship for 23 years led by the political leader Juan Manuel Rosas (1829-1852). As much as deep crisis defines one side of the coin, the other is its strong ability to recover and overcome them. Crisis and recoveries mark the rhythm of this country, one of the world's richest at the beginnings of the 20th century, and drawn into a very difficult time at the beginning of the next century. Furthermore, for the period between the end of the 18th century and the 19th, it had the worlds' highest sustained growth rate over a period of time, mainly due to its comparative advantage in meat and grain production (Skidmore and Smith 2005). The abundance of land was counterbalanced with an initial struggle over capital and labor, which were provided from abroad. Both were mainly supplied from Europe, the former from Britain, the latter predominantly with immigrants from Spain and Italy.

At the beginning of the 21st century, in 2002 more than 50 percent of the population was living under the poverty line. This crisis emerged after in the 1990s, it implemented a rigid economic policy *Plan de convertibilidad* (Convertibility Plan) with an Argentinean Peso tightly tied to the US Dollar: 1 Argentinean peso – 1 US dollar. Something similar was being applied in Brazil, though with more flexibility until 1999 when it devaluated its Real. But Argentina did not, and followed up its plan until it crashed. The consequences ranged from rocketing unemployment to an almost civil crisis with a desperate society rushing to the banks to get their money from the Banks while the Economy Ministry implemented the 'corralito' (little fence) mechanism that constrained the amount of money people could withdraw from their accounts. The economic crisis was coupled with a political one, when that same year the President resigned (Rock 2002).

But as severe as the crisis was in 2001 and 2002, it did not last for too long and the late few years it has been close to booming. Its Pampas are one of the world's most fertile soils, doing justice to the label 'grainer of the world'. Those lands produce the basis of the country's economic, namely its agricultural exports (meat and grains) (Skidmore and Smith 2005), which recently have been facing an increasing demand driven in part by China and India.

Argentina is the second largest country in South America with almost 40 million people (38.7 million people, 2005) from which 90.1% live in urban areas, and 26.4% are under the age of 15. Unemployment accounts for 10% of the labor force (1996-

2005) (1,141 thousand people), while employment share is higher in services (75%), followed by manufacturing (24%) and agriculture (1%) (of a total of 9,639 thousands) (1996-2005[9]) (UNDP 2007).

The following table illustrates some of the recent changes.

Table 1. Socio-economic overview, 1997-2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005
GDP	8.1	3,9	-3.4	-0.8	-4.4	-10.9	8.8	9	9.2
GDP per capita		2.7	-4.4	-1.8	-5.4	-11.7	7.8	8	8.2
Employment (annual average rate)									
Activity rate	42.2	42.2	42.6	42.6	42.5	42.4	45.7	45.9	45.7
Open unemployment rate	14.9	12.9	14.3	15.1	17.4	19.7	17.3	13.6	11.6
Rate of Visible sub-employment	13.2	13.5	14.3	14.6	15.6	19.3	17.1	15.1	12.6
	Year	Poverty	Indigence	Year	Poverty	Indigence	Year	Poverty	Indigence
Persons living in poverty and indigence (%)	2002	45.4	20.9	2005	26	9.1	2006	21	7.2

Source: (CEPAL 2006, ECLAC 2007)

The Human Development Index places the country within the group of high human development index (#38) after Poland and before the United Arab Emirates. It is the first Latin American country in that group, seconded by Chile with the #40. High alphabetization (97.2%), a relatively high life expectancy (74.2), a GDP per capita of US$ (PPP) 14,280 add into that direction (UNDP 2007). Nonetheless inequality is relatively high (the Gini Index for 2004 is 51.3, note that the 2000 survey in US indicates an index of 40.8) (UNDP 2007). Most public investment on education[10] goes into the pre-primary and primary levels (45), then into secondary education (38), and then into tertiary education (17) (UNDP 2007). The share of researchers per thousand labor force is 2.06 (FTE, 2005), an the total FTE S&T personnel is 45,361 from which 24,680 are researchers, 7,188 PhD scholars/R&D assistants, 13,493 technicians (RICYT 2006).

One of the cognitive areas with a strong cumulative trajectory is the Life Sciences, which have witnessed major achievements in Argentina. The country hosts three Nobel prizes: one in Physiology and Medicine (Bernardo Houssay, 1947), another in Chemistry (Luis Leloir, 1950), and the most recent one in Medicine and Pharmacology (César Milstein, 1984). Still this gained reputation is counterbalanced by

[9] Data refers to the most recent year available during that period.

[10] The country has had a low investment on education: 3.3% of GDP in 1991 and more than a decade later only 3.8 % of GDP (UNDP 2007).

low investment in R&D (0.4 % of GDP, 2000-2005)[11] (UNDP 2007) and low public investment on education, as mentioned above.

3.2. Tracing the evolution of GM maize in Argentina

Argentina is the second largest grower of GM crops after United States (57.7 million hectares of GM crops) with 19.1 million hectares of soy, maize and cotton, which account for 19% of global biotech crop hectarage (James 2007).

The first approval for a GM crop in Argentina goes back to 1996 with RR® soybean (James 2007). Two years later the first GM maize was approved (CONABIA 2008). Since then, several new events have been approved. The next table illustrates those corresponding to GM maize, approved over the last ten years.

Table 2. GM maize: traits, events, applicants and approval date in Argentina

Introduced trait	**Transformation event**	**Applicant**	**Date of approval**
Lepidopteran Resistence	"176"**	Ciba-Geigy	1998
Glufosinate-ammonium tolerance	"T25"	AgrEvo S.A.	1998
Lepidopteran Resistente	"MON 810"	Monsanto Argentina S.A.I.C.	1998
Lepidopteran Resistente	"Bt 11"	Novartis Agrosem S.A.	2001
Glyphosate tolerance	"NK 603"	Monsanto Argentina S.A.I.C.	2004
Lepidopteran Resistence & Glufosinate-ammonium tolerante	"TC 1507"	Dow AgroSciences S.A. and Pioneer Argentina S.A.	2005
Glyphosate tolerance	"GA 21"**	Syngenta Seeds S.A	2005
Glyphosate tolerance and resistence to Lepidopteran	"NK603x810"	Monsanto	2007
Lepidopteran resistance and tolerance to Glufosinate-ammonium and Gliyphosate	"1507 x NK603"	Dow AgroSciences S.A. and Pioneer Argentina S.R.L.	2008

**The production, commercialization and/or distribution of these events is banned according to a Resolution N° 125 issued by the National Institute of Seeds, on May 24th, 2007.
Source: (CONABIA 2008)

Argentina has a long tradition of local R&D efforts on this crop from academic research to local seed firms that have lead the development of new varieties. Going back to its early origins, maize varieties resulted from the combination of those brought by Italian immigrants and American varieties existing before the Spanish Colonization. Between then and now there has been a long history of maize development and improvement built based on trials and errors, genetic improvements, conservation and

[11] The data is for the most recent year available in that period (UNDP 2007).

enhancement of genetic variation of maize, intense public research efforts and industrial development of those varieties.

Research and development of maize has a well-established tradition. The first attempts of hybridization go back to the 1920s when government initiatives were put in place. By 1945 the first double hybrids were achieved at the Experimental Station 'Angel Gallardo', and four years later they were registered at the Official Register office. During the 1950s the Ministry of Agriculture and Livestock and INTA (the National Institute of Agricultural Technology) were responsible for the first hybrid maize, which experience and trajectory were later fundamental inputs for industrial advancement and efforts in this area (Rossi 2007). Along the history of maize improvement in Argentina, INTA has been a key player through its Maize improvement program (Bárcena et al. 2004) implemented since 1962. INTA's achievements have relied upon government support and close ties with CIMMYT[12] in Mexico and CIAT in Colombia.

According to Rossi (2007) the continuous progress in maize productivity shown in Argentina (see Figures 1 and 2) correlates with the type of cultivars adopted over time. Genetic improvements have had to do with the number of lines in the spike, the number of grains per line, and their proliferation. The most recent commercial hybrids have better root's sanity and quality, their leaves are more erected, keep the foliage green for longer time and are less affected by hydric stress during flowering. Apart from the genetic improvement of hybrids, the management at the production phase has also been key in the productivity increase observed over time. Local improvements were strengthened by contributions from US and Europe. For example in the late 1980s European hybrids were available for colder soils and frosting conditions enabling the expansion of the land used for maize production in the country (Rossi 2007).

As for the regulatory function related to vegetal GMOs, three main bodies should be mentioned: the National Institute of Seeds (INASE), the Advisory National Commission of Agro-Biotechnology (CONABIA) and the Office of Biotechnology, all of them within the same Secretary of Agriculture, Livestock, Fish and Food (SAGPyA).

INASE, created in 1991, is a decentralized organism in the orbit of the SAGPyA oriented to control the production and commercialization of seeds, including imports and exports. It has to do with controlling quality standards of seeds, registration of commercializers and varieties in the national register of cultivars. In practice the ability of the Institute to control all the volume of planted seeds across the country is constrained. The Seed law currently ruling in Argentina is from the year 1973, and since 1991 INASE, the National Institute of Seeds, has been in charge of assuring compliance with it, even though it is under revision, as it is the UPOV 1978 to which Argentina subscribes.

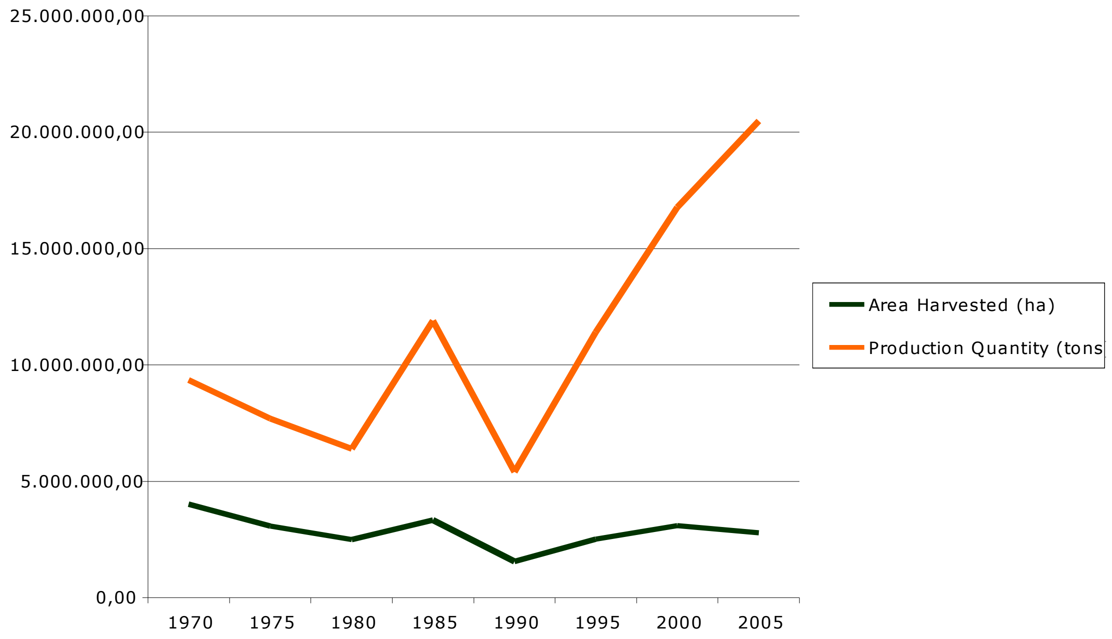
CONABIA in turn was created as an advisory body on technical and bio-safety requirements. It involves representatives from both, public and private organizations related to agro-biotechnology[13]. Its main role is to advise the Secretary of Agriculture on biotechnology related issues (GM being an important part of it), which ultimately holds the decision capacity. For instance between 1991 and 2005 922 vegetal GMOs

[12] Both centers are members of the CGIAR network, the International Maize and Wheat Improvement Center-CIMMYT and the International Center for Tropical Agriculture-CIAT.
[13] For more information, please see http://www.sagpya.mecon.gov.ar/new/0-0/programas/biotecnologia/index_en.php

have been assessed for their liberation in the environment (CONABIA s/f). The executive secretary of CONABIA is the Office of Biotechnology, which was created in 2004 for advising and assisting with biotech and biosecurity issues, and with liberalizations to the environment and commercialization of vegetal and/or animal GMOs.

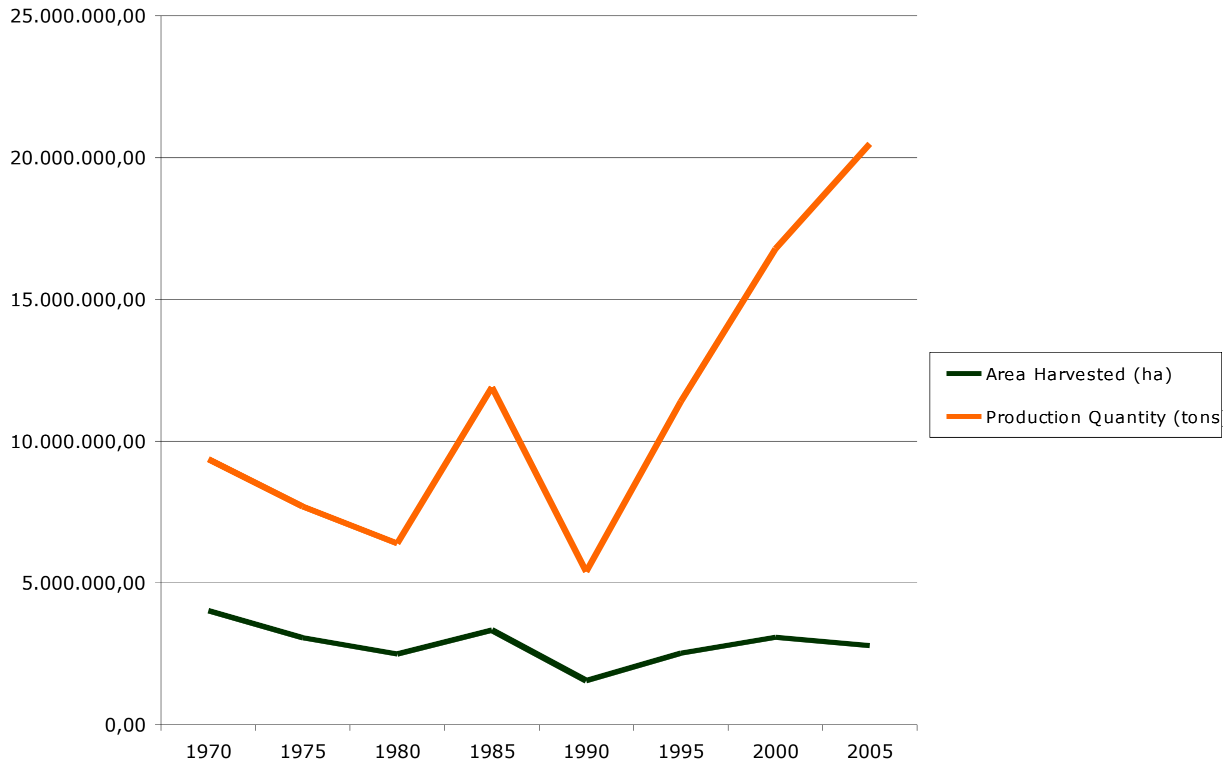
For approval, a GM crop goes through the following process: a company brings the trait into the Office of Biotechnology and the first step is to get CONABIA's environmental risk assessment, and then SENASA's, one more regulatory office in charge of evaluation in terms of dietary, human and animal risks. The third instance is the Market Direction within SAGPyA, which evaluates the potential impact in terms of the future commercial markets of that variety. Once the Secretary of Agriculture receives these three dictums, it decides whether it approves or not. If it is approved, then a resolution is passed establishing that the seeds containing the transformation even are approved for commercialization. Then the company has to go to INASE and ask to list the new variety that includes the event to be able to commercialize it. The process might take two or three years of trials, and experiments to fulfill the requirements expected from a new variety, to then get INASE's approval of the new variety. In the case of varieties with the event GA21, requirements are different as maize with this event is banned into the European Union.

Figure 2. Argentine Maize: Area harvested (ha) and production (tons), 1970-2005



Source: (FAOSTAT 2008)

Figure 2. Argentine Maize: Area harvested (ha) and production (tons), 1970-2005



Source: (FAOSTAT 2008)

4. Changing and interacting landscapes: enabling and hindering factors

4.1. Interacting technologies: GM maize, a marriage dependent upon good-quality locally developed hybrids

Open pollination varieties that used to dominate the market have been increasingly substituted by hybrid cultivars, which rate of adoption has been very high. Part of this shift obeys to productivity reasons, yet it has been accompanied by strong industrial interest given that the hybrids themselves embodies the key for intellectual property protection (Rossi 2007). Hybrid seeds carry along a built-in advantage in terms of property protection, as they have to be re-purchased every season, which is very attractive for seed companies. According to an interviewee this explains why most local seed companies' efforts have been in maize rather than in soy, as maize enables them to capture the rent.

Now conventional maize coexists with GM maize in Argentina, though the latter accounts for more than 70% of the total planted area (see table 3). Farmers' main reasons for adopting GM maize are cost reduction and the attractiveness of forgetting about insecticides, reducing the fungi and mico-toxins, and its innocuousness over beneficial insects and vertebrates (Rossi 2007).

Table 3. Evolution of maize production in Argentina, selected years

	1997-98	2003-2004	2004-05	2006
Production tons	19,360,656	19	20,482,572	14,500,000
Performance (kg/ha)			7,359	6,000 (decrease due to hydric stress)
% of world total	N/d	2.7	2.75	2.09
Percentage of area (total cereals and oleaginous)		10.47%	11.5%	10.93
Maize planted area (has)		2.988.400	3,403,837	3,180,000
Share of GM maize		54%	53%	Around 70%[1]

Source: (SAGPyA 2006, SAGPyA 2007)
Source: (Trigo and Cap 2006)

The success of genetically modified maize depends on the match between the gene and the variety in which it gets introduced. This is crucial as the genetic transformation refers to the resistance of the crop, but it is useless if the variety in which is introduced is not good enough. Thus, it depends upon the variety's productivity and virtuousness. Broadly, the case is that MNE's own the genes, but the know how and improvement of locally adapted varieties has been carried on by local firms and the key role of INTA, as mentioned above.

Local seed firms have been part of the coupling, though in an uneven game. According to an interviewee, transgenic maize turned local companies into crucial pieces of the puzzle because their varieties are adapted to local weather and soil conditions, which became key as bases for those events. "Earlier these companies could be valued around US$1 or 2 million, and now their might be worth US$60 million. In other words, the trans-genesis revalorized their actives, even when the technology was not generated locally."

Until the GM business, there was a relative balance between local seed companies and MNEs, mediated by the already mentioned key role of INTA. But with the commercialization of GM seeds however, the landscape was altered (Bárcena et al. 2004). For instance, Morgan, the third largest local seed company in Argentina with annual sales of approx. $25 million, was acquired in 1996 by Mycogen (which paid $27.4 million in cash including repayment of long-term debt[14], today owned by DowAgroSciences. Currently that landscape includes branches of other MNEs like Cargill (today the local seed division belongs to Monsanto), Asgrow (later acquired by Nidera), Dekalb (today is Monsanto) (Rossi 2007).

One of the potential outcomes of the reconfiguration of the landscape is the decline of those improvement programs carried on for long time by local firms and organizations such as INTA. This landscape not only hosts less local firms in the business, as local companies are lesser and get acquired by multinational ones (Bárcena et al. 2004), but also go through a global problem in which INTA is not an exception:

[14] For more information, see http://www.secinfo.com/dV179.99b.c.htm, July 2008.

the overall trend of decreasing public investment on agricultural research that countries and most national agricultural research organizations are facing (James 1996). The problem, and the quest for sustained national policies, is then, twofold.

First, as easy at it is to dismantle years of research and development and the efforts of developing a germplasm bank as INTA has done it, re-building those achievements could be an endless and unbearable task. INTA Pergamino, the branch in charge of the maize program, has been increasingly pushed to rely on private support, which challenges the ability to keep that effort.

Second, and in relation to that, it is happening that the range of maize varieties and therefore, the genetic basis is narrowing down due to the concentration of genes and modified varieties in the hands of also concentrated players in the business. This entails an important biological threat that should be carefully consider and subject of public policies. In the words of an interviewee, the problem is that "…as genetic variation decreases, specialization increases and so it does the vulnerability. A narrow genetic basis is a very vulnerable phenotype; it is very vulnerable to environmental changes, new plagues, or new genetic changes, etc. That requires a prompt response from seed breeders, and to get new varieties adaptable to those changes. The foreign firm will not do it unless it has a specific demand from a specific market. If all maize will have one or two events Bt, because it will be one of Syngenta and one of Dow, with small differences, that is dangerous. Here we are going to have one or two events, and not only maize but across cotton, sunflower, and soy; a series of species with all the same event. If we have a problem, what is going to happen? Argentina cannot do research on events. But the State has to preserve genetic variation and has the right to say to Dow or Monsanto how many Bt are you going to have in 2 or 3 years? The state has to anticipate and take care of that".

4.2. Regulations, policies and supporting organizations

Summarily, changes in regulations and policies are of two main types. The first one has had to do with the *creation* of new organizations and/or institutions. To this category belongs the very young Science, Technology and Productive Innovation ministry, created by the new government administration (December 2007). It is important to note that, to a very important extent, agrobiotechnology policies and regulations are in the scope of the Secretary of Agriculture, Livestock, Fish and Food (SAGPyA), within the Economic and Production Ministry.

Another organization created from within, but with a lobbying function is Maizar. Maizar was created in 2004 to develop a value chain around maize, contemplating the interests of a wide range of actors. It is comprised of five types of partners: (a) researchers, scientists and technologist, universities, and organizations like INTA, etc.; (b) supplier companies: seed companies, agrochemicals, etc.; (c) farmers, both individuals and groups such as cooperatives, associations, etc.; (d) commercializers, exporters, etc.; and, (e) A the industry, including meat, feedlot, pork, milk, and poultry, and both dry and humid grinding. The reason for creating Maizar was the decline in the produced volume of maize in a context of increasing consumption and demand. Even if at the beginning the idea was to have two different groups (one focused around INTA and aimed at getting farmers associated, and another fostered by the industry) the result was a single group with all interests placed around the table.

The second type of changes in the institutional environment has to do with *altering* existing institutions. Regulations for granting and/or constraining access to public knowledge have gone through different rationales. Until 1959 access to and use of cultivars' varieties was publicly granted to everybody as cultivars had an 'open pedigree'. In 1959 the secretary of Agriculture established a 'close pedigree' rule for private developers: that is those who developed hybrid formulas did not have to disclose them nor had to get parental seeds controlled, only if they wanted to do it. This was established as a mechanism for protecting intellectual property. Public institutions however remained ruled by the 'open pedigree' principle, which imposed them to disclose their formulas and had parental seeds controlled, and facilitated the inbred lines to whoever required them. These mechanisms favored private appropriations of public research (Rossi 2007).

Varieties' property rights are now in revision, as the shift from UPOV 1978 into UPOV 1991 is planned to take place. Part of the problems of the 1978 UPOV[15] Convention still ruling in Argentina is that, unlike the 1991 Convention, it does not include the concept of 'essentially derived varieties'. Essentially derived varieties refer to varieties that involve changes but are based upon previous ones and their property rights. It intends "…to prevent the exploitation of mutations of protected varieties and varieties that had undergone a minor change in relation to the initial variety, for example by using biotechnology, without the holder of the initial variety right being able to share in the revenues" (Kiewiet 2006) (p.1). The 1978 Convention carries on an asymmetry in the IPR regime favoring one type of actors against others. That regime establishes that genes could be patented, and those traditional varieties in which genes are introduced (as they differ from previously developed traditional variety) could be subject of a new property right but without granting acknowledgment to the developer of that traditional variety (Gutiérrez 2003). This constitutes an important issue as in the case of maize. Given the features of the events available for maize, the variety is crucial as it for the gene to efficiently function upon the variety's strengths; it is the variety what defines the performance, adaptation, etc.

4.3. GMOs and the public

The public has not been a visible part of the puzzle. Argentina has not characterized by visible debates or public involvement against GMOs. The introduction of GM crops seemed to take place in a context of public unawareness. Furthermore, debates were mainly introduced by international NGOs like Greenpeace few years after GM crops were introduced (Vara 2005).

The GM industry decided to create a NGO to raise public awareness about and support to biotechnology and GM. Thus, Argenbio[16] was created as a non-for profit association funded by the seed industry to divulgate information about biotechnology, reaching different types of audiences working with journalists, nutritionists, pediatricians, etc. Regulatory aspects however are not tackled through Argenbio but through the Association of Seed companies.

Part of the debate has concentrated on deforestation, and indirectly on soy, but not particularly on the GM character but on the mono-crop paradigm that is expanding

[15] UPOV accounts for Union for the Protection of New Varieties of Plants.
[16] The shareholders of Argenbio are Bayer, Syngenta, DowAgrosciences, Pioneer and Monsanto.

with soy. Other part of the issue is that until now GM maize has been an industrial input mainly for the animal feed industry, Argentina does not export semolina or flour for human consumption. Moreover, until now genetic modification in maize has had to do with insecticides, but that scope is expected to expand as new traits are developed for altering the maize content, which would be oriented to end consumers, hence society's involvement might differ.

New traits altering maize content will certainly require changes in farmers' practices. Farmers tend to plant different maize varieties for different markets in the same land, even if refuges separate them. But if genetic modification advances in other directions, and maize content is at stake (i.e. higher oil content), turning into end-consumer markets, demands might be larger and farmers will need to prevent cross-pollination by keeping tougher controls and farming practices. Still the civil society has not organized and had a voice in the agricultural GM subject.

Final remarks

Major shifts have been crosscutting the maize sector in Argentina, and the institutional environment. For enhancing the distributional consequences of emerging technologies active policies are necessary. Policies are required to turn those technologies into opportunities for the country. They play a differential role in that process; the one that accounts for turning the costs of technological change into benefits, as described by Rosenberg (1982): "Thus, the transfer of technology must not be conceived as a once-and-for-all affair. It is not something that happens at a single point in time. It is rather, and ongoing activity. […] the successful transplantation of a technology involves the domestic capacity to alter, modify, and adapt in a thousand different ways […]. An economy that lacks the domestic capacity to do these things is most unlikely to make successful use of innovations developed far away and in response to a very different set of circumstances. Conversely, an economy that possesses or can acquire this capacity is in a position to draw upon more advanced technologies abroad in ways that can yield spectacular results" (Rosenberg 1982)(pp.272-273).

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