GENETICALLY MODIFIED CROPS
IN ARGENTINE AGRICULTURE: AN OPEN ENDED STORY*

Eduardo Trigo, Daniel Chudnovsky, Eugenio Cap and Andrés López

* Translation of the original *"Los transgénicos en la agricultura argentina. Una historia con final abierto"* published by Libros del Zorzal, Buenos Aires, Argentina, 2002

CONTENTS

Acknowledgements

This book was prepared by *Centro de Investigaciones para la Transformación* (CENIT) (www.fund-cenit.org.ar) under the direction of Daniel Chudnovsky and Eduardo Trigo, in collaboration with the Trade Knowledge Network of the International Institute for Sustainable Development (www.iisd.org), Canada, and the International Centre for Trade and Sustainable Development (www.ictsd.org), Switzerland, with financial support from the Rockefeller Foundation, the International Development Research Centre (Canada) and the Department of Agriculture of Argentina.

The authors wish to acknowledge and thank Aaron Cosbey for his valuable comments and suggestions on an earlier draft of this study as well as the Inter-American Institute of Agricultural Cooperation (IICA) for its support to the publication and dissemination of this book.

Preface

As a result of the November 2001 Doha Declaration, a program on negotiations regarding international trade and the environment was introduced into the activities of the World Trade Organization (WTO) for the first time. This program includes, among other issues, the effect of environmental measures on market access and environmental labeling requirements. In addition, multilateral negotiations about agricultural subsidies play a significant role on the debate about the interaction between foreign trade and the environment, and overall, on sustainable development.

It is within this context that the debate over these major issues in several international forums, takes on a new dimension and imposes the need to conduct intensive research and further study in order to analyze the emerging topics under discussion and their implications for ongoing negotiations.

As an active member of the Cairns Group, Argentina has adopted a consistent position in all international forums, particularly in the GATT and the WTO, against agricultural subsidies in industrialized countries that distort foreign trade and harm the environment.

Despite an unfavorable international context, in the 1990s, Argentina's agricultural production and exports showed a significant growth thanks to the advent of new technologies, machinery and equipment.

An earlier study carried out by the CENIT (Chudnovsky *et al*, 1999) on the impact of trade liberalization on agricultural production in the Argentine Pampas revealed that no-till practices, a technology generated abroad but particularly fit for the Argentine soil, has greatly contributed to the development of agriculture in such region causing no environmental damage.

Genetically modified organisms (GMOs) fall into to a second set of innovations, in this case of a biotechnological nature, developed abroad and adopted by the Argentine agriculture sector since 1996.

As with the development of any new radical technology, GMOs have been the source of much international controversy over the costs and benefits it brings to farmers, to consumers, and to the multinational corporations that own such biotechnologies. This controversy, summarized in Chapter I, has now moved on to regulatory and foreign trade aspects, is present in critical issues such as the approval process for GMOs, national and international GMO labeling requirements, etc., which are analyzed in Chapter II.

The dissemination of GMOs, and particularly that of RR soybean, has occurred at such a rapid pace that Argentina currently ranks second, only to the U.S., in terms of agricultural surface cultivated with transgenic crops and is therefore a major player in the international arena.

Chapter III focuses on the incorporation process for these biotechnologies as well as their environmental and social impact on the transformation process of Argentine economy and agriculture during the 1990s. Chapter IV provides an assessment of the institutional framework and the role played by major agents in the development of agricultural biotechnology. In the light of such analysis, Chapter V discusses the economic implications of the dissemination of RR soybean and, to a lesser extent, that of Bt corn and Bt cotton.

On the basis of the findings resulting from the research efforts undertaken as well as the heated international debate over these concerns, the last chapter is devoted to the challenges posed by GMOs to the sustainable development of Argentine agriculture and points out the main topics that make up the international and domestic agenda on the matter.

CHAPTER I

GENETICALLY MODIFIED ORGANISMS IN AGRICULTURE: FACTS AND PUBLIC PERCEPTION

Introduction

At present, Public opinion tends to mistakenly identify food biotechnology with the development of transgenic organisms or genetically modified organisms (GMOs). It should therefore be fully understood that biotechnology is, in fact, far older than GMOs and that, along the lines of its modern form, it employs various technologies other than genetic engineering, which leads to the creation of GMOs.

According to Cohen (1994), agricultural biotechnology can be defined as any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses. By this definition, we may say that biotechnology has been long used by man for the making of bread, cheese, yoghurt and alcoholic beverages (wine, beer), or the improvement of crops and pets.

Modern biotechnology takes these traditional techniques as a starting point and integrates them into a set of new technologies and disciplines. Hence, more than a separate science, biotechnology is rather a mix of scientific knowledge from various disciplines (genetics, molecular biology, biochemistry, embryology, cellular biology) converted into productive processes by linking them with such practical disciplines as chemical engineering, information technology, and robotics (ADB, 2001). At the same time, although classification criteria in this respect abound, according to Trigo *et al* (2001), modern biotechnology can be divided into three large groups: i) molecular tools for plant breeding, including such specific techniques as marker-assisted selection; ii) recombinant DNA technologies (which lead to genetic engineering)[1]; and iii) diagnostic techniques.

There have been diverse concerns and controversy about the opportunities and risks emerging from modern biotechnology; yet, the most heated debate seems to have focused on the use of GMOs in agriculture. Since the first products containing GMOs were placed on the market in 1994, the controversy over their costs and benefits has become polarized, encouraged by two clearly antagonistic positions —"pro-GMO" and "anti-GMO" standpoints. This should come as no surprise for "radical" innovations —and GMOs fall into to this

[1] Genetic engineering involves: i) the deletion, modification, or moving of genes within a living organism; ii) the transfer of genes from one organism to another; iii) the modification of existing genes or the construction of novel genes and their incorporation in any organisms (Royal Commission on Genetic Modification, 2001). As specifically regards GMOs, they can be defined as any organism into which a segment of nucleic acid has been introduced and stably incorporated into the genome through a deliberate procedure and with the purpose of otaining a defined phenotype. As a result of this procedure, a GMO will express one or more novel traits as compared with its "conventional" counterpart, and such traits will in turn be passed through to the progeny of the GMO.

category— usually generate uncertainty as to their potential effects and impact[2]. In fact, in the light of history, it becomes clear that many "radical" innovations now in widespread use had to wait long before they won broad consumer/user acceptance[3].

From a "pro-GMO" perspective, there is a tendency to emphasize the advantages, both current and potential, of such goods, including: improvement of the nutritional value of food crops, reductions in pesticide and herbicide use, improved crop yield, potential production of industrial raw materials and vaccines, etc. Moreover, GMO advocates point out the extraordinarily important contribution of biotechnology innovations to the alleviation of hunger around the globe. On the contrary, the "anti-GMO" standpoint has been particularly vocal in taking issue with the potential health and environmental risks derived from the production and consumption of such organisms as well as with the dangerous concentration of GMO technologies and products in the hands of a few transnational corporations (TNCs).

Whereas some evidence exists as to the benefits that may be derived from GMOs —i.e., reduced herbicide and pesticide use— and the so-called "second generation" GMOs are in the pipeline —featuring better medicinal and nutritional properties than their conventional counterparts—, no scientific evidence has so far been produced that this type of organisms cause health and/or environmental damage. Notwithstanding, GM technology fails to escape "heated" debate particularly because: i) not enough time has elapsed for GMOs to be considered innocuous; ii) there is profound mistrust, especially in Europe, of the regulatory capacity of governments over scientific and technological developments; iii) the debate over GM technology-inherent risks mingles with property-rights related issues over GM breakthroughs and, particularly, with the "anti-globalization" wave spreading over the world.

To date, these controversies have failed to prevent the cultivation of GM crops from expanding year by year and in some cases —soybean, for example— from becoming dominant varieties at a world level. According to data provided in James (2002), in 2001, the global area of GM crops increased by 19 per cent (compared to 11 per cent in 2000 and 43 per cent in 1999). A new increase was expected during 2002, especially if transgenic crops received final approval in Brazil, and if India approved the use of Bt cotton. In 2001, already 46 per cent of global soybean acreage was planted with GM varieties —without including the Brazilian area so far illegally cultivated with GM seed—; in the case of cotton, this percentage falls to 20 per cent; for canola, it comes down to 11 per cent; and for corn, it drops to 7 per cent (James, 2002).

For the time being, however, GM production is concentrated in only four countries: USA (68% of the total GM area worldwide), Argentina (22%), Canada (6%) and China (3%). The remaining 1% is distributed among other nine countries reporting the use of GM crops in 2001: South Africa, Australia, Romania, Mexico, Bulgaria, Spain, Germany, Uruguay, and Indonesia. In addition, there is a high degree of concentration by crop; in 2001,

---

2. The fear of using e-commerce is a current example along these lines.

3. See Hotchkiss (2001) for a good summary of the extended controversy over the pasteurization process.

soybean accounted for 63% of the global area planted with GM varieties, followed by corn (19%), cotton (13%), and canola (5%) (James, 2002).

The high degree of concentration of GM production within a small number of countries and crops, along with the fact that patent and other property rights over such products remain in the hands of a few Transnational corporations, constitutes another issue to be taken into account in the assessment of the different standpoints in this respect adopted both by the national states and the various agents of the commercial chain involved in the production and consumption of GMOs, as well as by the assorted “pro” and “anti” NGOs, which have a strong bearing on the debates over this matter.

This chapter begins with an analysis of the main arguments presented for and against the use and impact of GMOs. Then two central issues on the subject are addressed, one from the “supply” perspective and the other from the “demand” point of view. The former focuses on the nature and impact of transformations in the commercial, productive and innovative dynamics of the industries interrelating with agricultural biotechnology. The latter reviews consumer perceptions of GMOs and the reactions triggered by such perceptions in the various agents involved in GMOs’ commercial chain.

a) Benefits and Costs of Biotechnology: Evidence and Public Perceptions

i) Arguments in Favor of Biotechnology

According to Trigo *et al* (2001), biotechnology can be expected to improve potential yield, stability and sustainability of agricultural production, to increase the nutritional value of food crops, and to expand the potential uses of processes and products related to the agricultural sector. To be more specific, some of the benefits of agricultural biotechnology are the following:

- Increases in agricultural productivity, thereby reducing the pressure to expand cultivated areas to forest and marginal areas;
- Improvement in the quality and nutritional value of food crops, including an enhancement of vitamin and micronutrient contents of food grains, thus greatly benefiting consumers in developing countries, whose low income status prevents them from having access to additional micronutrients and vitamins on a regular basis;
- Increases in crops’ disease and pest resistance, thereby reducing the use of agrochemicals;
- Increases in tolerance to droughts, floods, salinity, heavy metals and other biotic and a biotic stresses;
- Improvement in productivity and quality in the production of different types of meat and other animal by-products;

- Use of non-food substances in crop foods to produce medicinal drugs, fuels, oils, etc.

In fact, all throughout the evolution of agriculture, efforts have been undertaken to improve plant and animal traits through conventional practices such as hybridization, among others. When a hybrid is formed by combining two plant species or varieties, thousands of genes are randomly combined and usually selection/hybridization processes need to be successively repeated in order to obtain a novel variety that brings in all the desired traits and, to the extent possible, stays rid of undesirable genes.

The advantages of modern biotechnology in this field would be the following: i) possibility of bringing in desirable genes from any variety or species and regardless of hybrid viability requirements; ii) possibility to introduce, selectively and with increased precision, only one novel gene, thereby preserving the rest of the original genes of the variety being modified; iii) the modification process is faster than traditional hybridization methods (SEBIOT, 2000).

First generation GMOs, the most commercialized transgenic crops to date, have often benefited farmers —in the form of reduced use of agrochemicals, less tillage, etc.-, but they cannot modify the characteristics of the product that reaches the processing industries or consumers. This explains, in part, —as we will see further on— the resistance or mistrust towards the dissemination of GMOs in such links of the commercial chain — and in particular, among consumers.

In turn, with few varieties approved for sale at present, some of the "second generation" GMOs might offer tangible advantages to consumers – better flavor and/or nutritional properties, inclusion of vitamins, medicinal attributes – and to farmers – i.e., varieties with higher oil or protein content (See Chart I-1 for a summary of main GMOs in the pipeline).

In addition to the specific benefits that GMOs may have, it has also been argued that their dissemination might be a useful tool to reduce poverty and hunger at a worldwide level. On the one hand, biotechnology would help increase the production of food with no increase on the pressure over the environment. In turn, higher efficiency in the production of food might lead to a decrease in price. Last but not least, as long as "second generation" GMOs contain, for instance, vitamins usually absent from the staple diet of the poorest social classes, they may also contribute to improving the health conditions in such classes (Trigo *et al*, 2001). In this respect, it should be borne in mind that this type of arguments has been acknowledged in a joint report prepared by prestigious scientific institutions in Brazil, China, USA, Great Britain, Mexico, India and other developing countries (Royal Society *et al*, 2000), which in turn support the need for continued research in this area.

ii) Arguments against GM technology

From an opposite perspective, GM technology opponents raise questions about the effectiveness of some of the GMO advantages claimed by biotech advocates. It is argued

—primarily by “green” and anti-GMO NGOs such as *Greenpeace, Friends of Earth*, *RAFI*, *Grain*, and the like— that the the most appropriate solution to global hunger or poverty is not to be found in GMOs but in effective policy tools both at national and international levels (for instance, bringing about improvements in the distribution of income).

Furthermore, a report by the European Commission (EC, 2000) indicates that there is no conclusive evidence as to the profitability of GMOs for farmers given that cost-benefit estimates are dependent on a combination of assorted factors. It is specifically argued that the main positive effect of GM technology is not actually derived from the use of GMOs themselves but from the simplification and flexibility of agricultural work, therefore minimizing the role played by GMOs in terms of microeconomic profitability.

Table I-1. Overview of GMOs in the *pipeline* in the short and medium term

Short term (1-5 years)	**Input traits**	
	▪ Herbicide tolerance extended to cotton[ab], corn[a], rice[a], sunflower[a], wheat[b], potato[a], lupines[b], clover[b], peas[b], forage, beetroot, sugarcane[a], alfalfa[a], tomato, lettuce, sunflower, eucalyptus[a], canola[ab] and soybean[a]. ▪ Insect resistance in alfalfa[a], rice, soybean[a], sunflower[a], tomato[ab], sugarcane[a], sweet potato[a], peas[b], apple, cabbage[a] and tobacco[a]. ▪ Durable insect resistance using Bt and other genes in cotton[ab], sunflower[a] and corn[a]. ▪ Virus resistance in wheat[a], potato[ab], lupines[b], white clover[b], tomato, sweet pepper, sugarcane[ab], barley[b], papaya[ab], tobacco[a], melon[a] and pumpkin[a]. ▪ Fungus/bacteria resistance in corn, wheat[a], banana, sunflower[a], rice, potato[a], canola[b] and tobacco[a].	
	Product-related Traits	
	▪ Healthier/more nutritious food (for human and animal consumption) in corn[a], soybean[a], canola[a], wheat[ab]. ▪ Solutions for vitamin deficiencies — Golden Rice[b]. ▪ Increased microelements —iron levels in rice[b]. ▪ Improved chemical structure — enhanced flavor, better color, increased storage— in potato[a], tomato[a], canola[b], banana[a] and pineapple[ab]. ▪ Improved quality in wheat fiber.	
Medium term (5-10 years)	▪ Increase in wheat yield through hybridization.	

a: Currently being tested in one or more Latin American countries.

b: Currently being tested outside Latin America.

Source: Trigo *et al* (2001).

More importantly, GMO opponents point to a series of effects —either current or potential— that may arise, at different levels, from the widespread adoption of GMOs. Some of such impacts would be the following:

- Unpredictable effects on the health of consumers (allergenicity, toxicity, etc.).
- Gene flow to wild species, thereby producing in the latter undesirable alterations, which might be potentially dangerous for biodiversity and the environment.
- Protracted use of GMOs in combination with a given herbicide might generate resistance to such herbicide in insects and weeds.
- Development of antibiotic-resistant bacteria as a consequence of the use of antibiotics as "markers" to evaluate the results of the genetic modification process. (In fact, efforts are being undertaken to substitute new markers for the antibiotic ones.)
- Increased dependence of farmers on suppliers of inputs and seeds as well as a prospective dissemination of "sterile" GMO seeds (dubbed "terminators" in the jargon of "green" NGOs) and higher seed purchase costs.
- Private concentration and exploitation of these technologies in the hands of a small number of TNCs might not only pave the way for dominant-position abuses on the part of these firms —for instance, in the form of excessively high prices for seeds or agrochemicals—, but also guide GMO research efforts in terms of their own profitability criteria exclusively, ignoring the needs of farmers or markets deemed unattractive from an economic point of view. (This issue is further analyzed in a following section.)

We do not intend to enter into the controversies over these arguments. However, it is worth mentioning that, to date, the available evidence does not show that GMOs pose risks to human health (The Royal Society, 2002). With regard to environmental impact, it has been noted that the effects derived from GMOs do not, *a priori*, differ from those posed by conventional hybridization (National Academy of Sciences, 2002). Yet it has also been indicated that there is still not enough evidence on the matter, and therefore, the regulatory framework for such organisms need to be kept in place and further developed (Royal Society *et al*, 2000). Along these lines, it is important to bear in mind that, although some early evidence relating to potential adverse environmental effects has been dismissed (i.e., the Monarch butterfly[4] case), new evidence has already been furnished and will surely be further analyzed[5], thus reinforcing the need to adopt a cautious attitude in this respect.

---

[4] A study conducted some years ago had revealed that a variety of Bt corn affected Monarch butterflies in the U.S.. However, more recent work has provided counter evidence.

[5] For instance, a research commissioned by English Nature, the British governmental agency that champions the conservation of natural resources and biodiversity, has revealed the existence of the "gene stacking" phenomenon, i.e. the accumulation of genes from separate GM varieties. This was found out in a research

The same applies to the possibility of gene transfer to non-GMO species. The most recent case —particularly notorious because it involves Mexico, a country considered a global center in the field of genetic diversity applied to corn— revealed that some varieties of corn cultivated in Oaxaca and Puebla were contaminated with GMO corn. In these scenarios, caution is once again of utmost importance and regulatory agencies may impose both restrictions —for instance, the EPA prohibits the cultivation of Bt cotton in Hawaii, Southern Florida and Puerto Rico— and regulations designed to prevent conventional crops from being cross contaminated by GMO crops. The use of "refuges" planted with non-GMO varieties in order to prevent the development of insect resistance to herbicides and pesticides constitutes another precautionary measure highly recommended for minimizing adverse environmental impacts caused by these organisms.

Rounding up this section, it would be useful to put into perspective the discussion on the benefits and costs originating from GMOs according to the approach suggested by Zarrilli (2000), who draws a distinction between "technology-inherent" risks and "technology-transcending" risks —a classification applicable to benefits as well. On the one hand, technology-inherent risks are those associated with threats to human health and the environment and should be analyzed in light of the current regulations on the approval and marketing of GMOs —Chapter II concentrates on this issue. On the other hand, "technology-transcending" risks are related to the social, economic and like impacts of GMOs, and should be considered from a different point of view, concerning, for example, the regulation of the practices of the TNCs that control the technologies for GMO development. (This topic is further reviewed in the following section as well as in Chapter II).

Apropos of GMO benefits, whilst some of them are "technology-inherent" (e.g., those linked to second generation GMOs), some others are beyond those advantages intrinsic to GM in that they require the analysis of a series of economic, political, social and like factors and the submission of said factors to specific policy tools —the alleviation of hunger around the world, among others.

This valuable insight serves to provide a framework for the frequently confusing debates on GMOs in which, as we will see further on, both types of benefits and risks usually get mixed up, thus usually ending up in a propagandistic impact rather than a conscientious assessment of the impact of these technologies on the various areas of interest for society at large.

---

study conducted in Canada, where three varieties of rape were being grown, each one resistant to a different herbicide. After three seasons, researchers discovered that the genes from the three varieties had accumulated in plants growing from seed spilled at harvest (known as "volunteer plants"). These plants are now resistant to all three herbicides and are on road to becoming weeds, with farmers regularly resorting to other types of herbicides to control them.

b) The origin of biotechnological innovations

Although the public sector still plays a major role in biotechnological innovation in agriculture, especially in developing countries, it is the large TNCs who are increasingly leading and concentrating innovative flows in this field. These are well established companies with long records in chemistry and in life sciences —such as Monsanto, Bayer, Novartis (the product of a merger of Ciba Geigy and Sandoz), Rhone-Poulenc, Dow, Dupont, Hoechst, Zeneca, Bayer, etc.— well-known, among other things, for their heavy investments in the field of research and development (R&D), which many times exceed 10% of their turnover. It has been estimated that the 1998 R&D budget of these huge corporations amounted to US$2.6 billion, 40% of which was allocated to agricultural biotechnology (Byerlee and Fischer, 2001).

To get a clear picture of the current degree of technological concentration in the field of GMOs, it should be noted that Monsanto holds almost 40% of the permits for the release of these organisms into the environment issued in the U.S. as of February 2002, whilst other four companies —Pioneer, Agrevo, Dupont and Dekalb— have another 20%. In fact, actual concentration is even higher since Dekalb —and other companies also holding a considerable number of permits such as Agracetus, Calgene, Asgrow, etc.— have been acquired by Monsanto, and Pioneer is owned by Dupont. In contrast, the Agricultural Research Service, the principal in-house research agency of the USDA, has only 2.3% of the permits issued as of February 2002 and there are only four universities in the list of the first 25 beneficiaries —each university holding approximately 1% of the permits issued.

The advent of GMOs reinforces a tendency already evident over the last years towards heavier involvement of the private sector in technology research and development efforts for the agricultural sector. In the U.S., for instance, as from the early 1980s (i.e., concurrent with a ruling by the U.S. Supreme Court authorizing the use of utility patents for living organisms) and for the first time in history, R&D expenses in the field of agriculture incurred by the private sector exceeded those incurred by the public sector. Since then, the gap between private and public sectors has been widening almost steadily. Moreover, the private sector is not only focusing its efforts on applied research but is also increasingly involved in basic science activities (Economic Research Service/USDA, 1999). It is utterly clear that these trends cause serious concern about and because of the fact that, whereas agricultural technologies developed by government institutions become public goods, private companies obviously intend to maximize the returns on their innovations through various mechanisms. Consequently, it can be assumed that, given a certain technology, the externalities or spillovers of private R&D efforts on agriculture are less than those of the public sector. In other words, this is a clear example of the typical trade off resulting from the extension of mechanisms for the appropriation of innovations which, on the one hand, foster private sector R&D efforts but, on the other hand, tend to limit the dissemination of innovative results, thus also limiting their social returns.

Nonetheless, debates about the consequences of the changes introduced into innovative dynamics in the agricultural sector do not end here. In fact, over the last years, there has been a significant “wave” of mergers and acquisitions in the agrochemical, biotechnological and seed sectors that has led to the emergence of a select group of conglomerates which, through the integration of such activities, have reached a position to provide comprehensive technological "packages" (see Table I-2).

Table I-2. Mergers and acquisitions in the agrochemical, biotechnologal, seed and food industries in the U.S. and Europe

	Agrochemicals	Biotechnology	Seeds	Food
Monsanto (merged with Pharmacia, 2000)		• Agracetus (1995) • Calgene (1996) • Ecogen (13%) • Millennium Pharmaceutical (joint venture) • Paradigm (2000)	• DeKalb (1996) • Asgrow - corn/soybean (1997) • Holden's Foundation Seeds (1997) • Cargill Intl. Seeds, Plant Breeding Intl. (1998) • Delta & Pineland (alliance 1994)	• Joint venture with Cargill for the food industry (1998) • Monsanto sells brands such as Nutrasweet (2000)
Bayer (Aventis Crop Sciences)	• Hoechst and Schering establish Agrevo (1994) • Agrevo and Rhone-Poulenc merge and form Aventis (1999) • Bayer acquires Aventis for US$6.6 billion (August 2001)	• Plant Genetic Systems (1997) • PlantTec • Biogemma (joint venture between Rhone-Poulenc and Limagrain)	• Nunhems, Vanderhave, Plant Genetic Systems, Pioneer Vegetable Genetics, Sunseeds (1997) • Rhone-Poulenc forms an alliance with Limagrain, who owns Nickersons, Vilmorin, Ferry Morse	
Syngenta (Novartis+ Astra-Zeneca)	• Ciba-Geigy and Sandoz merge and form Novartis (1996) • Novartis buys Merck's pesticide division for US$910 million (1997) • Syngenta is formed by the merger of Novartis's agriculture division with AstraZeneca Agro Chem (1999)	• Zeneca Ag. buys Mogen International N.V. (1997) • Alliance with Japan Tobacco for rice (1999)	• Northrup-King, S&G Seeds, Hilleshog and Ciba Seeds merge (1996) • Rogers Seed Co.	• Owner of Gerber Foods • Novartis forms Altus, a joint venture with Quaker Oats for nutraceuticals (2000)
Dow Chemical	• Dow acquires 40% of Dow Elanco, which was in the hands of Eli Lilly, for US$900 million (1997) • Rohm and Haas Ag. Chem (2001)	• Mycogen (1996) • Ribozyme Pharmaceuticals Inc. Proteome Systems Limited (1999)	• Mycogen buys Agrigenetics (1992) • United AgriSeeds becomes a part of Mycogen (1996) • Danisco Seeds (JV 1999) • Illinois Foundation Seed (agreement 1999) Cargill Hybrid Seeds U.S. (2000)	
		• Alliances with	• Pioneer (1997)	• Quality

DuPont		Human Genome Sciences (1996) • Curagen (1997)	(20%) • Hybrinova (France) • Acquisiton of the remaining 80% of Pioneer (1999)	Grain (joint venture with Pioneer), Protein Technologies, Cereal Innovation Centre UK (1998) • Joint venture with General Mills (soybean protein)
BASF	• Acquisition of the herbicide business from Sandoz North America (1996) • It acquires American Cyanamid for US$ 3.8 billion (2000)		Acquisition of 40% of Svalöf Weibull (1999)	
Astra Zeneca		• Incyte Pharmaceuticals	• Advanta: merger of Zeneca Seed and Vanderhave (1996) (owner of Garst Seed Co., AgriPro Seeds, AgriPro Wheat, Interstate Seeds)	
SAVIA (formerly, Empresas La Moderna)		• DNA Plant Technology (1996)	• Seminis —SAVIA's seed division— formed through the acquisition of Asgrow (1994) • Petoseed (1994) • Royal Sluis	• Bionova (fresh fruit and vegetables)

Source: Data provided by Carl Pray, and updated with information from Byerlee and Fisher (2001) and from the web sites of the companies involved.

This concentration of key technologies in the hands of a small number of private agents has already raised great concern with respect to the market power that these agents may exercise, both in terms of restricting the already limited competition in the seed market, and in terms of imposing growing restrictions on farmers[6]. There is no doubt that, in view of the variety of technologies, types of agents, product characteristics, market segments, etc., involved in the agriculture technology business, there will be a wide range of coordination mechanisms (vertical integration, strategic alliances, cross licensing, contract agriculture, etc.), and it shall be incumbent upon the regulatory authorities in the field of

[6] For instance, the potential use of "terminator" seeds (sterile seeds) —which would force farmers to buy a fresh supply of seeds each year from private agents— constitutes one of the topics most heatedly debated on in this respect. It should be noted that biotechnology companies argue that "terminator" seeds would help curtail gene transfer from GMO species to non-GMO varieties. On the other hand, it is important to bear in mind that hybrid seeds —also sterile— are used in agriculture all over the world.

competition defense to review said mechanisms (Shoemaker, 2001)[7]. Public sector involvement in the supplementation of private sector research efforts —be it by facilitating the entrance of new competitors into the market through pre-competitive research or by focusing on fields of research deemed unprofitable by private enterprises, for instance—constitutes another remedy for damages cropping up from excessive concentration in the agricultural biotechnology market (Byerlee and Fischer, 2001).

From the point of view of developing countries, concrete fears and concerns have been expressed about this scenario. (Table I-3 provides some information as to the integration of the leading biotechnology TNCs into some of the major developing countries.) Out of all the R&D efforts undertaken by the leading TNCs in the field of biotechnology, just a few aim at solving the problems and satisfying the needs of developing countries (Byerlee and Fischer, 2001; Cosbey, 1996). Moreover, as long as advances in biotechnology trigger the development of substitutes for natural products traditionally exported by such countries —cocoa, vanilla, sugar, among others—, the concentration of R&D activities within the developed world may adversely affect the interests of the developing countries (Cosbey, 1996). And this adds to fear on account of the prospective patenting, and ulterior private appropriation, of living organisms in developing countries, from which highly profitable biotechnological innovations can be derived. (In the anti-GMO jargon, such practices are dubbed "bio-piracy".)

In light of the circumstances, major TNCs are now offering some technologies free of charge to public research institutes in developing countries as a means to improve their image in the eyes of the citizens and the incumbent authorities. In April 2000, Monsanto succeeded in deciphering the genetic code of rice, which was made available to a consortium of eleven public research institutes led by Japanese scientists, who in turn furnished this information to researchers all over the world. Syngenta undertook a similar effort with public research institutes and, in collaboration with Myriad Genetics, decoded the genetic map of rice. In addition, a group of TNCs with technologies for the development of "*golden rice*" (rice enriched with vitamin A) intend to offer free licenses for such technologies to Asian developing countries (James, 2001).

[7] For example, an agrochemical firm with a seed company of its own may restrict the use of a given technology so that such technology can only be applied to the seeds of its own affiliate, thus limiting competition in the latter's market.

Table I-3. Market presence of the leading agricultural biotechnology companies in major developing countries

Parent Company	India	China	South East Asia	South Africa	Brazil	Argentina
Monsanto/ Pharmacia (Holdens, DeKalb, Asgrow, Cargill International, Delta & Pineland)	• Mahyco (joint venture for cotton; 26% share) • E.I.D. Parry (corn, sorghum and sunflower with DeKalb) • Cargill	• Casig (corn with DeKalb) • Provincial seed companies Xinjiang and Shaanxi • Provincial seed company Hebei (cotton). • Cargill (Liaoning)	• DeKalb (joint venture with Charoen Pakphand) • Cargill	• Delta & Pineland • Calgene • Carnia (Cargill)	• Agro ceres • Asgrow • BrasKalb • Monsoy • Cargill	• Asgrow • DeKalb • Cargill
Du Pont (Pioneer Hi-Bred Int.)	• Joint venture with Southern Petrochemic als	• Pioneer Research Subsidiary	• Pioneer	• Pioneer	• Pioneer	• Pioneer
Aventis (AgrEvo, PGS, Nunhems, Sunseeds)	• Proagro first associated with PGS; in 1988 Agrevo acquires Proagro. • Sun seeds	• Senseeds join venture.	• Sunseeds	• Aventis	• Aventis • Granja 4 Irmaos (rice)	• Aventis
Syngenta (merger of Novartis and Astra/Zeneca). Northrup King, Rogers, S&G Seeds, Hilleshög (through Novartis); rights to technology but no rights to the germoplasm of Advanta through Zeneca)	• Novartis • ITC/Zen eca		• Novartis		• Northrup King	• Northru p King
Dow (Mycogen, Cargill USA and Canada)					• Dinamilho • Hibridos • Colorado	• Morgan S.A
Empresas La Moderna (Seminis, Peto, Asgrow-Vegetables)	• Seminis	• Petoseeds (joint venture with CASIG and subsidiary in Shangai)	• Peto seeds		• Peto seeds	

Source: Byerlee and Fischer (2001).

However, regardless of the initiatives by the leading companies, it is clear that the public sector in developing countries must assume an active role in this field in terms of international negotiations concerning intellectual property rights (i.e., the TRIPS Agreement, which is discussed in the following chapter) as well as in terms of a more stringent legislation on competition defense and enhanced R&D capabilities in biotechnology, in accordance with the above mentioned aims. In this respect, it has been suggested that the development of private/public partnerships may constitute a means for developing countries to access the technologies and tools required to improve their GMO research and regulation capabilities (Byerlee and Fischer, 2001).

c) Impacts of GMOs: public perception and consumer attitudes

One of the highlights that can be drawn from the GMO public debate is that a vast majority of consumers take a negative view of GM food products. This holds true particularly for European consumers, although recent signs would indicate that the level of resistance to GMOs might be stabilizing or even beginning to fade[8].

According to a report presented by the EC (2000) compiling the results of the EU polling instrument *Eurobarometer*, more than 60 per cent of Europeans are highly concerned about genetically modified foods[9]. Opposition to GM food is widespread amid the British public, who are among the strongest opponents to GMOs. A poll carried out in 1999 by the independently-owned market research company MORI showed that over three-fourths of Britons were against field trials of GMOs; yet a year later, a survey conducted by *CropGen* revealed that 50 per cent of respondents would buy and eat genetically modified foods, compared with 46 per cent who would still reject GMOs. These data were later confirmed through a February 2001 survey by the firm NOP indicating that 48 per cent of Britons would consume GMO-containing food, whilst 44 per cent would not (according to the results of a similar poll made by said global market research firm, in 2000 respondent shares were 46 per cent as against 50 per cent, respectively). In addition, a survey carried out in 1999 by the Institute of Grocery Distribution pointed out that 51 per cent of respondents were very or somewhat concerned about food safety hazards potentially deriving from GMO foods, whilst 38 per cent was very or somewhat worried about their environmental effects (Davies, 1999).

In France, a poll conducted by Ipsos for the CFS, GNIS and UIPP organizations (seed companies, plant breeders and agrochemical manufacturers associations) and released at the beginning of this past February showed that, when asked about their purchase attitude towards food products containing authorized GMOs, 20 per cent of those polled answered that they would *certainly* buy GM products, and 32 per cent expressed that they would *probably* do so.

In the U.S., a survey carried out in 2001 by the Pew Initiative on Food and Biotechnology found that 32 per cent of respondents were very concerned, and 33 per cent were somewhat concerned, about the safety of eating genetically modified foods in general. Nonetheless, a poll conducted in February 2002 by said research project revealed that a majority of the population still believes that the benefits that can be derived from GMOs outweigh their risks. Furthermore, according to a survey made by Time magazine in February 1999, 58 per cent of those surveyed would probably avoid purchasing GM foods if they were labeled. Insofar as Canadian consumers, a poll by Leger Marketing released in July 2001 indicated that 16 per cent of respondents considered that the presence of

[8] Since available public opinion studies on consumer attitudes towards GMOs are conducted by diverse organizations, which frequently have an opposing vested interest, and poll questions usually vary from one survey to another, it is difficult to establish valid trends on the subject.

[9] It should be noted that, whereas the results of the public opinion polls and surveys explored in this section are illustrative of consumer perceptions, they do not necessarily reflect consumer attitudes towards GMOs upon making actual purchase decisions.

GMOs in food was very dangerous for human health; 31 per cent believed it was somewhat dangerous; 15 per cent thought of it as not very dangerous; 6 per cent said that it had no impact at all; whilst the remaining 32 per cent of respondents did not know or refused to answer.

In the case of Japan, a survey carried out in 2002 pointed out that support for pesticide-resistant grains fell from 52 per cent to 33 per cent over the 1997-2000 period; and for GM food, it dropped from 45 per cent to 31 per cent (Dickson, 2001). By contrast, Biotechnology Australia, a multi-departmental Government agency reporting to the Australian Department of Industry, has recently released a poll that reveals an improvement in the acceptance of GMOs, even though rejection levels remain considerably high. Moreover, the share of people willing to buy GMO-containing food grew from 9 per cent to 15 per cent between 2000 and 2002, and that of those who would not buy GM foods went down from 46 per cent to 41 per cent over the same period of time.

Within this scenario, the capacity to exert pressure (sometimes translated even into direct action) of "green" NGOs and consumer organizations —which have been particularly vocal in taking issue with GM technology— is significantly high and, as a consequence, gives rise to deep concern in their potential direct targets (governments, companies, farmers, etc.). Although the ultimate objective of these organizations is the outright prohibition of GMOs —something which is very unlikely to happen in the current context—, some of their other demands appear to find more fertile ground —for instance, the implementation of internationally standardized testing methods more stringent and transparent than the ones currently effective, as well as informative food labeling so that consumers are made aware of the food they eat. Accordingly, all their efforts strongly underpin GM labeling initiatives, a practice widely supported by both European and American consumers (more than 90 per cent of American consumers favour mandatory labeling of GM food). This issue is analyzed in detail in Chapter II.

As already pointed out, and taking into consideration that GM technology constitutes a radical innovation, it should not come as a surprise that GMOs encounter a high level of resistance by the general public, even more so when said radical innovation is closely linked to such a sensitive, thorny issue as genetic manipulation[10]. Although, on the one hand, genetics shows great promise for the therapeutic and food industries among others, on the other hand, it generates concern regarding such issues as clonation or GMOs —which constitutes the focus of this study. Such concerns are related not only to the

[10] For instance, a survey carried out in Japan in 2000 revealed that 59 per cent of respondents were favorably inclined toward genetic engineering as a means of improving the quality of life —compared with 54 per cent in 1997—; nonetheless, it also showed that more those surveyed also became convinced that genetic engineering could actually make life worse —12 per cent in 1997 and 24 per cent in 2000. Meanwhile, according to Eurobarometer polls, the portion of respondents thinking that food production is a useful application of biotechnology decreased from 54 percent (1997) to 43 per cent (2000). In addition, in 1999 another Eurobarometer survey found that the share of respondents thinking that biotechnology "will improve our way of life in the next 20 years" had fallen to 46 per cent from 53 per cent in 1993.

"material" consequences of these phenomena on the environment, human health, and the like, but to their ethical and religious impacts as well[11].

Furthermore, as wisely pointed out by some analysts (Dickson, 2001), the critique of GMOs by a significant share of developed societies —and, to a certain extent, also by developing countries— should not be studied in isolation, but rather as part of the fears and uncertainties stemming from two other factors that exert a profound influence on both our present and future: i) globalization, associated to the increasing presence of TNCs all over the world; and ii) the growing power of science and technology. In the public´s perception, both phenomena concur in many aspects as, for instance, it is precisely the very same TNCs that appear to be in control of a major part of the key technologies in today's world.

Within the purview of this study, it has already been noted that GMOs are controlled and commercialized by a mere handful of leading biotechnology TNCs, and this situation in turn gives rise to objections concerning the impacts of said TNCs on farmers, their market power and even their capacity to wield influence (via lobbying, funding, and alike methods) over the agencies responsible for the regulation and research of the impacts deriving from GMOs. (Needless to say, events such as the mad cow disease and the like, which have raised serious doubts as to the proper implementation of health control measures, are far from contributing to building public trust in the governmental agencies in charge of protecting public health.) Moreover, threats to biodiversity, to the preservation of traditional crops or to the control of natural resources on the part of developing countries (Duttfeld, 2000; Altieri and Rosset, 1999) are also considered within the set of arguments that are influential in echoing and amplifying the "critical" perception of GMOs.

Likewise, the perceptions and choices of consumers in different countries are shaped by various factors, including their income level, which constitutes one of the major influential elements. In this respect, and generally speaking, it becomes clear that consumers in the most advanced countries would appear more minded to reject GMOs and to pay a differential price for non-GM varieties although, to date, they do not seem to perceive much benefit from consuming such food. Furthermore, despite the lack of conclusive evidence as to the potential adverse effects of GMOs, this provides no grounds for complacency given that there is still no 100 per cent guarantee that GM foods are risk-free. In addition, citizens in developed countries tend to be more concerned than those in the developing world about the environmental impacts of certain technologies, mainly because the latter's utmost priorities are focused on poverty, unemployment and the like issues. This clearly mirrors the obvious gap in the current social "agenda" of developed and developing countries[12].

---

[11] To illustrate this argument, it should be noted that a recent survey carried out in the U.S. revealed that support to GMOs was considerably higher on the part of populations with Jewish heritage than in populations with Christian tradition.

[12] A survey recently carried out in the Philippines and Mexico among groups of political representatives, businessmen, academics, NGO members, reporters, researchers and religious leaders suggests that both countries view biotechnology as a powerful new tool to address problems in agriculture, nutrition and the environment, and they do not seem to share Europe's fear of potential health risks for consumers. In turn, they

It should also be remembered that social and consumer attitudes towards GMOs are influenced, either directly or indirectly, by an intricate set of interests and actors ranging from farmers to seed companies, the food industry, etc., as well as by the stance adopted by their respective governments on this issue —which in turn is dependent upon various political and economic reasons. Therefore, in the case of Europe, for instance, an intensification of agricultural production as a result of the use of GMOs would undoubtly lead, *ceteris paribus*, to an increase in the amount of money that the European Union allocates to subsidies to the agricultural sector.

Limited and/or lack of knowledge about the intrinsic nature of GMOs (or, in general terms, about biotechnology and genetics) makes social attitudes and perceptions more easily malleable. In the U.S., for instance, a survey conducted in mid-2001 by the Pew Initiative on Food and Biotechnology revealed that 45 per cent of those polled had recently heard "nothing" or "not much" about GM foods. In Canada, a public consultation study carried out that same year by Leger Marketing showed that 78 per cent of Canadians did not know the meaning of the acronym GMO, and even after having been told that GMO stands for genetically modified organisms, less than half of respondents admitted to "having already heard" of GMOs. This lack of knowledge or information leads people to believe that only GMOs contain genes. In Argentina, for example, 38 per cent of consumers believe that ordinary tomatoes contain no genes, while genetically modified tomates do; and 46 per cent think that if a person eats transgenic food, his/her genes could be modified as a result (ASA, 2001). Argentine consumers appear to be no exception in this respect: according to a poll by Biotechnology Australia, 69 per cent of Australians believe that eating GMOs may modify their genetic constitution. Apparently, the European level of ignorance on the subject is not much lower.

In this scenario, it should come as no surprise that arguments which are not always solid or soundly grounded may succeed in shaping social perceptions of the costs and benefits that can be derived from GM technology. Accordingly, Ablin and Paz (2001), point out that "it is worth noting that consumers —concerned over the development of GMOs— tend to compare GM products to organic products, as if *natural* products were the market alternative to GMOs. However, the real alternative to GMOs is *conventional* products, whose content of herbicides, pesticides and other substances … does not conform to a *natural* description".

Notwithstanding, the current state of affairs should not lead to an underestimation of the power of consumers, of their representative associations and of "green" NGOs. In other words, consumers' lack of knowledge, by itself, provides no firm guarantee that GMOs have finally secured a strong position in the market[13], regardless of the fact that ethical or

are concerned about corporate control of the technology, and the potential impact of such crops on their countries' rich biological diversity (Aerni, 2001).

[13] In this respect, it should be noted that the EC (2000) public opinion study reveals that, from the consumer perspective, the most reliable and trustworthy sources of information are consumer organization first (26 per cent), just ahead of medical profession (24 per cent) and "green" NGOs (14 per cent), whereas international organizations and national public authorities rank last (respectively 4 per cent and 3 per cent).

religious considerations do not constitute neither rational nor irrational reasons from a scientific view and should therefore be analyzed in their own terms.

In this context, time could bring forth a higher level of consumer acceptance of GMOs — stemming from a consolidation of GM foods in the market—, but only as long as some issues conforming the "bunch" of fears and uncertainties previously mentioned are clarified or dispelled. Such issues include: i) the discovery of new confirmatory evidence as to the health and environmental safety of GMOs; (ii) the improvement of government regulatory and control frameworks, including increased clarity in the labeling regulations for GM foods[14]; iii) the implementation of effective traceability and segregation systems — assumed to be beneficial to farmers, as well, in the growing of second generation GMOs, as it is estimated that their price (unlike that of present day GMOs) will be higher than the price of conventional products; iv) a broader diversification of the sources of technology as well as the stringent enforcement of competition defense policies designed to avoid abuse-practices of (existing) dominant positions on the part of TNCs; v) the emergence of "second generation" GMOs, featuring beneficial properties of direct relevance to both consumers and the industrial sector; vi) an enhanced dialogue between companies, governments and consumers around the benefits and costs of these new technologies.

Hence, it is important to mention that, at least according to the available surveys, the level of acceptance of "second generation" GMOs appears to be relatively high. This reinforces the idea that the present hesitant attitude adopted by the general public towards GM foods can be attributed, to a large extent, to the lack of direct benefits to consumers offered by the GMOs currently on the market. And the same applies to the association of GMOs with lower environmental impacts as a result of the use of agrochemicals. In France, an Ipsos survey reported that two-thirds of respondents would approve of the use of GMOs provided that this led to a reduced use of pesticides or to any other environmental improvement. In the U.S., a survey carried out in 2000 by the International Food Information Council revealed that 54 per cent of Americans were likely to buy GM foods enhanced to taste better or fresher; and 69 per cent would favor GMOs enhanced to require fewer pesticides and herbicides. In turn, according to the Biotechnology Australia survey previously mentioned, 60 per cent of Australians would buy GM food if it had been modified to be healthier than traditional foods (65 per cent in 2000); 51 per cent, if it had been modified to taste better (41 per cent in 2000); 40 per cent, if they had a longer shelf life (36 per cent in 2000); and 45 per cent, if they were less expensive (36 per cent). (These results should be compared to the ones previously stated regarding consumption of GMOs currently on the market.)

[14] Accordingly, it is worth pointing out that, for public "psychological" reasons such as the mistrust aroused by certain recent events (the so-called "mad cow" disease, for instance), consumers frequently appear to listen more favorably to the arguments of GM opponents than to those of GM advocates (regardless of the quality of the scientific evidence produced by either group). As it has already been stated, the general suspicion about the source of the funds used by the scientists furnishing positive evidence in favor of GMOs or with respect to the pressures exerted on them do nothing but add to the decreased level of trust in the arguments supporting the innocuousness of GMOs. (Significantly, scientists against GM technology hardly evoke this sort of comments.)

d) The attitude of the different agents involved in the production chain

The stance adopted by the different agents in the GMO “chain” obviously varies according to their degree of commitment to the GM sector and the size of the costs and benefits derived from the diffusion of said organisms.

Needless to say, biotechnology companies constitute the strongest and staunchest proponents of GMOs, supporting various educational and advertising campaigns aimed at promoting the potential advantages and the harmlessness of GM technologies[15].

Among farmers, however, there appears to be a lot of dissent with regard to this issue. On the one hand, a distinction must be made between farmers from countries that have already adopted GMOs —who generally hold the most positive views about them— and farmers from countries where GMOs have not yet been authorized —who sometimes tend to take a dismissive attitude towards them, in the belief that GMO-free products will achieve better market penetration. Nonetheless, recent public opinion studies have revealed that in Great Britain, for instance, a vast majority of farmers are in favor of the use of GMOs. On the other hand, even within those countries in which GMOs are already in use, there is resistance among certain segments of farmers arising from the possible loss of export markets[16] as well as the likely abuse of market power by biotechnology companies, the potential adverse effects on the rural environment (including the emergence of resistant weeds, etc.), the potential contamination of conventional crops by GMOs, and the loss of independence on the part of farmers.

Meanwhile, food companies have shown a receptive attitude to public fears, enforcing strict segregation standards in order to provide consumers with GMO-free food. Accordingly, the UK Food and Drink Federation (FDF) and the British Retail Consortium (BRC) have worked together to produce a set of voluntary guidelines for the segregation of GMO-containing foods. In this regard, the FDF's director-general Sylvia Jay stated that “as soon as it became clear that most consumers did not want to want to eat food containing genetically modified ingredients, U.K. food and drink manufacturers started to seek supplies of conventional crops” (FDF, Press Release, September 7, 2001).

With regard to the commercialization stage, attitudes vary both among countries and among companies; notwithstanding, in Europe the cautious stance seems to prevail. For instance, own-brand products offered by British chains are generally labeled as “GMO-free”, and in some places, non-GM fed meat is already available, advertised either as “organic” or as “GMO-free”. Several European chains have followed this example;

---

[15] In this respect, the general public usually finds fault with biotechnology companies for having disregarded consumers’ need to be clearly informed about GMOs, thereby sparking a negative reaction on the part of NGOs and, later on, consumers.

[16] It has been reported that, in view of the potential commercial approval of a GM wheat developed by Monsanto, one of the associations grouping U.S. wheat growers has adopted a hostile attitude on the assumption that such release could derive in a loss of export markets (particularly in Europe). In turn, a U.S. association of corn growers objects to the use of genetically modified corn alleging similar reasons.

moreover, some supermarkets have phased out GMO-containing foods (EC, 2000)[17]. It has also been pointed out that some fast food companies such as Mc Donald's rejects the use of genetically modified potatoes.

[17] In some chains, the sale of own-brand products amounts to 90 per cent of the total turnover, and therefore, such chains have practically pulled genetically modified foods off their shelves.

CHAPTER II

REGULATORY FRAMEWORK: MAIN ISSUES

Introduction

This chapter concentrates on the most important aspects related to the regulatory framework for GMOs currently in force in the main food producing and consuming countries, as well as in the international relations arena. Bearing in mind the major risks emerging from the introduction of this new technology —discussed in the previous chapter—, this section analyzes the following issues: i) how are GMOs environmental and sanitary risks assessed? For this purpose, the current procedure and requirements for approval of the release of GMOs into the environment and their subsequent commercialization are thoroughly described; ii) what are the current legislations on citizens' rights of access to information regarding the presence of GMOs in foods? This refers mainly to the labeling system and therefore an overview of the local legislation on this subject is provided and debates in international negotiating forums are addressed. In addition, some evidence regarding the economic impact of labeling is herein presented; iii) what is the current legislation on intellectual property rights for innovations in biotechnology?

a) Approval process for GMOs

Since we are facing a radical technological innovation, and taking into consideration the fears and uncertainties aroused by their propagation, it should come as no surprise that GMOs be subject, as from the experimentation stage to the consumer stage, to different regulations aimed at minimizing the sanitary, environmental and other risks that could be derived from their use.

According to Oliver (2001), and not taking into account local particularities, the "basic scheme" that regulates the procedure for the approval of GMOs starts with a first stage in which permit applications for the experimentation and/or release into the environment of lab-developed varieties are assessed. At this point, the following aspects are evaluated: i) potential impacts on the agro-system in which tests will be carried out; ii) biological traits of the organism; iii) possible effects on human health. Approved events may then be released into the environment in the form of experimental crops; at this stage, they are subjected to both strict safety controls and further studies of their health and environmental impacts. Following this stage, which usually lasts several years, those events, which have passed the required tests, are authorized for commercialization. In any case, once on the market, they may be further monitored in order to assess new potential negative effects that may have not been previously detected.

At the same time, usually due to pressure exerted by consumer organizations and environmental NGOs, the use of labels, either voluntarily or compulsory, has become widespread. These labels serve the purpose of informing consumers whether or not food products contain GMOs —this issue is further discussed in following paragraphs.

In a country such as the U.S., for example, this complex regulatory process involves three different agencies: i) the Department of Agriculture (USDA), which is responsible for the granting of authorizations for the release of GMOs into the environment and for the assessment of the effects of such GMOs on agriculture; ii) the Environmental Protection Agency (EPA), which is mainly in charge of monitoring potential impacts of GMOs on the environment; and iii) the Food and Drug Administration (FDA), which deals with issues related to the food safety of humans and animals.

To date, no evidence exists that this regulatory process has resulted in the approval of any GM varieties, which have proven harmful to consumers[18]. This fact has been acknowledged, for example in the recent report by the Royal Society (2002), the most prestigious scientific institution in the UK. However, the report warns about the need to improve both the regulations and the tests to which GMOs are subjected; yet, it is therein admitted that the weaknesses of such tests apply either to new GM foods as well as "conventional" foods.

With regard to the impact on the environment, a recent study by the National Academy of Sciences (2002) pointed out that there is no difference between those effects which may emerge from plants modified through modern biotechnological techniques and those resulting from conventional breeding techniques (and, in fact, the former are subject to more rigorous testing than the latter). Nonetheless, it is suggested that the regulatory process be enhanced through a higher involvement of the general public, an improvement of the review process in the hands of scientific peers, and by presenting the data and methods used in the decision-making process in a clearer manner. Moreover, it is advised that the monitoring process be extended even after the GMOs have been approved for commercial use, given that environmental effects detectable during the testing phase, for example, may be different from those arising when cultivating larger extensions of land.

Notwithstanding, controversy persists even after scientific evidence has proven, for the most part, that GMOs *per se*, if properly tested and regulated, do not pose any particular health or environmental risks. Controversy may be elicited not only by environmental and sanitary concerns but also by economic factors, (e.g., diverging interests related to foreign trade issues); social matters (associated, for example, with the distribution of additional benefits derived from the application of GMOs in agriculture); ethical and religious considerations (is genetic manipulation *per se* acceptable?), and the like. In addition, each country may take a different stand in view of its own potential for genetic practices and the impact that the use of GMOs could have on such potential, or depending on how their local

[18] In fact, the only public case in which an error in the GMOs regulatory process was detected —at the post-approval stage— is that of StarLink, a GM corn variety today out of the market. Having been approved for animal consumption only —due to doubts concerning its allergenic potential for human beings— it was detected in a product manufactured by Kraft, who later had to withdraw from the market all products containing such GMO.

companies and institutions rank in the biotechnological "race". Last but not least, attitudes may vary according to the average income level of any given society.

Within this scenario, it is not surprising then that the details regarding the conditions for the approval of GMOs —both for experimental and commercial uses— may vary so much between different countries (see Baumüller, 2002). Thus, in the European Community, a *de facto* moratorium on the approval of new GMOs has been in force since October 1998, and only 14 GMO varieties had been approved until that date. Whereas it had been announced that this moratorium would be lifted towards the end of 2002, and even if this actually happens —a fact that should not be taken for granted given the ongoing debates on the issue[19]—, it must be considered that, should any solid scientific justification be found, EU member countries may temporarily restrict GMOs already approved at the European Union level (this explains why some of the 14 crops authorized by the EU are forbidden in several European countries). At the same time, the lifting of the moratorium would bring new and more strict directives regarding the procedures for the assessment and authorization of the release of new varieties (see below).

On the other end of the spectrum, in the U.S. there are approximately 50 varieties of approved GMOs, a fact that obviously gives rise to commercial conflicts whenever such products need to be exported to countries where any of these varieties have not been approved. However, it is worth mentioning that, from 1987 to 2002, over 7,500 events had been authorized for field release[20] only in the U.S., while the approval of an additional 300 products was still pending. This clearly illustrates the extremely slow pace of the regulatory processes involved.

Yet, as previously expressed, consumers and different representatives from the civil society, especially from developed countries, still not satisfied with the scientific testing which supports the process leading to the approval of GMOs, have demanded that labeling systems be implemented as a means of identifying those foods containing GMOs. The following section presents some relevant evidence on this issue.

b) Labeling of GMOs

i) Main aspects of the debate

The labeling of GMOs constitutes an issue far more complex than what it may seem at first sight. Initially, the aim of labeling would be to provide as much information as possible to the consumer. This is fully understandable because, as was discussed previously, there

---

[19] Even within each European country there are conflicting views concerning this issue, since there are some government and social sectors who favor putting an end to the moratorium mainly to avoid being left behind in the biotechnological "race" against the U.S., whereas other sectors oppose this measure.

[20] It is interesting to point out that other 300 applications were rejected, while more than 200 applications were withdrawn by applicants themselves.

are added fears as to the safety of GM foods. At the same time, labeling is strongly supported among citizens from both developed and developing countries.

However, some opinions are contrary to labeling. This explains why the practice has not been enforced in important countries such as Canada or the U.S., in spite of them being GMO producers. Among the cited reasons, which have the most diverse origin, intention and validity, is the complaint concerning the lack of information on herbicides and pesticides used to produce “conventional” crops?[21]. In the same manner, there could be other means of providing information about GMOs to consumers, such as advertising campaigns and call centers, to name a few, which could complement and even be more effective than labeling itself (since labels are not always read by consumers). However, the most publicized argument against labeling is probably the one that states that, as GM foods have not been proven different from their traditional counterparts, either in chemical composition or nutritional value (the so called “substantial equivalence principle” —see below), it would be misleading to label them, as consumers would be led to believe that these products are less safe and potentially harmful.

In fact, this discussion is tightly linked to legal considerations regarding whether it is legitimate or not, especially from the point of view of international trade, to enforce certain standards or labeling procedures based solely on the process by which a product has been obtained when, in fact, this difference in production does not translate into a difference in the end-product. In the case of the environment, for example, a production method may affect the features of a product in a way that the product itself may become a contaminant or degrade the environment when it is consumed or used —product-related processes and production methods (PPMs)—, or it may be that the production method has a negative impact on the environment through, for example, polluting gas emissions or toxic effluents during the production process (non product-related PPMs).

Not long ago, the WTO prohibited restrictions on imports based on non product-related PPMs requirements[22]. This doctrine has generated harsh criticism from environmental organizations, who challenge the definition of “similar goods” as used in the WTO’s doctrine. They argue that, even when two goods do not show physical differences, they can not be considered equal if they have been produced using different methods (according to this point of view, tuna caught with nets which do not allow dolphins to escape is not equal to tuna caught with dolphin-friendly nets).

The same objection on the “similar goods” concept can be applied to GMOs. Furthermore, even if the presence of GMOs cannot be determined in foods derived from them (since DNA chains are broken during the production process) this does not happen, for example,

[21] The argument for this position is that GM crops, in general, as opposed to conventional crops, require lower quantities of agrochemicals, which are considered highly pollutant.

[22] The most notorious case in this sense was the dispute between the U.S. and Mexico over tuna. This case set a legal precedent within the the WTO, which passed judgment in favor of Mexico and ruled the U.S. restrictions on the import of tuna, based on the fact that tuna fishing in this country was not “dolphin-friendly”, as an illegal practice.

in the primary forms of grains and oilseeds; in these cases, it is possible to test and detect the presence of GMOs.

Notwithstanding, in some recent rulings, the WTO has admitted the validity of non product-related PPMs, provided they are not applied in a discriminatory, arbitrary or unjustified manner. These rulings are related the U.S. prohibition of shrimp imports from countries which did not require the use of special devices to protect sea tortoises from falling into the nets used to catch shrimp.

Within this scenario, the U.S. defends the above mentioned principle of "substantial equivalence" in international negotiations[23]. This tenet was coined by the Organization for Economic Cooperation and Development (OECD) in 1996 and states that if a new food —or a new ingredient— is "substantially equivalent" to an existing product already available in the market, then the new food or ingredient may be dealt with in the same manner as its conventional counterpart. On the contrary, if significant differences are found following the comparison of both products, then a more thorough safety evaluation becomes necessary. This may require assessing the effects of the intake of the chemical compounds responsible for the difference through animal testing.

This principle, which has strong practical advantages in that it presents a relatively clear definition of a standard, which can be easily used to approve or reject a GMO variety, has been strongly criticized. Thus, Millstone *et al* (1999) consider that the excessive simplicity of this principle disregards the need for a biological, toxicological and immunological examination, which would require specific lab tests. In turn, the previously mentioned report issued by the Royal Society (2002), points out that the criteria used to assess the safety of GMOs based on the principle of substantial equivalence, should be explicit, objective and internationally standardized. It points out, as well, the need for further research on new techniques aimed at comparing GMOs with their conventional counterparts in a more accurate manner. However, the same report warns that, in fact, conventional hybridization technologies may also cause unpredictable rearrangements of the genome of the modified organism —of the same kind that is feared GMOs could produce. Therefore, those foods resulting from "traditional" procedures might also need testing very much in the same way as GMOs are tested or expected to be tested in the future.

Due to the numerous doubts regarding the long term effects of GMOs, effects which remain unknown yet as a result of either insufficient research, limitations in current techniques, or just because not enough time has elapsed in order to gather reliable empirical evidence; some countries, and especially those within the European Union, would rather abide by the "precautionary principle".

[23] Even within the U.S., this principle is not always applied. As agreed at the Codex Alimentarius, the Food and Drug Administration (FDA) has accepted that labeling be used in the case of irradiated foods (Einsiedel, 2001). Apparently, this labeling has not had any negative impact on the sale of irradiated food.

It is quite remarkable that the exact meaning of the precautionary principle had not been properly defined until very recently. This fact was noted by the U.S. in relation to the use of such principle by the European Union: in the absence of a precise definition, this principle could create legal uncertainty and be used for purposes other than those related to the protection of health and the environment. As a response to this claim, new regulations came into effect as of February 2002; these refer not only to the definition of the precautionary principle regarding GMOs but also concerning the introduction of other food products destined for human and animal consumption[24]. Thus, it has been settled that, in those cases where possible harmful health effects may be identified but where scientific uncertainty still remains, risk management measures may be adopted until sufficient information that may allow for a thorough evaluation becomes available. Such measures must not restrict commerce more than what is necessary in order to achieve the desired health protection level and must be reviewed after a reasonable period of time. At the same time, the new regulations establish the creation of a European Food Safety Authority which is entitled, among other things, to settle the conditions for the import of foods that might pose serious health risks, or to suspend any such imports altogether.

As can be concluded, there is still a wide margin for the precautionary principle to be used, as some critics' fear, for protectionist ends disguised in the form of environmental concerns. From a broader perspective, those critics of the precautionary principle argue that, if strictly enforced, it would block the development of any technology as long as there is the slightest theoretical possibility that it might cause any harm (Hathcock, 2000). This criticism is probably biased given that, so far, the definitions of the precautionary principle, including those proposed by the European Union, have included cost-benefit analysis and refer mainly to the risk of irreversible or potentially very harmful effects. However, this criticism brings to attention the possibility for abuse that the actual implementation of such principle could cause.

In any case, and not considering whether or not the parties in conflict are right or wrong, it is possible that labeling practices —whether voluntary or compulsory— become standardized in the long term for three reasons: i) the social pressure supporting them (most citizens in developed countries, hostile or not towards GMOs, are in favor of a labeling system); ii) eventually, with the advent of second generation GMOs, labeling would no longer be considered, as it is today, a negative GMO discriminatory practice but a positive one, since it would help to highlight the additional advantages of genetically modified products over conventional ones; iii) the adoption of provisions in favor of the use of labeling in the international arena (i.e., the Biosafety Protocol case —see below).

If this hypothesis is accepted, we should discuss the way in which the system might be implemented. The first controversy rises over the use of voluntary versus compulsory labeling. Voluntary labeling, which is not regulated by the WTO (a debate on this matter has also grown over the last few years), will grow spontaneously if the perceived benefits of selling "GMO free" products are higher than the costs incurred by producers to ensure segregation and identity preservation throughout the commercial chain. At the same time,

[24] Regulation (EC) No.178/2002

a voluntary label could be introduced to indicate that a product contains GMOs which are responsible for certain positive features, such as better taste, higher nutritional properties, etc.[25]. Governments could play a regulatory role on this kind of labeling so as to ensure that the information provided by the label is reliable and appropriate —private coordination could be, as it has been in certain cases, a substitute for public action.

The impact of compulsory labeling transcends national issues and extends into the international arena because, depending on its characteristics, it may conflict with WTO regulations —we will get back on this issue later[26]. In the case of compulsory labeling, Government must necessarily define its characteristics; this includes deciding on issues such as the definition of what "genetically modified" means; what kind of information should reach the consumer; which categories of foods should be included; what ingredients will be analyzed; what minimum percentage of GMO content will require labeling; how will the certification and verification systems be implemented; if labeling will include the feeding system used to raise animals, foods served in restaurants, fast foods, etc. It is not surprising that, due to the lack of international coordination on the matter, current and proposed systems are so heterogeneous (Phillips and Mc Neill, 2000; Baumüller, 2002).

According to Caswell (2000a), there are currently two broad approaches on the matter. The first is the one sustained by the European Union[27], Australia, New Zealand[28], Japan, Korea[29]

---

[25] Some authors have suggested that, from an economic perspective, voluntary labeling could be superior than compulsory labeling, because with compulsory labeling all consumers, and not just those interested in the label, would pay for the cost of the system. Likewise, given that consumers could look for information on certain GMOs, but not on all of them, and for different reasons (environmental, sanitary, ethical, etc.), a voluntary system would give rise to several labels aimed at the different buyer segments (Kalaitzandonakes and Phillips, 2000).

[26] Generally speaking, compulsory labeling is of a "positive" kind, that is, it s aimed at identifying products that contain or may contain GMOs. As opposed to this, voluntary labeling is of a "negative" kind, as those producers who wish to indicate that their foods are free from GMOs use it. However, as we mentioned before, in the future there could be voluntary labeling of a "positive" kind, if products containing GMOs had better qualities than their conventional counterparts in such qualities as flavor, nutritive properties and the like.

[27] In the European Union, the enforcement of laws on GMO labeling began in 1997. Subsequently, these laws were amended on several occasions. These regulations state that foods containing or made with ingredients, which contain more than one per cent of GMOs, must be labeled. Those products that have an incidental presence of GMOs in their composition and those who do not contain proteins or DNA derived directly from GMOs are exempted from labeling. In July 2001, the European Commission submitted a more stringent labeling proposal whereby labeling and traceability of products destined for human and animal consumption was established. It also decreed the compulsory labeling of every food containing GMOs, even in those cases where their presence may not be detected. On the other hand, labeling is not required for farm products (meat, milk, eggs) resulting from GMO fed animals. The European Parliament has recently approved this proposal, although it has introduced some amendments. Particularly, it has prohibited the import of products containing contingent traces of GMOs, which have not been approved by the European Union (the original proposal set a one per cent tolerance for such traces). The European Commission expressed its disagreement regarding this amendment and representatives from the biotechnological industry and the U.S. government rejected the new regulations, which they deemed expensive and inapplicable. Interestingly so, the British Food Standard Agency (FSA) has expressed its disagreement with the Commission's proposal, stating that it could imply that consumers face higher costs with no guarantee as to the effectiveness of the identification mechanism. Furthermore, this situation could lead to fraud, considering the difficulties of detecting the presence of GMOs. As a result, the FSA decided to keep the current system and have it complemented with additional rules for "negative labeling" (i.e., "free from GMOs"). Finally, the FSA pointed out that labeling of GMOs is related only to the rights of consumers to know and to choose, and not to possible health risks, as all authorized GMO products have passed rigorous safety tests.

and China. These countries have already implemented compulsory labeling systems for foods containing GMOs —in some of these countries there are also voluntary labeling systems for non GMO products, such as we have already seen in the case of Europe. The second approach is that of the U.S. and Canada. These countries encourage voluntary labeling when the end product differs from its conventional counterpart in its nutritional properties or allergenic potential. However, in spite of efforts, a credible and consistent labeling system has not been developed yet by any of these two countries[30].

Within this context, disagreements involving labeling issues have reached international negotiations and debates, as these may have a direct impact on the commercial flows of GMO products. In fact, the issue adds up to the general labeling debate and the impact it may have on world trade —particularly its possible use as a "protectionist" barrier—, although the heated topic of GMOs adds some special nuances to this discussion.

The following sections summarize the discussions involving GMOs in three international forums: the Biosafety Protocol, the Codex Alimentarius and the WTO.

ii) Labeling in international negotiations

<u>- Protocol on Biosafety</u>

The negotiations for the Cartagena Protocol on Biosafety (CPB) were initiated in 1996 by commission of the Conference of the Parties to the Convention on Biological Diversity, and ended in 2000, upon the signature of an agreement in the City of Montreal. For the time being, this is the only legal text destined to regulate the passage of GMOs across borders, since there are fears that they might have a negative effect on the preservation and the sustainable use of biological diversity, as well as on human health.

Debates at the CPB, which will come into force once it is ratified by at least 50 of the over 140 participating countries[31], were very strong. These debates were a result of the diverging interests and positions of the different countries regarding the GMO issue —and regarding other issues such as agricultural commerce, intellectual property rights,

---

[28] In December 2001 Australia and New Zealand implemented laws similar to those currently in force in Europe. Remarkably, it has been reported that upon the coming into force of the new legislation, several companies (including large transnational corporations such as Kellogg's, Unilever and Cadbury) have eliminated ingredients containing GMOs from their products, in order to avoid a possible loss of markets. In this sense, smaller producers, who lack the power to modify their supply structure to ensure the absence of GMOs in their products, would be the most severely affected by labeling enforcement.

[29] In Japan, the maximum content of GMOs allowed in non-labeled products is of 5 per cent, whereas in Korea it is of 3 per cent.

[30] Recent news indicates that an agreement about to be settled in Canada would establish a voluntary labeling system.

[31] Until August 2002 only 13 countries had ratified the CPB.

international trade, etc.. They were also a result of the close follow-up by a considerable number of NGOs, which, in general, lobbied for a strict control of GMO trade.

Within this context, it is not surprising that different negotiating groups were formed, including: i) the "Miami Group", formed by the U.S.[32], Canada, Argentina, Australia, Uruguay and Chile (countries which, for the most part, authorize the production of GMOs within their territories); ii) the European Union; iii) the "like-minded" group (most of the G-77 member countries plus China); iv) the "compromise group", formed by Switzerland, Japan, Norway, Mexico and South Korea.

Essentially, disputes were polarized between those countries whose interest was to prevent the imposition of regulations on international trade of GMOs (Miami Group) and those stating the need of taking into account the so-called "precautionary principle". This last approach opens the possibility of restricting the flow of food products about which there is no certainty as to the negative effects that they might have on health, the environment or on biological diversity.

The final text of the Protocol acknowledges the possibility of applying the precautionary principle[33]; and authorizes signatory countries to impose restrictions on the import of GMOs. The "Advance Informed Agreement Procedure" is created for this end. Such procedure must be implemented before the first international trans-boundary movement of a modified living organism (term used in the Protocol text) destined for deliberate introduction in the environment of the importing country, takes place. The importing country may then a) approve the import and set the conditions when appropriate, including conditions for future imports of the same GMO; b) forbid the import; c) request additional information; and, d) extend the time limit required to give an answer. Such a procedure may be applicable only in the case of a small group of modified living organisms — basically seeds and microorganisms (Cosbey and Burgiel, 2000).

In turn, it was decided that other modified living organisms should carry a label indicating that they might contain genetically modified material. However, and disregarding claims from "environmental" NGOs and several negotiating countries, it was established that the CPB include only GMOs destined for food or animal feed, or their processing. On the other hand, GMO-based products or products containing GMOs were not included.

Another complex issue, which was not clearly solved, is that of the coexistence of CPB and WTO regulations. On the one hand, it is established that the CPB must not be interpreted as an amendment to the rights and obligations vested on one party, in relation

[32] In fact, as the U.S. did not ratify the Agreement on Biological Diversity, it could only attend the CPB negotiations as an observer and, therefore, had no voting rights.

[33] Literally, the Protocol states (Article 10.6): "Lack of scientific certainty due to insufficient relevant scientific information and knowledge regarding the extent of the potential adverse effects of a living modified organism on the conservation and sustainable use of biological diversity in the Party of import, taking also into account risks to human health, shall not prevent that Party from taking a decision, as appropriate, with regard to the import of the living modified organism in question (…), in order to avoid or minimize such potential adverse effects".

to other international agreements already in force —e.g., those entered into within the WTO. On the other hand, this does not mean that the CPB will become subordinated to other international agreements. In this context, once the CPB comes into force, it is likely that some conflicting situations arise between its regulations and those of other agreements, such as the SPS or the TBT (see below).

Regarding the application of the precautionary principle, a country may reject scientific evidence supplied by the exporting country based on "reasonable" scientific doubt. Since the meaning of "reasonable doubt" is nowhere to be found —though supposedly CPB members are trying to reach an agreement on this matter—, different interpretations are likely to appear. It is foreseeable that these interpretations be more lax —in favor of the importing country— in the case of the CPB; and stricter in the case of the WTO —even though the CPB text makes it clear that any State invoking the precautionary principle must also comply with all the regulations established by the SPS (Cosbey and Burgiel, 2000). Since it has not been established which entity will be in charge of solving controversies concerning the CPB, conflicts might arise during its implementation.

<u>- The Codex Alimentarius</u>

The Codex Alimentarius was created in 1962 as a joint initiative of the WTO and the FAO. Its main role is to create international standards, recommendations, and guidelines concerning food health and safety. Traditionally, deliberations between the representatives of the Codex member governments are long and consensus on any given issue takes at least six years to achieve (Kalaitzandonakes and Phillips, 2000; Mc Kenzie, 2000).

The Codex began discussing the GMO labeling issue in 1993 and has not reached an agreement yet, not even on basic aspects such as which products should be labeled or what kind of label should be required. This lack of definitions brings serious consequences, inasmuch as standards set by The Codex are usually used to define whether a restrictive measure imposed on certain import is in accordance with the WTO agreements or not. If an agreement can not be reached on the labeling issue, the consequences would be not only higher costs and a growing segmentation of food trading markets, but also the impossibility to control whether labeling systems are being used as protectionist measures "in disguise".

According to Buckingham (2000), certain countries participating in the Codex, such as Australia, Brazil, Canada, New Zealand, Peru and the U.S., support the criterion of labeling foods based on safety, composition, use, and nutritional properties. On the other hand, European countries and India favor the use of compulsory labels for every food product resulting from biotechnology —as it can be seen, the position of each country is consistent throughout the different forums where the issue is discussed. In turn, the risk assessment issue is also a topic of discussion, since, while there are countries that abide by the scientific evidence available, other countries are unwilling to accept any kind of risk associated with biotechnology. Yet another group of countries demand that other risks, beyond those related to human health, be assessed. Such risks include those that may have an impact on society, the environment, the economy, and so on. At the same time, there are differences between the countries commercializing GMO foods. These differences concern detection and testing methods[34]; verification methods (the buyer will not necessarily acknowledge the procedures carried out by the exporting country); the thresholds of tolerance after which labeling should be required; etc. In this context, it is quite obvious that an agreement within the Codex framework will be hard to achieve.

- The World Trade Organization (WTO)

There are two agreements within the WTO than can be applied when issues concerning GMO labeling arise: the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) and the Agreement on Technical Barriers to Trade (TBT). The SPS Agreement allows a country to adopt regulations aimed at ensuring food safety, the protection of animals and plant preservation (sanitary and phytosanitary measures). This Agreement encourages members to use the international guidelines and recommendations whenever available (e.g., those rules prescribed by the Codex Alimentarius). However, members may enforce more rigorous rules based on scientific justification. In the same manner, restrictive measures can be applied even when scientific evidence is insufficient. Countries applying any such measures should, within a reasonable period of time, undertake further research to gather the necessary information in order to carry out an objective risk assessment based on the new evidence, and review all measures adopted. Likewise, measures should not be discriminating nor more restrictive for trade than would be necessary in view of the objective sought through their implementation. In this sense, according to Galperin *et al* (1999), some observers have pointed out that the SPS has been devised to deal with different degrees of risk. This implies that the probability of occurrence of different events may be established but that no decisions can be made over uncertain situations, such as that of GMOs, when the necessary information needed to make accurate predictions is unavailable. On the other hand, some unresolved issues lie within the SPS itself, key issues that are directly related to the GMO debate, such as the “equivalence” principle —the acceptance by different governments that those measures used by other countries with the same health protection standards as far as food, animals and plants are concerned, may be considered equivalent to their own measures.

The TBT Agreement encompasses restrictions to imports or exports based on standards and technical regulations. Basically, this Agreement requires that every technical regulation adopted regarding a product should take into account the principle of “national treatment” and not limit trade beyond what is necessary for the achievement of legitimate goals, such as guarding national security, protecting human health, or safeguarding animals, plants and the environment. It is worth noting that the text of Annex 1 of the TBT

[34] Detecting GMOs is not always possible. This is the case of soybean whose DNA chains are broken during the grinding process. This makes it impossible to find out whether certain oil has been produced from GM soybean or not. However, as we mentioned before, some labeling systems, such as that proposed by the EU, demand that these kind of products be clearly identified.

does not make any difference between "product-related" PPMs and "non product-related" PPMs and, therefore, leaves the possibility for the latter to be implemented as well.

Also noteworthy is the fact that, such as Zarrilli (2000) points out, developing countries have held divergent positions regarding their general approach towards the TBT and SPS agreements in the case of GMOs. In fact, whereas in the first case they have defended a close interpretation of the precautionary principle —out of fear that international agreements might be used as barriers of entrance to markets in developed countries—, in the second case, within the Protocol on Biosafety, they were for a more flexible approach, motivated, among other reasons, by the uncertainty brought about by a technology over which, at present time, they seem to have no power to monitor or control. This shows yet another aspect of this complex debate, given that the position on GMOs held by each country may have or may eventually result in consequences that might affect other aspects of the international trade regulatory system.

Needless to say, positions held by different WTO member countries concerning GMOs are consistent to those sustained in every other negotiation forums. Within this context, it is not surprising that complaints and discrepancies have already sprung, such as the complaints filed at the SPS by Canada and the U.S. regarding the new GMO traceability and labeling regulations adopted by the EU. These new measures are deemed to be too restrictive for trade and of difficult implementation. The U.S. has also complained about GMO regulation systems implemented in China (because of their lack of clarity) and Korea (due to difficulties related to their implementation).

However, some authors argue that complaints presented at the WTO regarding the labeling of GMOs are unlikely to be successful. According to Caswell (2000b), if the complaint is filed with the SPS, the respondent country could argue that labeling is necessary in view of the lack of evidence on GMOs safety. In turn, a *fall back position* would be provided by the TBT, whereby it would only be necessary to demonstrate that labeling is a cost effective method used for a specific and legitimate purpose: to ensure consumers' right to be informed. Even if, so far, the WTO Dispute Settlement Body (DSB) has limited, in certain cases, the discretional use of the precautionary approach, it is not certain that it will hold the same stance in the case of GMOs, given the pressure that some important governments and different social players are exerting on this issue.

iii) The economic impact of labeling

A key aspect of the labeling issue is related to its impact on costs and pricing in food markets. On the one hand, according to Ablin and Paz (2001), labeling should lead to differential pricing between GM varieties and conventional ones —in current market conditions, the former would sell at lower prices than the latter. Interestingly so, the same authors found out that after one year trading at the futures market in Tokyo, prices for GM and conventional soybean had not shown a significant difference so as to compensate for the lower production costs of GM varieties. Much less for producers to be able to bear the expenses involved in the introduction of a preserved identity system to benefit from the non GM market (the premium in favor of conventional soybean had reached a maximum of 12.6 per cent in August 2000, only to fall to 6 per cent in April 2001). Meanwhile, recent news reports informed that in the U.S. Mid Western region, price premiums for non GM corn and soybean varieties range from 3 per cent to 4 per cent, far from the figures that would be necessary in order for farmers to stop growing GMOs.

In fact, one of the consequences of labeling, is the need to develop the so-called "traceability" or "preserved identity" systems to allow for raw materials and inputs used in food products to be sorted out throughout the production and commercial chain (including the stages of harvest, storage, transportation, processing and commercialization) based on whether they include genetically modified elements or not.

Obviously, this would bring higher costs (called "segregation costs"). Ablin and Paz (2001) show different estimations of this situation in countries such as the U.S., Italy, Great Britain and Brazil, where the incidence of segregation costs on the price of conventional products shows significant variation —from 6 per cent to 50 per cent depending on the type of product. Research work commissioned to the consulting firm KPMG by the Australia-New Zealand Food Authority (ANZFA), points out that the cost of the labeling system, as proposed in those countries, was an estimated 6 per cent of sales for its first year of implementation, and of 3 per cent for the following years (ANZFA, 1999). A study carried out in Canada showed that compulsory labeling of transgenic products would trigger a 10 per cent increase in the prices for the general public and a 35-40 per cent increase in production costs (Golder, 2000). In turn, a recent report shows the estimations of different surveys carried out in Canada, Europe and the U.S., where labeling costs represent 0.6 per cent to 5 per cent of the price of the product that reaches the primary producer (Pew Initiative on Food and Biotechnology, 2002).The significant variation found in these estimations may be due to different factors, such as the type of product studied, the stipulated labeling requirements, the methodology that was used, etc..

Another study by Maltsbarger and Kalaitzandonakes (2000) explores the "hidden costs"[35] in the grain segregation process. They stress that such costs will be highly influenced by specific regional configurations of the production chain, which begins with the farmer and continues with the logistic, transportation, processing and commercialization systems. This fact makes it difficult to develop valid general estimations. At the same time, based on simulation models, they point out that segregation costs are highly sensitive to the specific requirements of each labeling system. Also, there is a tendency for these costs to increase in a non-lineal manner until they become "prohibitive", while the allowed threshold of tolerance for not labeling decreases.

Beyond the real cost of the segregation process —which is more certain to vary depending on the type of product, the availability of infrastructure, etc.— the critical issue is who will bear this incremental costs. According to Galperin *et al* (1999), a distinction should be made between the two generations of GMOs already mentioned. Concerning current

[35] For example, costs resulting from the under-use of the capacity of crop-lifters due to the need to keep GMO crops separated from conventional ones.

transgenic products, such a cost may be borne by the final consumer through a price premium for non-transgenic products. It may also happen that GMO prices be reduced as compared to the price of the other grains. In this case, producers would find that profits resulting from higher productivity and lower costs related to first generation seeds would be reduced. As stated above, this is already happening, although not to such an extent as to provoke a significant change in the intention of producers to grow GMOs.

As for improved transgenics ("second generation"), it is most likely that they reach higher prices than their conventional counterparts. In this case, always according to Galperin *et al* (1999), farmers will face an additional problem, since they will produce goods, which will no longer be considered commodities, and so they will have to face a reduced demand and less distribution alternatives. Such disadvantages will be compensated by a reduced competition and less dependency on the evolution of the harvests of other producers. It is likely that the expansion of second generation GMOs will lead to a growth of contractual agricultural mechanisms and other systems that may guarantee the predictability of transactions for farmers and the industrial and commercial sectors.

c) Intellectual property rights in biotechnology

Over the last two decades, the debate on the regulation of intellectual property rights has intensified. This trend is due to the fact that developed countries, and particularly the U.S., have been demanding a strengthening of such rights at the international level. This has been reflected, for example, in the signature of the TRIPS Agreement (Trade-Related Aspects of Intellectual Property Rights) within the framework of the Uruguay Round of the GATT. The advent of genetic engineering has added a new conflicting dimension to these debates, as fears arise regarding, for example, the scope that patenting living beings might have, or the private appropriation of natural products which traditionally have been grown by indigenous communities in developing countries.

The TRIP Agreement allows for signatory countries to exclude plants and animals from the patent system due to reasons founded in the protection of human life, the environment, etc.. However, intellectual property rights on plant varieties must be protected either by patents or by any other *"sui generis"* system. On the other hand, microorganisms must be protected by the patent system (Cosby, 1996). However, the interpretation of what was agreed upon in the TRIPS Agreement, particularly of definitions such as "microorganisms", "biological processes", etc., are subject to debate. Therefore, it is expected that the interpretation of rules and, consequently, the scope of protection of intellectual property rights these rules provide, will become clearer during the process of implementation of the Agreement.

Meanwhile, as Cosbey points out, a *"sui generis"* protection system already exists at international level, which is based on the rules provided by the International Union for the Protection of New Plant Varieties (UPOV) —although the TRIPS Agreement does not specifically mention the UPOV. Since 1961, the UPOV provides a framework of guidelines to ensure the protection of plant breeders whenever a new variety is developed. Today, some countries —Argentina among them— adhere to the UPOV Act of 1978, whereas other countries have already ratified the 1991 Act.

Both Acts state minimal rights to be granted to plant breeders. In order to be protected, a plant variety must be considered different from any other known variety; it must also be homogeneous or uniform, distinct and stable. Under the 1978 Act, the protection period was of 15 years, the 1991 Act extended it to 20 years.

There are, however, some exceptions to the "breeder's rights". On the one hand, farmers may keep seeds obtained in harvest for their own use —not for commercial use— without paying again the corresponding royalties to the breeder (this is called "*farmers privilege*") —the 1991 Act leaves to national authorities the decision whether to grant this exception or not. In turn, the *"breeders' exemption"* allows for a third party to carry out research on varieties previously protected.

In this sense, a basic difference between both UPOV acts is that the 1991 version introduces the concept of "essentially derived variety". It is considered that a variety is essentially derived from another when main genetic features of the new variety are equal to those belonging to a previous variety, which is called "initial variety". In this case, the breeder of the new variety may obtain propriety rights over the new variety, but such rights are also granted to the breeder of the initial variety. The introduction of this modification is aimed at protecting existing plant varieties, since under the 1978 Act it was possible that, through genetic engineering, a company could become the owner of all existing plant varieties of a certain crop by introducing a new gene into them (Gutiérrez, 1998).

What happens at the same time with the patenting system in the field of agricultural biotechnology? Following the 1980 U.S. Supreme Court decision in the Diamond vs. Chakrabarti case, patenting of living organisms was allowed for the first time —in this case a genetically modified bacterium. Further on, patents on substances extracted from nature and sub-cellular particles such as genes, etc. were authorized. As from 1986, and always in the U.S., patenting of more complex organisms, such as transgenic plants and animals, was also accepted. In this context, it comes as no surprise that the number of biotechnology-related patents has increased significantly since then (Correa, 1998). An important step confirming this trend was taken recently when, in December 2001, the U.S. Supreme Court ratified the validity of patents granted on new plants developed through genetic engineering or other kinds of biotechnology.

Although patents on agricultural biotechnology are also recognized in Europe, Japan, and other countries, in the U.S. these have long been the favorite tool of seed companies. This is due to the fact that the legal framework is more favorable and because the traditional protection system is deemed slow and, at the same time, grants strong exemption rights for both farmers and breeders (patents do not recognize the *"farmers privilege"* and strongly limit the scope of the *"breeders' exemption")* —PIP Workshop Report (2000). Meanwhile, European laws have not accepted yet the patenting of specific plant varieties —although they do accept biotechnological inventions applied to plants and animals. At the same time, it is worth mentioning that only four countries have adopted the last Ruling on the issue established at the European Union in1998.

CHAPTER III

ARGENTINE ECONOMY AND AGRICULTURE IN THE 1990s

Introduction

After a decade of production stagnation and macroeconomic instability, also referred to as the “lost” decade”, Argentina entered, during the 1990s, a period of price stabilization and economic growth. Even when price stability was maintained throughout this decade, economic growth failed to keep up with the high records of 1991-94 (8.7 per cent), and in 1995-2000 it merely amounted to 1.8 per cent (Table III-1). The GDP per capita increased throughout this period, reaching nearly US$9,000 in 1998, only to fall to US$7,800 in 2000.

At the end of 1998, Argentine economy entered a recessive phase which led to the present crisis. In 2001, the GDP dropped by 4.4 per cent, and it is estimated that this year the reduction of the GDP will be above 11 per cent. However, a renewed growth of the economy is expected for next year.

Price stabilization was achieved through the “Convertibility Plan”, adopted in April 1991, which rested on the legal guarantee that international reserves held by the Central Bank backed the total monetary base in pesos at a fixed exchange rate of one dollar per peso.

Although a dramatic reduction of inflation followed, the much sought-after convergence between domestic and international inflation took some time to materialize, thus leading to a fall in the real exchange rate —despite the fact that the initial parity could not be considered low in historic terms. Much as there was price deflation between 1999 and 2001, the appreciation of the dollar against the euro as well as the Asiatic and Brazilian devaluations significantly contributed to the erosion of the price-competitiveness equation/ratio in Argentine production at the said three-year period.

The combination of macroeconomic stabilization and the adoption of thorough structural reforms facilitated the success of the economic program between 1991 and 1994. During those years, the gross domestic fixed investment showed a cumulative increase of 120 per cent. Meanwhile, fiscal accounts revealed a positive trend as a result of a substantial growth in revenues, deriving from a higher level of activity as well as stringent anti-evasion measures.

Despite these results, there were already some signs that raised doubts as to the viability of the program. Until that moment, the success of the plan had been mostly based on two circumstances which could not be sustained indefinitely: the availability of special resources through the sale of public assets, and favorable external conditions in terms of credit costs and availability —which translated into a significant voluntary flow of foreign capitals over the 1991-1994 period. From the point of view of opponents to the economic program, these two facts accounted for the continuity of the said program despite some unresolved problems essential to any growth strategy, namely: low domestic savings rate, difficulty in closing the fiscal gap, and large cumulative balance of payments deficits (resulting from trade balance deficit, caused in turn by the joint effect of the delayed exchange rate, the commercial opening, and the local economic reactivation).

Exports grew very slowly, in opposition to the strong dynamism of imports. Despite its recovery, investment was still at a lower point, in terms of percentage of the GDP, than that of the 1970s. These rates were also lower than those needed in order to guarantee a sustainable long term growth of the economy.

Table III-1 Global supply and demand - Growth rates
In percentage, estimated according to prices as of 1993

	GDP at market prices	Imports	Consumption	Gross domestic investment	Exports
1990	-2.3	-1.9	-1.3	-17.2	18.0
1991	11.8	80.1	13.7	29.4	-3.6
1992	11.0	65.7	12.6	29.2	-1.0
1993	6.4	14.9	5.8	14.3	4.7
1994	5.8	21.1	5.0	13.7	15.1
1995	-2.8	-10.0	-3.6	-13.1	22.6
1996	5.5	17.4	5.9	8.9	7.8
1997	8.1	26.6	7.9	17.7	12.0
1998	3.9	8.4	3.1	6.6	10.1
1999	-3.4	-11.3	-1.3	-12.6	-1.3
2000	-0.8	-0.2	-0.5	-6.8	2.7
2001	-4.4	-13.9	-5.2	-15.7	2.7
Cumulative annual growth rates					
1976-1981	1.3	22.0	2.4	0.3	6.0
1982-1990	-0.9	-7.9	-0.6	-6.9	5.1
1991-2000	5.1	23.6	5.4	9.7	7.7
1991-1994	8.7	42.7	9.2	21.4	3.6
1995-2000	2.1	6.2	2.4	1.8	5.1

Source: prepared by the authors based on data provided by the Ministerio de Economía - Argentina
http://www.mecon.gov.ar

When, at the end of 1994, the so-called “Tequila effect” broke loose, the Argentine economy was strongly affected, even more so considering the existing domestic difficulties. The flow of foreign capitals decreased dramatically, interest rates increased rapidly, there was a strong withdrawal of bank deposits —which caused difficulties for many financial institutions—, and the economy entered a recessive phase. The GDP fell by 2.8 per cent during1995 (Table III-1).

The two main negative consequences of the recession were the dramatic slump in fiscal revenue and the considerable increase of unemployment rates (unemployment rose to over 18 per cent in early 1995). Although this last problem improved slightly over the following years, it has now become the Achilles' heel of the Argentine economy and society (Table III-2).

Table III-2 Social indicators - 1991-2002

	Total unemployment - Urban areas	Total unemployment - Greater Buenos Aires area	POVERTY Greater Buenos Aires	POPULATION BELOW POVERTY LINE Greater Buenos Aires
1991	6.9	6.3	28.9	5.1
1992	6.9	6.6	19.3	3.3
1993	9.9	10.6	17.7	3.6
1994	10.7	11.1	16.1	3.3
1995	18.4	20.2	22.2	5.7
1996	17.1	18.0	26.7	6.9
1997	16.1	17.0	26.3	5.7
1998	13.2	14.0	24.3	5.3
1999	14.5	15.6	27.1	7.6
2000	15.4	16.0	29.7	7.5
2001	16.4	17.2	32.7	10.3
2002	21.4	22.0	49.7	22.7

Source: INDEC (Instituto Nacional de Estadísticas y Censos), Argentina - http://www.indec.mecon.gov.ar

The rise of unemployment can be attributed to different causes. Such causes were related to the process of structural reforms, which included the reduction of the state apparatus and the privatization of state-owned companies; the closing down or downsizing of local firms, who were unable to face fiercer competition derived from the opening up of trade; and the relative fall in the price of capital goods.

In any case, the persistence of high unemployment rates and the increase of poverty and indigence rates (which according to Table III-2, reach record levels) as well as the worsening of income distribution, represent the most negative legacy from the economic policy applied in the 1990s.

Although following the Tequila crisis the local economy showed a strong growth, from 1996 to 1998 —with investment and exports as the growth "engines" (Table III-2)—, the persistence of fiscal problems and the growing level of indebtedness of the public sector, as well as the continued dependency on international financial markets to finance current account deficits, were still weak points in the macroeconomic scheme.

All of these problems worsened in late 2001 as a consequence of the unfavorable international context, which was caused by the economic recession in industrialized countries. This resulted in a massive bank run (which was not stopped in time by freezing all deposits), the increase of social unrest, and the resignation of the acting president.

In December 2001, the new administration declared the default of the Argentinean foreign debt (amounting to US$135 billion). In early 2002 a new president and a new economic team abandoned the convertibility system and thus the peso was substantially devalued, all this amidst a deep financial crisis, which worsened the economic, political and social situation of the country.

a) Structural reforms

The 1990s witnessed a deepening of the structural reform program, which had begun in the late 1880s. As far as commercial policy was concerned, the process of reduction of commercial restrictions was completed, until these finally disappeared in early 1991.

Simultaneously, tariff levels were reduced at successive instances; from an average tariff of nearly 30 per cent, in October of 1988, to 18 per cent in January of 1991. Furthermore, nearly all taxes and withholdings on exports were eliminated, an issue of particular relevance for the farming sector. Due to the high speed and wide scope of its implementation, this process was very drastic. It also lacked policies to help support the adaptation of local manufacturing companies, which, after years of strong protectionism, were forced to face foreign competition.

The commercial opening-up was of special impact for the capital goods sector. Back in 1993, a zero tariff was set for the import of such goods (whether locally produced or not). At the same time, a 15 per cent refund was set for national manufacturers, so that they might apply a discount on the selling price of their goods at the local market. In 1995, as a result of MERCOSUR negotiations, the tariff on capital goods increased, and in 1996 it reached 14 per cent, although exemptions were applied on goods, which were not produced locally.

In turn, integration agreements with Brazil, which had originated in 1986 with the signature of the Program for the Economic Integration and Cooperation (PICE), were redefined. On the one hand, they were extended to Paraguay and Uruguay, thus creating the MERCOSUR (Southern Cone Common Market). On the other hand, there was a general and automatic lowering of duties, which, starting with a minimal preferential rate of 50 per cent for trade within the region, would exempt it completely by late1994. In that same year, the four partners were expected to unify their foreign trade policy and form a Customs Union.

A massive privatization program was also undertaken, which began in 1989/1990 with the sale of the national telephone company (ENTEL), the national airline (Aerolíneas Argentinas), oil-producing areas, mass communication media, railways, and road maintenance (toll concessions). It was later extended to other areas, such as electricity, natural gas, and drinking water services. State owned steel manufacturing companies and petrochemical industries were also privatized. Simultaneously, licenses for the exploration and exploitation of mines and oil and gas fields were granted without compromising state ownership. Finally, the domestic and foreign commercialization of crude oil and other fuels was deregulated.

Legislation on direct foreign investment (IED), already broadly liberalized since 1976, was amended in 1989 with the objective of eliminating regulations still in force. At the same time, the State reform law authorized the in-flow of foreign capital in the privatization program for sanitary, electricity, gas, telecommunication and postal services.

In 1995 previous legislation on invention patents was amended, following the guidelines established in the TRIP Agreement within the GATT's Uruguay Round. The new law that came into effect in 2000 increased the protection period from 15 to 17 years, introduced patenting for pharmaceutical products, and eliminated compulsory licenses.

The structural reform program was completed with the deregulation of different markets involving goods and services, and by introducing more flexibility in labor relations.

As part of the deregulation process of the farming sector, different entities (such as the National Grains and Meats Board and the National Forestry Institute) were suppressed. Land, river and sea cargo transportation was deregulated and quotas for international transportation between Argentina and Chile and between Argentina and Brazil were eliminated.

As to ports and water transportation, existing private ports were authorized, state-owned ports were privatized and new private ports were set up. Also port grain lifters formerly owned by the National Grains Board, were privatized.

Meanwhile, sector policies were nearly fully abandoned, except for those applied in the automotive sector, and the less significant, but still relevant, sectors of mining and forestry; all of which enjoy tax stability and exemptions.

Although some measures aimed at increasing the tariff protection level were taken throughout the decade, alternative protection mechanisms (such as antidumping, safeguards, etc.) were more actively used, mainly in response to the pressure exerted by certain sectors and due to the accumulation of significant trade deficits. Commitments made under the MERCOSUR were only partially honored (an "imperfect" Customs Union was achieved). It is clear that the reforms had a radical impact on the workings of domestic economy, as compared to what had happened during previous years.

The restructuring of the economy had a different impact on each sector. The most significant aspect was the decrease of the relevance of the manufacturing industry, as far as product structure is concerned, in favor of the service sector. In the 1990s, the growth of the industrial and primary sectors was below the average of the economy; whereas, electricity, gas and water, and construction grew above this average; and the service sector was in tune with the average dynamics of the GDP.

b) Changes in Argentine foreign trade

The reforms of the 1990s gave rise to a growth of both exports and, more significantly, imports (Table III-1). Thus, following 10 years of trade surplus, 1992 was marked by a deficit situation, which would only be reversed during the 1995-1996 decade, as a consequence of the recession caused by the "Tequila" crisis. The 2000-2001 period was also marked by trade surpluses resulting from the significant drop of imports.

The main factors behind the trade deficit during most of the 90s were the following (each one of them had a different relative incidence at different moments in time): a) the growth of the domestic activity level; b) the greater opening-up of trade; c) the appreciation of the real exchange rate; and d) the deterioration of trade terms and conditions. In turn, the persistence of the deficit also shows a structural problem regarding the competitiveness of the economy, particularly of its industrial sector, and derived from microeconomic, macroeconomic, and institutional causes. Anyway, despite these increases, exports and imports represented a reduced percentage in relation to domestic GDP (11.3 and 12.5 in 1996 and 2000, respectively).

Exports grew during the 1990s, and there was a trend towards an increase of manufactured content of the exporting basket. Farming manufactures (MOA) and industrial manufactures (MOI) increased from little more than 50 per cent of total exports, during the years 1980 to 1985, to nearly 65 per cent, from 1996 to 1998.

The geographic pattern of foreign trade was also redefined in the 1990s. This redefinition was the result of the MERCOSUR agreements, which led to a high increase in the percentage of Argentine exports to the MERCOSUR countries (34 per cent in 1995-99), and less exports to the European Union and countries outside the most important trade blocks. There was a great concentration of MOI exports (industrial manufactures) in the MERCOSUR, whereas around 90 per cent of sales to the European Union involved primary products and MOA (farming products).

There was also a significant change regarding the composition of imports. Imports of capital goods as well as parts and accessories for these goods increased to account for nearly half of total imports in 1999.

As far as the origin of imports, an increase in the importance of the MERCOSUR was also observed, although of minor relative magnitude as compared to exports. The European Union was the main supplying block and the U.S., followed by Brazil, was the main sources of imports.

c) Investment in science and technology

In the 1990s there was a substantial increase in imports of capital goods and direct foreign investment flows, as well as payments made to foreign countries for licenses, use of patents and trade marks, etc. At the same time, applications for invention patents by non-residents increased from around 2,500 a year, at the beginning of the decade, to over 6,000, towards the end of the period. In contrast, patent applications by residents did not increase at all.

The country's expenditure in scientific and technological activities also increased during the decade under review. As a percentage of the GDP, it increased from 0.33 per cent in the early years of the decade, to 0.54 per cent in 1999. During that year, investments in R&D represented 0.47 per cent of the GDP.

However, the effort made by Argentina in this field was not only inferior to that made by industrialized countries, but also as compared with neighboring countries, such as Brazil and Chile.

Within expenditures in science and technology, there was an increase in the relative weight of investment by the private sector. Still, government continued to be the main spender and source of financing in this area, although its overall participation decreased. Universities kept their share of the total expenditure.

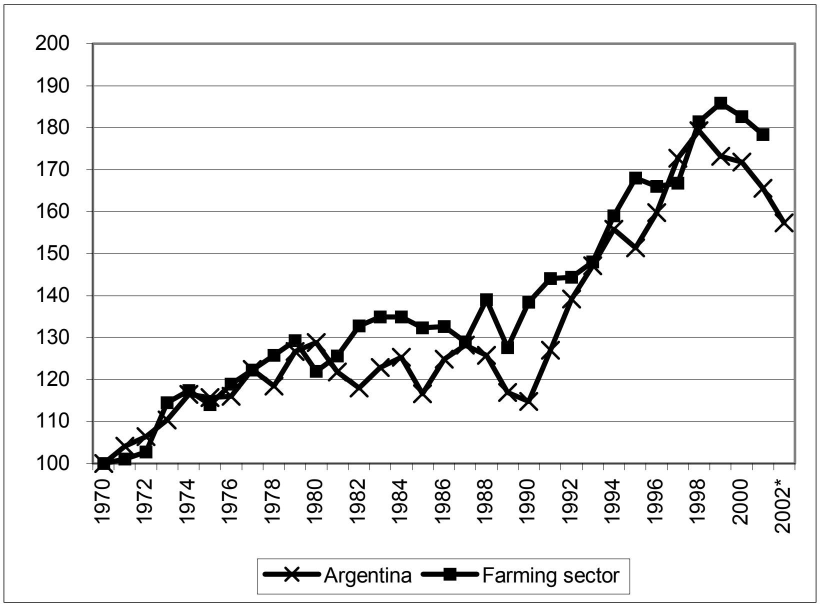
The relative weight of agriculture as the beneficiary of the spending in science and technology decreased from around 15 per cent, in the early 1990s, to only 10.6 per cent, in 1999. A greater consideration of environmental issues (health excluded) as a social and economic goal (amounting to 5.6 per cent in 1999) was observed.

The current institutional situation of the scientific and technological system of the farming and agro-business sector is disadvantageous. Allocated resources are scarce, either in absolute terms or in comparison to those of other countries. Recent estimations indicate that the country invests from 0.4 per cent to 0.5 per cent of the farming and agro-business GDP in these areas, whereas Australia and New Zealand invest around 3.0 per cent and Chile and Brazil around 0.8-0.9 per cent. The participation of the private sector in R&D is small, and represents only 15 per cent of total spending. However, along with technology companies, it currently represents the most important source of appropriable technologies and the main link with current available international technology.

d) Performance of the agricultural sector

The farming and agro-business sector currently accounts for 30 per cent of the goods component of the Gross Domestic Product. Furthermore, since 1990, and due to conditions triggered by macroeconomic reforms, it has proved to be one of the most dynamic sectors of the economy and has showed a steady positive growth rate since then; even in 1995 when the national product was reduced by 4.5 per cent (see Figure III-1).

Figure III-1 Development of the Argentine GDP and Added Value for the agricultural sector (1970/2000) Physical Volume Rate – Base 1970=100

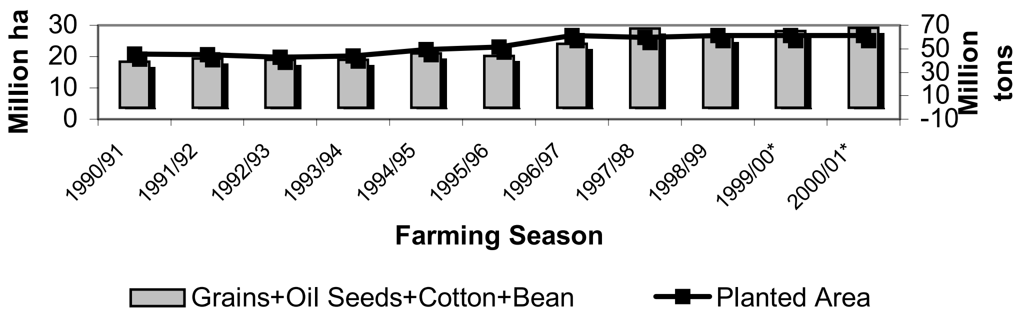


Source: Prepared by the authors based on data supplied by the Ministerio de Economía - Argentina http://www.mecon.gov.ar, and the INDEC (Instituto Nacional de Estadísticas y Censos), Argentina - http://www.indec.mecon.gov.ar

The development of the sector during the 1990s showed an outstanding increase in primary production, such increase ranged from 26 million tons of grains and oilseeds in 1988/89, to over 67 million in 2000/2001 (see Figure III-2). This resulted in a significant increase of grain and oil exports (see Figure III-3) and an accelerated process of transformation and readjustment of the agro-food sector: from 1990 to 1998 the total number of mergers and acquisitions of companies amounted to 10 billion dollars (this figure does not include investments in the primary producing sector). 1995 was the year of more activity, with 75 completed transactions. Most of these transactions involved companies dealing with the production of inputs and the processing and distribution of foods[36].

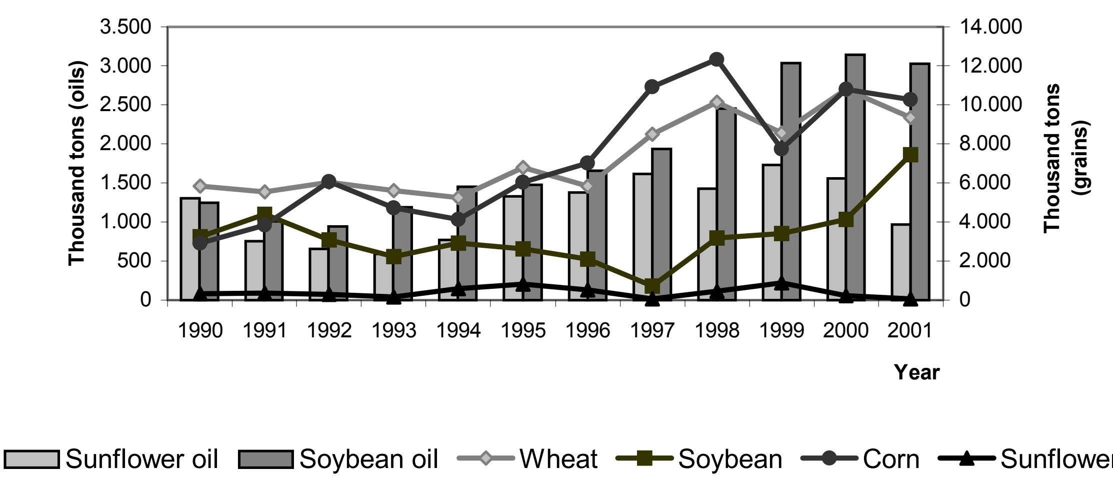
[36] Source: RABOBANK

Figure III-2 Argentina: evolution of production and planting areas



Source: Prepared by the authors. Based on data supplied by the Secretaría de Agricultura, Ganadería, Pesca y Alimentación, (SAGPyA), Argentina - http://www.sagpya.mecon.gov.ar

Figure III-3 Argentina: evolution of grain and oilseed exports



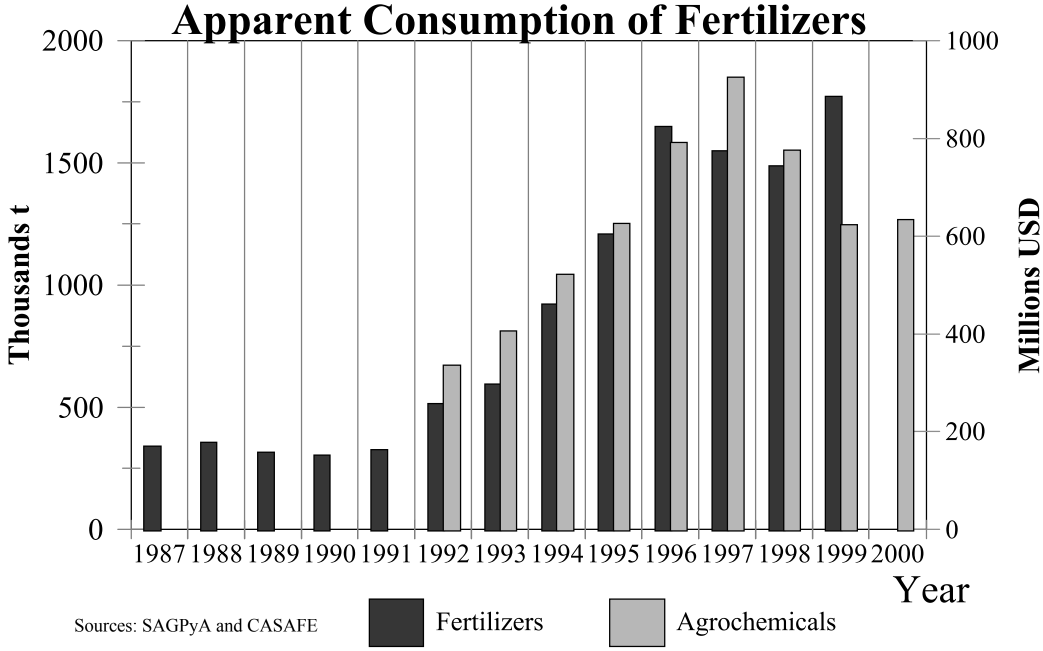
Source: Prepared by the authors. Based on data supplied by the Secretaría de Agricultura, Ganadería, Pesca y Alimentación, (SAGPyA), Argentina - http://www.sagpya.mecon.gov.ar

This transformation, which was simultaneous with the change in the approach towards macroeconomic policies of 1990, comprised every aspect, although grains and oilseeds (corn, wheat, soybean and sunflower), and the Pampas were, undoubtedly, its emblematic sectors[37]. This process was the result of the combination of two very distinct factors

[37] Rice, cotton and other cereals and regional products have shown significant increase in production and productivity, but not as significant as in the case of grains and oilseeds.

related to microeconomic —relative prices of commodities— and technological variables. These factors are: a relatively important expansion of the planted area, at the expense of livestock; and the increase in physical productivity per area unit (yield), resulting from the introduction of new technologies. In fact, a third factor concerning the 1997/98 season, which did not depend on farmers' decisions, should be added: the abundant rains associated with the "*El Niño*" phenomenon.

Figure III-4
Argentina: Sales of Agrochemicals and Apparent Consumption of Fertilizers



Source: Prepared by the authors based on data supplied by the Secretaría de Agricultura, Ganadería, Pesca y Alimentación, (SAGPyA) and the Cámara de Sanidad Agropecuaria y Fertilizantes (CASAFE) - http://www.sagpya.mecon.gov.ar and http://www.casafe.org.

The process of technological change, involves the intensification in the use of capital goods, fertilizers, agrochemicals (herbicides and pesticides) and machinery (Figure III-4), as well as a significant change in the composition of genetic inputs, i.e. the introduction of transgenic crops.

Table III-3 Transgenic events approved for their commercialization in Argentina until December 2001

Species	Introduced Feature	Transformation Event	Applicant	Resolution
Soybean	Tolerance to Glyphosate	"40-3-2"	Nidera S. A.	SAPyA N° 167 (3-25-96)
Corn	Resistance to Lepidoptera	"176"	Ciba-Geigy	SAPyA N° 19 (1-16-98).
Corn	Tolerance to Ammonium-Glyphosate	"T25"	AgrEvo S. A.	SAGPyA N° 372 (6-23-98)
Cotton	Resistance to Lepidoptera	"MON 531"	Monsanto Argentina S.A.I.C.	SAGPyA N°428 (7-16-98).
Corn	Resistance to Lepidoptera	"MON 810"	Monsanto Argentina S.A.I.C.	SAGPyA N° 429 (7-16-98)
Cotton	Tolerance to Glyphosate	"MON 1445"	Monsanto Argentina S.A.I.C.	SAGPyA N° 32 (4-25-01).
Corn	Resistance to Lepidoptera	"Bt 11"	Novartis Agrosem S.A.	SAGPyA N° 392 (7-27-01).

Source: Comisión Nacional Asesora de Biotecnología Agropecuaria (CONABIA) http://www.sagpya.mecon.gov.ar/0-0/index/programas/conabia

The first transgenic crop commercially released into the Argentine market, in 1996, was soybean tolerant to glyphosate herbicide. Later, transgenic varieties of corn and cotton tolerant to herbicides and resistant to insects have been approved (see Table III-3). Since its release date, the expansion of glyphosate-tolerant soybean has increased considerably, even more than in the U.S., the first country to introduce this kind of crops. The area planted with herbicide-tolerant soybean increased from less than 1 per cent of the total area planted with soybean, in the 1996/97 season, to more than 90 per cent (around 9 million hectares) in the 2000/01 season (Table III-4). The adoption of lepidoptera-resistant corn has also been of significance, but with lower values than those observed for soybean; accounting for 20 per cent of the total cultivated area during the last farming season (third year since its introduction). Glyphosate-tolerant soybean already accounted for 50 per cent of the area planted with soybean within three years of its introduction. The adoption of Bt cotton has, in turn, been very limited, accounting for only 7-8.5 per cent of the total planted area. Today, Argentina is the second largest country, after the U.S., in terms of farming area planted with transgenic crops (James, 2001). This situations is mainly a consequence of the remarkable expansion of glyphosate-tolerant soybean.

Table III-4 Adoption of transgenic varieties in Argentina and the U.S. (Percentage out of the total cultivated area)

CROP	2000		2001	
	USA(1)	**ARG(2)**	USA(1)	**ARG(3)**
RR SOYBEAN	54.0	**80.0**	68.0	**90.0**
Bt COTTON	15.0	**2.7**	13.0	**7-8.5**
Bt CORN	18.0	**6.0**	18.0	**20**

(1) Source: Agricultural Statistics Board. NASS. USDA. June, 2001.
(2) Source: Asociación de Semilleros Argentinos. ASA. - http://www.asa.org.ar
(3) Source: Asociación de Semilleros Argentinos. ASA. - http://www.asa.org.ar

Changes in production trends described above seem to indicate that the readjustment of macroeconomic policies in force until 1990 meant a true turning point for the production performance of the sector, mainly concerning grains and oilseeds. It also promoted a new production strategy in which technological inputs are used intensively.

This process was triggered by a substantial change in the expectations of the economic players (both within and outside the sector). On one hand, agriculture and its related value chains would no longer be discriminated against in favor of other economic sectors and, on the other hand, the opportunities that had previously resulted from inflation and distorsive economic policies (such as differential exchange rates, for example),were also significantly reduced. The elimination of withholdings on agricultural exports, often mentioned as one of the key discriminatory instruments, would have hardly been enough by itself to jump start such a significant transformation process.. The isolated effect of such measure would have been comparable to an equivalent increase of international prices for products of the sector; something that had happened several times before with no major structural consequences whatsoever.

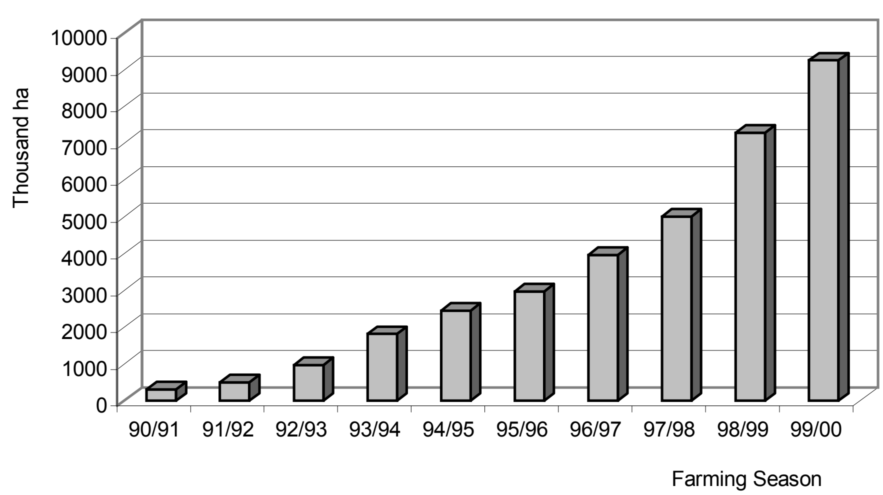
The importance of the above changes for the Argentine economy cannot be contested. The relative weight of the agri-food/agri-industrial sector, regarding both GDP goods and total exports, is of such significance that there is no room for discussion. However, in order to make a final evaluation, we should analyze the effect that this phenomenal change has had on the environment, and on the social actors linked to farming production. Regarding the former, the main question is if intensive practices have made Argentina lose its reputation as an “environment-friendly” producer, reputation which it enjoyed until recently as a consequence of its traditional production strategies. The second issue refers to the impact on income distribution and the appropriation of economic surpluses resulting from the transformation and, consequently, the impact these may have on the social fabric supporting Argentine farming production. We will refer to these issues in the following sections.

e) An environmentally "virtuous" intensification

Regarding the environmental impact that the huge increase of Argentine agricultural production over the last decade, the main issue to be considered is the fact that this expansion has taken place *pari pasu* with an equally outstanding increase of no-till (NT) practices, as the main farming management strategy of the Pampas crops[38].

As can be seen on Figure III-5, which represents the evolution of the area of no-till planting system, the use of this practice has increased from around 300,000 hectares in the period 1990/91 to over 9,000,000 hectares in the 2000/2001 season and it is projected to reach 11,000,000 million hectares in 2002/2003 (see Chapter V). The expansion of such practice was originated in a number of different but convergent factors.

Figure III-5 Evolution of NT planting area



Source: Prepared by the authors based on data supplied by the Asociación Argentina de Productores en Siembra Directa (AAPRESID) - http://www.aapresid.org.ar

The first factor, and probably the most relevant, is that in most major areas of the Pampas, the cumulative effect of soil erosion resulting from traditional tillage and "agriculturalization" practices was beginning to negatively affect operative results[39]. This effect on yields and,

[38] The no-till planting system consists basically in laying the seed in the ground at the required depth with a minimal disturbance of the soil structure. This is made through specially designed machinery which eliminates the need for plowing and minimizes the tillage required for planting a crop.

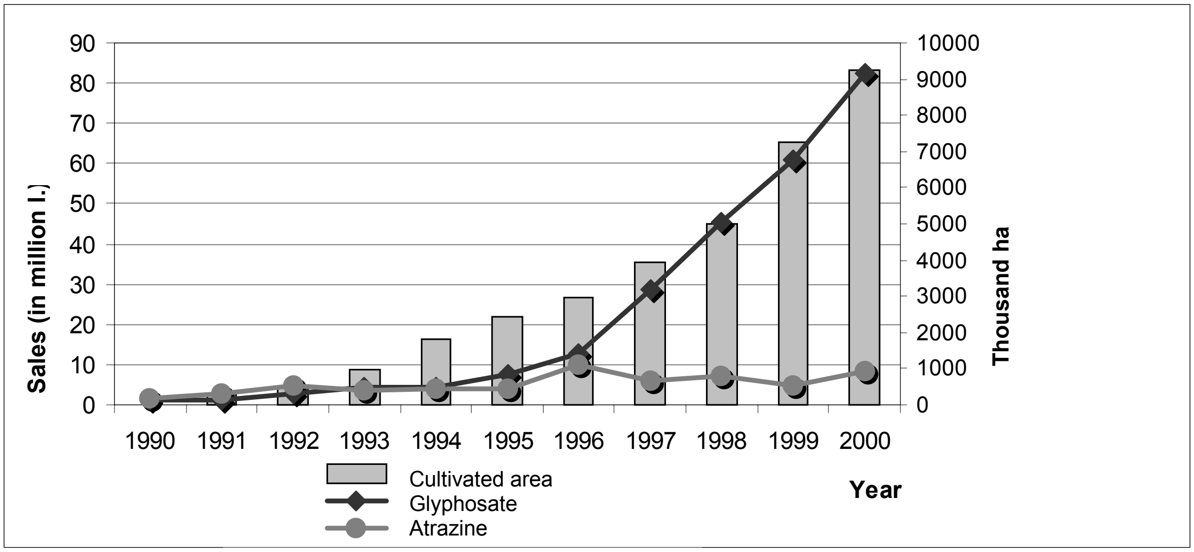
[39] "Agriculturization" can be defined as the permanent substitution for agriculture, in place of the farming-cattle-breeding rotation, which was the dominant production strategy used in Argentina until the mid 1970s.

therefore, on the economic feasibility of agriculture, interacted later with two other factors. The first of these factors was the great availability of farming machinery, which followed the reduction of tariffs on the import of capital goods. The second was the reduction of direct costs of tillage through the use of no-till planting practices.

The diffusion of the no-till planting system made it possible to recover part of the lost productivity. At the same time, it was an important reason for the expansion of production, as it encouraged the increase of the area planted with late planted soybean into new areas. This was a consequence of the reduction of the time required between wheat harvest and soybean planting, which allows for the successful use of short cycle soybean varieties. These two effects have, undoubtedly, been the main economic factors leading to changes in production techniques. But probably, the most important aspect of the widespread of no-till techniques, coupled with the introduction of transgenic soybean, is the “virtuous intensification” or “environment-friendly” nature it has bestowed upon the process of technological change.

The coupling of no-till planting techniques with herbicide-tolerant soybean combines two technological concepts: on the one hand, new mechanical technologies which modify the crop’s interaction with the soil; on the other hand, the utilization of general use, full range herbicides (with glyphosate in first place) which are environmentally neutral, due to their high effectiveness in controlling any kind of weed, and their lack of a residual effect. Both things imply a more intense use of inputs, which is usually described as a “hard” intensification. However, as can be seen in Figure III-6, this “hard” intensification is, at the same time, a “virtuous” one, because it has simultaneously lowered the consumption of atrazine, a herbicide with residual action and, therefore, of negative impact on the environment.

Figure III-6 Evolution of no-till techniques and composition of the type of herbicides used in Argentine agriculture

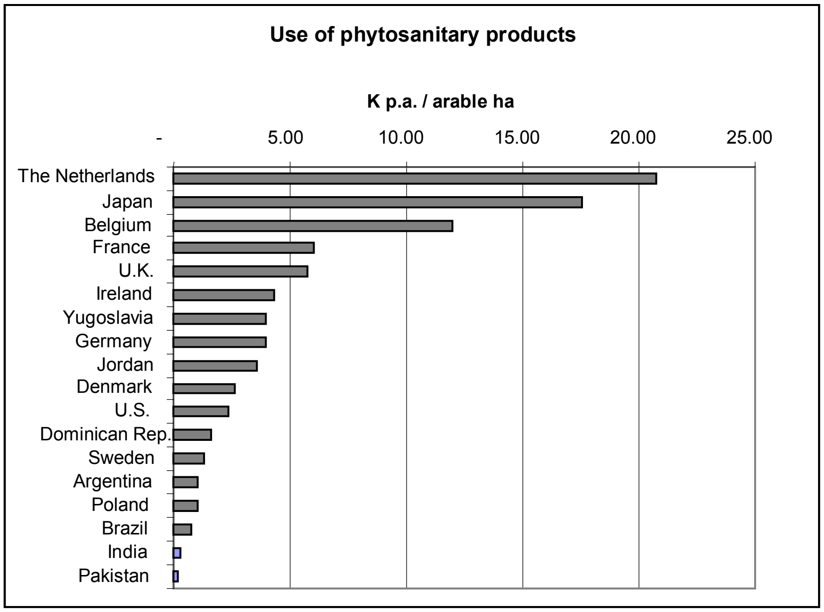


Source: Prepared by the authors based on data supplied by the Cámara de Sanidad Agropecuaria y Fertilizantes (CASAFE), and the Asociación Argentina de Productores en Siembra Directa (AAPRESID), Argentina - http://www.casafe.org and http://www.aapresid.org.ar.

Even after the increase in the use of agrochemicals during the period, the total use per hectare of arable land was still far below than that of other countries (See Figure III-7).

The virtuous nature of the process is reaffirmed when we consider that a significant part of the productivity gap of major crops may be bridged through the adoption of disincorporated technologies. These "soft" or knowledge intensive technologies are aimed at optimizing (in some cases through the reduction of application levels) the inputs used in productive processes (for example, integrated control of plagues, use of biocides or fertilizers in response to economic thresholds, etc.). The increase in the use of fertilizers recorded during the decade was still far below the intensity of use recorded in other countries; furthermore, it seems to have stabilized following the1996/97 season.

Figure III-7 Use of phytosanitary products in selected countries - Year 1998



Source: Instituto de Investigaciones Económico-Financieras y del Mercado de Capitales. Bolsa de Comercio de Córdoba - http://www.bolsadecordoba.com.ar. Based on data supplied by CASAFE, Cámara de Sanidad Agropecuaria y Fertilizantes - http://www.casafe.org

If we also consider the favorable externalities which are generated though the progressive recovery of soil fertility and other potential impacts —such as benefits on the greenhouse effect reaped from this type of practices, among others— there is no doubt that the overall environmental impact of these transformations has been a positive one[40].

f) Indicators of the social impact caused by productive transformations

A detailed review of specific impacts on the different social actors linked with agriculture is beyond the scope of this study. However, the development of certain variables may be highlighted when reviewing the situation of social players, *vis a vis* the rest of the economy and within the sector itself. In this sense, the evolution of price relations between the

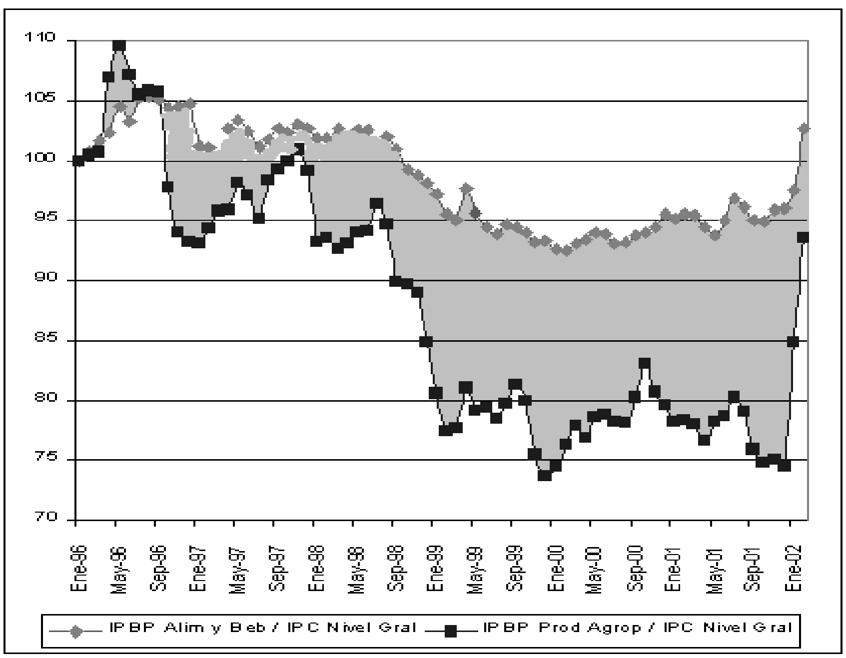
[40] Recent research carried out in the U.S. (Lal *et al*, 1998) suggests that conventional tillage methods hardly contribute to the release of greenhouse effect gases, particularly CO_2. According to these studies, as from the beginning of their farming activity, this method has cost planted areas in the U.S. as much as 5 billion metric tons of carbon equivalent (MMTC) (55 billion worldwide). However, the interesting question here lies in the capacity to capture carbon or mitigate the greenhouse effect (counterpart of carbon emission). Some research data (based on information mentioned at *Rescuing the Environment*, La Nación, Campo, October 24, 1998), indicate that no-till planting practices —as a replacement of traditional tillage methods— could capture up to 17 MMTC per one million ha.. As far as Argentina is concerned, the 11 million ha projected to be managed with the no-till system in 2002/2003 could capture up to 187 MMTC. In the future, this issue may become an asset for Argentina regarding the sale of carbon-capturing credits to other countries. Yet it is worth mentioning that, for the time being, the emission permits market that will come into come into effect during the 2008-2012 period only contemplates changes in land use resulting from forestry and re-forestry and not from other practices such as the no-till planting system.

sector and the rest of the economy, and the size and number of the exploitable area in this period, provide a hint on the trends as to the distribution of the resulting benefits of the process.

Vis a vis the other sectors of the economy, this sector shows a sustained reduction of the income, of production and farmers (as a percentage of the grand total); and a drop of primary production in the agro-industrial processing stage.

These trends become evident when we compare the evolution of the Producer Price Index for Agricultural Products, Food and Beverages with the General CPI for the second half of the 90's (Figure III-8). Both curves fall over the whole period, thus showing the worsening of the position of farming as compared to the rest of the economy. However, the fall of the curve representing farming products is much more abrupt, indicating also the deterioration of primary production as compared to other components of the agro-food chain.

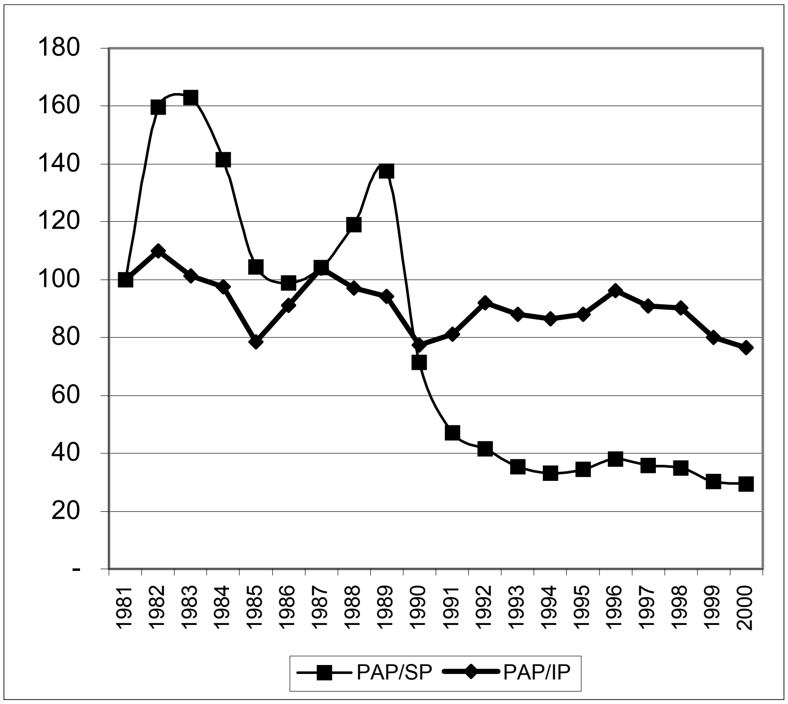
Figure III-8 Evolution of the relation between the Producer Price Index for Agricultural Products, Food and Beverages And the General Level of the CPI (Consumer Price Index) January 1996 = 100



Source: Prepared by the authors based on data provided by the INDEC (Instituto Nacional de Estadística y Censos), Argentina - http://www.indec.mecon.gov.ar

The intensity of this trend is confirmed through the analysis, for the same period, of the relation between prices for agricultural products from the Pampas, the prices of domestic industrial products, and the rates for public and private services, which shows a cumulative deterioration of around 60 per cent for primary prices (Figure III-9).

Figure III-9 Evolution of relative prices of agricultural products from the Pampas, domestic industrial products and services from 1980 to 2000
Base 1980=100



Source: Based on information supplied by the Comisión Económica para América Latina y el Caribe (CEPAL) - http://www.eclac.cl and the INDEC (Instituto Nacional de Estadística y Censos), Argentina - http://www.indec.mecon.gov.ar

Summing up, these price relations show that the production changes described above have taken place within a context of apparent deterioration of the terms of exchange between the sector and the rest of the economy[41].

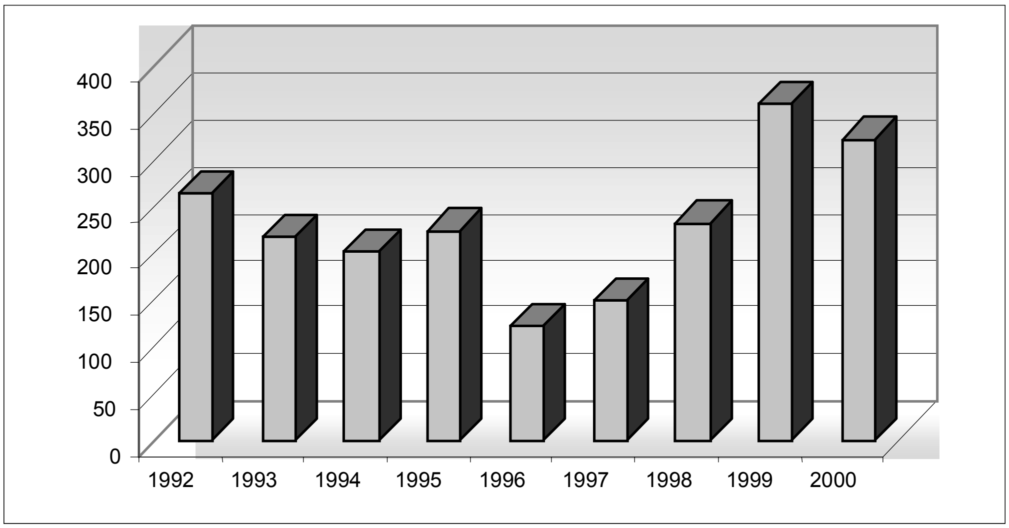
Profitability of farming production within the prevailing price-cost context as of 1991 was not unfeasible in itself. However, net income became lost ground in terms of its purchasing power, relative to the basket of goods and services available for consumers. Peretti (1998) points out that the fall of the purchasing power of the income of medium-sized producers from the chore area of the Pampas was of 49 per cent, when averages for the period 1982-1988 are compared to those for 1992-98. Lattuada (2000) states that if such analysis

[41] This comment must, however, be considered on technical and methodological grounds, particularly while analyzing its actual impact on the sector. It should also be taken into account that it refers to the nature of the products under comparison as well as the weightings applied. The farming products' basket has remained unaltered througout the 1990s, whereas other baskets (food and beverages, industrial products, and services) have suffered significant changes over the same period. Novel dairy products, breakfast cereals, tractors with GPS (Global Positioning System), mobile communications, cable and satelite television, electronic mail and banking, and the like did not exist or were not available in Argentina in 1990 and, consequently, price indexes for services and manufactured products may not be comparable over time with those of primary products.

were extended to the year 1999, and taking into consideration the average prices for that year, this reduction would dramatically increase to around 83.5 per cent.

The size of the economic unit measured in hectares (Figure III-10) increased gradually over the period, although not in a linear manner. This fact is likely to have been the consequence of the 1996-96 peak in international prices for grains and oilseeds, which helped mitigate the negative redistributive effects of domestic price ratios.

Figure III-10 Evolution of the economic unit measured in hectares (1992/2000)



Source: Data from Lattuada (2000) and Portsman (2000).

As there is no official census data on the evolution of farms, it is very hard to draw general conclusions as to the evolution of agricultural land concentrations in the Pampas. However, some trends may be anticipated from partial studies carried out in areas that may be considered representative[42]. All the available information indicates that there is a strong process towards concentration of the land. A study carried out by Mora & Araujo (Mora & Araujo, www.bolsadecereales.com.ar, 2000) shows that, between 1992 and 1999, the number of farms dropped from 170,000 to 116,000, i.e., a 32 per cent reduction. At the same time, there has been an increase in the median size of farms, from 243 to 357 hectares. The classification by size (small, medium and large) proposed by Pucciarelli (1997) takes into account a different set of parameters and is more precise than grouping them by area. When the analysis is done according to this classification, we find that, from 1993 to 1999, small farms decreased from 85 per cent to 69 per cent; medium ones increased from 9 per cent to 18 per cent, and large ones, from 6 per cent to 13 per cent. In

[42] Among these, (i) the Experimental Farming Census at Pergamino District (1999), and (ii) a survey designed with probabilistic methods, which has been carried out by the consulting firm Mora & Araujo for the past 10 years. This survey includes a sample of 800 cases that may be extrapolated to the general universe of farms in the Pampas.

the same manner, by 1999, the area accounted for by each group was: small farms, 28 per cent; medium farms, 23 per cent and large farms, 49 per cent[43]. This process is no different from what has taken place, and continues to take place, in most of the countries, which have an agro-export sector. For example, in the U.S., the average area of farms tripled to 448 acres (around 168 ha.)[44], over the period 1934-1994. Moreover, this process would have evolved much further had it not been for the protection provided by federal programs for intervention in the mechanisms of allocation of production factors for the farming activity (set asides, loan rates, deficiency payments, etc.). In this sense, a study carried out by the USDA Economic Research Service[45] reveals that 66 per cent of U.S. commercial farming producers are subsidized.

One last aspect worth highlighting with regard to the impact of the changes that took place in Argentine agriculture over the 1990s refers to the capability of the sector to create jobs. The technological path taken by Argentina in the early XX century meant following a laborsaving technological approach, through mechanization, tractorization and, over the last three decades, the increase of the average power of equipment, which has increasingly led towards scale economies. All this has translated, over the decades, into an important reduction in the number of direct jobs in the sector, which fell from 1.86 million in 1926 to 783,000 in 1993.[46] However, since that same year, the trend has significantly reverted (see Figure III-11) to reach 966,000 jobs in 1999 (latest available data). This positive difference of nearly 200,000 jobs is likely the result of the simultaneous processes of agriculturization and intensification of production previously mentioned. The introduction and rapid expansion of late-planted soybean (planted after the wheat harvest), has also played a substantial role. Concerning the 1999-2000 season, this practice implied a virtual increase of 3 million hectares of arable land, and thus, a significant amount of additional labor. The most remarkable aspect is that this increase in the employment level took place simultaneously with (i) an increase in partial productivity of labor in the primary sector of 3.26 per cent per year for the period 1990-97; (ii) an increase of almost five percentage points in the overall unemployment rate of the Argentina's economy. Thus, the technological package which led to a process of virtuous intensification, as far as the environment is concerned, seems to have had positive effects from a social perspective, at least in what concerns job creation.

---

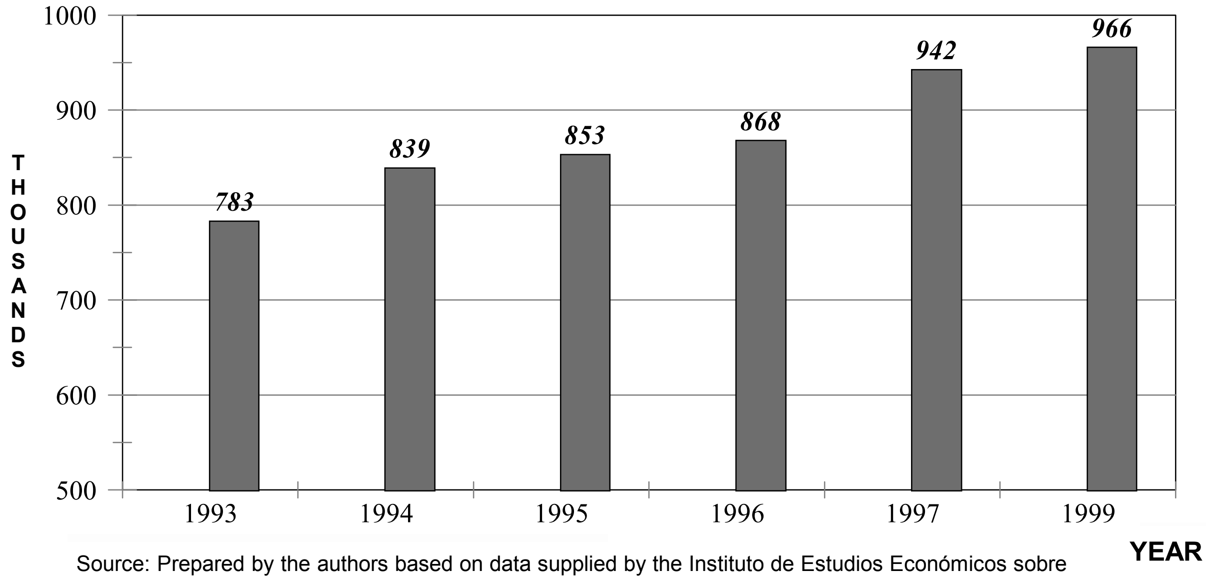
[43] Mora & Araujo's work uses the "farm" concept to refer to those production units under the same management and not necessarily the same ownership, since there has been a remarkable increase of farm renting.

[44] Economic Research Service, *Structural and Financial Characteristics of U.S. Farms*, 1994: 19th Annual Farm Report to Congress. AIB-735. August, 1997.

[45] Economic Research Service. *Op. Cit*.

[46] This reduction of nearly one million jobs had a negative aspect: the laying off of labor (socially undesirable effect), and a positive one as well: the amazing increase in productivity of workers, made possible by modern mechanical technologies, a fact which has enabled the sector to maintain its international competitiveness throughout the XX century.

Figure III-11. Evolution of the employment in the agricultural sector (1993.1999)



Source: Prepared by the authors based on data supplied by the Instituto de Estudios Económicos sobre la Realidad Argentina y Latinoamericana (IERAL: http://www.ieral.org), Instituto Nacional de Estadística y Censos y Cuentas Nacionales (INDEC: http://www.indec.mecon.gov.ar)

CHAPTER IV

THE INSTITUTIONAL FRAMEWORK AND MAIN PLAYERS INVOLVED IN THE DEVELOPMENT OF AGRICULTURAL BIOTECHNOLOGY

Introduction

A review of recent literature on the subject of the development and widespread adoption of agricultural biotechnology (Qaim et al, 2000; Krattiger, 2001; Traxler and Byerlee, 2001; Paarlberg, 2001; Pardey, 2001; Trigo et al, 2001) shows that, as opposed to what happens with conventional technologies, R&D capabilities in themselves do not seem to be the main factor determining a country's ability to profit from the potential benefits offered by this particular kind of technology. Other factors, such as the level of development of the inputs supply industry of (seeds and agrochemicals), the existence of regulatory systems in the area of biosafety; and the ability to effectively implement risk assessment procedures to ensure health and environmental safety in the use of technological innovations, particularly of GMOs, also play an important role, especially at this stage of development of the biotechnology industry. Indeed, the ability to develop a specific biotechnological event may be a strategic one but, as stated in Chapter I and further on in this chapter, the required investments are of a considerable magnitude.

These observations gain particular relevance in the case of a country such as Argentina which, given its agricultural and ecological characteristics, can take advantage of new developments as soon as these become commercially available in their countries of origin. In this chapter, the existing R&D capabilities of Argentina and the way in which they relate to the origin of innovations which are or will be in use in the near future are analyzed. A review on intellectual property laws in Argentina, the situation of both the seed and agrochemical industries and of the biosafety regulatory system, are also presented.

a) R&D capabilities and the origin of biotechnological innovations

Since there is no reliable inventory of the organizations involved in agricultural biotechnology R&D, it is quite difficult to evaluate the nature of existing capabilities, invested resources, and their impact on the use of biotechnology in productive sectors.

In spite of all this, and based on the scarce information available and the findings from the analysis of the applications for permits to release GMOs, it may be concluded that Argentina has significant research capabilities for the development of agricultural products. At present time, these capabilities are not playing a relevant role in terms of practical applications, except in the veterinary field, related to diagnosis and epidemiological issues.

According to the information used to elaborate the Biotechnology Program of the Pluriannual National Plan of Science and Technology 1998-2000, there were, in Argentina, approximately one hundred and fifteen biotechnology companies and biotechnology research and development organizations (INTA, other government agencies, CONICET institutes, university centers and privately owned R&D units). Seventy-eight of these -forty-one companies and twenty-seven research organizations— were devoted to agriculture and the rest to the health, chemical, mining and energy sectors.

Based on this information, in the year 2000, the International Service for National Agricultural Research (ISNAR), carried out a survey on research organizations (both public and private) doing work on agricultural biotechnology in Latin America and the Caribbean. This survey collected a total of eighteen responses from Argentina (six government laboratories, ten laboratories from public universities and/or the CONICET, and two from private companies) over a total of forty-one contacted institutions. The focus of the survey was on the type of existing capabilities, the available resources and the focus of their work (Cohen *et al*, 2001).

According to the information provided by Argentine laboratories participating in the survey and taking into account the limitations of the relatively low response level (under fifty percent), it may be concluded that Argentina has approximately twelve organizations with major capabilities in molecular biology and genetic engineering, which employ approximately 300 researchers and represent a total investment of US $3.5 million, excluding researchers' salaries (estimate based on fourteen responses to the question on investment resources). Major laboratories include the INTA's Castelar institute (Biotechnology, Genetics, Plant Physiology, Veterinary Sciences), the Institute of Genetics and Biotechnology - INGEBI (CONICET), the Center of Photosynthetic and Biochemical Studies - CEFOBI (CONICET), the Institute of Biochemical Research of the Campomar Foundation, the Center of Animal Virology - CEVAN (CONICET), the laboratories of some public universities, such as those at Universidad Nacional de la Plata, Universidad Nacional de San Martín and Universidad Nacional de Tucumán and the agricultural division of BioSidus[47], this last one within the private sector. This figure is an indicator of one of the main problems currently faced by the R&D sector in Argentina —in general terms and not only in biotechnology— and represents a dramatic contrast with the investment levels found elsewhere, both in government and private sectors, as previously mentioned in Chapter I. For example, the Rice Biotechnology Program of the Rockefeller Foundation, aimed at obtaining transgenic rice, has a budget of approximately US$100 million. In the U.S., the USDA annual investment in agricultural biotechnology is of approximately US$100 million; whilst Japan invested approximately US$260 million in the year 2000 (Kalaitzandonakes, 2000). Table IV-1 shows a list of agreements between private companies and different suppliers of research services, which indicate the intensity of the interactions in this area, as well as the amount of the required investments. Only the twelve agreements for which there is information available , represent a total of US$838 million (cumulative for several years), with a range of US$20 million to US$218 million for the genomics project being carried out jointly by Monsanto and Millenium. The gap between the resources allocated by Argentina and those allocated by other countries speaks for itself and, although until now it does not seem to have had a major negative impact as it has not constituted a barrier for the utilization of innovations that have become available, it is not reasonable to expect this to be so be the case in the future. RR soybean

[47] This listing is only presented for illustrative purposes as it is based on information provided by those organizations participating in the ISNAR survey, and not on official census data of the existing capabilities.

constitutes a very special case in terms of its adaptability to different environments, a feature that is not easily transferable to other crops and situations. Therefore, future local investment —or, in this case, the lack of it thereof— will play an increasingly important role in the ability that Argentina may have to continue to profit from the potential benefits of these new technologies.

Table IV-1 Agreements for research in agricultural biotechnology (1996-2000)

Company	Company	Area of research	Year	Amount of the agreement
AgrEvo	GeneLogic	Resistance to disease	1998	$45 million
AgrEvo	Netgenics	Bioinformatics	1999	NA
American Cyanamid	Hyseq	Genomics	1999	$60 million
Aventis	Lynx	Functional genomics	1999	NA
BASF	SunGene	Plant biotechnology	1999	NA
BASF	Metanomics	Plant biotechnology	1999	NA
BASF	Incyte	Genomics	1996	NA
Bayer	Arqule	Library screening	1999	$30 million
Bayer	Exclixis	Chemical screening	2000	$200 million
Bayer	Paradigm Genetics	Herbicide development	1998	$40 million
Ceres	Genset	Sequencing	1999	NA
Dow Agro	BioSource Technologies	Functional genomics	1997	NA
Dow Agro	Integrated Genomics	Product development	1999	NA
Dow Chemicals	Diversa	New enzyme	2000	$80 million
DuPont	Maxygen	New genes	1999	NA
DuPont	Lynx	Gene identification	1998	$60 million
FMC	Xenova	New insecticides	1998	NA
Hitachi	Myriad Genetics	Proteomics	2000	$26 million
Monsanto	Paradigm Genetics	Functional genomics	1999	NA
Monsanto	Genetracer	Plant and animal genomics	1997	NA
Monsanto	Millennium	Plant genomics	1997	$218 million
Monsanto	Molecular Applications	Function of new proteins	1999	NA
Novartis	Myriad Genetics	Cereal genome	1999	$34 million
Novartis	Chiron	Combinatory chemistry	1997	NA
Novartis Agribus	Diversa	New enzymes	1999	NA
Novartis Institute	Invitrogen	Functional genomics	1999	NA
Paradigm Genetics	Lion BioSciences	Genomics	2000	NA
Pioneer	CuraGen	Genomics	1998	NA
Pioneer	Maxygen	Gene performance	1999	NA
Pioneer	Oxford GlycoSciences	Protein analysis	1998	NA
RhoBio	Celera Agüen	Corn genes	1999	NA
RhoBio	CSIRO	Gene expression	1999	NA
Rhone Poulene	Agritope	Functional genomics	1999	$20 million
Rhone Poulene	Inst. Of Molecular Biology	Rice genome	1999	NA
Zeneca	John Innes Centre	Wheat genome	1998	NA
Zeneca	Maxygen	Input-product feature	1999	$25 million

Source: Kalaitzandonakes, Nicholas G., Amer. J. Agr. Econ. 82(5) (Number 5, 2001)

Table IV-2 Techniques employed by biotechnological research in selected countries of Latin America

No.	Techniques	Country * ARG	BRA	CHI	COL	CRI	VEN
Cellular biology techniques							
1	Micropropagation	15	9	13	39	8	11
2	Anther cultures	3	2	3	9	-	2
3	Embryo retrieval	4	1	4	6	1	3
4	Protoplasm fusion	-	1	-	2	-	-
5	*In vitro* germplasm preservation	5	3	3	14	4	10
6	*In vitro* insemination	-	2	-	1	-	-
7	Embryo handling	3	5	-	1	-	2
8	Cloning of animal cells	-	3	-	1	-	-
9	Other - cellular biology	3	3	5	21	3	6
Genetic engineering techniques							
10	Agrobacterium	13	12	6	7	4	4
11	Bioballistics	4	11	7	6	3	5
12	Electroporation	-	7	1	1	-	4
13	Microinjection	-	4	-	1	-	-
14	Others - genetic engineering	9	5	2	2	1	-
Genetic marker techniques							
15	Restriction Fragment Length Polymorphism	7	9	3	10	-	2
16	Randomly Amplified Polymorphic DNA	15	24	11	14	2	5
17	Micro-satellite markers	13	10	8	12	3	-
18	Amplified Fragment Length Polymorphism	13	6	7	8	1	-
19	Others	6	9	10	4	-	2
Diagnostic techniques							
20	Enzyme Linked Immunoabsorbent Assay	8	12	3	13	-	3
21	Monoclonal antibodies	1	5	2	4	-	1
22	Nucleic acid probes	1	5	1	1	-	4
23	Polymerase Chain Reaction	12	29	12	11	-	4
24	Others	-	5	5	20	2	1
Microbial techniques							
25	Design of biocontrol agents	1	3	2	7	-	-
26	Design of biofertilizers	2	2	-	2	-	1
27	Fermentation, food processes	2	4	-	17	-	-
28	Animal growth hormones	2	2	-	-	-	-
29	Rumen Manipulation	-	1	-	-	-	-
30	Design of vaccines by DNAr	5	-	-	1	-	-
31	Others – microbiology	6	1	2	17	2	1
TOTAL		**154**	**195**	**110**	**252**	**34**	**71**

Source: Cohen et al 2001

* The entries in each cell indicate the number of times the use of each technique was mentioned in response to the survey and may be interpreted as the number of projects, in progress in each country, that make use of the identified techniques.

Regarding the type of capabilities, collected data shows that existing capabilities are rather diversified and range from the most “conventional” to the most advanced techniques (Table IV-2).

There is also a great diversity in research focus. According to the ISNAR survey, agriculture- related applications include the diagnosis of phytopathogens in several crops, the development of biological control agents and the use of micropropagation techniques, molecular markers and genetic engineering of different crops, including, among others, garlic, onions, potatoes, sunflower, corn, wheat, alfalfa, strawberry, tomatoes, rye, citrus, cranberries, sugar cane, *yerba mate* and some forestry-related species (other sources). In most cases, work currently under progress is at the experimental level, though several laboratories report routiney use of the most advanced techniques, such as molecular markers and other genetic engineering (Cohen *et al*, 2001).

This last aspect is fully confirmed when we analyze the content of the regulatory “pipeline” in terms of approvals for the release of GMOs into the environment. In this respect, it is clear that most applications are filed by multinational companies that operate in the Argentine seed market (Table IV-3). In addition, the majority of both applications to and approvals by the National Advisory Committee on Agricultural Biotechnology (CONABIA), concentrate on a small number of species, with a predominance of corn, soybean and sunflower (Table IV-4). Only in the case of potato and alfalfa there is a major presence of R&D activity carried out in the country, specifically by the INTA.

In summary, the capacities of Argentina in the area of agricultural technology are not out of tune with those of other countries in the region, including Brazil. However, investment levels are very distant from those of the industry at international level. This fact is clearly proven by the situation of the current and potential offering of products applied in agriculture, which is dominated by events originating outside of the country and released by multinational companies operating in the Argentine seed market.

Table IV-3 Permits for the release of GMOs into the environment by type of organization

	1991/93	1994	1995	1996	1997	1998	1999	2000	2001	Total
Transnational corporations	11	17	26	28	62	65	70	52	49	**380**
Local companies	8	4	6	6	12	12	10	10	4	**72**
Government agencies	2		4	6	4	13	1		8	**38**
Universities								3	2	**5**
Total	**21**	**21**	**36**	**40**	**78**	**90**	**81**	**65**	**63**	**495**

Source: prepared by the authors based on data obtained from the Comisión Nacional Asesora de Biotecnología Agropecuaria, CONABIA - http://www.sagpya.mecon.gov.ar/0-0/index/programas/conabia

Table IV-4 Permits for the release of GMOs into the environment by type of crop

	1991/93	1994	1995	1996	1997	1998	1999	2000	2001	Total
Soybean	3	5	9	5	7	12	10	15	10	**76**
Corn	8	10	18	23	41	40	44	22	23	**229**
Cotton	4	2	5	4	7	4	5	9	8	**48**
Wheat	1		1	2	2	2	1	3	3	**15**
Sunflower		2		2	17	24	18	7	4	**74**
Potato			1	1	2	3	1	4	3	**15**
Alfalfa					1	4		1	8	**14**
Others	5	2	2	3	1	1	2	5	4	**25**
Total	**21**	**21**	**36**	**40**	**78**	**90**	**81**	**66**	**63**	**496**

Source: prepared by the authors based on data obtained from the Comisión Nacional Asesora de Biotecnología Agropecuaria, CONABIA - http://www.sagpya.mecon.gov.ar/0-0/index/programas/conabia

b) Intellectual property rights and biotechnology in Argentina

Two pieces of legislation constitute the institutional framework for the protection of intellectual property of agricultural technology products in Argentina. These are the 1973 Seeds and Phytogenetic Creations Law (No. 20.247), which deals with awarding breeders rights in the creation and discovery of plant varieties, and the Patents Law No. 24.481 and its amendment, Law No. 24.572.

Law No. 20.247, and its related decrees (like Decree No. 2819/91 which created the National Institute of Seeds - INASE) not only set forth the legal framework for protection rights over plant varieties, but also laid down the conditions for seed trading. In relation to protection rights, the law adopts the principles of the UPOV 1978 Act, to which Argentina adhered formally in 1995. In this respect, there are exemptions in favor of the parties that carry out plant improvements and for farmers who save seed for their own use. The exemption in favor of researchers is dealt with in a general manner and allows for the use of registered varieties with no previous authorization from the breeder, granting protection to the new variety even if it only differs in one trait from the original one. This fact has been considered to be a weakness in the law, which does not mention varieties obtained through biotechnological procedures either, probably as a result of the early date in which the provision was adopted. On the other hand, the clause referring to the "own use" of seed is subject to the following conditions: i) that the party saving seed for its "own use" must give proof of being a farmer; ii) that the saved seed must be the product of the farmer's own harvest; and iii) that it must be used for planting by the farmer in the land he farms.

This legal framework not only refers to the issue of intellectual property. It also establishes the framework for the organization of seed marketing in Argentina through the creation, in 1991, of the INASE. Until its dissolution, in December 2000, the INASE was the agency responsible for regulating seed trade and ensuring the availability of quality seed by preventing frauds and forgeries (for which it had been vested with police powers). It also established the basic conditions to enforce breeders' property rights.

As to the protection of the breeders' rights themselves, the legal framework was completed with the creation, in 1991, of the Argentine Association for the Protection of Plant Breeding (ARPOV), an institution which gathers all the parties involved in the development of varieties in Argentina (subsidiaries of transnational corporations, local companies, state-owned agencies such as the INTA, universities, cooperatives) under the condition that seed production is to be conducted in Argentina. ARPOV is responsible for managing license agreements of varieties, including an auditing system for such agreements. INASE and ARPOV have laid down the groundwork for the development of the seed market over the last two decades. However, the institutional framework itself has changed in recent times as a result of the dissolution of the INASE as an autonomous institution, in December of 2000, and the transfer of its functions to the Secretariat of Agriculture, Livestock, Fisheries and Food (SAGPYA). Since then, and althought there still exists a regulating authority with powers to enforce current rules and regulations, the administrative flexibility that the INASE used to have is now gone, and so is a good portion of its proven operational effectiveness. This brings obvious consequences in terms of the possibilities for the increase of the illegal seed trade.

As to invention patents, a new law was enacted in the year 2000 (Law No. 24.481 and its amendment, Law No. 24572). Pursuant to this law, it is now possible to patent pharmaceutical products, a long-awaited vindication of multinational companies, since this was not possible with previous laws. This legislation is consistent with the provisions of the TRIPS agreement and authorizes patenting biotechnological products and processes, as long as the product meets the required patenting conditions, i.e., they are new, involve an inventive step and has industrial applications.

Within this framework, and as long as those conditions are met, it is now feasible to patent microorganisms and genes, as well as processes and biotechnological products and any artificial genetic construction obtained through genetic engineering and other recombinant DNA techniques. Since 1983, a series of patents have been granted over genes, vectors, plasmids or proteins related to the different types of *Bacillus thuringiensis (*Bt gene), including those incorporated into Bt corn and Bt cotton released commercially in the country[48].

[48] According to the information provided by the INPI (National Institute of Industrial Property), by the end of 2001, thirty-one patents involving Bt genes had been granted. The first one is dated July 1993 in favor of Monsanto and the most recent, April 2001, had been granted to Novartis (see Table IV-1).

The original law prohibited patents over plants and plant varieties. However, upon enactment of this law, the government vetoed the relevant section (Article 7, Clause C). Therefore, it may be interpreted that patents over plants, animals and essentially biological procedures for obtaining them are currently not excluded. However, in the case of plant varieties, restrictions over patents originate in dispositions settled by the UPOV Act of 1978 which prevent double protection. On a later date, the decree No.260/96, which regulates the law, reinstated the prohibition against plant and animal patenting, a fact which created uncertainties which have not yet been clarified (Correa, 1999).

Summing up, the regulatory framework of biotechnology products is based on the traditional body of regulations governing the seed market and that of patent legislation. These complement each other to protect the invention, the gene or the event and its "physical vehicle", i.e., the variety. Both sets of regulations converge towards providing an adequate protection framework for inventions. However, there is still some controversy on certain issues that will need to be solved as new jurisprudence is developed on account of those applications that are being reviewed by the patents office.

c) Seed and agrochemical industries

The seed industry in Argentina has a longstanding tradition which dates back to the 1950s and has been one of the cornerstones of the development of agriculture in the country by laying the foundations for continued genetic improvement of main crops[49].

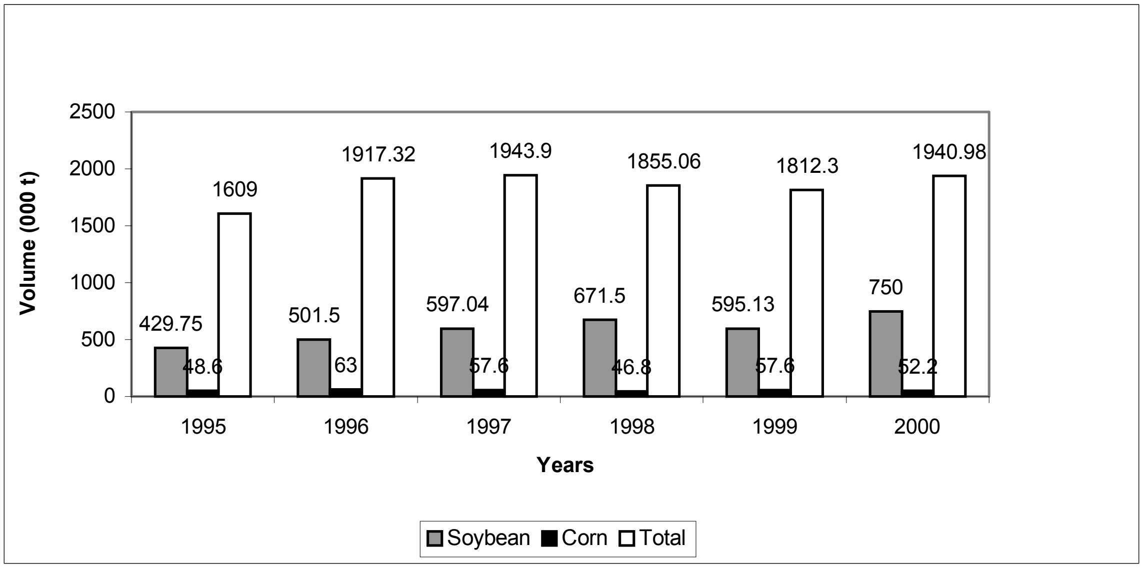
In the late1990s, the local seed market was one of the biggest in the world and the second largest in Latin America. It reached a volume of over 1.9 million tons (Figure IV-1) for a total value of over US$850 million in 1997, with soybean being, by far, the most important component, followed by corn as a distant second. These two crops, together with sunflower, make up 72 per cent of the total market[50]. Since then, the volumes of the market have stabilized, although there has been a significant decrease, in economic terms, as a result of the strong reduction in the price of soybean seed which started that year (for more details, see www.asa.org.ar).

The size of the seed market is a major factor that should be reckoned with in view of the economic possibilities it offers for biotechnology. It is worth mentioning two relevant aspects regarding both its structure and its operation. The first one is related to the sale of of illegal seed (known as "white bag") by seed multipliers offering seed without the authorization of the companies which hold the production rights, a practice which during the 90s was very difficult to control. The other relevant aspect refers to the legitimate practice by farmers of keeping seed for their own use.

[49] Originally, the industry was organized around the activities carried out by the INTA in the public sector, a group of local firms such as Buck and Klein (specializing in wheat), Morgan (with its focus on corn) and the subsidiaries of transnational companies such as Cargill, Asgrow, Dekalb, NK and Ciba-Geigi. For a detailed analysis of the genesis, evolution and structure of the industry until the 80s, see Gutierrez (1988).

[50] Data obtained from ASA.

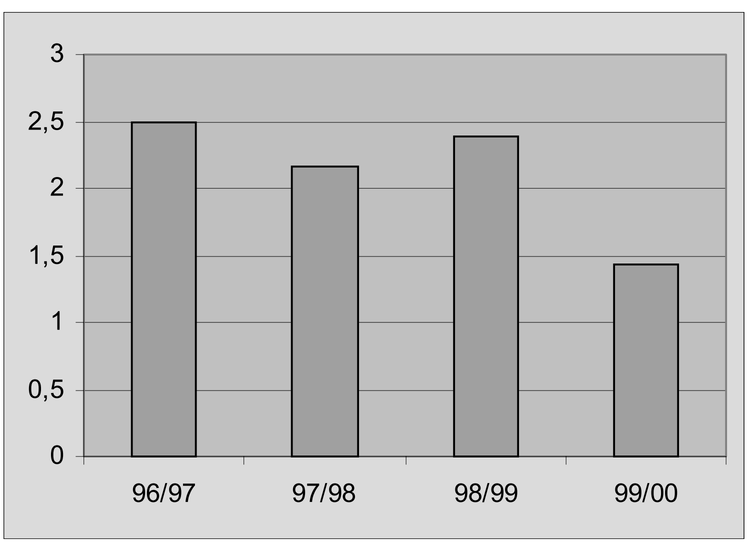
Figure IV-1 Argentine seed market (in thousand tons)



Source: Asociación de Semilleros Argentinos, ASA - www.asa.org.ar

The plateau experienced by the seed market a starting in 1996/97 may be explained by the introduction of transgenic seed and the resulting need of farmers (and even of illegal seed producers) of obtaining original seed of the new varieties. The stagnation of commercialized volumes in subsequent years, in spite of the continued increase of the cultivated area, might indicate the second part of the cycle, i.e., the use of "white bag" seed and of farmers' own seed. This last practice became much more attractive due to the low prices of agricultural commodities of the period 1999/2000, and it also had an influence in the fall of the price of seed. Graph IV-2 shows the relationship between the prices of RR soybean conventional soybean seeds for the 1996-2000 period.

Figure IV-2 Price ratio of transgenic soybean seed
as compared to conventional soybean seed



Source: prepared by the authors based on data of Márgenes Agropecuarios - www.margenes.com

It should be noted that this situation is also linked to the fact that the great expansion in production has taken place with self-pollinated species, in which genetic quality can be maintained through seed saved by farmers for their own use —or which may be used for clandestine multiplication practices. This happened in a period during which the double-planting of wheat-soybean became widespread, which may also explain why the practice of keeping seed for the following planting season made up such an important portion of the market.

With regard to other crops, such as corn hybrids, in which it is difficult or even impossible to maintain genetic integrity through the farmer's own seed, the market shows a more transparent behavior. In this case, the use of hybrids, which had already become widespread in the 1980s, was strengthened by the emergence of high-performance genetic material during the 90´s, even though the incorporation of transgenic events was not as extended as in the case of soybean.

The introduction of Bt corn resistant to sugarcane borer (*Diatraea saccharalis*), at present the most important pest affecting corn in the humid Pampas, facilitates control since chemical techniques are complicated and not highly effective. However, the relatively high cost of the seed still limits its use and makes other control strategies "competitive", such as the practice of early planting to avoid attacks with high insect population pressure [51] [52]. These considerations also apply to Bt cotton.

Own seed keeping, "white bag" practices, and the price differential of soybean seed between Argentina and other countries, mainly the U.S., have drawn continued attention, and even the intervention, of U.S. congressional committees[53].

Aside from the existence of the "white bag", there are other substantial differences between the situation in Argentina and in the U.S.. One of them is the legal right of the farmer to retain part of its grain as seed for the next season. Another difference is the fact that Argentine soybean production is not subsidized, as it is the case in the U.S. and therefore, subsidies to farmers also affect the behavior of derivative markets such as those of seed and glyphosate (see below).

The third factor is the way in which the RR gene was first transferred to Argentina. Originally, access to the RR gene was the product of an agreement between Asgrow and Monsanto in the U.S., whereby Asgrow Argentina had the right to use the gene in its registered varieties. When Nidera acquired Asgrow Argentina, it gained access to the gene and widely disseminated it in Argentina. When Monsanto tried to patent the gene in

[51] An analysis carried out by the Argentine Association of Regional Consortiums for Agricultural Experimentation (AACREA), estimated that the economic damage caused by an attack by this lepidoptera should represent more than 7.7 per cent of gross income in order to justify the higher cost of using transgenic seed (equivalent to $25-35 per bag).

[52] The other genetically modified corn sold in Argentina is the Liberty Link (LL) corn, an ammonium gluphosinate resistant corn (active ingredient under the Liberty trademark). This corn has an overprice of approximately $3 per bag (i.e., approximately 5 per cent).

[53] According to research carried out for the U.S. Congress by the U.S. Government Accounting Office, Argentina, the 1998 price for farmers of a 50lb. RR soybean bag ranged from $12 to $15; whereas this price in the U.S. amounted to $20- $23 per bag (GAO, 2000).

Argentina, it was unable to do so because it had already been "released". However, through private settlements that explicitly recognized ownership over this patent and stipulated the royalties to be paid, Monsanto licensed the RR gene to other companies that also sell it in Argentina (Ablin and Paz, 2000).

Therefore, conditions were never granted for the breeder company, Monsanto, neither to charge farmers with a "technology fee" nor to restrict the use of the seed by farmers, as it is the case in the U.S..

For transgenic corn and cotton seed, there is a "technology fee" charged to farmers. In some cases, this fee is higher than in the U.S.. This is related to the fact that, in both crops, there are patent applications for the involved events. In the case of corn, since it is a hybrid and farmers may not save grains for planting, the relative weight of certified seed in the market increases. In the case of cotton, the issue is more related to a marketing strategy, which is based on formal agreements between the seed supplier and the farmers which limit the right for "own use" of the latter. As a consequence , the price for Bt seed in Argentina is similar to that in the U.S., a fact that has determined the slow rate of adoption of this technology in Argentina—in relation both to RR soybean and Bt corn , as well as with Bt cotton in other countries (Qaím 2002).

As a result, we may conclude that the main problem in Argentina is illegal trade, which may represent between 35 to 50 per cent of the market. This situation might entail certain risks, such as a potential reduction in productivity (seed with lower genetic quality and germinatting power) or phyto-sanitary issues. The existence and expansion of illegal practices might also mean that many of the breakthroughs in biotechnology —and in other conventional technologies as well— may not find an effective way to be incorporated into production[54]. The dissolution of INASE, at the end of 2000, worsened the situation.

Regarding the structure of the seed market in Argentina, it should be taken into account that, as it is the case in the rest of the world, since the late 1980s a strong process of consolidation and transnationalisation has taken place. Due to this process, the subsidiaries of transnational corporations have become leaders in the supply of seeds, particularly of transgenic ones.

As indicated in Figure III-3, all commercial transgenic events released for sale in Argentina belong to transnational corporations. At the same time, most of the events which have passed the initial stages of approval have also originated in TNCs. The exceptions are some INTA products (corn, alfalfa), potato (INTA, Biosidus) and tobacco (CIDCA-UNLP).

In the 2000 planting season, all glyphosate-resistant soybean varieties sold in Argentina came from four transnational corporations: Pioneer, Nidera, Monsanto and Novartis; and three small local companies: Don Mario, Relmó and La Tijereta (licensed by Monsanto).

[54] Partly, this is a consequence of the reduction in size of the potential market and the subsequent decrease of incentives for innovation this would bring. However, it should also be noted that as there are no formal links between R&D processes and the producers and distributors of seed, no effective paths exist for innovations to be incorporated into production processes. When these innovations do take place, they do so with much delay and responding to the need to "restore" the quality to "white bag" material.

In diatraea-resistant corn crops the number of suppliers is smaller (Pioneer, Monsanto, Novartis and a local company, Morgan, acquired by Dow). In the case of ammonium gluphosinate-resistant corn and Bt cotton, Monsanto is the only one.

This situation clearly reflects the diffusion pattern of agricultural technology in this first stage of its “product” cycle, i.e., of events essentially related to production inputs: the concentration of the generation of innovations in the hands of a small group of large companies, which are focused on temperate climate crops and markets, from where they are spread to the rest of the world through license agreements or through subsidiaries.

In this context, Argentina becomes a particularly attractive market in view of both its features and the existing local improvement programs and a seed industry capable of rapidly incorporating the new events into the varieties that are well adapted to local agronomical conditions. These adaptation processes (essentially back-cross breeding with local varieties) are conducted by the research and development centers that the seed companies have in Argentina[55].

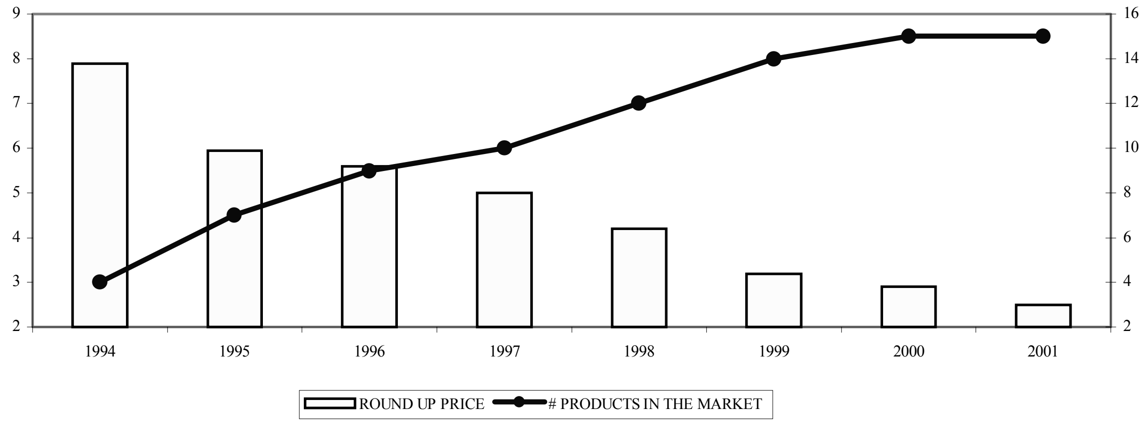
The situation of the agrochemicals marketshows a similar pattern to that of the seed market, both in terms of its evolution and of some of its structural features. As we have already seen (Figure III-7), sales of agrochemicals increased substantially in the 1990s and peaked in 1997, to a maximum of US$920 million. Sales then dropped to US$634 million in 2000, even though volumes for that year were higher than in 1997. In 2000, herbicides represented 70 per cent of the total market, a much higher proportion than at world level, where they make up only 43 per cent (James, 2001). In terms of herbicides, glyphosate represented more than 50 per cent of the market (US$264 over US$451 million) in the year 2000 (CASAFE).

As for the structure of the market for agrochemicals, the supply of glyphosate and related formulations is concentrated in a small number of companies, led by Monsanto. In 1998 and 1999 this company accounted for 50 to 77 per cent of all imports and for over 85 per cent of total local production, which is manufactured with imported active ingredients (Ablin and Paz, 2000). However, this market power did not prevent a substantial fall of glyphosate prices, from close to US$40 per liter in the early 1980s, to around US$10 per liter in the early 1990s and to less than US$3 during 2000; a much lower price than in the USA (which, according to Ablin and Paz, was of approximately US$9.5 per liter in 2000)[56].

[55] Pioneer has two research centers in Venado Tuerto and Pergamino, respectively. Monsanto has experiment stations in Camet, Bragado and Salto (María Laura).

[56] It is interesting to keep in mind that glyphosate, whose patent expired in 1987, was sold in Argentina at US$ 19/liter in the mid 1980s, i.e., higher than the price at which it was sold in industrialized countries (Del Bello, 1988).

Figure IV-3 Evolution of the price of glyphosate and number of gliphosate-based products available in the Argentine market (1994-2001)



Source: prepared by the authors. Based on information supplied by CASAFE - http://www.casafe.org, and the Secretaría de Agricultura, Ganadería, Pesca y Alimentación, SAGPyA - http://www.sagpya.mecon.gov.ar

Several factors seem to have contributed to the glyphosate prices have evolved. Among others, we can mention the fact that, as there were no patents, glyphosate became a "generic" product. This facilitated the arrival of new players for its production, distribution and import. The second factor was the impact of the reduction of import tariffs, which, in the case of agrochemicals, these ranged from 20 to 30 per cent, which undoubtedly triggered a reduction in the price of imported inputs. These factors eventually reflected in the local market through an increase of imports and of competition between the different companies doing business in Argentina, which significantly increased the number of products available, from an offering of four formulations in 1994 to fifteen in 2001 (see Figure IV-3).

d) Biosafety regulatory system

The Argentine biosafety regulatory system pivots around the National Advisory Committee on Agricultural Biosafety (CONABIA), an agency within the Secretariat of Agriculture, Livestock, Fisheries and Food (SAGPyA), pursuant to Resolution 124/91. CONABIA is a multidisciplinary and inter-institutional organization with advisory duties. Its main responsibility is to assess, from a technical and scientific perspective, the potential environmental impact of the introduction of GMOs in Argentine agriculture. CONABIA reviews applications for field tests and flexibilization of genetically modified plants. It also advises the Secretariat on issues related to trials and/or the release into the environment of GMOs and other products that may be derived from or contain GMOs. However, it does not have regulatory responsibilities in the case of other products developed through recombinant DNA technologies, such as industrial enzymes or microbial inoculants.

Diagram I shows the procedures for analysis, review and decision-making as well as the functions and interactions that take place at the different instances of the Argentine biosafety regulatory system.

In terms of the structure of the Argentine regulatory system, three main aspects should be emphasized. The first one is related to the conceptual basis of the regulations and the other two are relevant to the organizational dimension. On the conceptual level, the system is based on the evaluation of the product and not of the process through which it was obtained. Therefore, the evaluation takes place on a case by case basis, taking into account the characteristics of the product and its suggested use, taking into consideration the process only in those cases where the environment, the agricultural production or the health of humans or animalsh could be at risk.

As to organizational and operational matters, CONABIA does not have a structure of its own; but it acts through the institutions and regulations that make up the general regulatory system of the agricultural sector. These are the former INASE and the SENASA (National Service of Agricultural Food Health and Quality), and current Argentine plant protection regulations as provided in the Decree-Law of Sanitary Defense of Agricultural Production No. 6,704/63 and its amendments and other regulations on seed and phytogenetic creations and animal health. In addition, the procedure for approval of biotechnological events includes an analysis of the impact of releases on current export markets , which is carried out by the National Directorate of Agricultural Markets. It is worth noting that CONABIA is a multi-sectorial organization made up by representatives from the public sector, academic and from organizations in the private sector related to agricultural biotechnology. CONABIA members perform their duties as individuals and not as representatives of the sector they come from.

This system has being effective from 1991 to this date and its main virtue has probably been its capacity to evolve in tune with the developments of the sector. Evidence of this is the fact that it has taken part in the application processes for almost 500 permits for releases into the environment. Moreover, its members have been active participants in the international debate on biosafety and its related regulatory processes. These aspects have been acknowledged in the agreements signed with different countries with the purpose of sharing experiences and exchanging information as well as in a recent report by the ISNAR International Biotechnology Service (IBS), concluded that: "In total, the organization and operation of the Argentine biosafety system make it a useful model for other countries facing the challenging task of ensuring the safe and responsible use of agricultural biotechnology"[57].

Notwithstanding, the cited report draws attention to certain issues that need to be addressed in the future, of which the most important are, from an operational point of view, the relatively low hierarchy of the legal and institutional framework of CONABIA and the limited research capacity on biosafety in Argentina. These aspects gain relevance in view of the complexity of the issues that the system will have to face in the future —including an increased diversity of both crops and market situations and, most likely, a greater need for public information on the costs and benefits of introducing new GMOs in the Argentine

[57] See Burachik and Traynor (2001)

agriculture. We may also add the issue of how the “markets” dimension is evaluated within the process of approval for commercial release of GMOs.

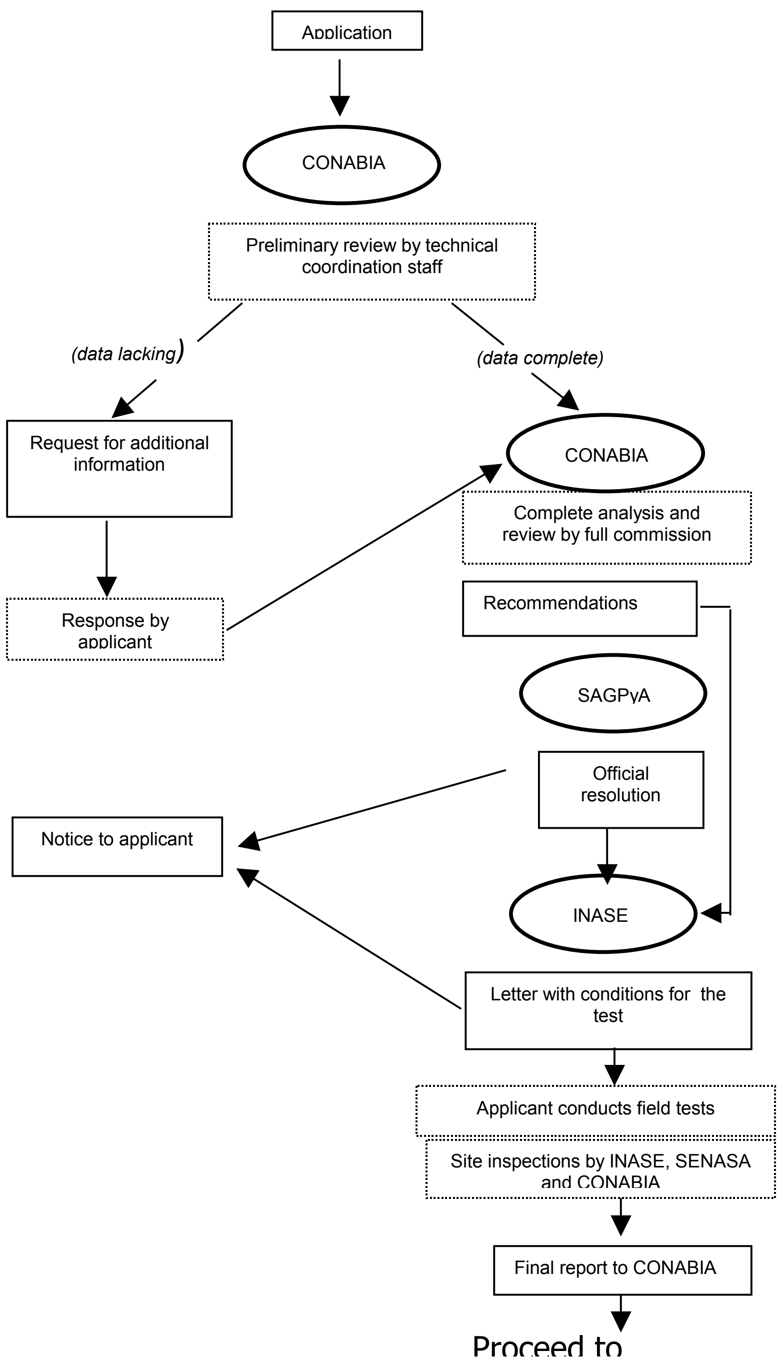
Regarding its legal and institutional framework, the CONABIA is an advisory agency that operates pursuant to a resolution by the Secretary of Agriculture. This fact not only represents a source of uncertainty in terms of the continuity of its policies but also prevents the establishment of an adequate system of penalties for those who do not comply with stipulated procedures —something that may only be achieved through a law. In addition, the relatively low legal-institutional category of this agency gains relevance when considering the need to comply with commitments undertaken by Argentina as a member of the Convention on Biological Diversity, which requires that biosafety regulatory systems be ruled by laws. During 2001, the Secretariat for Agriculture, Livestock, Fisheries and Food actively cooperated with members of the Argentine Congress in the drafting of a law on biosafety. Unfortunately, due to the institutional crisis that broke out on December 2001, the draft was never brought to the floor and there is no evidence that it will be in the near future. This draft entailed a major improvement on the current situation, since it clearly set forth a conceptual framework, as well as issues and instances to be considered as participants in risk analysis procedures.

The need for additional research has been emphasized more than once . Burachik and Traynor (2001) identified four areas of high priority but not exclusive of others . These are related to: i) the identification and level of incidence of major pest insects, plant viruses and weed species that affect the agricultural production in the different regions of Argentine; ii) the development of ecological information on the effects specific diseases and pests have on the development, persistence and spread of crop-related weed species affecting commercial crops; iii) research on baseline levels of resistance to different Bt toxins in target pest populations and iv)an inventory of the situation of endangered or beneficial species found in cultivated ecosystems. Addressing these issues currently faces restrictions beyond biosafety and that are related to the country’s current situation and its impact on the research system. This last subject exceeds the scope of this work.

On a final note, market analysis, which is carried out by the National Directorate of Agricultural Markets of the SAGPyA, is linked with the assessment criteria used in the preparation of the technical report. In this respect, the determinant variable is the status of the event under study in the destination markets in terms of whether the product has been approved or not and, as a result, whether the addition of this event to Argentina’s export supply might represent a potential barrier to the access to these markets. As a result, only those events approved by importing markets would be released. This simple and transparent criterion has in fact worked effectively until now. However, there are some drawbacks from the perspective of future investments in the sector, given that approval decisions depend on variables that are subject to change, on the other hand, could be difficult to foresee, particularly, in the case of new events under review . This criterion might act as a disincentive for R&D activities in Argentina, particularly in those cases concerning areas or problems that are relevant for Argentina but of lesser importance for other countries, where they might never get to be evaluated and approved. Undoubtedly, this issue will become increasingly important as the “pipeline” of innovations becomes more varied and complex.

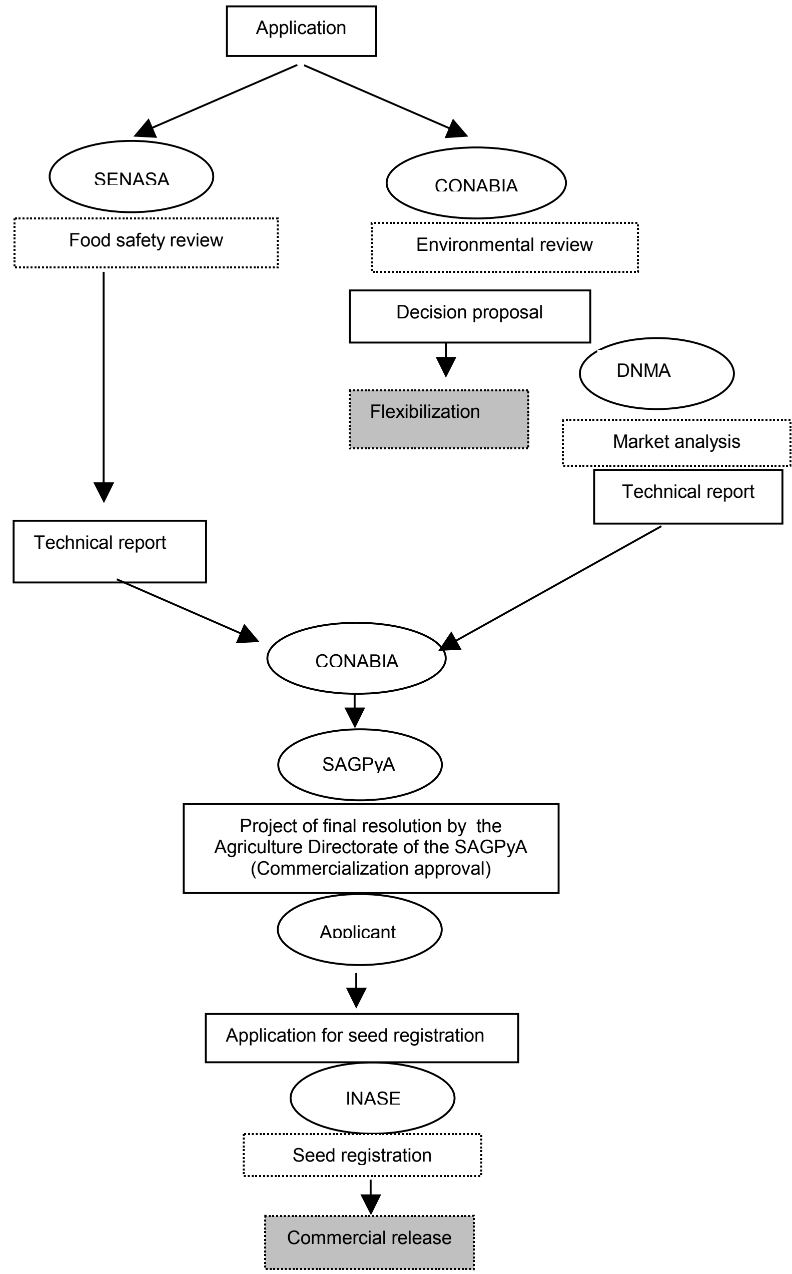
To summarize, Argentina was among the earliest countries to establish a biosafety regulatory system and there is a certain consensus regarding its past effectiveness as an adequate groundwork for monitoring the developments of the last decade. However, it is becoming evident that both its legal-institutional context and its technical-scientific capabilities are becoming outdated in view of the requirements that will need to be met in the future. This situation has been acknowledged by the authorities and other social players involved with biotechnology. The real possibilities for moving foreard are strongly dependent on the institutional and economic situation that Argentina is currently undergoing.

Field test approval procedure for GMOs in Argentina



Source: Commercializing Agricultural Biotechnology Products in Argentina: Analysis of Biosafety Procedures - ISNAR 2001

Commercial release approval procedure for GMOs in Argentina



Source: Commercializing Agricultural Biotechnology Products in Argentina: Analysis of Biosafety Procedures - ISNAR 2001

Annex VI.1

Bt GENES PATENTED IN ARGENTINA

Date of application	Date of concession	Patent No.	Holder
23/02/90	30/07/93	AR 243.234	MONSANTO COMPANY
18/05/89	30/11/93	AR 244.805	CIBA-GEIGY A.G.
24/09/84	15/04/96	AR 248.617	MYCOGEN PLANT SCIENCE INC.
31/07/90	15/04/96	AR 248.618	PRESIDENZA DEL CONSIGLIO DEL MINISTRI-UFFICIO PER LA RICERCA SCIENTIFICA E TECNOLÓGICA
11/11/93	31/07/97	AR 250.879	ZENECA LIMITED
05/10/92	28/10/97	AR 251.175	CIBA-GEIGY A.G.
09/06/95	29/05/98	AR 252.016	LIGNOTECH USA, INC.
15/11/94	30/06/98	AR 252.159	ZENECA LIMITED
31/01/95	18/09/98	AR 252.494	MICRO FLO COMPANY
08/09/89	30/04/99	AR 253.312	MYCOGEN PLANT SCIENCE INC.
17/01/86	27/08/99	AR 253.592	PLANT GENETIC SYSTEMS N.V.
27/11/95	21/05/97	AR 206	DAIRYLAND SEED CO, INC.
24/01/96	06/08/97	AR 793	ABBOTT LABORATORIES
20/11/95	22/10/97	AR 1.321	ZENECA LIMITED-COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANISATION
22/07/96	29/04/98	AR 2.914	ZENECA LIMITED
07/10/97	23/02/00	AR 8.885	VITALITY BIOTECHNOLOGIES LTD.
31/10/97	08/03/00	AR 9.138	MYCOGEN CORPORATION
24/11/97	07/06/00	AR 10.305	MYCOGEN CORPORATION
27/11/97	28/06/00	AR 10.662	ECOGEN INC.
24/02/98	12/07/00	AR 10.897	MONSANTO COMPANY
24/09/97	02/08/00	AR 10.993	ECOGEN INC.
20/11/97	02/08/00	AR 11.013	ECOGEN INC.
15/12/97	02/08/00	AR 11.036	MONSANTO COMPANY
09/01/98	16/08/00	AR 11.395	AGRICULTURAL GENETIC ENGINEERING RESEARCH INSTITUTE (AGERI)- UNIVERSITY OF WYOMING
13/03/98	27/09/00	AR 12.067	MYCOGEN CORPORATION
13/03/98	27/09/00	AR 12.068	MYCOGEN CORPORATION
19/06/98	27/09/00	AR 12.252	UNIVERSITY OF WYOMING
28/07/98	27/09/00	AR 12.263	MYCOGEN CORPORATION
07/08/98	31/01/01	AR 13.937	MYCOGEN CORPORATION
18/12/98	07/02/01	AR 14.144	ECOGEN INC-MONSANTO COMPANY
30/03/99	18/04/01	AR 15.256	NOVARTIS A.G.

Source: INPI (Instituto Nacional de la Propiedad Industrial) - http://www.inpi.gov.ar

CHAPTER V

PRODUCTIVE, ECONOMIC AND ENVIRONMENTAL IMPACTS: A MACRO AND MICROECONOMIC PERSPECTIVE

Introduction

The previous chapters provide a detailed analysis of transgenic technologies in terms of both their history and the actors involved in their development. Moreover, the attitudes adopted by consumers and public interest groups from different countries regarding food and environmental safety concerns are also discussed in this work. And, in order to give a comprehensive overview, the institutional dimension —i.e., the normative and regulatory frameworks governing the assessment of potential risks derived from the release (approval for commercial use) of GMOs— is also explored.

As already mentioned, as of the date of publication of this book, five transgenic events have been released in Argentina, namely:

- Glyphosate-tolerant soybean (RR);
- Lepidoptera-resistant corn (Bt);
- Lepidoptera-resistant cotton (Bt);
- Ammonium-glufosinate resistant corn (LL);
- Glyphosate-tolerant cotton (RR).

Ammonium-glufosinate resistant corn or LL corn was commercially released in 1999, and the glyphosate-tolerant cotton or RR cotton became available one year later, so at present there is not enough information available to provide a thorough assessment of their impact on the sector. Consequently, the following review is focused on the first three of the above mentioned varieties.

a) THE CASE OF GLYPHOSATE-TOLERANT SOYBEAN (RR)

Methodology

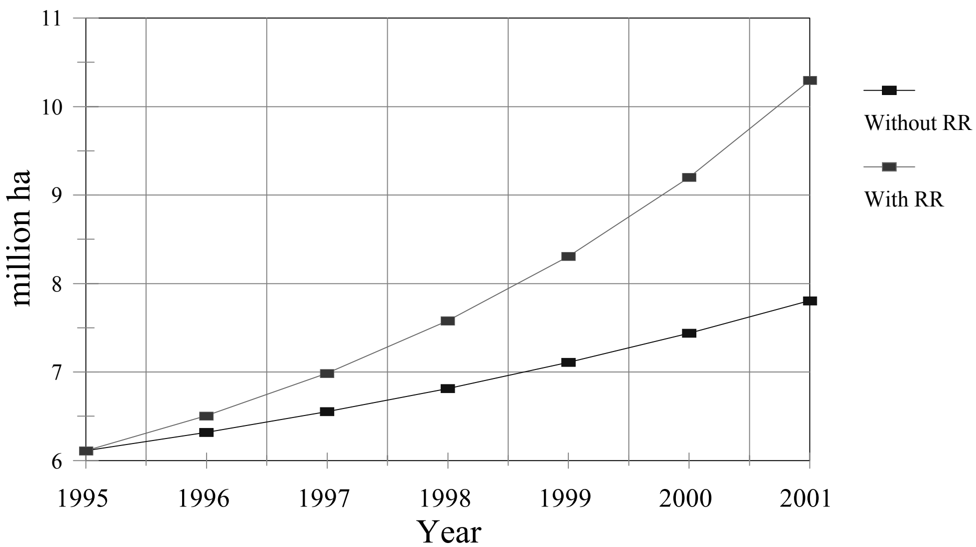
The evolution of the benefits to growers and input suppliers was estimated using the simulation model for the generation and diffusion of agricultural technology Sigma v2.02[58].

For the purposes of this analysis, historical RR soybean data was simulated using the model. This means that a baseline was generated for the 1996-2001 period, under the assumption that RR soybean was not available (see Figure V-1). The most visible quantitative manifestation of the availabitity of transgenic soybeans in 1996 was the shift

[58] *Un modelo de simulación para estimar el impacto de la investigación y transferencia de tecnología agropecuaria*. (A simulation model for impact assessment of the generation and diffusion of agricultural technology.) IES. INTA. 2002. The theoretical details of the SIGMA model have been summarized in Annex IV.

in the expansion trend of the planted area, which went from 200,000 ha. (before 1996) to 600,000 ha. per year[59] (after 1996) (see Figure V-2).

Figure V.1. Arg.: Evolution of the area planted with soybeans (in two alternative scenarios)



Source: Prepared by the authors. "With RR" technology figures are based on data provided by the Secretaría de Agricultura, Ganadería, Pesca y Alimentación (SAGPyA) - http://www.sagpya.mecon.gov.ar. "Without RR" technology figures were simulated with Sigma V 2.02.

Next, the adoption paths of new technologies were simulated based on data available in the Technological Profile Study (TPS)[60]. The data included in the study is broken down by growing area and by technological level (TL) of farmers —LTL: low-, MTL: medium-, and HTL: high-tech level[61]. Table V-7, in Annex III, provides further details as to the percentage distribution of farmers per TL.

Gross benefits to the farmers resulting from the introduction of RR technologies, accumulated throughout the 1996-2001 period, are derived from two factors, namely:

1. Production costs were reduced by an average of 20 US$/ha, this being a conservative estimate[62]. This is applicable to single-crop soybean as well as to the double-crop wheat-soybeans schemes . This reduction in costs is achieved through the elimination of mechanical weeding practices and/or substitution of costly selective herbicides required by conventional crop varieties.

---

[59] See Brescia, V. (2001).

[60] *Perfil Tecnológico de la Producción Agropecuaria Argentina* (Technological Profile of the Argentine Agricultural Production). 2nd. Edition. Instituto de Economía y Sociología (IES). INTA. August 2002.

[61] The technological level (TL) is a yield-related attribute. In most agricultural production activities analyzed in the TPS, there exists a direct correlation between this variable and the size of the farm.

[62] See Penna, J. and Lema, D. (2000).

2. The expansion of the soybean planted area, over the trend set prior to 1996, was mainly attained through the combination of no-till practices with a double cropping system (wheat-soybeans). This means that, in this particular instance, RR soybeans did not substitute for other crops (the substitution effect is explained by the expansion of planted area "without RR"). Therefore, the additional production —net of the pre-1996 trend— may be considered as a benefit accruing to the farmer.

Gross benefits to technology suppliers were estimated based on the price per liter for each for each one of the years considered in the case of glyphosate (a strong declining trend[63] was observed) and on the cost per hectare, in the case of RR seeds[64]. In the latter, the price was assumed constant throughout the entire evaluation period (at 35 US$/ha.) due to a lack of accurate data regarding the end result of the intricate price formation process for RR seeds, for each one of the planting seasons. The complexity and intricacy of such process is attributable, in part, to the variety of existing contractual agreements between suppliers and farmers, including exchange barter systems like, i.e. seed-for-grain .

Figure V-3 presents a summary of the distribution of accumulated benefits, disaggregated by subsectors within the value chain, computing as a benefit to seed suppliers the value deriving from the " suggested retail price", multiplied by the number of hectares planted with RR soybeans — assuming the inexistence of "white bag" (illegal) seed . In addition, in Figure V-4, a more realistic estimate is shown (assuming sales of of "white bag" RR soybean seeds represent 50 percent of total RR soybeans sales) as well as a 30 US$/ha reduction in farmers' costs (due to lower seed expenditures)[65].

Farmers´ share in the distribution of gross benefits stemming from the expansion of RR soybean increases from 82.4 percent (assuming no "white bag" soybean seeds are used for planting) to 86.67 percent (computing the assumed share of 50 percent of "white bag" soybean seeds). The percentage difference may, *a priori*, appear to be too small, particularly when taking into consideration that, in the *"white bag"* scenario, seed suppliers would lose no less than 50 percent of potential sales income. This can be explained by the fact that the largest share of gross benefits results from an increase in production due to the expansion of second-crop soybeans, which is graphically represented, in Figure V-1, by the area between the "with RR" and "without RR" curves. This circumstance underestimates, in relative terms, the magnitude of the income transfer from suppliers to farmers, implicit in the availability of seed sold outside the legal channels that safeguard the breeder's rights.

One other source of sectoral benefits generated as a consecuence of the adoption of RR soybeans in Argentina, should be mentioned: the expansion of the area planted as a second-crop, following wheat, mentioned in the previous paragraph (which reached 4 million hectares in the 2001/02 planting season), has generated a significant increase in production but is has also had a considerable bearing on the observed growth in direct

[63] Taken from www.CASAFE.com.ar. February 2002.

[64] Source: Revista Márgenes Agropecuarios. December 2001.
[65] Details on the evolution of surplus distribution can be found in Annex II (Tables V-2a and V-2b).

employment levels in the agricultural sector[66], inducing a process which is diametrically opposite to the one that is has been occurring in the rest of the economy, i.e. the net destruction of jobs . As Figure III-11 shows, direct employment in the sector increased from 782,000 jobs in 1993 to 966,000 in 1999, in parallel with an increase in partial productivity of labor of 3.2 percent per year for 1990-97 ; this as a direct consequence of the adoption of labor-saving technologies (no-till + RR soybeans). Should the technological revolution of the agricultural sector in the Pampas had not taken place, the drop in the share of labor in the distribution of the wealth created in the 1990s would have been worse.

Environmental impacts

Although it is used in higher volumes per hectare than competing products, glyphosate is a broad-spectrum herbicide with no residual effects and it is rapidly degraded in the soil, features that constitute an advantage over atrazine, which was the most commonly used herbicide before the introduction of RR technology in soybeans and does show residual activity. This means that it can eventually get in contact with underground water, with all its negative environmental implications.

From the standpoint of public health risks derived from potential intoxication, according to the classification of pesticides by toxicity prepared by the World Health Organization (1988), glyphosate falls in the category of toxicity class IV herbicides ("virtually non-toxic"). A recent study[67] reveals that the adoption of the RR soybeans, in Argentina, has led to an 83 percent reduction in the use of toxicity class II herbicides and a 100 percent drop in the use of toxicity class III herbicides (i.e., they have been phased out). For further details, see Table V-1.

Table V-1 Conventional and RR soybeans: differences of type and use of herbicides

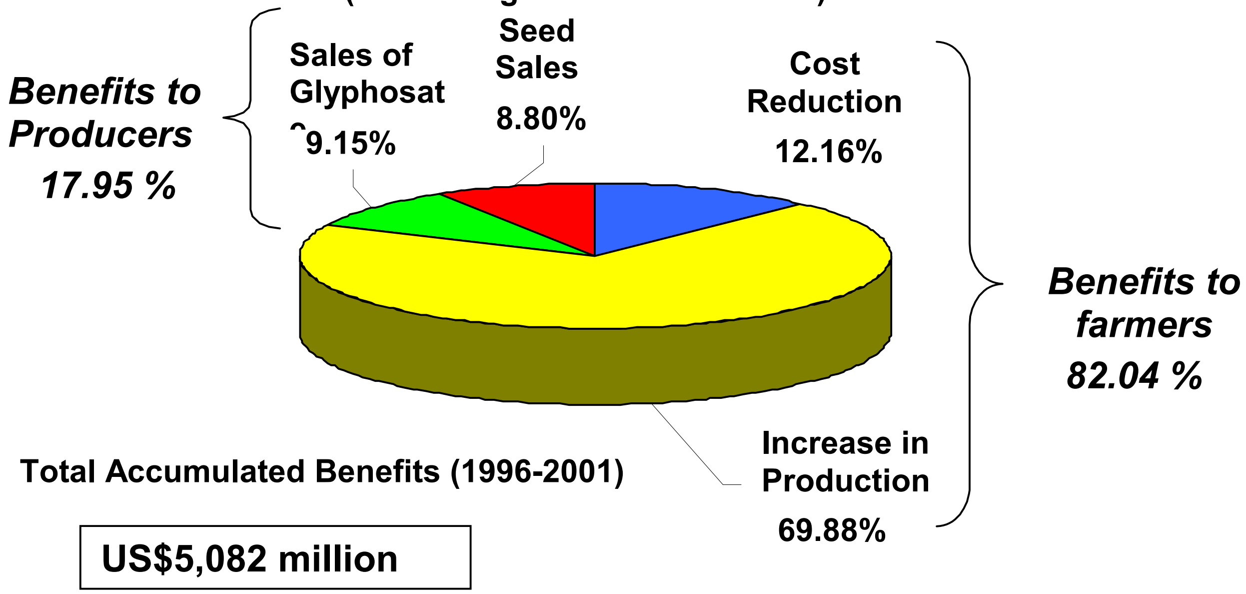
	Conventional soybean	RR soybean	Percentage Change
Number of applications	1.97	2.30	16.8
Amount of herbicide (l/ha)	2.68	5.57	107.8
Which is in			
Toxicity class II (l/ha)	0.42	0.07	-83.3
Toxicity class III (l/ha)	0.68	0.00	-100.0
Toxicity class IV (l/ha)	1.58	5.50	248.1

Source: Qaim, M and Traxler (2002). *Op. Cit.*

66 In view of the impossibility to disaggregate the data by specific activity or area, the incidence of an expansion of /the demand for other crops should not be excluded, particularly in the extra-Pampas, in terms of the net change in the aggregate employment level within the sector.

67 Qaim, M and Traxler. G. *Roundup Ready Soybeans in Argentina: Farm Level, Environmental and Welfare Effects.* Paper presented at the 6th ICABR Conference on *Agricultural Biotechnologies: New Avenues for Production, Consumption and Technology Transfer*. Ravello, Italy. July 2002.

Figure V-3 Adoption of RR soybean. Distribution of benefits. ("white bag" seed not included)

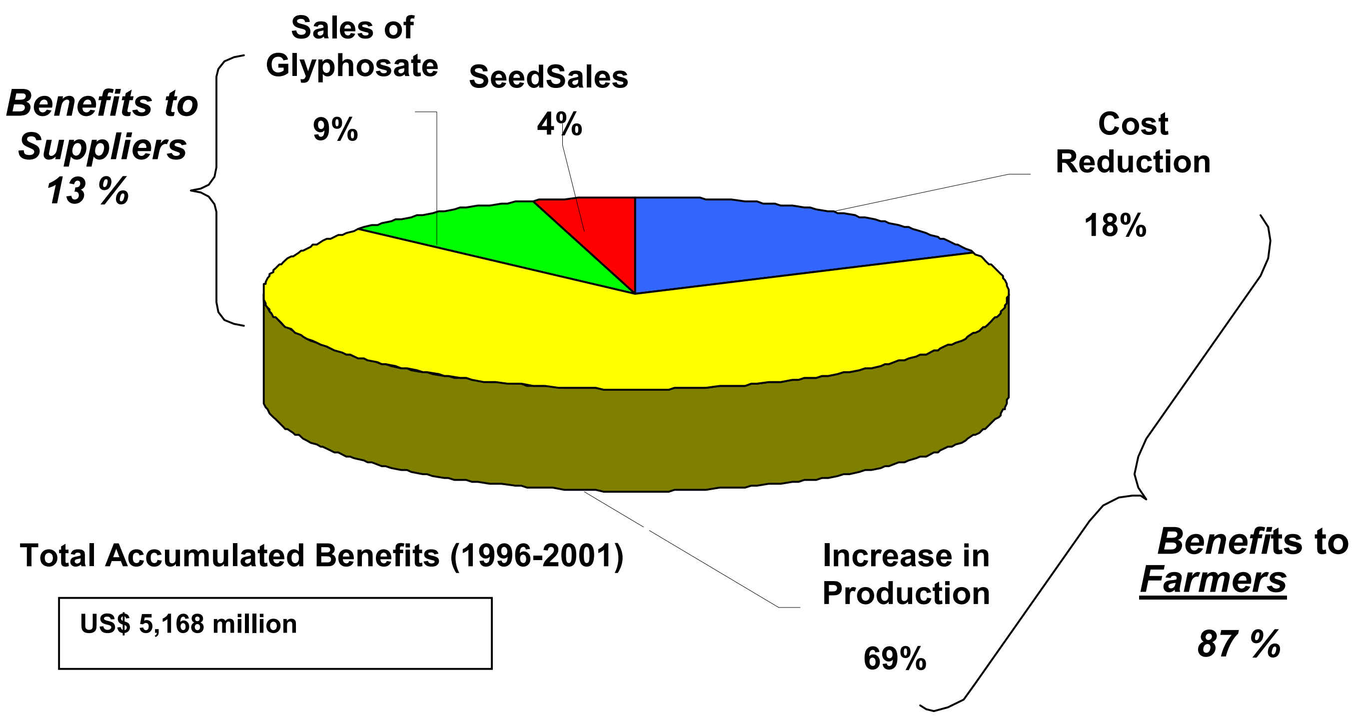


Source: prepared by the authors based on information analyzed with the SIGMA v2.02 model.

Furthermore, most of the expansion of the area planted with soybeans was done by means of the wheat-soybean double-crop system and this crop system can only be implemented through the adoption of no-till practices, which constitute a technology clearly beneficial to the soil structure.

The four areas most adversely affected by agricultural productive activities are: soil, water, biodiversity and health (of those doing farm work). In light of the evidence available to date, it can be asserted that the adoption of RR soybeans in Argentina has proved environmentally beneficial, as compared to the production systems it has replaced.

Figure V-4 RR soybean Adoption. Benefits Distribution.
(including "white bag" seed)



Source: prepared by the authors based on information analyzed with the SIGMA v2.02 model.

b) THE CASE OF LEPIDOPTERA- RESISTANT COTTON (Bt)

Methodology

The evolution of the benefits to growers and input suppliers was estimated by means of the simulation model of generation and diffusion of agricultural technology Sigma v2.02 for the Northwestern and Northeastern regions and the province of Santa Fe.

Based on the findings of Elena's work[68], the impact stemming from the adoption of Bt cotton was estimated at 30 percent net increase in production per ha, with maximum adoption ceilings increasing per TL, that is: 40 percent for LTL, 50 percent for MTL, and 70 percent for HTL. (This scenario is illustrative of the differential restriccions to access to working capital, required to afford the cost of transgenic seeds.)

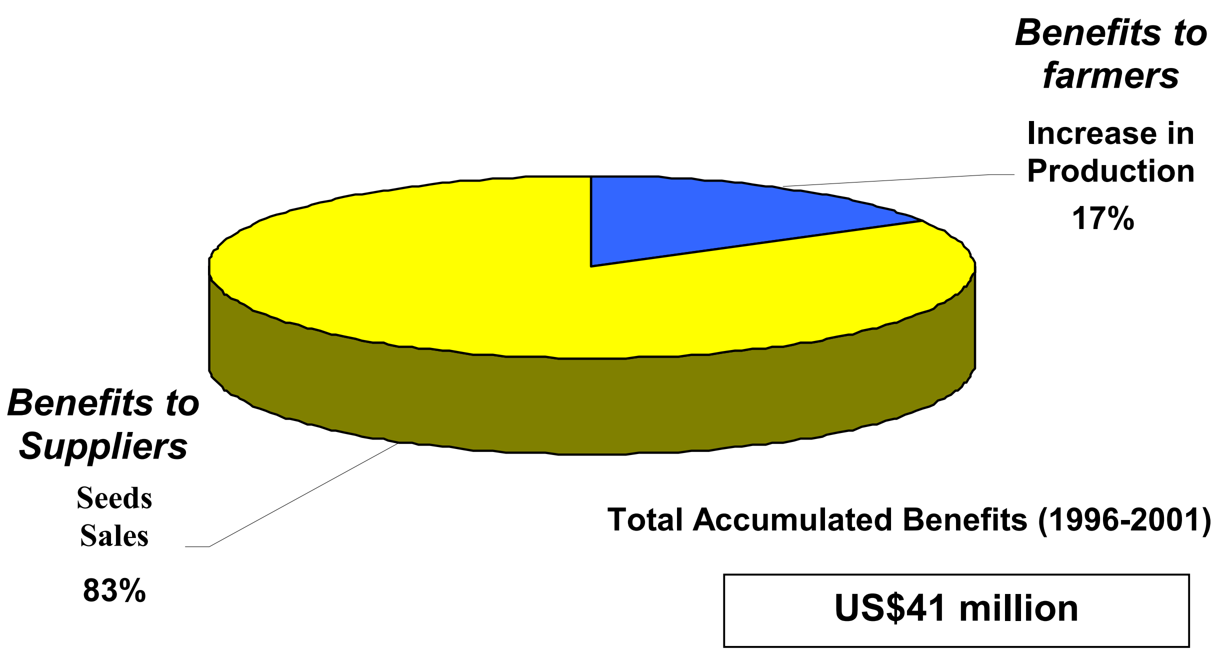
[68] See Elena, M.G. (2001).

The estimated increase in production resulting from the adoption of Bt varieties actually corresponds to the average reduction of losses caused by lepidoptera insects attacks and therefore, there is no real growth in terms of yield per ha, compared to average yield levels in the absence of lepidopteran insects attacks.

As in the case of soybeans, Bt cotton data was simulated for 1998-2001 , and a two-year projection was made for 2001-2003 . In fact, data from a recent study[69] show a significant drop of the acreage planted with Bt cotton for the 2001 planting season (from 20,000 to 9,000 ha) due both to a dramatic fall in international prices and to floods striking cotton-growing provinces. Nonetheless, there has been, for that planting season, an increase, in percentage terms, in the area planted with transgenic cotton, from 2.7 percent to 7-8.5 percent of total area (see Table III-4). For the purposes of the simulation exercise of the adoption path for this new technology, planted area for 2001 was assumed to be the one generated by the mathematical model, That differ from the actual observed values.

A summary of the distribution of gross benefits among main the main actors of the value chain is shown in Figure V-5[70].

Figure V-5. Bt Cotton Adoption. Distribution of Benefits



Source: prepared by the authors based on information analyzed with the SIGMA v2.02 model.

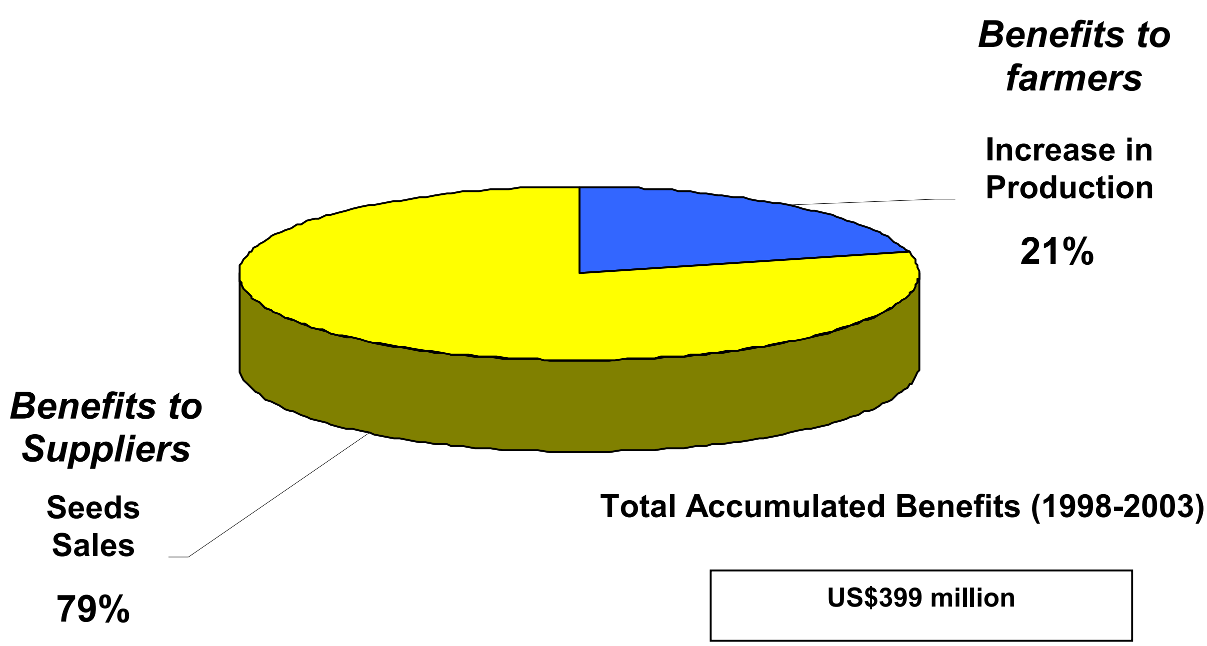
[69] See Qaim, M. (2002)
[70] The evolution of the generation and distribution of benefits along the simulation period is presented in Annex II (Table V-3).

c) THE CASE OF LEPIDOPTERA-RESISTANT CORN (Bt)

Methodology

The adoption process of lepidoptera-resistant corn was simulated for a 1998-2001 period, and a projection of results was made to 2003. Based on published data (Márgenes Agropecuarios, December, 2001), a 5 percent increase in yield was assumed to be the net effect of the adoption of transgenic corn percent. The benefit stemming from the adoption of Bt corn was estimated based on the same criterion used in the Bt cotton simulation, i.e., as insurance against "corn borer" attacks. In other words, in the absence of pest attacks, Bt corn shows no advantages over conventional hybrids. Taking this circumstance into consideration, adoption ceilings (for all three TLs) were set at 50 percent. The difference between technological levels was introduced into the simulation by means of increasing adoption rates, starting from LTL (the lowest ones) , reflecting the asymmetries in the availability of and access to technical information on the advantages that the technology offers, that is: the most advanced farmers (HTL) stay always closer to the "state-of-the-art" technology; they are early adopters of technological innovations and they are usually more willing to try new things. Farmers with a low technological level, on the other hand, generally need to be thoroughly convinced of the advantages offered by a new technology before actually adopting it. The results of the estimation of gross benefits as well as their distribution among the involved actors are summarized in Figure V-6[71].

Figure V-6 Bt corn Adoption. Distribution of Benefits.



Source: prepared by the authors based on information analyzed with the SIGMA v2.02 model.

[71] Table V-4, in Annex II, illustrates the evolution of the generation and distribution of benefits along the simulation period.

d) CONCLUSIONS

Agricultural technologies incorporated to biological inputs —such as the seeds analyzed in this paper— are usually neutral to scale , basically because they can be incorporated into production functions without having to invest in capital goods and no minimum farm size is required. In the case of RR soybeans, it holds true that no-till practices are required in wheat-soybean systems , but this does not represent a constraint for small farmers, given the presence, throughout the soybean-growing region, of agricultural machinery contractors that provide a very efficient service. In fact, it is only in large-scale farming operations that investments in this kind of capital goods can make economic sense. Besides, there are some special cases —the already discussed Bt cotton, for instance— in which the input price differential (higher than that of conventional alternatives) represents such a substantial increment in direct costs that it may induce a bias against farmers with limited access to working capital. As it is to be expected that larger farmers have fewer restrictions in this regard, the final result might give the impression of the existence of a bias in favor of large scale farms. In fact this is not so, because the lifting of a restriction of this kind is significantly less costly, since it only requires short-term financing (from either public or private sources such as input suppliers). restrictions on technology adoption that are directly linked to scale (i.e., machinery) are, however, much more difficult to neutralize: they may require, for example, improvements in the way production is organized (i.e. promoting associative schemes to induce an increase in scale) and/or medium-term financing, consistent with investments in capital goods. As a result of this situation, the share of benefits to be received by farmers with low technological level (who, in the case of cotton, are also the smallest ones) amounts to 12 percent (see Annex I, Table V-3), in spite of the fact that they plant 27 percent of the total acreage with the crop (see Annex I, Table V-6).

With respect to Bt corn, as a result of differential rates of adoption by technological levels, LTL farmers —who, unlike cotton growers and regardless of some degree of positive correlation, are not necessarily the smallest ones— would receive 13,2 percent of the benefits (see Annex I, Table V-4), although they grow 21 percent of the total acreage (see Annex I, Table V-6).

In short, transgenic technologies reviewed in this chapter do not show any bias against small farmers. This is evident in the case of soybeans , since adoption ocurred at a same (high) rate throughout the sub-sector. In the other two cases, asymmetries were detected in the adoption paths but, as already explained, such asymmetries should not be attributed to the technology itself but to external factors linked to restrictions on short-term financing or to access to (and understanding of) the information related to innovation itself.

Two distinct groups arise out of the analysis of the distribution of benefits among actors in the value chain (summed up in Table V-5, of Annex I), namely: RR soybeans, on the one hand; and Bt corn and Bt cotton, on the other. The clear asymmetry in favor of soybean growers in terms of benefits derived from the availability of glyphosate-tolerant varieties makes is easy to understand the percentage of the Argentine cultivated area planted with RR soybeans in 2001 (90 percent of total area) (see Table III-4), even higher than that of the U.S. (68 percent) for the same planting season, inspite the fact that this particular technology was available in that country earlier than in Argentina.

In the other group (Bt cotton and Bt corn), the situation is diametrically the opposite : the largest share of benefits (around 80 percent) is captured by input suppliers. Besides the cause-effect relationship between this outcome and the small impact of the technology, measured as productivity increases, it should be noted that the sales strategy for Bt cotton adopted by the seed company (individual agreements entered into with each grower) severely hinders the sales of “white bag” seed, thus limiting the additional cost-reduction alternative —a benefit that is available in the case of by RR soybeans. The price of Bt seed (four times higher than its conventional counterparts) also appears to be a significant barrier to its diffusion. Accordingly, a recent study (Qaim, 2002) concludes that the price maximizing both the profits of seed companies and the adoption of technologies on the part of growers is equal to 50 percent of the list price for the 2001/02 planting season.

On the other hand, due to the fact that Bt corn is a hybrid variety, the protection of breeder´s rights is ensured , without the need for specific regulatory tools. These results and implications are consistent with the levels of adoption reported both for Argentina and for the U.S. (see Table III-4).

ANNEX I

Figure V-2 SOYBEAN: Evolution of the planted area (1964/65 – 2000/01)

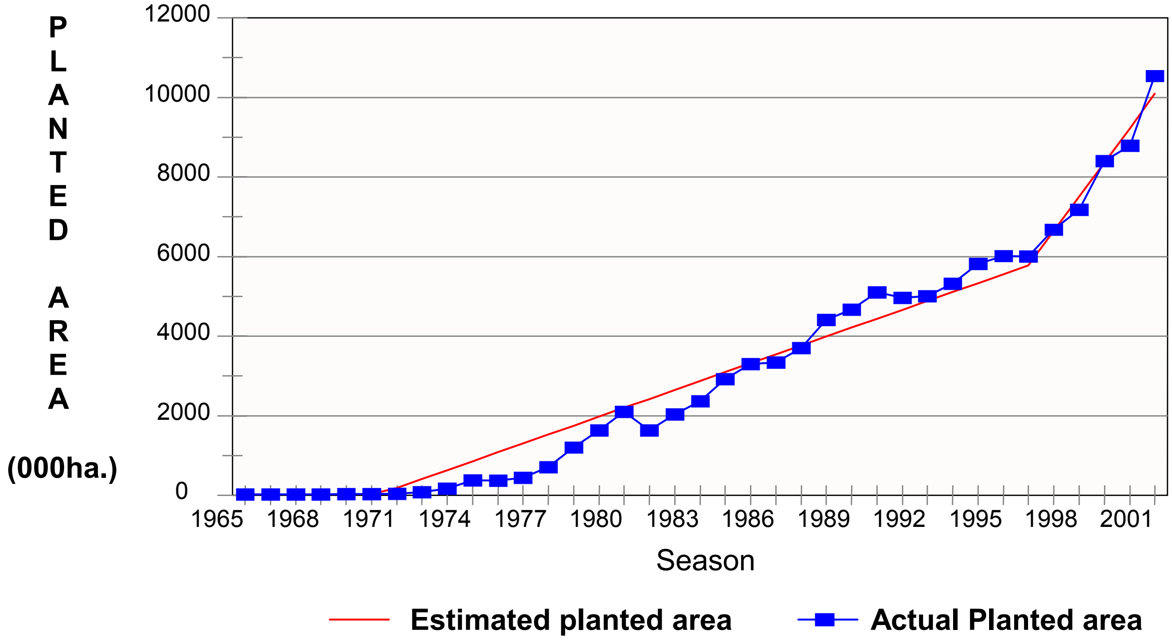


Table V-2a RR soybean Adoption. Evolution of the distribution of benefits ("white bag" seed not included)

Year	BENEFITS TO GROWERS[1] (million US$)			BENEFITS TO SUPPLIERS (million US$)			TOTAL BENEFIT
	< COSTS	> PRODUCTION	TOTAL	GLYPHOSATE	SEED[2]	TOTAL	
1996	33.48	91.43	124.91	28.89	16.02	44.91	169.81
1997	63.94	214.86	278.79	47.76	33.41	81.17	359.97
1998	97.32	306.29	403.61	56.17	49.43	105.61	509.22
1999	124.04	594.57	718.61	74.62	75.24	149.86	868.47
2000	142.83	875.18	1,018.02	93.37	99.09	192.46	1,210.48
2001	156.53	1,469.76	1,626.28	164.27	174.32	338.6	1,964.88
Total	**618.14**	**3,552.08**	**4,170.23**	**465.09**	**447.51**	**912.60**	**5,082.83**

(1) The distribution of benefits per TL is as follows (expressed in percentage out of the total): LTL:19,8; MTL: 51,9; and HTL: 28,3.
(2) It was estimated that 50 percent of the total RR soybean planted were "white bag" lots or seed kept by saved by farmers for their own use. Despite the lack of reliable data, this figure appears to have consensus among experts in this field.

Table V-2b Adoption of RR soybean. Evolution of the distribution of benefits (including "white bag" seed)

Year	BENEFITS TO GROWERS[1] (million US$)			BENEFITS TO SUPPLIERS (million US$)			TOTAL BENEFIT
	COSTS	PRODUCTION	TOTAL	GLYPHOSATE	SEED	TOTAL	
1996	50.22	91.43	141.65	28.89	8.01	36..9	178.54
1997	95.91	214.86	310.76	47.76	16.71	64.46	375.23
1998	145.99	306.29	452.27	56.17	24.71	80.89	533.17
1999	186.06	594.57	780.63	74.62	37.62	112.24	892.87
2000	214.25	875.18	1,089.43	93.37	49.54	142.92	1,232.35
2001	234.79	1,469.76	1,704.55	164.27	87.16	251.44	1,955.99
Total	**927.22**	**3,552.08**	**4,479.30**	**465.09**	**223.75**	**688.85**	**5,168.15**

(1) The distribution of benefits per TL is as follows (expressed in percentage out of the total): LTL: 19.8; MTL: 51.9; and HTL: 28.3.

Table V-3 Adoption of Bt cotton. Evolution of the distribution of benefits

Year	Benefits to growers (million US$)				Benefits from sales of Bt seeds (million US$)	Total benefits (million US$)
	LTL	MTL	HTL	TOTAL		
1998	0.01	0.05	0.06	**0.12**	**0.59**	**0.71**
1999	0.02	0.12	0.15	**0.3**	**1.49**	**1.79**
2000	0.05	0.3	0.32	**0.67**	**3.37**	**4.04**
2001	0.12	0.62	0.54	**1.28**	**6.42**	**7.70**
2002	0.24	1.03	0.72	**1.99**	**9.97**	**11.97**
2003	0.40	1.35	0.83	**2.58**	**12.91**	**15.5**
Total	0.84	3.48	2.64	**6.95**	**34.76**	**41.72**
%	12.0	50.0	38.0	**100**		

Table V-4 Adoption of Bt corn. Evolution of the distribution of benefits

Year	Benefits to growers (million US$)				Benefits from sales of Bt seeds (million US$)	Total benefits (million US$)
	LTL	MTL	HTL	TOTAL		
1998	0.12	0.71	1.17	**2**	**7.47**	**9.48**
1999	0.31	1.79	2.66	**4.77**	**1.81**	**22.57**
2000	0.79	4.05	4.99	**9.83**	**36.70**	**46.53**
2001	1.77	7.55	7.34	**16.67**	**62.26**	**78.93**
2002	3.3	11.07	8.91	**23.28**	**86.94**	**110.21**
2003	4.82	13.36	9.71	**27.89**	**104.17**	**132.06**
Total	11.11	38.54	34.78	**84.43**	**315.36**	**399.79**
%	13.2	45.7	41.1	**100**		

Table V-5 Distribution of accumulated benefits, among main actors (%)

		GROWERS	INPUT SUPPLIERS
RR SOYBEAN	"White bag" seed not included	**82.04**	17.96
	Including "white bag" seed	**86.67**	13.33
Bt COTTON		16.7	**83.3**
Bt CORN		21.1	**78.9**

Table V-6 Distribution of planted area by technological level (TL)

CROP	LTL	MTL	HTL
SOYBEAN	18,0	**54,0**	28,0
COTTON	27,0	**54,0**	19,0
CORN	21,0	**48,0**	31,0

Table V-7 Distribution of the number of farmers by technological level (TL)

CROP	LTL	MTL	HTL
SOYBEAN	24,0	**56,0**	20,0
COTTON	45,0	**47,0**	8,0
CORN	34,0	**48,0**	18,0

ANNEX II [72]

The aim of this document is to briefly introduce a model developed at INTA's for the specific purpose of estimating the impact of institutional investment on the generation and diffusion of agricultural technology.

Among other things, the methodology to be presented in this paper will assist in:

a) Reconstruct the adoption of curves disaggregated by area and by technological level, with a view to assessing diffusion efforts;

b) Identify economies of scale relative to specific issues of common interest in the field of agricultural research;

c) Assess, *ex-ante*, the social return of alternative strategies in the development of technological generation and diffusion;

d) Make recommendations to decision-makers at all levels that could require them.

Due to its modular nature, this methodological approach is applicable to various fields or areas as well as to different aggregation levels. Furthermore, it strives both for clarity in its logic and operatiion and for generalization potential in terms of its technique, cost level and information requirements.

The methodological tool developed has been denominated SIGMA. It consists of a mathematical simulation model that allows for *ex-post* and *ex-ante* analyses of aggregate sector impact, measured as changes in the total output, of alternative strategies for the allocation of resources in the field of research and diffusion of agricultural technology. In brief, SIGMA estimates how much more would be produced, compared to current levels projected into a given time horizon, if specific technologies were generated, adapted and transferred. When applied to Regional Centers or Experiment Stations, the results from the simulation runs become valuable source material or information facilitates the allocation of resources within the system (that is, it helps to appraise the institutional rate of return on investments on specific subject areas). At the national level, the conclusions drawn from this model can shed some light as to where efforts should be focused, by assessing the impact of alternative strategies (*ceteris paribus* all other parameters) once the SUPPLY dimension has been introduced into the analysis (the SIGMA model deals with those aspects related to the DEMAND for technology) in issues of common interest, in line with the criterion of the search for economies of scale.

[72] A simulation model for impact assessment of the generation and diffusion of agricultural technology by Eugenio J. Cap Omar A. Miranda

The following assumptions are made: [73]

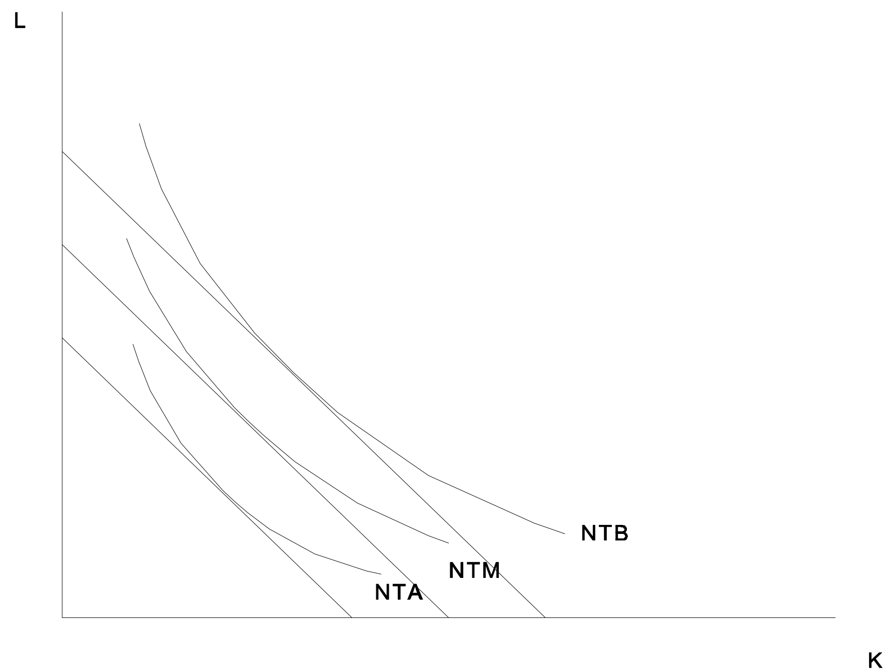
- There are three technological levels (TL) among farmers from relatively homogenous agroecological areas: low (LTL), medium (MTL) and high (HTL), associated, respectively, with a set of techniques, inputs and a resulting productivity indicator (as measured in terms of average yield). (See Figure 1.)

- There exists "upward mobility" among TLs, which is made possible by the adoption of AVAILABLE techniques and inputs, together with the capability to use them efficiently. This "inter-level mobility" (ILM) rate is defined as the percentage of the area of a given TL that gets "promoted" each year to the next TL, in terms of productivity[(18)]. This mobility is unidirectional, that is, promoted areas cannot be "demoted".

- The National Agricultural Research Systems (INIAs, Universities, Foundations, etc.) and International Centers have the capacity to generate a NEW technology. Its (future) adoption by farmers is represented by a non-linear function (sigmoid), whose parameters are given by the nature of the innovation and the socio-economic profile of the target audience.

---

[73] The <u>mobility rate</u>, such as it has been defined, can be conceived as an indicator of the RATE OF ACCUMULATION OF HUMAN CAPITAL in the agricultural subsector which is being considered. This is so since, to have access to the inputs and information to optimize them is a NECESSARY yet not SUFFICIENT condition to effectively attain the productivity levels associated with the top TL. To the acquisition of the required KNOW-HOW (which is not the same thing as having access to information), we must add an increase in entrepreneurial ability (including the means to evaluate risks and the willingness to take such risks). This implies a process which is unavoidably slow and cumulative, clearly linked to one of the least studied components of any economic system, which Hayami and Ruttan (1985) call "**cultural endowment**". This cycle of human capital accumulation adds credibility and support to the assumption of the unidirectionality of the phenomenon of inter-level mobility. Although it is acknowledged that both micro- (i.e., as erroneous business decisions) and macro-economic circumstances (i.e., changes in price ratios) can lead to a drop in productivity due to the suboptimal utilization of inputs, that does not necessarily imply an involution in the process of human capital accumulation: if the environment returns to its *ex-ante* status, productivity would probably pick back up after a brief lag. A similarity could be drawn between this situation and the underutilized capacity of an industry, augmented as a consequence of business cycle-related causes and its incidence on fixed costs.



The model´s key component consists of a reconstruction of the process of adoption, by farmers, of technological innovations that shift the isoquant that represents them (as a combination of inputs and factors), achieving a more efficient use of resources, which implies a reduction in production costs. The most significant implicit assumption that SIGMA makes is that coexistence of the three isoquants or technological levels (TLs) cannot be satisfactorily explained resorting to analytical tools provided by the neoclassical economic theory, since according to it, if farmers are profit-maximizers, they would all move to the isoquant nearest to the origin (HTL). This does not imply that the rationality of farmers is being questioned. Instead, it recognizes the existence of barriers associated with incomplete and/or non-existent markets, as well as of restrictions to the adoption of available technology and its optimum utilization, caused by the undersupply of public goods (such as infrastructure), or pure private ones (like refrigeration or storage capacity) or mixed ones, such as entrepreneurial skills or level of training of farmers.

In highly developed countries, the analysis of the process of adoption of technology starts from an assumption which points to the differences between them and Latin America and the Caribbean. In highly developed agricultural economies, farmers operate —for the most part— within the same isoquant, whereas in the less developed ones, a *continuum* of isoquants can be identified following the “most advanced farmers” (HTL), increasingly further from the origin, reaching levels of production inefficiency representative of the interphase between economic and social marginality levels.

SIGMA should not to be thought of as an alternative to other models proposed in the literature for the study of the phenomenon of the adoption of new technologies, but as a contribution that improves them. It tries to identify and explain the dynamics of two processes that take place at the same time. According to previous studies[74], the adoption of a specific innovation occurs at a rate which is considerably higher than the values found for the inter-level mobility[75]. There is another significant difference between these two processes: its mathematical representation (linear for the ILM and non-linear (sigmoid) for the adoption of a single innovation).

Basically, SIGMA I uses the following general expression[76]

E_t = {Δ ((attributable to available technology , Δ (attributed to new technology}

where E_t represents the increase in the economic surplus generated at time **t** in a given area, through the generation and diffusion of technology.

The use of the model

SIGMA has been mostly applied in *ex-ante* simulations because it was originally designed for that purpose[77]. However, it has been further developed in order to enhance its applicability, thus rendering it a valuable tool for analyses under other conditions, such as the simulation of scenarios interrelating retrospective and prospective findings, or *ex-post* assessments. The latter, more precisely, offers the possibility to test and validate the model through the study of specific situations.

Below, a brief description is provided of the four cases or situations that can be analyzed by means of this model.

---

[74] Byerlee, D.; Hesse de Polanco, E. (1982): *La Tasa y la Secuencia de Adopción de Tecnologías Cerealeras Mejoradas: El Caso de la Cebada de Secano en el Altiplano*. (The Rate and Sequence of Adoption of Improved Cereal Technologies: The Case of Rain-Fed Barley in the Mexican Altiplano.) (Working Paper, 82/6). CIMMYT, Mexico.

[75] Cap, Eugenio (1993): *Competitividad del sector agropecuario argentino. Marco conceptual y metodológico del modelo de generación de excedentes*. INTA, Directorate of Strategic Planning. Buenos Aires, Argentina.

[76] For a detailed description of the mathematical model, see the Annex.

[77] Cap, E.; Miranda, O. (1993): *Análisis* "ex-*ante" de impactos de la investigación agrícola en la Argentina para siete rubros productivos en escenarios alternativos* ("Ex ante" analysis of agricultural research impacts in Argentina for seven productive activities under alternative scenarios). In *Actas del Simposio Internacional: La investigación agrícola en al Argentina. Impactos y necesidades de inversion* (Proceedings of the International Symposium: Agricultural Research in Argentina: Impacts and Investment Needs). INTA / IICA / Minnesota Universtiy. Buenos Aires, Argentina. August 26-27.

Case # 1

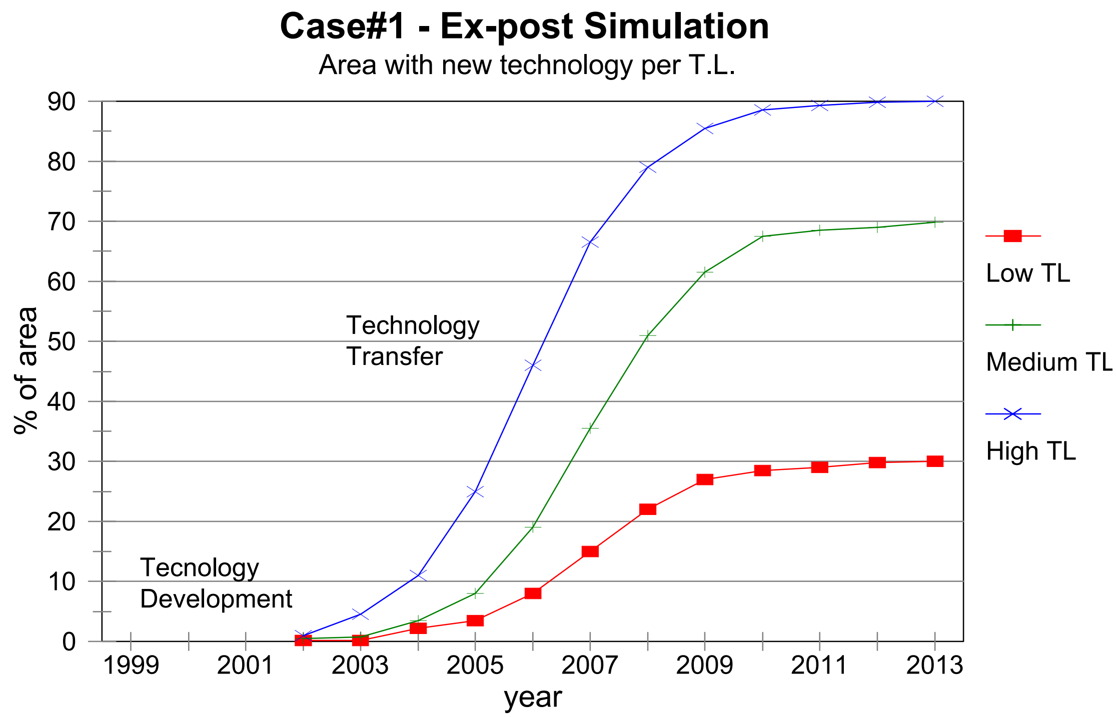
On the basis of both retrospective and current information, it is possible to rebuild the technology adoption curves per technological level for a certain area. This makes it possible to quantify the impact of available technology, in the process of being transferred. This allows, for instance, to assess the effectiveness of institutional efforts in a given item or group of items for a given year through the analysis of objective economic indicators.

Required information (per item and for a specific area)

- Area under production and yield per technological level for time 0.
- Increase in productivity resulting from the adoption of the technological innovation.
- Technology adoption rate.
- Percentage of area per technological level adopting the innovation as of a given year.
- Adoption ceiling per technological level (maximum percentage of the area that could adopt the new technology). It is a function of the severity of the restrictions to adoption[78].
- Time horizon and costs incurred in developing and adapting the technological innovation.
- Direct, indirect and labor costs incurred in the transfer of the innovation.

[78] Some of the restrictions identified in a recent work are the following: (1) insufficient profit margin of the application of the technological change (TC); (2) difficulties with access to proper inputs; (3) difficulties in obtaining the required labor —in terms of quantity and/or qualification— due to the new technical scheme; (4) insufficient financial surplus and/or lack of credit at rates consistent with the rates of return from models with introduction of TC; (5) lack of a proper articulation with the agro-industry in order to adjust production to the requirements of the demand, and identify the required TCs; (6) lack of knowledge on the part of farmers about the existence and/or application features of technological alternatives with higher yields; (7) lack of business-like attitude (capacity to take risks, implementation of corporate planning practices as well as management and control systems, professional staff in managerial activities, etc.); (8) lack of professional services (public or private) in a condition to provide advisory assistance on TCs; (9) difficulties in marketing higher production volumes (lack of zonal markets, poor coordination with marketing agents in concentration markets, transport restrictions); (10) difficulties or lack of knowledge regarding the marketing of products without normal channels (i.e., new fruits and vegetables, special products responding to specific demands from importing countries, etc.); (11) restrictions in some levels deriving from the production scale; (12) restriction resulting from the social organization of production (leasing, sharecropping, hiring, etc.); (13) poor conservationist legislation; (14) lack or poor elements and/or means for the spreading/transfer of technology. Cap, *et al* (1993). *Perfil Tecnológico de la Producción Agropecuaria Argentina* (Technological Profile of the Argentine Agricultural Production). 2 vol. INTA, Directorate of Strategic Planning. Buenos Aires, Argentina.

Figure 1 shows an ex-post estimation of the speed of the adoption process for the three technological levels of a new technology, for the area of Cuyo, Argentina.

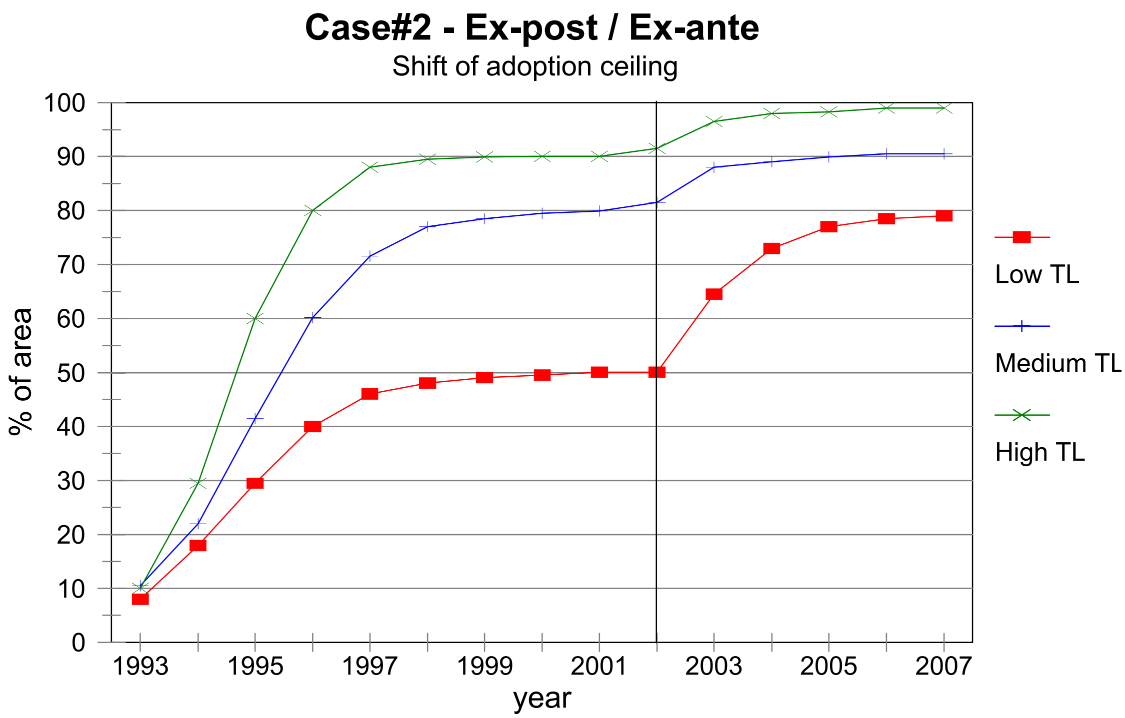


Case # 2

It allows the the retrospective estimation of adoption levels starting from time 0 (availability of the technology) until, a given year (just as it is done in Case # 1), but it also includes the option of doing an *ex-ante* analysis of the simulation of changes in certain variables, such as an increase in the adoption ceiling and the rate of of technology adoption. The originality of this Case lies in the capacity to combine *ex-post* and *ex-ante* analyses in one simulation run, thus allowing for an estimation of the economic impact of strategies designed to promote adoption of specific innovations.

Required information (per item and for a specific area)

- Same as in Case # 1 plus:
- Estimated costs of simulated intervention strategies.



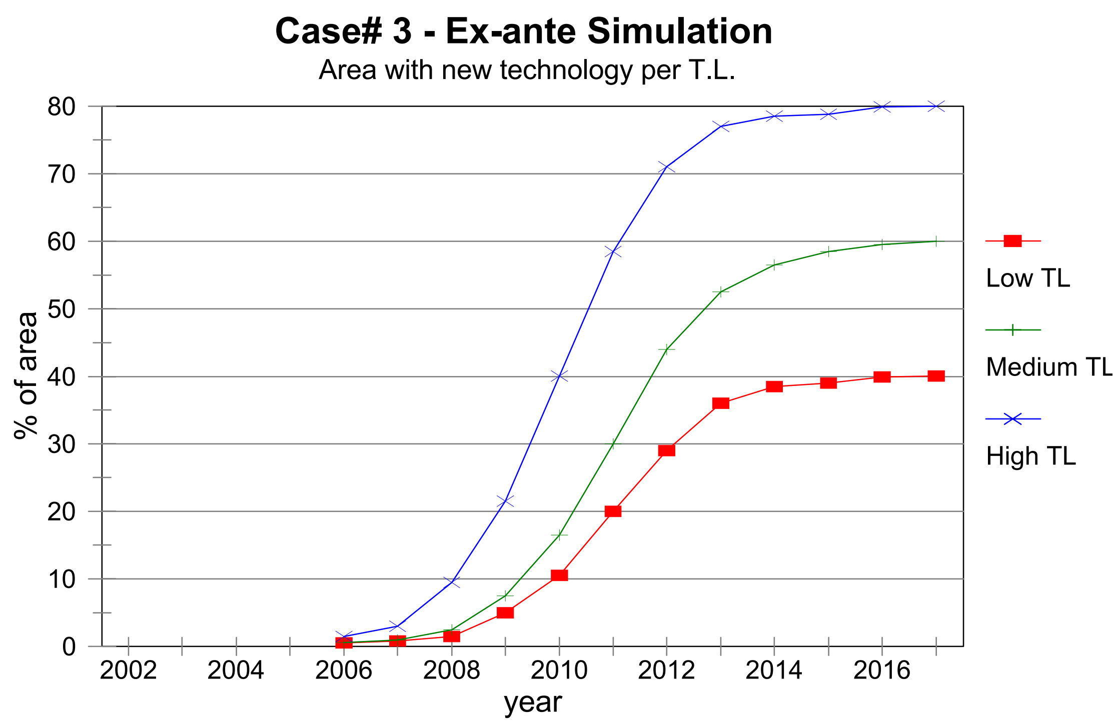
Case # 3

It offers the possibility of simulating the future adoption of technology currently not yet available (i.e currently in the generation or adjustment phase of the innovation process). This version of the *ex-ante* analysis incorporates impact assessment of the transfer of new technology. Therefore, at a regional level, it allows the estimation of the social return of projects that include the generation and transfer of technology for a specific item, through objective indicators that can be of assistance in the process of institutional planning.

Required information (per item and for a specific area)

- Area under production and yield, per technological level, for time 0.
- Increase in productivity resulting from the adoption of the technological innovation.
- Technology adoption rate.
- Adoption ceiling per technological level (maximum percentage per level that can adopt the new technology). It is a function of the severity of the restrictions to adoption.
- Magnitude of the problem to solve (or of the improvement to be generated), i.e., yields losses in kg/ha due to a pest or disease (in such cases, information on frequency of occurrence is also required).

- Geographical area affected by the problem (or that is to benefit from the new technology).
- Probability of success of the project.
- Year of availability of the technology.
- Time horizon as well as direct, indirect and labor costs estimated to be incurred in generating and adapting the technological innovation.
- Direct, indirect and labor costs deriving from the transfer of the innovation.



Mathematic Appendix

1. The SIGMA model

The SIGMA model defines the surplus produced in excess of the current output, as a function with the following general expression:

$$E_t = f\,[\,x_t^{\,d}\,[W\,[\,R\,(Bp)]]\,,\; x_t^{p}\,[Y^{p}\,(tec^{P})\,,$$

$$p_t\,((\,\varnothing\,(tec^{p}),\,K,\,\alpha\,(Bp))],\; S(tec^{d} \in D,\, tec^{p}),\, z\,]$$

where:

- E_t: Additional output in year **t**
- x_t^d: increase in productivity (yield) in year **t** by adopting available technology in year $\mathbf{t}_0$
- w: annual rate of inter-level mobility
- R: restrictions to inter-level mobility
- Bp: supply of public goods (extension, infrastructure, macroeconomic policy, etc.)
- x_t^p: increase in productivity (yield) in year **t** attributable to the adoption of new technology ($x_t^p > 0$ if $\mathbf{t} > \mathbf{t}_d$, where $\mathbf{t}_d$ is the time of availability of the technology; $x_t^p = 0$ if $\mathbf{t} < \mathbf{t}_d$)
- Y^p: potential productivity of the new technology
- tec^p: currently non-available technology (to be developed)
- tec^d: available technology
- D: stock of available technologies.
- p_t: level of adoption of non-available technology (tec^p) in year **t** ($p_t > 0$ if $\mathbf{t_d} > \mathbf{t}$)
- φ: parameter that measures the time it takes for 50% of farmers to adopt a specific new technology
- K: adoption ceiling, K ε (0,1].
- α: restrictions to the adoption of a specific technology
- S: sustainability related to the set of technologies used, S ε (0,1]
- z: vector of random variables

Therefore, the problem (P) that policy-makers face can be formulated as follows:

(P) max E_t (choosing Bp, tec^p)
subject to restrictions, i.e., budgetary[79]

For this theoretical model, as E_t approaches maximum from the "left", its partial derivatives (specified below) are associated with a sign (> ó <), which is consistent with explicit or implicit hypotheses of the model[80]:

---

[79] This optimization problem should be analyzed using a piecemeal/second best approach, since neoclassical economics cannot be used due to the violation of its fundamental assumptions. A viable alternative would be to use benefit/cost ratio (B/C) indicators or internal rates of return (IRR) per restriction to the inter-level mobility for the available stock of technology and per subject matter for technologies that are still in the development process.

[80] 1) $A > x^d > E$; $a > w > E$; $a > Bp < R$

1. $\frac{\partial E_t}{\partial x^d} x \frac{\partial x^d}{\partial w} x \frac{\partial w}{\partial R} x \frac{\partial R}{\partial Bp} > 0$

2. $\frac{\partial E_t}{\partial x^p} x \frac{\partial x^p}{\partial y^p} > 0$

3. $\frac{\partial E_t}{\partial x_p} x \frac{\partial x_p}{\partial p} x \frac{\partial p}{\partial \varnothing} < 0$

4. $\frac{\partial E_t}{\partial x_p} x \frac{\partial x_p}{\partial p} x \frac{\partial p}{\partial K} > 0$

5. $\frac{\partial E_t}{\partial x_p} x \frac{\partial x_p}{\partial p} x \frac{\partial p}{\partial \alpha} x \frac{\partial \alpha}{\partial Bp} > 0$

6. $\frac{\partial E_t}{\partial S} \geq 0$ *if S=1;*

> 0 *if S<1*

1. Empiric model

The empirical formulation of the SIGMA model is as follows:

$$VE_T = \sum_{t=0}^{T} \sum_{k=1}^{K} \sum_{i=1}^{3} ([[\beta^d_{ik} x ((W_{ik}) x A_{(i-1)kt})]$$

$$+ [\beta^p_{ik} x (K/(1 + e^{-\alpha(t-\varnothing i)}) x A_{ikt}]] x p^{FOB}_k)$$

where:

- VE_T: value of the additional output at time T (simulation horizon) expressed in currency units to facilitate the aggregation of crops or productive activities. Applying the discount rate to the sequence $\{VE_t\}_0^T$, the Net Present Value (NPV) can be calculated.
- t: time period (year)
- k: crop or productive activity (in this case, k=1)
- i: technological level, i ε [1,2,3], where: 1=L, 2=M, 3=H
- $ß^d$: productivity gap between actual and potential yields using AVAILABLE TECHNOLOGY, per technological level
- A: area dedicated to produce **k**

---

2) A > xp > E; a > p > E; a >φ < p; a > K > p; a > α < p

3) A > Bp < α

4) A > S > E

- $ß^p$: productivity gap between actual and potential yields using TECHNOLOGY NOT YET AVAILABLE, per technological level
- K: Maximum adoption ceiling (0,1]
- e: base of natural logarithms
- α: parameter of the sigmoid function, associated with to restrictions to adoption of technology
- φ: Adoption half-time (in years), associated with the intrinsic characteristics of a given technology
- p^{FOB}_k: FOB price (unitary) of item k

Note: the first equation term allows the estimation of the increase in output, in year T, attributable to the adoption of available technology and its optimal use. The second term quantifies the pure effect of new technology (net social benefit).

CHAPTER VI

SUMMARY AND CONCLUSIONS

a) Early adoption of GMOs in Argentine agriculture

The intensification of agricultural production in Argentina during the 1990s constitutes, without doubt, one of the positive impacts stemming from the structural reforms and economic policies implemented at the beginning of said decade.

The elimination of taxes and withholdings on agricultural exports as well as the substantial reduction of import tariffs on inputs and capital goods, along with the Convertibility Plan and the deregulation of some markets created favorable macroeconomic conditions, paving the way for a large expansion of production volumes for cereals and oilseeds (from 26 million tons in 1988/89 to over 67 million in 2000/2001), and particularly for soybeans, which soon became Argentina's leading export. The increase in export value occurred within a context of erratic international prices and in the face of competition with other countries which, unlike Argentina, profit from government subsidies to production and exports.

This growth in agricultural production constitutes the result of both a substantial expansion of the planted area (basically at the expense of livestock) and an increment in physical productivity per unit area, derived from a significant adoption of new technologies. By dint of such increase in the planted area, the Pampas agricultural sector succeeded in reversing labor dismissal trends observable over the last years, and went on to generating nearly 200,000 jobs from 1993 to 1999.

The process of adoption of technologies involves the procurement of capital goods, fertilizers and agrochemicals (herbicides and pesticides) as well as a momentous change in terms of genetic inputs: the introduction of transgenic crops in Argentine agriculture.

The first transgenic crop commercially released into the Argentine market, in 1996, was soybean tolerant to glyphosate herbicide. Later on, transgenic varieties of corn and cotton tolerant to herbicides and resistant to insects were approved.

As from its release date, the rate of expansion of glyphosate-tolerant soybean in Argentina has increased considerably, exhibiting a growth even higher than the one in of the U.S., which was the first country to introduce this kind of crops. The area planted to herbicide-tolerant soybean shot up from less than 1 per cent of the total area planted to soybeans, in the 1996/97 season, to more than 90 per cent (around 9 million hectares) in the 2000/01 season. The adoption of lepidoptera-resistant corn has also been of significance —yet with values lower than those observed for soybeans—, accounting for 20 per cent of the total cultivated area during the last farming season (third year since its introduction). The diffusion of Bt cotton has, in turn, been very limited, amounting to 7-8.5 per cent of the total planted area. At present, Argentina ranks second, only to the U.S., in terms of agricultural surface cultivated with transgenic crops and is therefore a major player in the international arena.

Regarding the environmental impact of the sharp increase of Argentine agricultural production during the last decade, the main issue to be considered is the fact that this expansion has taken place *pari pasu* with the outstanding increase of no-till (NT) practices, as the main farming management strategy for the Pampas crops[81].

The use of the no till planting system rose from approximately 300,000 hectares in the 1990/91 period to over 9,000,000 hectares in the 2000/2001 season. This technology constituted an important factor in the expansion of production, as it promoted the increase of the area cultivated with late planted soybean (planted after the wheat harvest) to new production areas. During the 1999/2000 season, for example, this was translated into a virtual increment of 3 million hectares of arable land.

But probably the most important aspect of the widespread adoption of no-till techniques, coupled with the introduction of transgenic soybean, is the “virtuous intensification” or “environmentally friendly” nature it has bestowed upon the process of technological change.

The coupling of no-till planting techniques with herbicide-tolerant soybean combines two technological concepts: on the one hand, new mechanical technologies which modify crop interaction with the soil; on the other hand, the utilization of general-use, full range herbicides (with glyphosate in first place), which are environmentally neutral, due to their high effectiveness in controlling any kind of weed as well as their lack of residual effect. Both factors imply a more intense use of inputs. However, as pointed out in Chapter III (Figure III-6) and Chapter V (Table V-1), this intensification is, at the same time, deemed “virtuous”, because it has simultaneously lowered the consumption of herbicides with the highest toxicity level.

It is worth noting that, even after the increase in the use of agrochemicals throughout the period, the total use per hectare of arable land was still far below the one recorded in other countries (see Figure III-7). Furthermore, the utilization of said product appears to have stabilized after the1996/97 season.

If we also consider the favorable externalities generated through the progressive recovery of soil fertility along with other potential impacts —such as benefits on the greenhouse effect reaped from this type of practices, and the like—, there is no doubt that the overall environmental impact of these transformations has been a positive one.

From this perspective, Argentina would fit into a win-win model in which commercial release facilitates the expansion of agricultural production at the same time that it fosters the adoption of environmentally friendly technologies developed abroad. Therefore, this technological package seems to have produced positive effects from the social point of view as well, for it has encouraged a dramatic increase in jobs derived from the agricultural sector (see Figure III-11). Moreover, the significance of this effect is reinforced by the fact that it took place simultaneously with an increase in labor productivity within the sector and

[81] The no-till planting system consists basically in laying the seed in the ground at the required depth with a minimal disturbance of the soil structure. This is made through specially designed machinery that eliminates the need for plowing and minimizes the tillage required for planting a crop.

during a period in which the rise in unemployment rate constituted one of Argentina's thorniest social problems.

In fact, Argentina enjoyed favorable conditions for a rapid adoption of GMOs. The Argentine seed industry profited from the active participation of national companies and subsidiaries of multinational corporations as well as public institutions; and, to top it off, the country also cherished a long-standing tradition in the field of germplasm improvement. At the same time, momentous institutional decisions were made, particularly with regard to biosafety regulations —the creation of the CONABIA, in 1991, being one of the most important ones.

The aforementioned elements, along with the fact that Argentina constitutes the major area —amounting to 26 million ha. of cultivable land— for the potential use of new technologies outside their country of origin, provided the proper incentives and a most suitable "landing field" for the rapid adoption of these biotechnological inputs.

By contrast, public (and private) resources allocated to research and development in Argentine agriculture —especially in the area of biotechnology— are scarce as compared to corresponding efforts at the international level. Beyond their meaningful contribution to R&D activities on some crops (such as alfalfa) and into the sphere of veterinary science, institutes devoted to agricultural biotechnology research in Argentina have hardly participated in the events approved by the CONABIA. As it is shown in Table IV-3, it has been multinational companies who in Argentina —as well as in many other countries— have taken the lead in the process of releasing new technologies into the environment. Anyway, it is important to bear in mind that, so far, only RR soybean stands out as an exceptional case in the diffusion of GMOs.

The massive adoption of the RR soybean can be accounted for by the reduction in production costs (regardless of the size of the crop farm) and, above all, by the expansion of cultivable area brought about by said variety.

These elements are not distinctive of the Argentine case. What does draw a distinction in this specific case, however, is the instrumental role played by certain idiosyncratic institutional factors in the rapid and effective expansion of RR soybean. The first factor refers to the manner in which the RR gene was first transferred to Argentina. Originally, access to the RR gene was achieved through negotiations between Asgrow and Monsanto in the U.S., whereby Asgrow Argentina was granted the use of the gene in its registered varieties. Later on, when Nidera acquired Asgrow Argentina, it gained access to the gene and widely disseminated it in Argentina. Consequently, when Monsanto tried to patent the gene in Argentina, it was unable to do so because it had already been "released". However, through private settlements that expressly identify the ownership over this patent and stipulate the royalties to be paid, Monsanto was able to license the RR gene to other companies that commercialize it in Argentina. Therefore, conditions were never met for the breeder company —i.e., Monsanto— to be entitled to charge the technology fee nor to restrict the use of the seed by farmers, as is the case in the U.S..

The second factor is related to the operational aspects of the seed market and its effect on the price of RR soybean. On the one hand, under the UPOV Convention of 1978, farmers can legitimately keep seeds for their own use; on the other hand, there are clandestine operations (the so-called “white bag”) through which seed multipliers offer seed without the authorization of the companies holding the corresponding legal production rights. Both factors have driven down the price of RR soybean, thus promoting the rapid adoption of said technology.

Within this context, the stunted growth of the seed market over the last years should come as no surprise, regardless of the sharp increase observed in the acreage planted to soybean —the leading crop in such market. Therefore, the plateau experienced by the seed market as from the years 1996/97 may be explained by the introduction of transgenic seed and the resulting need of obtaining original seed on the part of farmers (and even of clandestine seed producers) (see Figure IV-1). The use of “white bag” seed as well as of farmers’ own seed would account for the evolution of the market in the following years, a practice which surely had an impact on the substantial reduction in the price of RR soybean seed as compared to that of conventional seed over the 1999/2000 period (see Figure IV-2).

It should be noted that this situation is also linked to the fact that soybean seed falls into the category of autogamous species, in which genetic quality can be maintained through seed retained by farmers for their own use —or which may be used for clandestine multiplication practices. Along these lines, we should also take into account the relevance of the widespread adoption of the wheat-soybean double-crop system during the period under analysis, which undoubtedly constituted an additional inducement to keeping seeds for the next season.

The third factor contributing to the wide diffusion of RR soybean in Argentina is the increasing reduction in the price of glyphosate (see Figure IV-3), which stemmed from a fiercer competition in local markets by dint of the introduction of new agents in the manufacturing and commercialization of said product.

Keeping in mind that so far Argentina has encountered no difficulties in accessing target markets for its RR soybean exports and that, in spite of the perceptions of foreign consumers, price differentials between conventional and RR soybeans in the world market do not penalize the latter (see Chapter I), it is hardly surprising that almost all Argentine soybean crop is RR. Neither is it surprising that not only input suppliers but also farmers, the scientific community and government authorities are all in favor of this new technology.

Only a few NGOs, such as Greenpeace, have introduced part of the international debate in Argentina. Yet, Argentine public opinion —overwhelmed by major issues such as unemployment, poverty and corruption, and in the face of anti-globalization campaigns focusing their criticism on banks and privatized companies— has offered not much fertile ground for negative views about these new technologies.

Unlike RR soybean, Bt corn and Bt cotton feature a much less dynamic performance. Firstly, Bt varieties have been released much more recently, and secondly, farmers tend to consider Bt crops as some sort of insurance, yielding higher or lower profits depending on pest behavior during each season.

In addition, a technology fee to be charged to farmers is applicable to transgenic corn and cotton varieties and, in some cases, this fee is higher than in the U.S.. This is related to the fact that, in both crops, there are patent applications for the involved events and that, in the case of corn, it is a hybrid variety. As a consequence, farmers may not keep their own seed for planting, and therefore, the relative weight of the certified seed in the corresponding market increases.

As far as cotton is concerned, the real issue lies on the commercialization strategy, which is based on formal agreements between the sole supplying company and the farmers, whereby the latter's right to their "own use" of the seed is restricted. As a result, farmers have no choice but to pay for the seeds four times the price of conventional varieties, and this, in turn, hinders the diffusion of this technology in the country.

It is clear from the above discussion that one of the main problems in Argentine agriculture is the illegal trade of seeds, potentially amounting to 35-50 per cent of the market. Besides the risks that this situation might entail in terms of a potential reduction in productivity (seed with lower genetic quality and germinatory power) or with respect to phyto-sanitary issues, the existence and growth of illegal practices might also mean that many of the breakthroughs in biotechnology —and in other conventional technologies as well— may not find an effective way to be incorporated into production. In other words, the dissemination of new knowledge takes much longer than it actually would if the seed market worked under normal conditions. The dissolution of the National Institute of Seeds (INASE), at the end of 2000, aggravated the situation for it constituted the regulating authority responsible for the enforcement of effective rules and regulations. Hence, at present, there has been no clear reassignment of responsibilities as to the police power within the sector; and this, in fact, has extended to the GMOs market given that, in terms of sanctions, GMOs are regulated by the same rules and regulations applicable to the conventional seeds' market. It is critical that this problem be urgently dealt with, in view of the evident adverse impacts that it may have on the operation of the overall genetic input industry.

Finally, some clear and obvious differences arise from the comparison of RR soybean to both Bt corn and Bt cotton. In the case of soybean, the fact that the adoption of this new technology has proved neutral to farm size, on the one hand, and the equitable distribution of benefits among input suppliers, farmers and the Argentine economy as a whole, on the other hand (see Figures V-2 and V-3), clearly indicate that this is a "win-win" scenario. The evidence available for Bt corn and Bt cotton does not point in the same direction, although actually the performance observed in these cases does not differ much from the one found in other contexts. It can thereby be concluded that the situation herein depicted is not attributable to country-specific conditions, but to results stemming from the nature of these technologies and to the way in which this is reflected on the performance of the actors in the process of adopting said technologies.

b) Looking ahead

The crisis Argentina is currently experiencing poses a major obstacle to the analysis of any future scenario. The country's present situation is substantially different from that of the previous decade.

Whereas the default of the foreign debt, the lack of international financing and the stagnation of the local financial system aggravated the already critical economic and social situation of the country, the devaluation of the local currency —regardless of withholdings on exports (particularly agricultural and energy exports) being in force once again— should prove beneficial to the performance of tradable sectors and, especially, to the performance of agriculture.

Though not enough time has yet elapsed to analyze the effects of the abandonment of Convertibility in January 2002, there is no doubt that the devaluation of the peso has modified economic relations between the agricultural sector and the rest of the economy as well as among the different actors in the agro-industrial chain. In view of the impact of exports within the farming production, changes are likely to be propitious for the primary sector, exhibiting quite significant increases in the share of the total income currently received by farmers vis-à-vis their situation prior to devaluation[82]. In this context, no change should be brought forward in the macro- and micro-economic performances described above; on the contrary, the new scenario should promote the consolidation of trends observed over the last years, at least in the case of price ratios.

Based on the aforementioned findings and the characteristics of Argentine agriculture, it is possible to draw some conclusions and highlight some implications.

In the first place, we cannot fail to single out the exceptional nature of the RR soybean case and the highly unlikely reoccurrence of the set of factors converging on it; therefore, all policies and strategies to be adopted hereafter cannot be a simple "projection of past situations". Moreover, it is worthy of mention that, even within the crisis that Argentina is undergoing, there are several sustained positive factors which should be taken into consideration when developing a strategy in this field.

A review of technologies in the pipeline suggests that, in the next five to ten years, there will be a flow of incremental innovations rather than radical innovations. This process will go hand in hand with a steady increase in the number of species adopted as well as with a diversification of the sources of supply of new technologies, with countries such as China becoming a major supplier of new transgenic events.

This means that, even if the innovative flow that is to come does not have the radical impact featured by soybean, Argentine agriculture will still find it attractive. Firstly, because the focus will remain on temperate and subtropical crops, broadening out to encompass a

[82] According to a study carried out by the "Instituto de Economía y Sociología" of INTA on the basis of data furnished by the Secretaía de Agricultura, Ganadería, Pesca y Alimentación (SAGPyA) and *Márgenes Agropecuarios* magazine, the gross margin (in U.S. dollars) for soybean for the 2002/2003 season is estimated to have increased by 52 per cent, thus reflecting the dramatic drop in the "non-tradable" components of the production cost.

wider range of options in terms crops and events. Secondly, because the coming second and third generations of innovations will benefit consumers. Thirdly, because despite the dire state of affairs, Argentina still fulfills the required structural conditions to reap the benefits of innovations generated abroad. This refers to the 26 million ha. of commercial farming, with farmers used to adopting technological changes, with a dynamic area of technological services and inputs, and with an extensive logistic and territorial network. As already stated, these have been the factors determining the processes that have taken place so far, and they will —no doubt— continue to promote and offer significant incentives in order to ensure a steady expansion of new breakthroughs towards Argentine agriculture, and even more so within the context of a real effective exchange rate more beneficial for the agricultural sector, such as the one that may be anticipated for the coming years.

Yet foreign innovative processes are likely to mirror the priorities and the biases of the economies of their countries of origin, which most probably are quite different from the Argentine ones. This suggests that the encouragement of biotechnological research in the country must always constitute an overriding priority, even in such case when it may be deemed incompatible with the situation the country may be going through at that time. In the mid- and short-term, this issue will most probably consist in having a keen perception of the idiosyncratic characteristics of Argentine agriculture and trying to incorporate them into the negotiations related to the transfer of technology and investments in the sector.

Secondly, other GMOs are likely to feature higher costs of adoption than those of RR soybean —such is the case of Bt cotton, among others. This prospect further highlights the significance of a proactive policy at a national level in terms of research in agricultural biotechnology, not only to ensure that idiosyncratic issues concerning Argentine agriculture are duly addressed, but also as a tool to come up against the competition by promoting alternative sources of “events” in order to prevent possible monopolistic behaviors within the seed market.

Argentina has a modern legislation on competition defense approved in 1999 (Act 25156) and in force since 2000. However, the contestability of the genetic inputs’ market can only be secured if, besides the required legal instruments, the country is in a condition to diversify the supply of innovations.

Regardless of the concentration of supply in the seed market and the potential need for instruments to promote competition within said market, the dissolution of the INASE has strongly weakened the regulatory framework, which is far from being the one currently required. As previously mentioned, the genetic inputs’ market has been deprived almost completely of a regulating body entitled with police power to prevent unfair competition, anti-competitive conduct and other problems arising from the spread of “white bag” transactions. Therefore, steps must be urgently taken to address and solve these issues for they do not only have repercussions within the seed market but in the biosafety regulatory system as well.

All the aforementioned aspects as well as the consensus as to the need both to establish and enforce proper protection standards against risks (effective or perceived) and to make consistent information available to the public, and the strong possibility of an increasing degree of complexity from a scientific, technical, and commercial perspective in terms of issues, crops and events to be dealt with, indicate that it is absolutely necessary that the CONABIA should be institutionally vested with the power required and that its scientific and technical capabilities should be reinforced. Accordingly, it is imperative that the discussions started in 2001 and interrupted by dint of the institutional events of December 2001 should be continued.

The rule applicable to market analyses for the approval of the new transgenic events should be further reviewed. Moreover, all topics related to the labeling and traceability of GMOs and their derivatives should also be addressed.

With regard to market assessment, the rule in force —whether the event has or has not been already approved in the major export markets— has proved effective during the relatively quiet decade of the 1990s, but in the face of a scenario of events increasingly diverse and complex, as the one that can be anticipated, it will probably end up producing an adverse effect on investments, particularly in the field of R&D at the national level. In other words, it would not appear profitable to invest in the development of biotechnology solutions to country-specific problems —for instance, the Río IV disease that strikes corn— if knowing in advance that such innovations will not pass market assessment when the time comes for their release. The fact that RR soybean had already been approved in the EU —the main destination of Argentine exports— has definitely been a contributing factor to the dynamism that characterized the diffusion process of said crop in our country. But today's scenarios differ considerably from the ones in 1996 and it would therefore constitute a mistake to make market access projections on the basis of such data.

On the one hand, the Cartagena Protocol is about be ratified; yet, on the other hand, regardless of the Protocol's regulations, there is an increasing number of countries whose national legislations are adopting higher labeling and traceability requirements concerning GMOs, apparently paving the way for the gradual development of differentiated markets for conventional and transgenic products —a process that would be further consolidated as second and third generation GMOs are released into the market.

Unfortunately, Argentina is in no condition to defray the costs of the aforementioned processes. The only data available has been furnished by the few studies carried out in other countries (mentioned in Chapter II). There is no information, neither in the private nor in the public sectors, that can be used for an assessment of the potential economic implications stemming from the segregation of products, both for the primary sector and the food processing industry. Efforts should be undertaken to generate this information and to attract the investments required to develop the logistics that the new market conditions demand.

Lastly, those issues requiring the formulation of specific policies should be clearly identified. Furthermore, the complexity of the topics addressed in the debate calls for capacity building in terms of follow-up and analysis of ever-changing national and international realities. The release of GMOs in Brazil and the eventual amendment of the European Union moratorium as well as the significant role played by China —and lately by other countries such as India— in this technology should contribute to the redefinition of the international and regional strategy adopted by Argentina on these issues. This book is a contribution to the permanent task that should be systematically carried out not only with the support of international organizations but, above all, with the staunch support of the Argentine public and private sectors.

Bibliography

Ablin E. y S. Paz (2000) "Productos transgénicos y exportaciones agrícolas: reflexiones en torno de un dilema argentino" (mimeo) Buenos Aires

Ablin, E. y S. Paz (2001); "El debate internacional sobre productos transgénicos. Opciones para las exportaciones agrícolas argentinas", Boletín Informativo Techint, Nº 307, Julio-Septiembre, Buenos Aires.

ADB -Asian Development Bank- (2001), Agricultural Biotechnology, Poverty Reduction, and Food Security, Manila.

Aerni, P. (2001), "Public Attitudes Towards Agricultural Biotechnology in Developing Countries: A Comparison between Mexico and the Philippines", Center for International Development at Harvard University, Science, Technology and Innovation Program, Discussion Paper.

Altieri, M. A. y P. Rosset (1999), "Ten Reasons Why Biotechnology Will Not Ensure Food Security, Protect The Environment And Reduce Poverty In The Developing World", AgBioForum, Volume 2, Nº 3 y 4.

ASA -Asociación de Semilleros Argentinos- (2001), Biotecnología, Argentina y los Argentinos. Estudio de Percepción Pública, Mayo-Junio.

Australia New Zealand Food Authority (ANZFA). (1999), Report on the compliance costs facing industry and government regulators in relation to labelling genetically modified foods.

Baumüller H. (2002) "Domestic Import Regulations for Genetically Modified Organisms and their Compatibility with WTO Rules" (mimeo) International Centre for Trade and Sustainable Development (ICTSD), Geneva

Bisang R. (2201) "Shock tecnológico y cambio en la organización de la producción. La aplicación de biotecnología en la producción agropecuaria argentina" (mimeo)

Brescia, V.(2001) Cambio Estructural en la Dinámica del Área Sojera Argentina. IES. INTA. Documento de Trabajo. Noviembre

Buckingham, D. (2000), "The Labeling Of GM Foods - The Link Between Codex And The WTO", AgBioForum, Volume 3, Nº 4.

Burachik, M. and P.L. Traynor. (2001) Commercializing Agricultural Biotechnology Products in Argentina: *Analysis of Biosafety Procedures*. International Service for National Agricultural Research ISNAR The Hague, The Netherlands

Byerlee, D. y K. Fischer (2001), "Accessing Modern Science: Policy and Institutional Options for Agricultural Biotechnology in Developing Countries", IP Strategy Today, Nº 1-2001.

Byerlee D. and G. Traxler. (2001) "The Role of Technology Spilllovers and Economies of Size in the Efficient Design of Agricultural Research Systems"en J.M. Alston, P.G. Pardey and M.J. Taylor eds "Agricultural Science Policy: Changing Global Agendas". Johns Hopkins Univefsity Press, Baltimore

Byerlee, D.; Hesse de Polanco, E (1982): La Tasa y la Secuencia de Adopción de Tecnologías Cerealeras Mejoradas: El Caso de la Cebada de Secano en el Altiplano Mexicano. (Documento de Trabajo, 82/6). CIMMYT, México.

Cap, Eugenio (1993): Competitividad del sector agropecuario argentino. Marco conceptual y metodológico del modelo de generación de excedentes. INTA,Buenos Aires

Cap, E.; Miranda, O. (1993): "Análisis ex-ante de impactos en la investigación agrícola en la Argentina para siete rubros productivos en escenarios alternativos". Documento presentado en el Simposio Internacional La investigación agrícola en la República Argentina: Impactos y necesidades de inversión. INTA/IICA/Universidad de Minnesota. Buenos Aires

Caswell, J. (2000a), "Labeling Policy For GMOs: To Each His Own?", AgBioForum, Vol 3, Nº 4.

Caswell, J. (2000b), "Labelling GMOs in food: Trojan horse or good policy?", Agbiotechnet, Volume 2, November.

Cohen, J. (1994), Biotechnology Priorities, Planning, and Policies: A Framework for Decision Making, ISNAR Research Report Nº. 6.

Cohen J., J. Komen and J. Verástegui (2001). Plant Biotechnology Research in Latin American Countries: *Overview, Strategies and Development Policies*. IV Latin American Plant Biotechnology Meeting, REDBIO , Goiania, Brazil.

Correa C. (1998), "Tendencias en el patentamiento de biotecnología", en 2o. Congreso sobre Propiedad Intelectual, Universidad de Buenos Aires

Correa, C.M.(1999) Normativa nacional, regional e internacional sobre propiedad intelectual y su aplicación en los INIAs del Cono Sur. Programa Cooperativo para el Desarrollo Tecnológico Agropecuario del Cono Sur. PROCISUR. Montevideo, Uruguay

Cosbey, A (1996), "The Sustainable Development Effects of the WTO TRIPS Agreement: A Focus on Developing Countries", International Institute for Sustainable Development, Working Paper.

Cosbey, A. y S. Burgiel (2000), "El Protocolo de Cartagena sobre la seguridad de la biotecnología. Análisis de resultados", nota informativa del IIDS, Winnipeg.

Chudnovsky D. S. Rubin, E. Cap y E.Trigo (1999) "Comercio internacional y desarrollo sustentable. La expansión de las exportaciones argentinas en los años 1990 y sus consecuencias ambientales" CENIT DT 25, Buenos Aires .

Davies, P. (1999), "GM Technology and its Global Adoption", draft.

Del Bello, J.C. (1998) "Difusión de plaguicidas y estructura de la oferta" en Barsky et al La agricultura pampeana. Transformaciones productivas y sociales Fondo de Cultura Económica IICA Cisea. Buenos Aires

Dickson, D. (2001), “Public attitudes to biotechnology: where are they heading?”, delivered to the conference on New Biotechnology Food and Crops: Science, Safety and Society, United Nations Conference Centre, Bangkok, Thailand, 10-12 July 2001.

Dutfield, G. (2000), "Sharing the benefits of biodiversity: access regimes and intellectual property rights", Science, Technology and Development Discussion Paper No. 6, Center for International Development and Belfer Center for Science and International Affairs, Harvard University, Cambridge, MA

EC -European Commission- (2000), “Economic Impacts of genetically modified crops on the Agri-Food sector. A first review”, Directorate-General for Agriculture, Commission of the European Communities, Working Document Rev. 2.
Economic Research Service/USDA (1999), “Biotechnology Research: Weighing the Options for a New Public-Private Balance”, Agricultural Outlook, October 1999.

Einsiedel, E. (2000), “Consumers And GM Food Labels: Providing Information Or Sowing Confusion?“, AgBioForum, Volume 3, Nº 4.

Elena, M.G. Ventajas Económicas del Algodón Transgénico en Argentina. INTA. Estación Experimental Sáenz Peña. Chaco. Documento de trabajo. 2001.

Galperín, C., L. Fernández e I. Doporto (1999), “Los productos transgenicos, el comercio agrícola y el impacto sobre el agro argentino, Panorama del Mercosur, Nº 4.

GAO. Report to the Chairman, Subcommittee on Risk Management, Research, and Specialty Crops, Committee on Agriculture, House of Representatives. Biotechnology: *Information on Prices of Genetically Modified Seeds in the United States and Argentina.* Washington, D.C., USA, 2000.

Golder, G. *et al* (2000), Phase I Report Economic Impact Study: Potential Costs of Mandatory Labelling of Food Products Derived from Biotechnology in Canada, KPMG, Ottawa.

Gutierrez, M. (1998) “Semillas mejoradas” en Barsky et al op cit

Hathcock, J. (2000), “The Precautionary Principle – An Impossible Burden Of Proof For New Products”, AgBioForum, Volume 3, Nº 4.

Hayami, Y y Ruttan. V. (1985). *Agricultural Development. An International Perspective.* The John Hopkins University Press. Baltimore and London. 1987.

Hotchkiss, J. (2001), “Lambasting Louis: Lessons from Pasteurization”, en NABC REPORT 13: Genetically Modified Food and the Consumer, National Agricultural Biotechnology Council.

James, C. (2001), “Global Review of Commercialized Transgenic Crops: 2000”, ISAAA Briefs Nº 23.

James, C. (2002), “Global Review of Commercialized Transgenic Crops: 2001”, ISAAA Briefs Nº 24.

James, C. Global Review of Commercialized Transgenic Crops: 2001. The International Service for the Acquisition of Agri-Biotech Applications ISAAA *Briefs* No. 24-2001, Ithaca NY, USA.

Kalaitzandonakes, N.G. (2000). Agrobiotechnology and Competitiveness. *American Journal of Agricultural Economics* 82 (5): 1224-33.

Kalaitzandonakes, N. y P. Phillips (2000), "Editor's introduction", AgBioForum, Volume 3, Nº 4.

KPMG (2000), "Report On the costs of labelling genetically modified foods, prepared for theAustralia New Zealand Food Standards Council-Canberra.

Krattiger, A.F. Biotechnology and Proprietary Science Management: *Proposals to Strengthen Biotechnology Transfer in Latin America.* Regional Biotechnology Forum: A Latin American Biotechnology Initiative. Montevideo, Uruguay, 2001

Lal, R., J. M. Kimble, R. F. Follett, and C. V. Cole. 1998. The potential of U.S. cropland to sequester carbon and mitigate the greenhouse effect. Lewis Publishers, Wash., DC. 128 pp.

Lattuada, Mario; (2000). "Cambio Rural. Política y Desarrollo en la Argentina de los '90". Rosario, Ced-Arcasur.

Mac Kenzie, A. (2000), "The Process Of Developing Labeling Standards For GM Foods In The Codex Alimentarius", AgBioForum, Volume 3, Nº 4.

Maltsbarger, R. y N. Kalaitzandonakes (2000), "Direct And Hidden Costs In Identity Preserved Supply Chains" AgBioForum, Volume 3, Nº 4.

Millstone E., E. Brunner y S. Mayer (1999), "Beyond 'substantial equivalence'", Nature, Nº 401.

National Academy of Sciences (2002), Environmental Effects of Transgenic Plants: The Scope and Adequacy of Regulation, National Academy Press, Washington D.C.

Oliver, M. F. (2001), "Organismos genéticamente modificados: su impacto socioeconómico en la agricultura de los países de la Comunidad Andina, MERCOSUR y Chile", N. Lucas (ed.), Cinco estudios sudamericanos sobre comercio y ambiente, Grupo Zapallar, Quito.

Paarlberg, R.L. The Politics of Precaution. *Genetically Modified Crops in Developing Countries.* The International Food Policy Research Institute IFPRI, Washington DC, USA, 2001.

Pardey, P.G. The Future of Food. *Biotechnology Markets and Policies in an International Setting.* The International Food Policy Research Institute IFPRI, Washington DC, USA, 2001.

Penna, J y Lema, D.(2000) El impacto económico de la Biotecnología Agrícola en Argentina:El Caso de la Soja. Documento de trabajo no publicado.

Peretti, M. (1999) *Competitividad de la Empresa Agropecuaria Argentina en la Década de los ´90*. Revista Argentina de Economía Agraria. Nueva Serie. Volumen II-N° 1.

Pew Initiative on Food and Biotechnology (2002), Knowing where it's going. Bringing food to market in the age of genetically modified crops, Proceedings from a Workshop Sponsored by Pew Initiative on Food and Biotechnology and Economic Research Service of the USDA.

Phillips, P. y H. Mc Neill (2000), "A Survey Of National Labeling Policies For GM Foods", AgBioForum, Volume 3, Nº 4.

PIP -Plant Intellectual Property- (2000), "Workshop report", Plant Intellectual Property European Workshop, University of Sheffield, Enero.

Porstmann, Juan C.; (2000), "Unidad agrícola económica. Una definición olvidada", Síntesis Agroeconómica, nº 69, Federación Agraria Argentina, Marzo.

Pucciarelli, A. *Estructura Agraria de la Pampa Bonaerense: los tipos de explotaciones predominantes en la Provincia de Buenos Aires.* En: Barsky, O. ed.; Pucciarelli, A, ed. (1997). *El Agro Pampeano: El Fin de un Período*. 207-290. FLACSO; Universidad de Buenos Aires, Oficina de Publicaciones del CBA.

Qaim, M.(2002) Bt Cotton in Argentina: Analyzing Adoption and Farmer´s Willingness to Pay. Department of Agricultural and Resource Economics. University of California, Berkeley (mimeo) april

Qaim, M., A.F. Krattiger and J. von Braun. Agricultural Biotechnology in Developing Countries: Towards Optimizing the Benefits for the Poor. Center for Development Research ZEF, Dordrecht, The Netherlands, 2000.

Qaim, M y Traxler. G. (2002) *Roundup Ready Soybeans in Argentina: Farm Level, Environmental and Welfare Effects.* Trabajo presentado en la 6° Conferencia ICABR sobre: *"Agricultural Biotechnologies: New Avenues for Production, Consumption and Technology Transfer"*. Ravello, Italia, Julio.

Royal Commission on Genetic Modification (2001), Report of the Royal Commission on Genetic Modification.

Royal Society of London, U.S. National Academy of Sciences, Brazilian Academy of Sciences, Chinese Academy of Sciences, Indian National Science Academy, Mexican Academy of Sciences and Third World Academy of Sciences (2000), Transgenic Plants and World Agriculture, National Academy Press, Washington, D.C.

SEBIOT (2000), Plantas Transgénicas. Preguntas y Respuestas, Biotecnología en Pocas Palabras, 1, Sociedad Española de Biotecnología.

Shoemaker, R. (2001), "Economic Issues in Agricultural Biotechnology", Agricultural Information Bulletin 762, Economic Research Service, US Department of Agriculture.

The Royal Society (2002), Genetically modified plants for food use and human health—an update, Policy Document 4/02, London.

Traxler, G. and D. Byerlee. Linking Technical Change to Research Effort: An Examination of Aggregation and Spillovers Effects. *Agricultural Economics* 24 (2001): 235-246.

Trigo E.J. The Situation of Agricultural Biotechnology Capacities and Exploitation in Latin America and the Caribbean. En: *Agricultural Biotechnology in Developing Countries: Towards Optimizing the Benefits for the Poor*. Center for Development Research ZEF, Dordrecht, The Netherlands, 2000.

Trigo, E. *et al* (2001), "Agricultural biotechnology and rural development in Latin America and the Caribbean. Implications for IDB lending", Sustainable Development Department, Technical Paper Series.

Trigo, E.J., G. Traxler, C. Pray and R. G. Echeverría. Agricultural Biotechnology and Rural Development in Latin America and The Caribbean. *Implications for IDB Lending.* Inter-American Development Bank, 2001.

Zarrilli, S. (2000), "International Trade in Genetically Modified Organisms and Multilateral Negotiations. A New Dilemma for Developing Countries", UNCTAD/DITC/TNCD/1, October.