Protection of Biotechnology Intellectual Property Rights in Developing Countries: Economic Impact Analysis of Terminator Genes and Other Enforcement Mechanisms

By

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Abstract

The global area under genetically modified (GM) crops grew rapidly in the first ten years of GM technology adoption. However, the protection of innovators' intellectual property rights (IPRs) has remained controversial, especially in developing countries, where IPR enforcement is lax. Weak enforcement of IPRs in developing countries has resulted in the failure of markets to transfer rents from the primary producers who sow GM crops to seed developers, and has reduced the innovators' incentives to improve seed quality in developing countries. A range of IPR enforcement mechanisms has been developed to strengthen IPR protection in developing countries, which include: the World Trade Organisation's (WTO) Agreement on Trade Related-aspects of Intellectual Property Rights (TRIPS), GM levies and genetic use restriction technologies (GURTs). GURTs, also called terminator genes, are technological solutions to the IPRs market failures in developing countries, by rendering the second generation seeds sterile to prevent unauthorized use of genetic material and self-supply of commercial seeds by farmers and other plant breeders.

To explore the potential welfare effects of GURTs and other IPR enforcement mechanisms in developing countries, the economic surplus of producers, consumers and innovators in Roundup Ready® soybean production in Argentina is quantified and compared in several scenarios of IPR protection, employing a vertical linkage soybean model and a synthetic partial-equilibrium model. The results show that GURTs could markedly reduce welfare in the adopting country, unless the higher degree of rent appropriability leads to vastly more productive seeds. A simulation demonstrates that if GURT seeds become 90 per cent more productive than the current GM variety, then an adopting country could benefit from the adoption of GURTs.

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Chapter 1

Introduction

The protection of innovators' intellectual property rights (IPRs) in plant breeding has been strengthened in industrialized countries since genetically modified (GM) technology was invented (Wright, 2006). In contrast, IPR enforcement is lax in most developing countries because of different belief systems, insufficient institutions and legislation, and few incentives for local governments to protect foreign intellectual property rights (Levy, 2000). Weak enforcement of IPRs in developing countries has led to a widespread use of farm-saved seeds and emergence of non-licensed seed dealers; the result is that large multinational biotechnology companies are unable to fully capture their innovation rents from the producers who have a "free ride" by using their technologies. This may discourage further research and development (R&D) efforts to develop new varieties that are suitable to local agro-climatic conditions.

The search for alternative IPR systems in developing countries has caused great concerns for stakeholders in the GM crop industry. Several enforcement mechanisms have been developed to protect investment in new innovations and improve the IPR environment in developing countries, which include the World Trade Organization's (WTO) Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), a GM technology levy, and Genetic Use Restriction Technologies (GURTs).

GURTs are new technological means invented by biotechnology firms to protect the IPRs of their innovations. The first GURT technology patent was granted to the United States Department of Agriculture (USDA) and Delta and Pine Land Company in 1998 (United States Patent and Trademark Office, 1998). More than 50 GURT patents are held by universities, governments and private firms in the US (Shi, 2006; see Appendix B). Despite the availability of the technology, GURTs have not been used in field trials or been commercially developed yet (Collins and Krueger, 2003), considering potential health and environmental concerns, as well as potential adverse impacts of GURTs on the access to innovations for developing countries. There are two types of GURTs; variety GURTs (V-GURTs) and trait-specific GURTs (T-GURTs). V-GURTs (also called terminator genes) can render seeds sterile, and prevent unauthorized use of genetic material and self-supply of commercial seeds by farmers. V-GURTs[1] are potential technological solutions to the IPR market failures in developing countries. GURTs could significantly enhance the innovator's ability to capture rents from their innovation, which may result in more investment in plant breeding R&D and higher yielding seeds that are suitable for local growing conditions.

Trait Use Restriction GURTs (T-GURTs) involve the external application of inducers to trigger the expression of some specific traits. For example, traits of tolerance to salt or heavy metals could be switched on or off. Traits can be activated at the time of purchase or activators can be purchased for later use (Jefferson et al, 1999). The key to T-GURTs is to switch on or off some target characteristics of a plant, through inducible promoters regulating the expression of the transgenes (FAO, 2001). T-GURTs could be

[1] If there is no specific explanation, GURTs is used to refer to V-GURTs throughout the paper hereafter.

used in all crops to enhance certain valued added traits or to protect the plants in extreme harsh weather.

There have been several recent studies that have tried to estimate the welfare effects on developing countries of adopting GURTs (Goeschl and Swanson, 2000 and 2003), R&D investment by innovating firms (Lence and Hayes, 2005), innovator's rent appropriability and productivity increases (Srinivasan and Thirtle, 2003). In these studies, it is common to compare the welfare effects of GURTs with a baseline of no IPR enforcement. Such a baseline may not be relevant, since the current situation of weak IPR protection in developing countries is not sustainable with the introduction of the TRIPS agreement and alternative IPR enforcement mechanisms, developed by the bio-science multinational companies. These alternatives include GM levies, which were proposed by Monsanto in the soybean seed market of Brazil (Reuters, 2005).

The objective of this study is to explore the potential effects of GURTs and other IPR enforcement mechanisms on the distribution of economic welfare in developing countries and provide some evidence for policy making on IPR regulation. Using the studies mentioned above as starting points, this thesis presents a background on GURTs in agricultural biotechnology and considers their economic impacts on developing countries from a new perspective. We not only consider GURTs as a tool to guard the IPRs of agricultural innovators, but also consider potential productivity increases that may arise from increased appropriability of research expenditure. We set a range of yield improvements to analyze how much more productive GURT seeds would have to be to offset the adverse effects that could result from higher monopoly seed prices. Based on farm level survey data collected by Qaim and Traxler (2005), and data of production, consumption and elasticities from other sources, this research will employ a synthetic partial-equilibrium model and a vertical linkage production model to estimate the welfare effects of GURTs and other IPR enforcement mechanisms applied in Roundup Ready® (RR) soybean production in Argentina. Sensitivity analysis is conducted on the productivity increase of GURT seeds, soybean supply elasticities, and adoption rates of GURTs to examine the potential economic impacts of GURTs on producer's surplus, seed price, and supply quantities. The economic surplus of producers, consumers and the innovators is quantified in various IPR protection scenarios including the black market for seeds, TRIPS retaliation, technology levy, and GURTs. The results show that GURTs could markedly reduce welfare in the adopting country, unless the higher degree of rent appropriability leads to vastly more productive seeds. As the soybean supply elasticity increases, primary producers lose more if GURTs are introduced without any productivity increase. Even when GURT seeds become 16 per cent more productive than current GM crop varieties, the producer's surplus is falling as the adoption rate of GURTs increase. The model's results suggest that GURT seeds would have to be at least 90 per cent more productive than current GM varieties for the adopting country to benefit from the adoption of GURTs. These results can also inform the debate about the future adoption of GM crops in developing countries. If GURTs are commercialized and bundled into GM crops, then potential adopting countries may not ever have the option of maintaining seed markets in which IPRs are not protected. The results of this model provide some insight into how such a scenario could affect an adopting country.

This thesis is organized as follows. There are seven chapters altogether. Chapter 1 is the introduction. Chapter 2 presents background information on the world GM crop production and the health and environmental concerns associated with GM technology; the RR soybean technology and its adoption; the legislation of IPRs protection in plant breeding in industrialized countries and developing countries, with a detailed IPR status of RR soybean innovation. Chapter 3 introduces various forms of IPR enforcement mechanisms that are relevant to agricultural biotechnology, including the WTO's TRIPS agreement, GM levies, and GURTs. Chapter 4 reviews the literature on GM crop adoption and the economic impacts of GURTs in developing countries. This chapter presents summaries of the important studies from two primary strains of research[2], with emphasis on the quantitative research work on GURTs. Chapter 5 presents the economic models, methodologies and data used to analyze the welfare effects of GURTs and other IPR enforcement mechanisms in adoption of RR soybeans in Argentina. Chapter 6 focuses on the aggregate welfare effects of various IPR enforcement mechanisms, including the WTO's TRIPS agreement, GM levies, and GURTs in the soybean sector of Argentina. The quantitative results of the welfare analysis conducted in Chapter 5 and a discussion of the results is presented. The results provide an indication of how a developing country, such as Argentina, which adopts the new technology, but ignores IPRs of the innovators, could be affected if various IPR enforcement mechanisms were in place. Chapter 7 presents conclusions that are drawn from the welfare analysis. Policy suggestions on IPR regulation in developing countries and limitations of this study are also discussed.

[2] There are two main categories of research that have investigated the economic impacts of GM technology in adopting countries. One category has examined the technological effects of GM crops on environment and farm income, while the other category has focused on how different types of intellectual property rights mechanisms affect the distribution of welfare that is generated by the adoption of GM technology in developing countries.

Chapter 2

Background

This Chapter presents background information on global GM crop production and the health and environmental concerns associated with GM technology; the RR soybean technology and its adoption; the legislation of IPRs protection in plant breeding in industrialized countries and developing countries, with a detailed description of IPR status of RR soybean innovation.

2.1. GM Crop Production: A Primer

2.1.1. GM Crop Technology

GM crops, also called Genetically Engineered (GE) crops contain altered genetic materials or have genes transferred from other organisms to introduce new agronomic traits to production. The common targeted traits of GM crops include herbicide tolerance, pest and pathogen resistance, abiotic stress tolerance, and product quality. For example, RR soybeans and RR cotton are herbicide tolerant; *Bacillus thuringiensis* (Bt) corn and Bt cotton is pest tolerant. GM technology has been applied in many major field crops, including soybeans, corn, cotton, and canola (Table 2-1). By planting GM crops, farmers may benefit from increased yields, less use of herbicide and pesticides, lower production costs, reduced cost of labour, and capital equipment; and improved agricultural productivity (Moschini, 2001).

2.1.2. Why is GM Technology Controversial?

Despite the enhanced production efficiency in agriculture, the emergence of GM crops and GM food has also triggered some health and environmental concerns.

According to the World Health Organization (WHO), the human health concerns are mainly about: (1) GM technology may introduce new antigens and toxins, which may be toxic or may trigger human allergic reactions; (2) possible antibiotic resistance effects: antibiotic-resistant marker genes and viral promoter genes were used as markers to indicate if a GM process was successful; (3) the stability of the inserted genes (WHO website).

The 2003-04 State of Food and Agriculture (SOFA) of the Food and Agriculture Organization of the United Nations (FAO) provides a critical scientific assessment of health and environmental impacts of GM crops. It concludes that there are no exceptional food safety problems with any current GM products. The scientific assessments of SOFA show that there have been no allergic or toxic effects that have resulted from consumption of GM products; the risks of antibiotic-resistant marker genes and viral promoter genes used in the GM process are very small (FAO website).

The main issues of environmental concerns include (WHO website):

(1) Gene contamination: the modified crops could cross with related crops or wild plants, and the consequences are unknown. Some organic food production could be contaminated by the drift of GM pollen. This can be controlled by requiring minimum distances between GM crops and organic crops.

(2) Faster induction of resistant pests. Insects may become resistant to Bt crops, and emerge as “super pests”.

(3) Detrimental effects on beneficial insects. There are fewer weeds for birds to feed on in fields of herbicide tolerant GM crops.

2.1.3. Global GM Crop Production

In spite of the GM crops’ controversy, their global planting area has grown rapidly, since they were first being commercially planted in large-scale in 1996 (Just 2006). By 2006, global GM production grew to 252 million acres in 22 countries (James, 2006). The largest adopter was United States with 54.6 million hectares, followed by Argentina, Brazil, Canada, India and China (Table 2-1, James, 2006). GM soybeans have been the principal biotech crop, which covered 58.6 million hectares, 57% of global biotech area; followed by maize, 25.2 million hectares at 25%; cotton,13.4 million hectares at 13% and canola, 4.8 million hectares at 5% of global biotech crop area in 2006 (James, 2006).

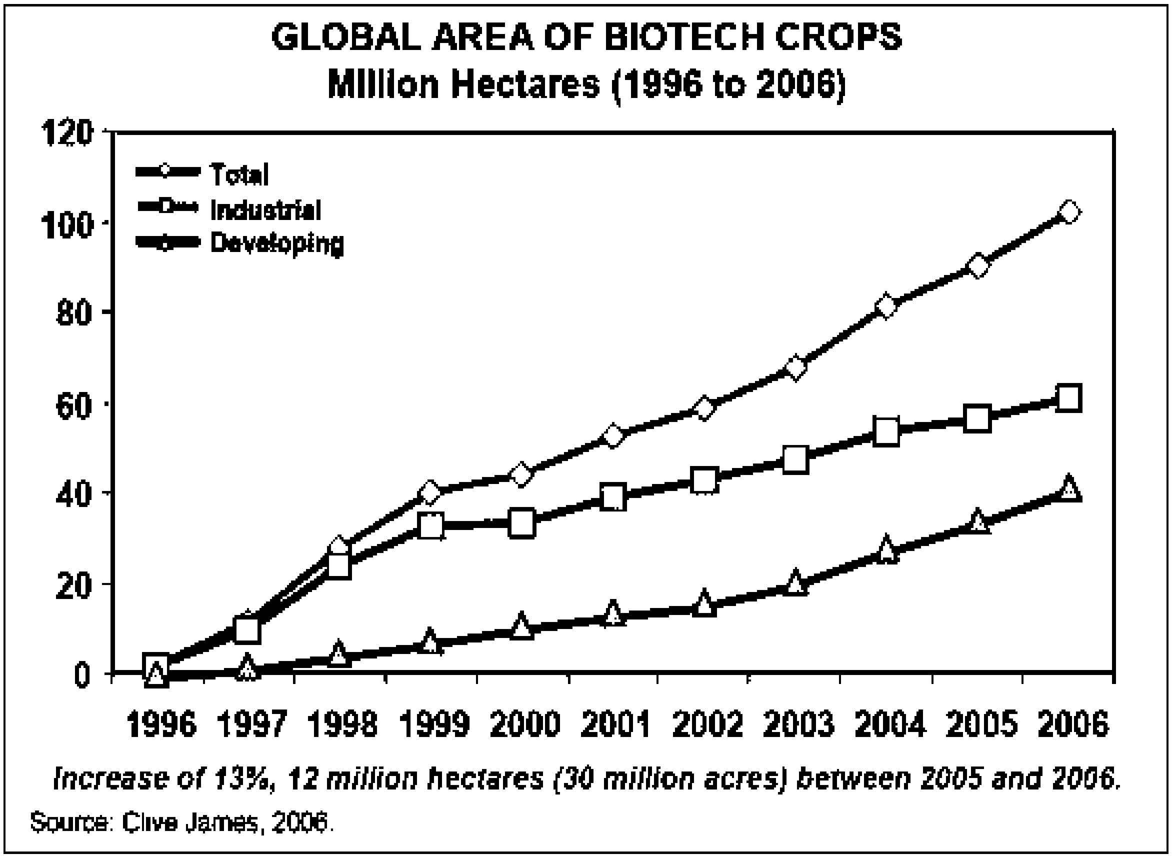
Table 2-1 Global Area of Biotech Crops in 2006: by Country (Million Hectares)

Rank	Country	Area (millions hectares)	Biotech Crops
1	USA	54.6	Soybean, maize, cotton, canola, squash, papaya, alfalfa
2	Argentina	18.0	Soybean, maize, cotton
3	Brazil	11.5	Soybean, cotton
4	Canada	6.1	Canola, maize, soybean
5	India	3.8	Cotton
6	China	3.5	Cotton
7	Paraguay	2.0	Soybean
8	South Africa	1.4	Maize, soybean, cotton
9	Uruguay	0.4	Soybean, maize
10	Philippines	0.2	Maize
11	Australia	0.2	Cotton
12	Romania	0.1	Soybean
13	Mexico	0.1	Cotton, soybean
14	Spain	0.1	Maize
15	Colombia	<0.1	Cotton
16	France	<0.1	Maize
17	Iran	<0.1	Rice
18	Honduras	<0.1	Maize
19	Czech Republic	<0.1	Maize
20	Portugal	<0.1	Maize
21	Germany	<0.1	Maize
22	Slovakia	<0.1	Maize

Source: James, 2006.

Of the ten biggest GM producing countries, eight are developing countries (see table 2-1). Developing countries have increased their GM crops planting area steadily in the first ten years of GM technology adoption (figure 2-1), and their growth rates of GM crop planting area have been faster than industrialised countries (James, 2006). India, China, Argentina, Brazil and South Africa account for the bulk of developing country GM area; these countries are playing more and more important roles in the world GM crop production (table 2-1). China has a strong public research sector with thousands of researchers specialized in plant biotechnology. Dozens of biotech crops are being developed and field testified, including the three major staples: rice, maize, and wheat, as well as cotton, potato, tomato, soybean, cabbage, peanut, melon, papaya, sweet pepper, chili, rapeseed and tobacco (James, 2006).

Figure 2-1 Global area of GM crops: industrial and developing countries



However, in some countries, the adoption of GM crops has been treated very cautiously. For example, in Japan and some European Union (EU) countries, the process of accepting and introducing GM crops is very strict and slow, although the EU has approved Monsanto's RR soybeans and Novartis's BT corn (Hanrahan, 1998). Some of the reasons for slow approval include strong opposition to GM food from consumers, concerns of the environment and health, and traditional protectionist pressure to keep out competing agricultural imports from exporting countries that produce GM crops (Hanrahan, 1998). In EU countries, labelling is mandatory on products that may contain genetically modified organisms (GMOs); and the traditional food market and GM food market are segregated (Hanrahan, 1998).

2.2. Round-up Ready Soybeans

In 1995, RR soybeans were developed at Monsanto by being injected with an enzyme from a strain of agro bacterium which controls the synthesis of amino acids (Moschini, Lapan and Sobolevsky, 2000). RR soybean seed contains a gene that is resistant to Roundup®, the commercial name of an inexpensive herbicide, glyphosate, also developed by Monsanto. Glyphosate herbicide is no longer covered by patents, and is a low cost, broad-spectrum herbicide that kills many types of weeds. Due to the significant cost reductions of weed control and farming management, RR soybeans were adopted quickly by major soybean producers in the world. In 2005, RR soybeans adoption rate was 93 per cent of the soybean area in the US (Brooks and Barfoot, 2006), and it nearly reached 100 per cent in Argentina (Brooks and Barfoot, 2006). In Brazil, the acreage of herbicide tolerant soybeans planted in recent years exceeded 40% of the total acreage (Brooks and Barfoot, 2006). This occurred even when Brazilian regulations officially prohibited the planting of GM seeds.

2.2.1. RR Soybean Adoption in Argentina

Argentina is one of the important players in the world agricultural market. The liberalization reform that occurred in the 1990s has greatly benefited agriculture production, especially soybeans (Schnepf, et al., 2001). Argentina is the third largest soybean producer in the world, behind Brazil and the US (Table 2-2). Due to its low rate of internal consumption, it is also the one of the biggest exporters of soybeans, soybean oil and soybean meal (Table 2-2). Most of the soybeans and soy products from South America are exported to India and China.

Argentina has been a pioneer in adoption of GM crops in South America and the world. In 1996, RR soybeans were brought into Argentina by Monsanto for the first time and were approved for cultivation by the government of Argentina. Given non-patent protection for RR seeds, farmers were able to save their seeds for planting in the next season. And glyphosate (Roundup®) was cheap, which together gave Argentina a distinct competitive advantage over other producers in the world market for soybeans. Since then RR soybean adoption has grown rapidly and extensively, from less than 10 per cent in 1996, to more than 90 per cent in 2001 (Qaim and Traxler, 2005). Over the next few years, GM soybean seeds were smuggled and grown illegally in Brazil, Paraguay, Uruguay and Bolivia.

Table 2-2 Soybean production and exports 2005/06 (In thousands of metric tonnes)

Top producers	Production	Exports	Exports as % of production
1. US*	83,368	33,443	40%
2. Brazil*	55,000	39,850	72%
3.Arentina*	40,500	37,575	93%
4. China	16,350	-	
5. India	6,300	-	
6. Paraguay	4,000	2,600	65%

* Includes soybean, soy meal and soy oil in the export products.

Source: USDA, 2006

2.3. Intellectual Property Rights in Agricultural Innovation

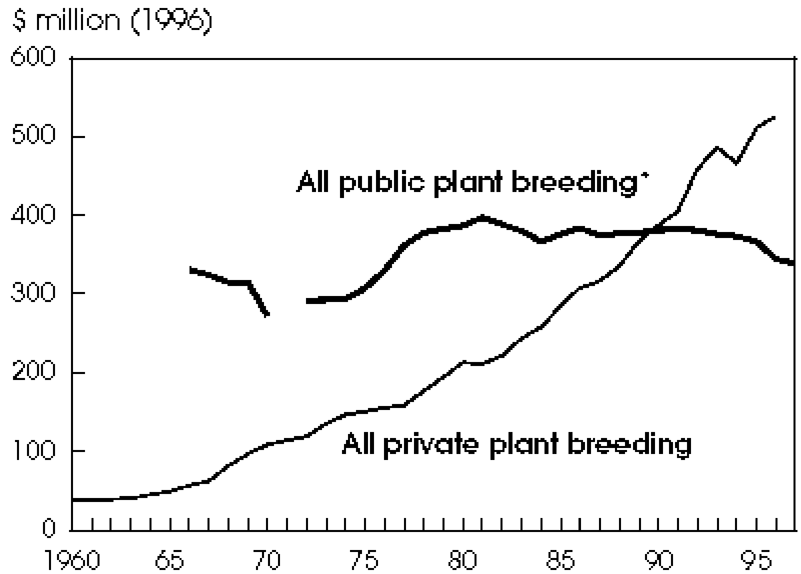
Intellectual property is the property of intellect and knowledge, which in commerce are protected by legal sanctions, including patents, trade marks, designs, copyright, and trade secrets. IPRs grant their owners defensive rights to prevent the commercial exploitation of their intellectual properties. IPR laws and enforcement mechanisms, such as contracts and agreements, are used to provide incentives for innovators to generate new ideas and invest in R&D. In agricultural innovations, IPRs usually take the forms of patents and plant breeder's rights.

2.3.1. IPRs & Investment in Research and Development

Most innovations, particularly in the fields of medicine and agriculture, are the results of substantial investment in R&D in public or private research institutions. The R&D of agricultural biotechnology has happened primarily in the private sector of developed countries (Frisvoid et al., 1999). For example, Monsanto, one of the biggest American multinational biotechnology firms, currently accounts for about half of all U.S. field trials and the dominant share of commercial acreage of GM crops (Frisvoid et al., 1999). In the plant breeding sector, the forces of globalization and the pressures on public budgets have shifted more plant breeding R&D from the public to the private sector in the past 20 years, especially in the U.S. for soybeans and in Canada for canola. Figure 2-2 shows the trends of R&D investment of plant breeding in the public and private sectors between 1960 and 1997 (USDA, 2002). Real inflation-adjusted R&D investment in the public sector increased until the 1980s, then stagnated in the mid-1990s, and it began to decline. On the contrary, real private R&D investment in plant breeding grew at annual rate of 7 percent from the mid-1960s to the mid-1990s. Private R&D investment in plant breeding surpassed public investment by the mid-1990s (Figure 2-2).

Figure 2-2:

Between 1960 and 1997, Private-Sector Outlays for U.S. Plant Breeding Rose More Than Tenfold



1996 dollars are deflated.
*Data for 1971 not available.
Economic Research Service, USDA

The cost of developing and marketing new biotech crops can be very high. Table 2-3 shows how heavily the private sector has invested in agricultural research and how much more R&D was conducted in the industrialized countries than in the developing countries.

Table 2-3: Crop biotechnology research expenditures

	Biotech R&D (million US$ per year)	*Biotech as share of sector R&D*
Industrialized countries:	1900-2500	
Private sector	1000-1500	40
Public sector	900-1000	16
Developing countries:	165-250	
Public (own resources)	100-150	5-10
Public (foreign aid)	40-50	n.a.
CGIAR centres	25-50	8
Private sector	n.a.	n.a.
World total	2065-2730	

Source: Byerlee and Fischer (2001)

The return from R&D is dependent on how well intellectual property is protected (Gaisford et al., 2002). Adequate protection of IPRs can help private companies to earn profits from their innovations and stimulate their incentives to invest in R&D of advanced innovation in agricultural biotechnology research.

2.3.2. Protection of Agricultural IPRs in Industrialized Countries

There has been a long history in the legal system to respect and protect IPRs in the US and other industrialized countries, in which IPRs are clearly defined and effectively enforced (Kesan and Gallo, 2005). In the US, there are several intellectual property laws granting IPRs to plant biotechnology innovators, and mechanisms to encourage new ideas.

(1) The US Plant Patent Act 1930 distinguishes between 'products of nature' and 'human-made inventions'. The Act was designed especially for plants, and has been available from the U.S. Patent and Trademark Office in the Department of Commerce to protect novel clonally propagated plant varieties, including fruit trees, ornamentals, and berries. Plant patents are valid from the date they are granted until 20 years from the date of application (Wright, 2006).

(2) The US Patent Act of 1952 extends patent rights to agricultural innovations under a much more general category, which covers agricultural machinery, equipment, chemicals, production processes and other similar innovations. Patent protection under the Patent Act of 1952 is termed as "Utility patent protection" (Kesan and Gallo, 2005).

(3) The US Plant Variety Protection Act 1970 extends the category of an artificial nature to the reproducibility of plants and provides Plant Variety Protection Certificates (PVPCs) from the U.S. Department of Agriculture. Farmers are allowed to save seeds of varieties protected by PVPCs for replanting their crops, but they cannot provide or sell those seeds to others for planting.

(4) Case law of Diamond vs. Chakrabaty in 1980 (US), in which the role of patent protection for plants is reinforced and it allows the use of utility patents for biotechnology, after the emergence of GM technology. It granted patents for inventions of living organisms, such as plants and animals (Evenson, 2006).

Plant Patent holders can control the use of patented plant varieties, genetic materials, and methods, by requiring the buyers (breeders or farmers) to sign the following types of contracts (Wright, 2006):

(i) Bag label contracts, which restrict the use of the materials by farmers and others.

(ii) Material Transfer Agreements (MTAs), which define the rights and obligations of users dealing with patented materials.

(iii) Technology Use Agreements (TUAs, see Appendix A). TUAs restrict the use of plant genetic material by farmers. For example, TUAs require farmers not to save seeds or sell seeds to others; and they have to pay technology fees for planting GM seeds.

(5) Other plant breeding protection systems: besides patent protection provided by the above legislation, Plant breeders' rights (PBR), also known as plant variety rights (PVR), provide plant breeders exclusive rights to sell or reproduce new plant varieties within a limited period in member countries of the International Union for the Protection of New Varieties of Plants (UPOV). For example, in Canada, under PBR, plant breeders have the rights to control the multiplication and sale of the seeds for up to 18 years (CIPO, 2007). In addition to IP laws, the Canadian government also has a tax incentive system to support R&D conducted for new products and processes in private firms (Hirshhorn et al 2001).

2.3.3. Protection of Biotechnological IPRs in Developing Countries

While many developed countries have maintained comprehensive IPR protection systems and effective enforcement mechanisms, the IPRs of agricultural biological innovations are poorly protected in many developing countries because of the absence of institutions and low incentives to protect IPRs of foreign companies (Levy, 2000). The protection of the innovators' IPRs has been controversial. There are several factors that hinder the protection of plant breeding IPRs in developing countries:

a. High transaction costs: in most developing countries, there is lack of intellectual property laws to grant IPRs and the protection is limited. GM seed companies have to enforce contracts with farmers to not save or resell seeds. In most developing countries, it is difficult to enforce these private contracts due to the high transaction costs and monitoring costs involved (Cardwell and Kerr, 2008).

b. Farmers' right to save and reuse seeds: for thousands of years, farmers have selected seeds from their harvests and saved them for replanting in the next season. If they are forbidden from saving seeds and have to go to the seed company to purchase seeds every year, the financial burden could be significant for poor farmers in developing countries (Jefferson et al, 1999).

c. Threat to biodiversity: multinational firms have had free access to the genetic resources on which they developed new biotechnological products. The conversion from landraces developed by farmers, to genetic uniformed scientifically bred varieties, such as GM crops, is a potential threat to the crop genetic diversity.

d. Low incentives to protect foreign IPRs: As importers of biotechnology, the governments of many developing countries have very little incentive to protect IPRs of foreign companies.

2.3.4. IPRs in the Case of RR Innovation

In the U.S., there is a comprehensive IPR protection environment to protect inventions effectively in the market. RR technology is under patent protection; the innovator can restrict the use of their technology by requiring farmers to sign a technology use agreement (see Appendix A for an example of a Monsanto TUA) in which farmers have to agree not to save or resell seeds to other farmers for replanting. Farmers also have to pay technology fees for the RR seeds. Monsanto licenses the RR technology to seed companies which sell the GM seeds to farmers. However, Monsanto has not been able to obtain patents in either Brazil or Argentina (Schnepf, 2003). In Argentina, plant varieties cannot be patented and they are protected under national seed law (Qaim and Traxler, 2005), which was made to protect plant breeders' IPRs and it requires that all seeds have to be certified before they go for sale (GAO, 2000). However, the implementation of the law is so loose that an estimated 25 to 50 percent of the soybean seeds grown in Argentina is sold without certification (GAO, 2000) and farm-saved seeds and black market seeds are widespread (Table 2-4).

Table 2-4: Sources of RR soybean seeds in Argentina

Sources of soybean seeds	Estimated percentage of total soybeans planted	
	United States	Argentina
Commercial sales	80-85	28-50
Farmer-saved	15-20	25-35
Black market sales	0-2	25-50

Source: GAO 2000.

Given that there is no patent protection for RR technology in Argentina, Nidera, the largest seed company in Argentina, acquired free access to use the available RR varieties and now sells its RR seeds to farmers without requiring them to sign any contract to constrain reselling or saving seeds for the following year (Qaim and Traxler, 2005). Weak IPR protection, the wide-spread use of farm-saved seeds and the huge black market for seeds significantly affects the innovator's return on their investment of biotechnology in Argentina. Monsanto can only capture a small portion of their R&D rents by charging a much lower technology fee from those smaller seed companies (excluding Nidera, whose market share is 70 per cent) that want to keep long-term good relationships with Monsanto for future cooperation (Qaim and Traxler, 2005). Monsanto's incentive to undertake investment to improve the seeds that are targeted at developing countries is greatly reduced because of the inability to capture R&D rents. Table 2-5 demonstrates the IPR status of RR soybean innovators in US, Argentina and Brazil.

Table 2-5:

Comparison of innovator's IPR status in major RR soybean producing countries

	U.S.	Argentina	Brazil
Overview of IPR protection	strong	weak	weak
Soybean production share in the world market (%)	45	15	22
RR adoption rate (%)	68	90	40 (2004)
Patent for RR technology	yes	no	no
Technology fee ($/ha)	19.27	8.25	GM levies (2005)
Technology Use Agreement	yes	no	no
Farm saved seeds & black market	no	yes	yes

Sources: Reuters, 2005,
Qaim and Traxler, 2005,
Cardwell and Kerr, 2008.

The weak enforcement of IPRs in developing countries has generated significant market failures that the biotechnology firms are unable to capture their innovation rents from the producers who have benefited from a "free ride" on innovators' technology. There are some developments that have resulted from these market failures:

(1) The piracy of technology is wide-spread. For instance, in the RR soybean seed market in Argentina, one-third of the seeds are from the black market, and one third of the seeds are farm-saved; and another one third are certified seeds bought from the seed companies (Qaim and Traxler, 2005).

(2) The biotechnology firms have few incentives to invest in R&D of new varieties suitable to the local production conditions where IPRs are loose.

(3) The emergence of new IPR enforcement mechanisms at international level. In order to strengthen IPR enforcement in the developing countries, some international level IPR protection mechanisms have been established. These include the WTO TRIPS Agreement, GM technology levies, and GURTs. Private biotechnology firms have started to seek some solutions to the market failures by themselves: GM levies and GURTs were developed to fight the free-rider problem and reduce the high transaction costs associated with enforcing contracts in developing countries. Chapter 3 discusses these IPR enforcement mechanisms and their implications in details.

Chapter 3

IPR Enforcement Mechanisms in Developing Countries

Industrialized countries, led by the United States, hold a comparative advantage in biotechnology research in both scope and magnitude (Subramanian, 1990, 1991). Large multinational life-science companies have invested heavily to develop new plant breeding technologies. It is economically difficult for agricultural research firms in developing countries to develop new varieties adapted to local conditions. So most developing countries are consumers of GM crop innovations, and they rely on GM seeds developed by multinational corporations in industrialised countries. However, there are usually no equivalent legal systems to protect the innovator's intellectual property in these developing countries. The local governments have little incentive to establish effective IP regimes and enforce mechanisms to protect the foreign innovators' IPRs (Gaisford, 2001).

The search for alternative IPR systems in developing countries has caused great concerns for stakeholders in the GM crop industry. Several enforcement mechanisms have been developed to improve the IPR environment in developing countries. This chapter presents some background on these IPR mechanisms in the area of plant biotechnology and their implications in developing countries.

3.1. Agreement on Trade Related Aspects of Intellectual Property Rights

3.1.1. The TRIPS Agreement

The WTO TRIPS Agreement is the product of industrialised countries' concerns that their products protected by IPRs did not have the same level protection in developing countries, where there was often no equivalent effective and strong IPR system. The US proposed that the General Agreement on Tariffs and Trade (GATT) formulate legislation to establish effective IPR enforcement mechanisms in WTO member countries (Blakeney, 1995). The resultant TRIPS agreement was negotiated in the Uruguay Round of GATT in 1994, when the GATT was subsumed into the WTO. The WTO administers three agreements: GATT dealing with goods and services; the new General Agreement on Trade in Services; and TRIPS covering IPRs. The TRIPS agreement has set new uniform international standards on IPRs protection in WTO member countries. TRIPS Article 27.3 (b) requires all member countries and potential new entrants to provide patents or effective *sui generis* systems for eligible IPRs belonging to firms in other WTO member countries to reap the benefits of other WTO agreements:

> Members may exclude from patentability:
>
> (b) Plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof (WTO website).

3.1.2. The Enforcement of TRIPS: Cross-agreement Retaliation

To provide an umbrella for innovators' IPRs, the WTO's Single Dispute Settlement Understanding bundles trade sanctions (under GATT) with IPRs protection (under TRIPS) together. If there is a complaint on failure to protect IPRs from an innovating firm's host country that is brought to the WTO then the offending country may be subjected to a cross-agreement retaliation: the innovating country can put a tariff on the imports from the adopting country under GATT (Gaisford, 2001). So TRIPS is much more powerful than the international intellectual property protection organization, the World Intellectual Property Organization (WIPO). The WIPO is a voluntary organization without effective enforcement instruments, and many developing countries were not members (Cardwell and Kerr, 2008).

3.1.3. The Implications of TRIPS on Developing Countries

The TRIPS agreement requires that all WTO member countries, including developing countries, introduce and enforce either patent protection, effective *sui generis* systems, or combinations of both. Developing countries were allowed transitional provisions, which gave developing countries for up to five years delay in complying with TRIPS and establish effective IPRs protection systems. This transitional period expired in 2005.

The alternative IPR protection system to patents is the plant breeder's rights (PBR) system, also known as plant variety rights (PVR), which provide plant breeders exclusive rights to sell or reproduce new plant varieties within a limited period in member countries of the UPOV. It has been suggested by developed countries as a model for an effective *sui generis* system for IPR protection in the developing world. Unlike patents, PBR systems would allow farmers to save their harvest as seeds for replanting (Srinivasan, 2002).

There are several controversies surrounding the protection of IPRs in developing countries, particularly patents on pharmaceuticals and patents on seeds, which may negatively impact poor consumers and resource poor farmers, respectively (Cardwell and Kerr, 2008). Some of the key controversies surrounding the design of an appropriate *sui generis* system are outlined below.

(1) Farmers' right to save seeds: for thousands of years, farmers have selected seeds from their harvests and saved them for replanting in the next season. If they cannot save seeds, and have to go to the seed company to purchase seeds every year, the financial burden would be significant for poor farmers in developing countries (Jefferson et al, 1999).

(2) IPRs associated with traditional varieties (landraces): farmers have used landraces to select seeds for thousands of years. Landraces have contributed to the evolution of traditional varieties by exchanging or introducing new genes from neighbours or immigrants (Eaton, 2002). Many of the patented biotechnology products developed from the landraces originated mostly from the developing countries and there are debates on the ownership.

(3) Payment of monopoly rents for innovation may be harmful to the development process (Gaisford and Richardson, 1996). IPRs legislation grants monopoly powers to the innovator which could result in higher monopoly prices for the new products. Higher

monopoly prices for agricultural inputs and pharmaceuticals have been very contentious since they could affect the poor in developing countries (Gaisford, 2001).

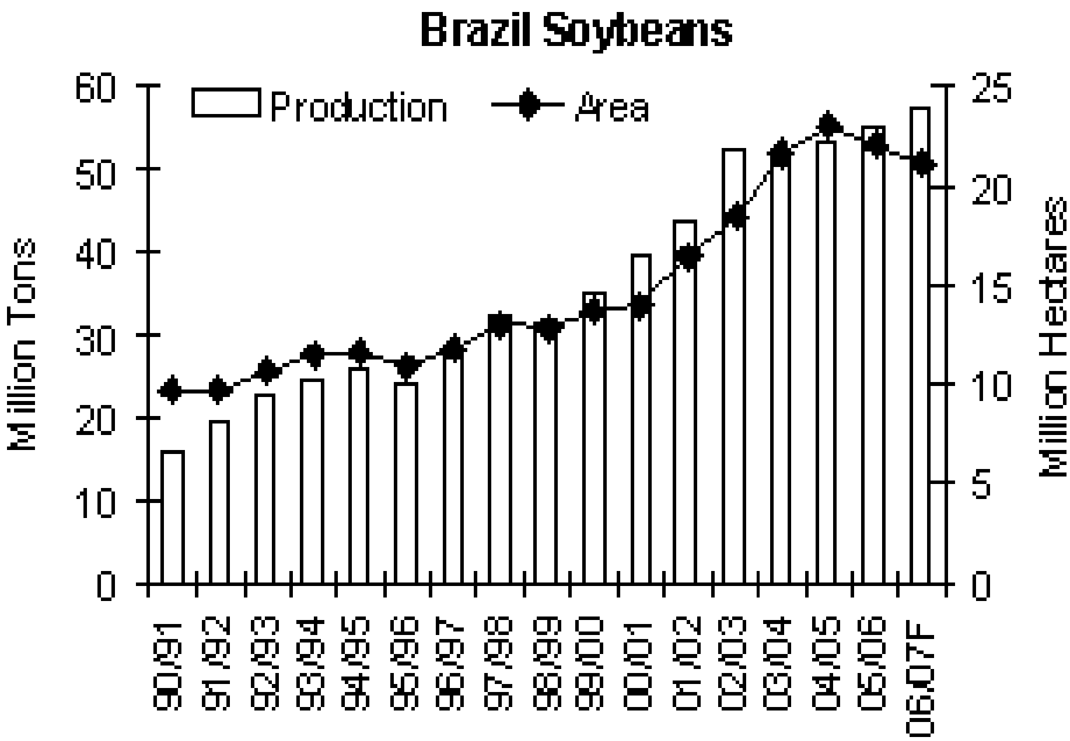
3.2. GM Technology Levies

3.2.1. Roundup Ready® Soybean Production in Brazil

Brazil is the second-largest soybean producer and exporter in the world after the United States (table 2-2). Strong supports from the government, abundant natural resources, foreign investment, and modern technologies have all contributed to fast expansion of Brazilian soybean production in both yield and area (Figure 3-1, USDA, 2006). However, in contrast to Argentina's quick adoption of GM technology, there was a ban on commercial production of RR soybeans because of the Brazilian government's cautious attitude towards the food safety and environmental effects of GM crops.

Despite the official ban on GM crops, a large black market for GM seeds has formed in Brazil over the last decade (Reuters, 2005). Due to the significant cost saving in herbicide, machinery, and labour in RR soybean production, farmers in the southern state of Rio Grande do Sul smuggled GM soybean seeds across the border from Argentina before the Brazilian government approved the cultivation of RR soybeans (Qaim and Traxler, 2005). The adoption rates of RR soybeans vary in different states in Brazil: from as low as 10%, to as high as 70% (USDA, 2006). According to the USDA, Brazil's RR soybean crop is estimated to be at least 40% of the total planting area (USDA, 2006).

Figure 3-1 the expansion of the soybean sector in Brazil



Source: USDA, 2006

3.2.2. GM Levies

The TRIPS agreement is not the only solution to protect innovators' IPRs. Innovating firms also seek alternative arrangements with adopters to capture more rents from their R&D investment (Cardwell and Kerr, 2008). For instance, after failing to get patent protection for RR soybeans in Brazil, Monsanto negotiated a GM levy with Brazilian seed association in 2005 to capture additional rents from their innovation

(Reuters, 2005). There has been a huge seed black market formed as a result of the ban on GM crops in Brazil. It is estimated that 95 per cent of RR soybean seeds are from the black market in Rio Grande do Sul, the third biggest soybean growing region in Brazil (Reuters, 2005).

The Brazilian National Association of Seed Producers accepted Monsanto's proposal on royalty payments for their RR soybean seeds at the first grow season after RR soybeans were authorized by the Brazilian government. Farmers have two options to pay the levy. They can either pay the GM levy, which is 0.88 Brazilian reals per kg (Reuters, 2005), when they purchase seeds from the seed company; or they can pay a two per cent royalty at the point of sale - usually an elevator. If seeds are purchased from an authorized seed dealer, then a certificate is issued and farmers are exempt from the elevator levy of 24 reals per hectare. By imposing a GM levy on using their RR technology, Monsanto can receive some proceeds from the primarily black soybean market in Brazil (Cardwell and Kerr, 2008). This levy has generated controversy because it may be less expensive for farmers to buy seeds on the black market then pay the two per cent royalty at the elevator (St. Louis Business Journal, 2005). Brazilian seed producers are concerned that the levy "… promotes illegal behavior by the producers and hurts legitimate seed producers." (Barison, 2005).

Countries that adopt GM crops may favour a GM levy, as the innovators can get some compensation from the GM levy for the loose IPRs, so the innovating country may not bring a complaint to the WTO which could trigger a trade sanction under TRIPS. Also a GM levy could reduce the high regulatory and transaction costs associated with enforcement of IPRs in developing countries (Cardwell and Kerr, 2008).

3.2.3 The Enforcement of GM Levies

In order to enforce the GM levy effectively, a reliable facility that can test the presence of GM crops is essential. To avoid paying the levy on GM seeds, there may be incentives for producers to falsely represent their GM crops as being grown from non-GM varieties. So it is essential to have an effective and reliable test system to verify the variety. There are several types of levies that could be collected at different stage of the supply chain (Cardwell and Kerr, 2008): a levy on seeds, an elevator check-off levy, an export levy or a combination of levy on seeds and at the elevator.

3.2.4. Implications of GM Levies

The GM levy was designed by seed companies in an effort to capture rents in the market where technology piracy prevails. This levy solution can influence the stakeholders in the soybean section.

(1) Increase the adopting country's government revenue. Some portion of the levy is likely to be channelled to the adopting country government: The levy proceeds will not only go to the innovator, but the local governments (Cardwell and Kerr, 2008).

(2) Promote R&D in new varieties. A portion of the levy proceeds may be put into the investment of R&D of new more productive varieties tailored for local agronomic conditions (Cardwell and Kerr, 2008). This R&D could increase agricultural productivity in the adopting country.

(3) Affect farmers' decision on where to buy the GM seeds. Monsanto's GM levy may induce farmers to buy seeds from the black market and then pay the lower royalty of 2 per cent at the elevator if they are caught.

3. 3. Genetic Use Restriction Technologies

GURTs represent a group of biotechnology-based switch mechanisms developed by agricultural biotechnology firms to restrict the unauthorized use of their innovations in markets where IPRs are not adequately enforced. By treating plants with a chemical, the gene for seed sterility can be switched on; such treated plants will produce sterile seeds. Farmers cannot use harvested seeds and have to buy fresh seeds every year from the seed companies.

The first GURT patent was granted to the United States Department of Agriculture (USDA) and Delta and Pine Land Company in 1998 (United States Patent and Trademark Office, 1998). More than 50 V-GURT patents are held by universities, governments and private firms in the US (Khachaturyan, 2006; Shi, 2006. see appendix B). Despite the availability of the technology, GURTs have not been used in field trials or commercially developed yet (Collins and Krueger, 2003). In 2000, the United Nations' Convention on Biological Diversity recommended a moratorium on field testing or commercial use of products related with GURT technology until there exists sufficient scientific evidence supporting further development and testing (Canadian Food Inspection Agency website).

There are two types of GURTs. Variety use restriction GURTs (V-GURTs), which are also known as terminator genes, can render the subsequent generation seeds sterile, and prevent unauthorized use of genetic material and self-supply of commercial seeds by farmers and other plant breeders. V-GURT strategies can be realized in three strategies (FAO, 2001). Strategy 1: Before being sold, the seeds are treated with a chemical inducer, leading to expression of the disrupter gene in the second-generation seed. Consequently, the second-generation seed is infertile. Strategy 2: The plant breeders treat all generations with a chemical before selling the seeds. Then the disrupter gene expresses in the seeds by default, causing the following generation seeds sterile. Strategy 3: To prevent growth of roots, tubes and many ornamentals during storage and extend shelf life, a chemical is applied to induce a second gene to block the growth. The primary targets of V-GURTs are self-pollinating crops, such as rice, wheat, soybeans, cotton, on which hybrid technologies are either infeasible or ineffective.

Specific Trait Use Restriction GURTs (T-GURTs) involve the external application of inducers by introducing gene silencing or by excision of the transgene to trigger the expression of some specific traits. For example, some traits of tolerance to salt or heavy metals would be switched on or off. Traits can be activated at the time of purchase or activators can be purchased for later use (Jefferson et al, 1999). The key to T-GURTs is to switch on or off some target characters of a plant, through inducible promoters regulating the expression of the transgenes (FAO, 2001). T-GURTs could be used in all crops to enhance certain valued added traits or to protect the plants in extreme harsh weather. The potential targets of GURTs are shown in table 3-1.

Table 3-1 Potential targets of GURT application

Sector	Trait examples	Remarks
Wheat	Nutrient quality, taste, yield, disease resistance, drought resistance, cold tolerance.	Staple crops, increased R&D expected
Rice		Staple crops, increased R&D expected
Maize		Staple/specialty products, gene flow containment desirable
Soybean	Nutrient quality; feed quality	
Cotton	Agronomic traits, color	Increased R&D expected
Oil crops	Fatty acid composition	Sunflower, olive, oil palm; canola: gene flow containment
Horticultural crops	Quality traits	V-GURTs for non-hybrids
Plantation crops	Agronomic traits	Coffee, banana
Cattle	Meat quality, feed conversion efficiency	Specialty products (pharmaceuticals)
Fish and other aquatic species	Environmental concerns, yield , low temperature tolerance, disease resistance	Salmonids, carp, tilapia Crustaceans, molluses

Source: Visser et al. (2001).

3.3.1. Potential Implications of GURTs

Although GURT technology is still under development and has not been released for commercial use, strong debates on the benefits, risks and potential impacts of GURTs have emerged. Some of these issues are discussed below.

(1) Strengthened IPRs.

GURTs provide seed innovators with near perfect IPR protection, and increase their ability to appropriate the rents created by their R&D efforts. It may also reduce the high transaction costs involved in the enforcement of IPRs. As a result, stronger IPRs may encourage innovators to invest more in R&D for more productive varieties.

(2) Productivity increases in agriculture.

"V-GURTs will only be commercially viable if they are applied to new breeds and cultivars with considerable productivity improvements" (FAO, 2001). GURTs have the potential to benefit both the agricultural innovators and producers, because the strengthened IPRs caused by GURTs gives seed companies greater incentive to conduct breeding research in crop species in developing countries, which may not be undertaken if IPRs were not adequately enforced. Farmers could benefit from GURTs if more productive crops are developed after the introduction of GURTs. The new breeds with high yield and drought resistant traits are highly desired for the growing world population and limited land resources available.

(3) Farmers' right to save seeds

Traditional agricultural practices have always seen farmers select seeds from their harvests and save them for replanting in the next season. If these crops are sterile, then farmers are forced to repurchase seeds every year, increasing the financial burden for poor farmers in developing countries.

(4) Genetic contamination control.

Biotechnology firms argue that GURTs could help to control unwanted horizontal gene flows (through cross-pollination and seed spill) of GM crops and reduce their potential environmental risks (Khachaturyan, 2006), since GURT plants are sterile.

(5) Decreased biodiversity.

Introduction of GURTs could reduce crop diversity and make farmers more dependent on commercial seeds and less capable of disease and insect control. It is believed that the landraces contain more genetic information than the commercial seed supply chain (Eaton, 2002). The farmers have been continuously breeding and improving local varieties, and they depend on the contribution of new genes to this dynamic process to maintain local adaptive fitness and productivity. The wide adoption of GURTs containing desirable new traits could result in the displacement of landraces, which may be a potential risk to the agricultural biodiversity (Eaton, 2002).

(6) The formation of seed monopolies.

The bio-science companies that invented GURT technology would be able to behave as monopolists and charge higher prices for GURT seeds above the marginal cost of producing the new seeds. Some concern has been shown about the abuse of monopoly power in the seed market after introduction of GURT technologies. Seed monopolies are distortions in the economy and may result in an unequal distribution of economic rents between producers, seed companies, and consumers in seed industry (Srinivasan and Thirtle, 2000).

(7) Restriction of access to genetic resources.

GURTs might also restrict producers, small breeders and public institutions from accessing genetic resources that are contained in GURT plants. This could limit the ability of farmers and small plant breeders to develop new varieties (Khachaturyan, 2006).

Chapter 4

Literature Review

The protection of plant breeders' IPRs, especially in developing countries, has become a controversial topic since the emergence of GM technology. There are two main categories of research that have investigated the economic impacts of GM technology in adopting countries. One category has examined the technological effects of GM crops on environment and farm income, while the other category has focused on how different types of IPRs mechanisms affect the distribution of welfare that is generated by the adoption of GM technology in developing countries. This chapter presents summaries of some important studies from each of these two strains of research, with emphasis on empirical research related to GURTs.

4.1. The Economic Impacts of GM Technology

Many studies have been done on the welfare effects of GM crops in both developed countries, such as the United States, and in developing countries, such as Argentina.

Falck-Zepeda et al. (1997) examine the distribution of economic welfare of the second-year planting of Bt cotton and Herbicide-Tolerant soybeans in the United States, using the economic surplus approach developed by Alston, Norton, and Pardey (1995). They quantified the increase of economic surplus, the share of the innovators, the share of US farmers, and the share of the consumers.

Moschini and Lapan (Moschini and Lapan, 1997) are pioneers in the modelling of welfare effects generated from the adoption of agricultural technology under various IPRs protection regimes. They include the monopoly rents that are captured in the input markets that result from the patenting of the new technology. By introducing IPRs into the analysis, they modified the classic surplus framework of public agricultural innovations that was developed by Alston, Norton, and Pardey (1995).

Moschini, et al. (2000) extends the analysis to an open economy and develop a three-region model for the soybean complex to evaluate the welfare effects of RR soybean adoption. Their results suggest that: (1) the United States gains substantially from adopting RR technology, with the innovators capturing the larger share of benefits. (2) Spill-over of RR technology to other countries can adversely affect producers' competitive position in the innovating country. (3) Consumer's welfare increases in every region after the adoption of the RR soybeans.

Using the economic surplus approach developed by Alston et al. (1995), Qaim and Traxler (2005) systematically examine the impacts of RR soybeans in Argentina based on farm-level survey data of five-years of adoption. They compute aggregate welfare effects over the 1996-2001 period with a three-region partial equilibrium model, comprising Argentina, the United States and the rest of the world. Their results show that:

(1) total factor productivity increases by 10 per cent after adoption of RR technology for five years in Argentina. (2) At the global level, the RR technology generated about 1.2 million dollars of economic surplus, with consumers capturing the largest share, followed by innovators, and soybean producers. (3) Farmers in developing countries can gain considerably when they obtain access to suitable foreign innovations through technology spill-overs.

4.2. Alternative Intellectual Property Rights Regimes in Developing Countries

Weak enforcement of IPRs in developing countries has resulted in alternative regimes to generate returns for agricultural innovators. Multinational firms have started to pursue their own methods of capturing more rents in adopting-country markets. The following empirical studies have examined the economic impacts of GM technology under a range of IPR regimes.

Vertical Linkage Production Models

Cardwell and Kerr (2008) analyze the welfare effects of introducing a GM technology levy by employing a vertical soybean production model and applying this model to the soybean sector in Brazil. Their results show that: first, a developing country's ability to enforce IPRs is central in determining the method of adoption. Second, a GM technology levy, proposed by Monsanto in Brazil, may be a transaction-cost efficient compromise to avoid TRIPS retaliation; thus it may be a technical solution to weak IPR enforcement in developing countries in the short run. However such a levy may make the innovators unable to collect monopoly rents in the long term.

There are several empirical studies that estimate and forecast the potential impacts of GURTs. Some important studies are described below.

Diffusion Models

Diffusion models are fixed-effect panel estimation models in which the diffusion of technology is a process in which the innovation gradually spreads through adoption (Jaffe et al., 2000). Diffusion models allow for heterogeneity among countries (Goeschl and Swanson, 2000) and are used to estimate productivity convergence and economic growth (Barro and Sala-i-Martin, 1995).

In the diffusion models developed by Goeschl and Swanson (2003), the diffusion of innovations occurs at the productivity frontier, such as the U.S., then they are diffused to developing countries. Based on the simulation of the diffusion of the high-yielding hybrid corn of a 38-year period, they simulate the potential impact of wide-spread adoption of GURTs in developing countries. They conclude that: (1) GURTs could be a powerful tool for the multinational seed companies to guard their IPRs and obtain higher profits from their innovations. (2) For the developing countries, contrast to the steady growing benefit from adoption of GURTs in the developed countries, the effects GURTs on yields will vary significantly depending the current state of a country's agriculture: those least developed countries, such as Ethiopia and Tanzania, which have the lowest yields would be mostly adversely affected by the wide-spread use of GURTs, for under current regime, the flow of innovations would be more easily appropriable.

While some developing countries could experience the similar trend in growth rate and favourite yield increase to developed countries, but come with a more delayed pattern.

Agricultural Research and Development Investment Models

Lence and Hayes (2005) develop a two-country *ex ante* simulation model of R&D in agriculture to examine the impacts of various IP protection levels in the United States and South America on the level of innovation, market equilibrium and the welfare of innovators and the producers in the RR soybean sector. Their model captures the interaction between the seed industry, farmers and grain markets. It allows for R&D that is conducted in one country to spill over into a second country. The results indicate that: (1) equalization of IPRs across countries encourages the US innovating firms to invest more in R&D of relevance to both countries. The innovators do not have incentives to develop new technology in the countries with low levels of IPR enforcement. (2) Technology fees charged in the United States, but not in South America, are harmful to American soybean producers. (3) GURTs, as a tool of IPR harmonization may enhance the total world welfare at an optimal level, if they are used together with restrictions on the extent to which the innovators can capture their IP rents. (4) The application of GURTs to strengthen the enforcement of IPRs in South America may increase the expected welfare of the US producers.

Appropriability Models

Srinivasan and Thirtle (2003) adapt the framework developed by Scherer (1986) to examine the appropriability of returns to research investment. This model assumes that an innovator cannot realize their rents immediately because it takes time for farmers to adopt new technology, and there is a time lag with the competitors' imitation of the technology. From a developing country's perspective, they forecast the potential impacts of GURTs in the seed market and find that GURTs could be more effective than intellectual property legislation in terms of increasing the appropriability of R&D investment. The appropriability of R&D investments may be more than tripled after the introduction of GURTs. There is a strong link between the appropriability and the private plant breeding effort. Increased appropriability could stimulate private biotechnology firms to investment more in yield increasing varieties in developing countries. This would increase the yield level of open-pollinated crops to the levels similar to the hybrids, which could benefit the GURT adopting countries.

4.3. Summary

There have been several recent studies that estimated the welfare effects on developing countries of adopting GURTs. In these studies, it is common to compare the welfare effects of GURTs with a baseline of no IPR enforcement. Such a baseline may not be sustainable for developing countries with the introduction of the TRIPS agreement and other newly developed IPR enforcement mechanisms (such as levies and GURTS). Using these previous studies as starting points, this thesis adds to the literature by considering the economic impacts on developing countries from a new perspective. We not only consider GURTs as a tool to guard the IPRs of agricultural innovators, but also consider potential productivity increases that may arise from increased appropriability of investment funds. We set a range of yield improvement to analyze how more productive GURTs seeds have to be to offset the adverse effects of higher seed prices. Based on farm level survey data collected by Qaim and Traxler (2005) and elasticities from other sources, this research employs a synthetic partial-equilibrium model to estimate the welfare effects of GURTs and other IPR enforcement mechanisms applied in RR soybeans production in Argentina.

Chapter 5

Welfare Analysis of GURTs in Developing Countries:

Roundup Ready® Soybeans in Argentina

This chapter presents the economic models, methodologies and data used to analyze the welfare effects of GURTs and other international-level IPR enforcement mechanisms in adoption of RR soybeans in Argentina. Based on available sources of elasticities and data of production, consumption and prices, employing a vertical linkage soybean model and a synthetic partial equilibrium model, the economic surplus of producers, consumers and the innovators is computed and compared in several scenarios, including the base line: the black seed market, TRIPS retaliation, a GM technology levy, and GURTs.

5.1. The Economic Models

5.1.1. A Vertical-Linkage Soybean Model

The vertical linkage soybean production model (Cardwell and Kerr, 2008) is used to analyze supply and demand changes under a range of IPR protection mechanisms in developing countries. We choose Argentina as a representative for developing countries to examine the welfare changes after the introduction of GURTs in RR soybeans. In this model three inputs are involved in the soybean production: seeds (S), land (L) and other inputs (C) which includes the cost of chemicals, elevator services and transportation services.

There are three key assumptions in this model:

(1) All inputs are used in fixed proportions. The three inputs are combined in a fixed proportion to produce an equivalent amount of the final output, soybeans (B). For example, to produce 3 metric tons of soybeans, we need 1 hectare of land, 75 kilograms of seeds (according to the seeding rate: see Schnepf, 2003), and a fixed quantity of other service inputs (C).

(2) The supply chain is competitive. This assumption is relaxed later when the model considers a noncompetitive seed market.

(3) Argentina is modeled as a small country. Argentina's market share in the world soybean export market was near 10 percent in the year from which the baseline data is drawn[3]. The model assumes that Argentina cannot affect their soybean terms of trade, and the world soybean price is exogenous in the model.

Figure 5-1 depicts the model. There are four linked markets: the soybean market, the other service market, the land market and the seed market. $P_{W,} P_{C,} P_L$ and P_B represent the world soybean price, other inputs price, land price and soybean seed price,

[3] Argentina's production of soybeans has expanded over the past few years, and future models might consider treating Argentina as a large country. This is discussed in the Limitations section, below.

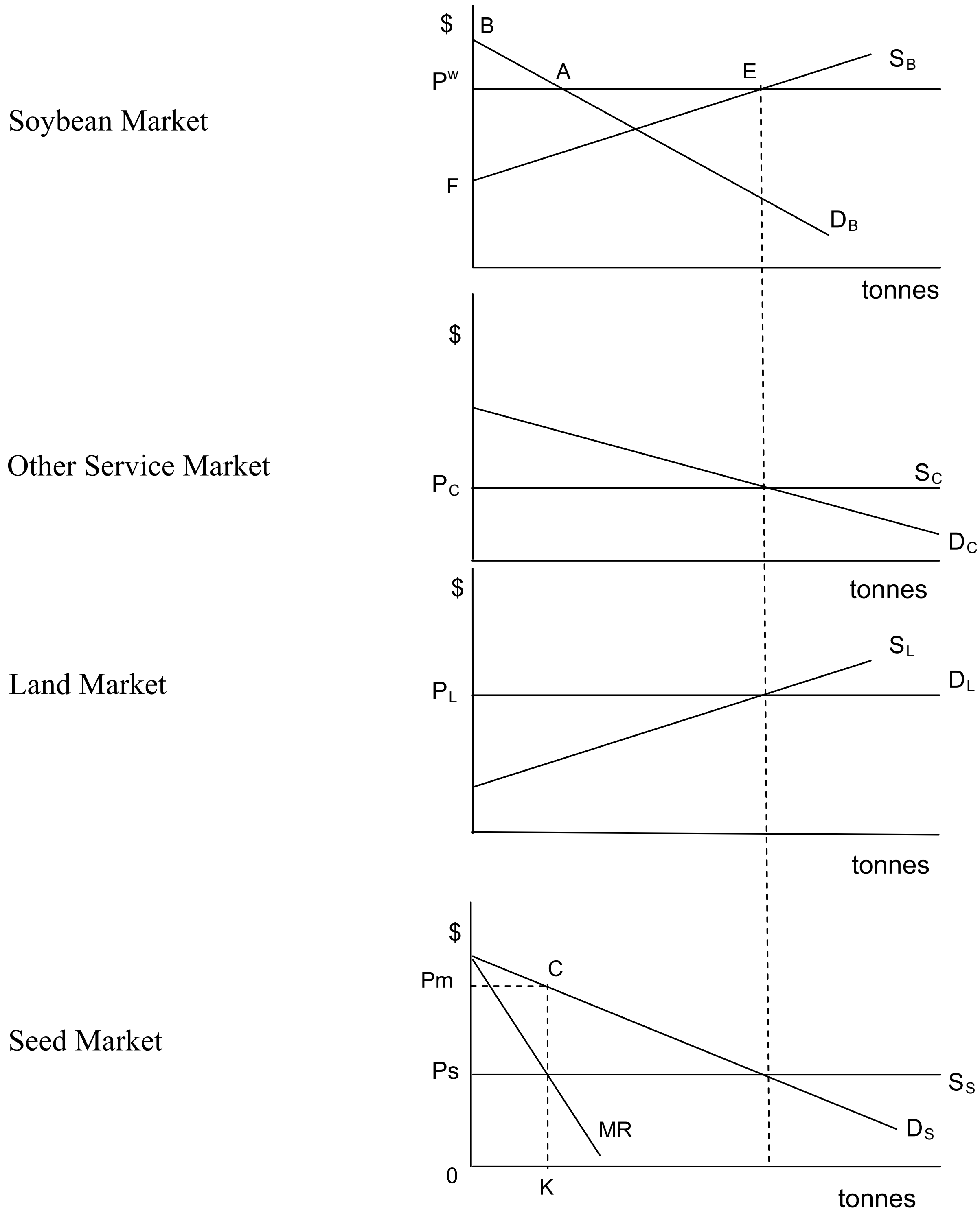
respectively. S_B, S_C, S_S represent the supply of soybeans, other inputs, and seeds, respectively. D_B, D_C, D_S represent the demand for soybeans, other inputs, and seeds, respectively. The supply curve of other services (C) is a horizontal line which represents constant marginal cost; land supply is upward sloping since land is limited resource; and the seed supply curve is a horizontal line which stands for the constant marginal cost of seed supply. By adding these three supply curves together, we can get the supply of the final output: soybean. That is the supply price of soybeans which is the sum of the costs of three inputs:

$$P_B = P_C + P_L + P_S$$

In this model, all the demand curves in the input markets are derivable. If the demand for two inputs is known, demand for the third input can be derived. For example, to derive the demand for other services (D_C), we need to find out how much producers are willing to pay for each unit of other service (D_C) by subtracting the prices he has to pay for seeds and land from the world price of soybeans. To derive the demand for land, we subtract the seed price and the price of other service from the world soybean price.

The vertical-linkage soybean production model allows us to analyze how policy and technology changes that occur at one stage of the supply chain affect the welfare throughout the entire supply chain. We can impose different IPR regimes and analyze their welfare effects on the soybean sector in Argentina.

Figure 5-1. The vertical linkage soybean production model



5.1.2. The Synthetic Partial Equilibrium Model

A synthetic partial equilibrium model is employed to quantitatively evaluate the welfare effects of a range of IPR and adoption systems. The model is built on linear soybean supply and demand schedules; parallel shifts of supply and demand curves induced by the various IPR mechanisms in a small country (Argentina) are assumed. Some other standard assumptions made are: no tariffs and no transportation cost.

First we calibrate the model to farm level survey data of Argentina's soybean production from Qaim and Traxler (2005) and other sources (see table 5-1). We obtain the equilibrium world price, production and consumption quantities for each country by setting excess supply equal to excess demand. The following methodology is used to obtain baseline production and consumption quantities and to derive baseline supply and demand functions. By definition, elasticity is expressed as:

$$\varepsilon = \frac{\Delta Q / Q_0}{\Delta P / P_0} = \frac{\Delta Q}{\Delta P} \bullet \frac{P_0}{Q_0} = \frac{1}{\beta} \bullet \frac{P_0}{Q_0} \quad (5.1)$$

Where ε represents the supply elasticity, P is price, Q is the quantity.

If the supply function and the demand function are written as:

$$P = \alpha + \beta Q^S \quad (5.2)$$

$$P = \gamma + \delta Q^D \quad (5.3)$$

Then $$\beta = \frac{\Delta P}{\Delta Q} \quad (5.4)$$

$$\frac{1}{\beta} = \frac{\Delta Q}{\Delta P} \tag{5.5}$$

Plug (5.4) into (5.1), we can get

$$\beta = \frac{1}{\varepsilon} \bullet \frac{P_0}{Q_0} \tag{5.6}$$

Plug (5.6) into the supply function (5.2), we can get:

$$\alpha = P - \frac{1}{\varepsilon} \bullet \frac{P^S{}_0}{Q^S{}_0} \tag{5.7}$$

Similarly,

$$\delta = P + \frac{1}{\eta} \bullet \frac{P^D{}_0}{Q^D{}_0} \tag{5.8}$$

Where η is the demand elasticity.

5.2. Parameters and Data Sources

Table 5-1 shows the parameter values and data sources used in the welfare calibration of the model.

Table 5-1 Parameters and data used in the model

Soybean production, 2001 (1,000mt) [a]	26,737
Soybean consumption, 2001 (1,000mt) [a]	1,062
Observed world market soybean price, 2001 (US$/mt) [a]	203
Soybean yield, 2001 (mt/ha) [a]	3.01
Cost reduction by RR soybean seeds [a] (US$/ton)	7.57
Price elasticity of soybean supply [b]	2*
Price elasticity of soybean demand [c]	-0.4
Soybean seeding rate (kg/ha) [e]	75
The GM technology levy (US$/ kg RR soybean seeds) [f]	0.43

* we choose the price elasticity of soybean supply to be 2, as when inelastic supply elasticity was used, the derived demand curve in the seed market would be also inelastic and the seed monopolist could extract all the rent, which is not sensible.

[a] Qaim and Traxler (2005)
[b] Gray, (2008)
[c] Moschini et al. (2000)
[d] Porras, *et al.*, (1998)
[e] Schnepf, (2003)
[f] Reuters (2005).

5.3. Parametric Specification of the Model

After we obtain the supply and demand functions in the soybean market, we can derive the supply function in the land market based on the data of cost of other input (C) and the seed price, using the vertical relationship in the soybean production model:

$$\alpha_B = \alpha_C + \alpha_S + \alpha_L \tag{5.9}$$

$$\alpha_L = \alpha_B - \alpha_C - \alpha_S \tag{5.10}$$

Once the supply function of land is specified, the seed demand can be derived according to the vertical soybean production model:

$$\gamma_S = P_B - \alpha_C - \alpha_L \tag{5.11}$$

$$\delta_S = -\beta_B \tag{5.12}$$

Table 5-2 reports the values of parameters for the supply and demand functions in the vertical soybean production model in the baseline scenario.

Table 5-2 The base values of parameters for the supply and demand functions in the vertical soybean production model

	Intercept (per ton of soybeans)	Slope
Soybean market Supply function	101.5	0.000004
Other inputs market Supply function	57	0
Land market Supply function	37.5	0.000004
Seed market Supply function Demand function	 7 91.33	 0 -0.000004

5.4. Welfare Analysis

The welfare analysis is conducted in four scenarios of different IPR mechanisms in the Argentine soybean sector: the baseline of a seed black market with no IPR protection, TRIPS retaliation, GM levies, and GURTs.

5.4.1. The Baseline: Black Seed Market (No IPR Protection)

Our baseline involves the sale of black market seeds, as descried in Chapter 2, which is the current IPR situation in the Argentine RR soybean seed market. Lack of IPR laws and contract laws, high transaction costs and uncertain benefits of stronger IPRs make Argentina have few incentives to protect foreign companies' IPRs. As a result, black market seeds and farm-saved seeds are widespread. We assume the Argentine soybean seed market is competitive. In the baseline scenario, total welfare in the soybean sector is the sum of consumer's surplus plus the producer's surplus. Shown in figure 5-1, total welfare is equal to area ABP_W plus area FEP_W.

5.4.2. TRIPS Retaliation

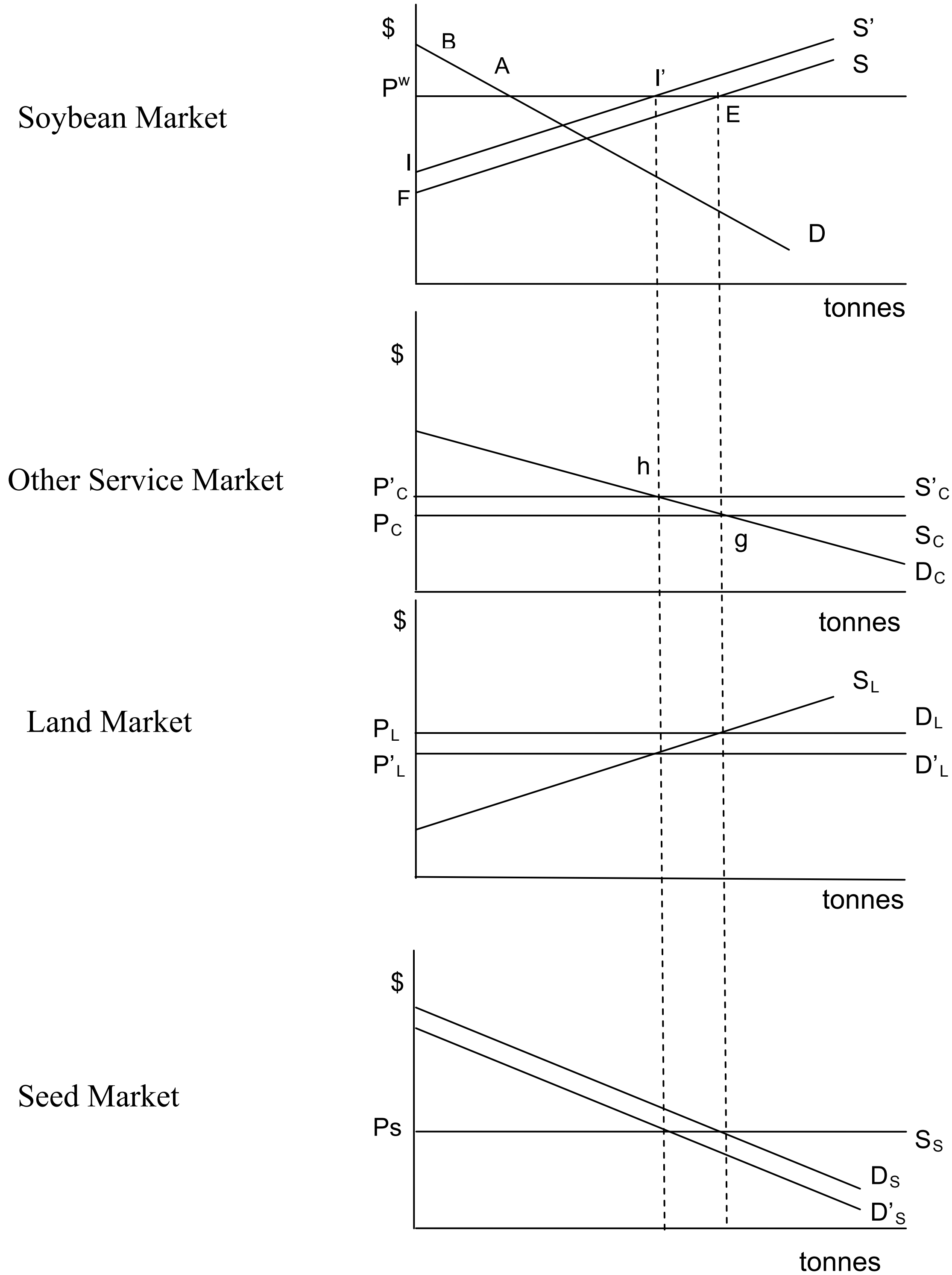
The second scenario is TRIPS retaliation. A black market in seeds leaves Argentina vulnerable to cross-agreement trade retaliation from the technology exporting country according to the TRIPS agreement. All WTO members are signatories to the TRIPS agreement and subject to its rules. To comply with the Article 27 of TRIPS, adopting countries must therefore either consider granting a patent to a GM crop or construct an equivalent *sui generis* system. Otherwise, if a member country is found to be in violation of the TRIPS agreement by a WTO panel, then trade retaliation may take place. In the case of TRIPS retaliation, if the tariff is not put on the soybean sector, the welfare of the farmers may not be affected, but the welfare of the adopting country as a whole will go down. The size of the penalty is based on the value of the loss of exports, which would be the revenue of the counterfactual monopoly (Gaisford et al., 2001). It would be the area of $PmCK0$ in Figure 5-1. The welfare of Argentina in the case of the TRIPS retaliation is equal to the total welfare of the baseline in black market minus the counterfactual monopoly rents.

5.4.3. GM Technology Levies

The TRIPS agreement is not the only solution to protect innovators' IPRs in developing countries. The innovating firms have also begun to make alternative arrangements with the adopters to capture more rents from their R&D investment. Monsanto negotiated a GM levy with The Brazilian National Association of Seed Producers in 2005. The soybean farmers are charged a royalty of 0.88 Brazilian reals per kilogram of certified RR soybean seeds by the seed companies (Reuters, 2005). Monsanto then receives royalties from seed companies. If the soybean farmers are found not having a certificate issued by a certified seed breeder, they will be charged a levy at the point of sale. The size of the levy is two per cent of the value of the harvest (Reuters, 2005). By imposing a GM levy, the innovating firms will be partially compensated for the use of their technology.

Suppose that the GM levy is imposed as an elevator checkoff (Cardwell and Kerr, 2008) in the Argentine RR soybean production. This leads to an increase in the marginal cost of other inputs and the supply curve in the other service market will shift up. Accordingly the supply curve in the soybean market will shift up due to the increased input cost (Figure 5-2). The area $P'_C\ Pcgh$ represents the proceeds from the GM levy. The reduction of the producer's surplus is $EFII'$ (Figure 5-2). The soybean industry welfare is equal to the total welfare in the baseline scenario minus the reduction of the producer's surplus.

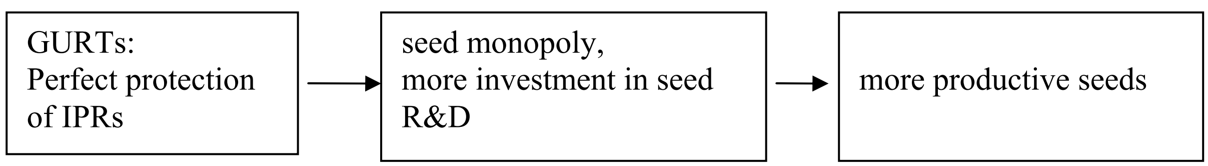
Figure 5-2. Welfare effects of a GM levy



5.4.4. GURTs

GURTs provide full protection to an innovator's IPRs by rendering second-generation seeds sterile. As a result, the innovating firm of a new technology will have a monopoly in the new seeds. The seed price will increase accordingly. At the same time, stronger IPRs will provide a higher return to innovating firms, thereby generating incentives to conduct more R&D, which may increase the yield of crops whose IPRs are protected by the built-in genetic technology. The relationship between the introduction of GURT technology and productivity increases in agriculture is illustrated in figure 5-3.

Figure 5-3. GURTs and productivity increase in agriculture



There are two factors affecting surplus changes after adoption of GURTs in the soybean industry: one is the emergence of a seed monopoly, and the other one is the increased yield associated with GURT seeds. After introduction of GURTs, the seed innovator will be able to behave as a monopolist and charge a monopoly price for the new GURT seeds, which is above the marginal cost of producing the GURT seeds. At the same time, GURTs could also lead to higher-yielding seeds that result from the innovator's ability to capture monopoly rents.

The GURT technology is not the only use restriction means to protect the innovator's rent in plant breeding. The hybrids of cultivated varieties, which have been available since 1920s (Goeschl and Swanson, 2003), share many similarities with GURTs. They both have built-in technologies to restrict the unauthorized use of the technology by farmers or other plant breeders. For instance, if hybrid seeds are saved and planted, there will be significant yield loss associated with poor seed quality (Visser, 2001). For the GURT seeds, it is impossible to reuse them because the second-generation seeds are sterile. So GURTs, like hybrid seeds, provide almost perfect IPRs protection and help the innovators capture their rents, thus giving them incentives to invest in seed R&D.

5.4.4.1. Methodologies Used to Measure the Shifts of Supply Curves

In our models, we assume parallel shifts of the supply curves caused by the improved productivity associated with GURTs seeds. The vertical shift of the supply curve k is defined as (Alston et al., 1995, Qaim and Traxler, 2005):

$$k = \theta \, r \, P^{w} \tag{5.13}$$

r : the adoption rate of GURTs. Here we assume only GURTs seeds are available, so r is equal to 100%.

P^{w} : the world market price of soybeans.

θ: defined as

$$\theta = \frac{\Delta Y}{\varepsilon} - \frac{\Delta C}{1 + \Delta Y} \tag{5.14}$$

ΔY : the yield change after adoption of GURTs

ΔC : the production cost change after adoption of GURTs

ε : the price elasticity of soybean supply

Using the available data of elasticity of soybean supply, the expected yield increase and the cost change after GURTs, we can get the value of θ from equation (5.14). Then we can calculate k by substituting θ, r and P^w into equation (5.13).

5.4.4.2. Sensitivity Analysis

Firstly, we set a range of yield increases associated with GURT seeds to explore the potential impacts of GURTs on producer's surplus, seed price and supply quantities. Higher yielding seeds are introduced to the Argentine model under perfect IPR protection. If we assume a wide adoption of GURTs, and the improvement of productivity is available, then the demand of GURTs seeds can be derived using the vertical soybean production model. Sensitivity analysis allows us to evaluate how much more productive GURT seeds must be for welfare to increase.

Secondly, given that the elasticity of soybean supply is a very important parameter in the soybean production model (see equation 5.6 for the relationship between the elasticity and the slope of the supply curve), we conduct sensitivity analysis on the supply elasticity to find out how seed price, supply quantities, and welfare changes after farmers' adoption of GURTs.

Lastly, we consider the situation that it is likely with GURTs introduced with higher seed price that farmers might go back to growing conventional seeds. So we relax the assumption that only GURT seeds are available. A scenario in which the producer's surplus is examined in combination of both GURTs seeds and conventional crops within a range of adoption rates of GURTs. We analyze what would happen to farmer's surplus at various combinations of adopting GURT seeds relative to the baseline (the current situation in the adopting country Argentina).

Chapter 6

Results and Discussion

This chapter focuses on the quantitative results that are derived from the welfare analysis conducted in Chapter 5. The quantitative results of aggregate welfare effects of GURTs and other IPR enforcement mechanisms are presented and discussed. The results provide an indication of how a developing country, such as Argentina, which adopts the new technology, but ignores IPRs of the innovators, may be affected if various IPR enforcement mechanisms were in place.

6.1. Quantitative Results

6.1.1. The Baseline: Black Seed Market (No IPR Protection)

Weak IPR protection, the wide-spread use of farm-saved seeds and resulting black market in seeds constitute the baseline scenario of our quantitative study. The RR black market baseline generates producer's surplus of 937 million dollars[4], consumer's surplus of 287 million dollars, and total welfare of 1.2 billion dollars. Consumer's surplus is unchanged across all scenarios because of the fixed world price. Table 6-1 summarizes the quantitative results of welfare analyses under various IPR protection scenarios in the Argentine soybean sector. The welfare changes in the various IPR enforcement scenarios in rows two through four are relative to the baseline scenario.

[4] In the result, everything is in US dollars.

Table 6-1 Comparison of Welfare Effects of IPR Enforcement Mechanisms [a]

IPR enforcement mechanism	Δ SP ($/ha)	ΔQ (1000t)	ΔPS (million $)	R (million $)	Δ W (million $)
TRIPS retaliation	0	0	0*	445**	-445
GM levy	0	-1,134	-211	198	-409
GURTs	28	-11,107	-715	445	-1,160

SP represents seed price, Q is supply quantity of soybeans, PS is producer's surplus, R is the seed innovator's rent, W is the welfare of the adopting country, Argentina.

[a] Welfare changes relative to no IPR protection.
* Producer's surplus is not affected because TRIPS retaliation is likely to target another industry.
** This is the penalty to Brazilian exports if the US retaliates.

6.1.2. TRIPS Retaliation

The second row of table 6-1 provides the changes of welfare in the Argentine soybean sector in the case of TRIPS retaliation. If the host country of the innovating company brought a complaint of piracy of GM technology caused by the adopting country's lax enforcement of foreign IPRs, then cross-agreement retaliation based on the value of the loss of trade could be authorized by a WTO panel. The loss of trade would be equal to the counterfactual monopoly revenue (Gaisford et al., 2001), as discussed in detail in Chapter 5. If Argentina was punished by TRIPS retaliation, it would lose 445 million dollars, which is represented by area of $PmCK0$ in Figure 5- 1. However, TRIPS retaliation is likely to be aimed at an Argentine industry other than soybeans, so soybean producer's surplus may not be affected. The change of producer's surplus in this industry is zero. But we still have to deduct these 445 million dollars from another industry as the result of the sanctions. So the total welfare in Argentina, as a result of this policy, would be reduced by 445 million dollars. This penalty is the largest effect that TRIPS retaliation could have on Argentina, because it may divert some of its lost exports to a third country (Gaisford, 2007).

6.1.3. GM Technology Levy

In Brazil, soybean farmers have to pay a levy of 0.88 Brazilian reals per kilogram of RR soybean seeds developed by Monsanto (Reuters, 2005). If soybean farmers are found not having a certificate issued by a certified seed breeder at the point of sale, then they have to pay a 2 per cent royalty. Now we consider a similar sized levy (0.43 USD per kilogram of RR soybean seeds) as an elevator check-off charged in Argentina's RR soybean market. In this scenario, producer's surplus would decrease by 211 million dollars due to higher input costs. The innovating seed company could collect 198 million dollars from the levy proceeds, which we assume all goes offshore to the innovating firm and should be deducted from the Argentine welfare. The total welfare in the soybean industry of Argentina would go down by 409 million dollars.

6.1.4. GURTs

GURTs can provide full protection of an innovator's IPRs by rendering second-generation seeds sterile. As a result, the innovating firm of a new technology will have a monopoly in RR seeds. The seed monopolists will maximize their profits by restricting the quantity supplied and charging a higher seed price accordingly. At the same time, stronger IPRs could provide higher returns to innovating firms, thereby generating incentives to conduct R&D, which may result in higher-yielding seeds. As shown in table 6-1, welfare of the adopting country's soybean industry is very sensitive to the GURT simulations. In the case of no productivity increase, if there is a complete adoption of GURTs, the higher seed price and restricted quantity of seeds supplied results in lower soybean output. Producer's surplus declines sharply by 715 million dollars, which is a fall of 76 per cent from the baseline. The innovators obtain 445 million dollars from the protection of GURTs, which we assume all goes offshore and should be deducted from the Argentine welfare, since the innovators are foreign companies. The soybean industry as a whole bears a welfare loss of 1.16 billion dollars.

Table 6-2 gives further detailed sensitivity analysis results of how the introduction of GURTs (100 per cent adoption) with a range of productivity increase levels can affect the seed price, the supply quantities and the producer's surplus. When there is no productivity change, there will be a seed price increase of 28 dollars per hectare, a decrease in soybean supply of 11 million tons, accompanied with producer's surplus loss of 715 million dollars (76 per cent down). If higher returns to R&D investments prompted seed companies to invest in producing higher-yielding seeds, then GURT seeds could become more productive. A simulation allowing for a 16 per cent productivity increase (16% was chosen to be comparable to the rate of yield increase of hybrid corn after the first five years of adoption; Pratt, 2004) generates a decrease in soybean supply of 9.6 million tons, an increase in seed price of 36 dollars per hectare, accompanied by a producer's surplus loss of 621 million dollars (66 per cent down), which is still a large loss of welfare for the producers. However, as the GURT seeds become more productive, the higher seed productivity offsets some of the negative impacts of the seed monopoly. When GURT seeds become 90 per cent more productive, there is an increase in soybean supply of 0.25 million tons, an increase in seed price of 74 dollars per hectare, accompanied by a producer's surplus gain of 28 million (3 per cent up). We can see welfare of the adopting country is increasing when the GURT seeds are more productive than the current GM crop, although the seed price is also increased simultaneously. So only at a productivity increase of 90 per cent does the adopting country begin to benefit from higher-yielding GURT seeds in the form of increased economic welfare.

Table 6-2 Potential Economic Impacts of GURTs with various productivity increase in Argentine Soybean Sector [a]

Productivity increase of GURTs seed	Δ SP (USD/ ha)	Δ Q (1,000 mt)	Δ PS (million USD)
0 %	28	-11,107	-715 (76%↓)
16 % [b]	36	-9,643	-621 (66%↓)
90 %	74	254	28 (3 % ↑)

SP represents seed price, Q is supply quantity of soybeans, PS is producer's surplus, R is the seed innovator's rent, W is the welfare of the adopting country, Argentina.

[a] Welfare changes relative to no IPR protection.
[b] According to the first five years adoption of hybrid corn in the United States.

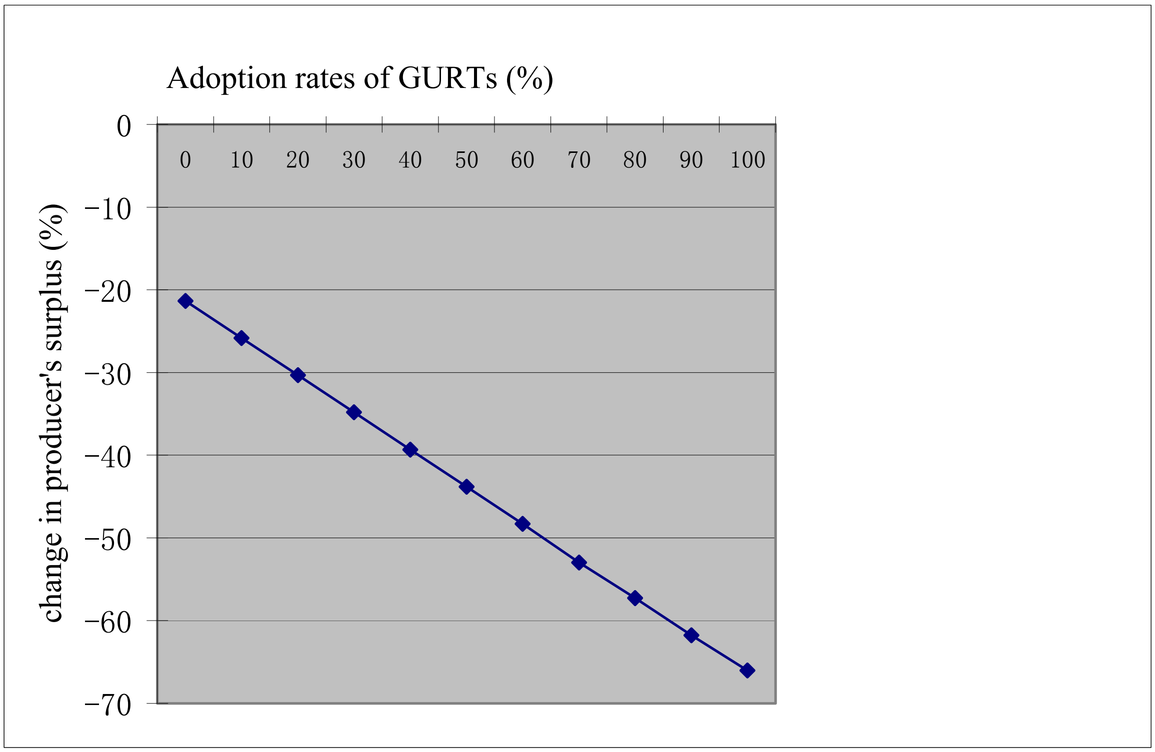
In the above analysis, a soybean supply elasticity of 2 is used to calibrate the soybean production model. We choose the price elasticity of soybean supply to be 2, as when inelastic supply elasticity was used, the derived demand curve in the seed market would be also very inelastic. With a very inelastic seed demand curve, a seed monopolist would capture most of the rents from the innovation and there would be little incentive for farmers to adopt the new technology. From chapter 5 we know that the supply elasticity is a crucial parameter in the soybean production model. Therefore we reduce the supply elasticity to its half and then double it to examine how different supply elasticities can affect the simulation results. Table 6-3 shows the results of sensitivity analysis on soybean supply elasticities. When the supply elasticity is reduced to one (half of the base value), there will be a decrease in the producer's surplus of 1.7 billion dollars (74 per cent down), a decrease of 12 million tons in soybean supply, an increase of 74 dollars per hectare in seed price. When the supply elasticity is increased to two (twice as large), there will be a decrease in the producer's surplus of 227 million dollars (76 per cent down), a decrease of 8.8 million tons in soybean supply, an increase of 6 dollars per hectare in seed price. Compared with the producer's surplus in the baseline, we find that when the soybean supply becomes more elastic, the soybean sector of the adopting country would lose less after the introduction of GURTs.

Table 6-3 Potential Economic Impacts of GURTs in Argentine Soybean Sector with various soybean supply elasticities

Supply elasticities	ΔPS (million US dollars)	Δ SP (US dollars per hectare)	Δ Q (1,000mt)
2 (base value)	-715 (76%↓)	28	-11,107
1 (base value × 1/2)	-1,675 (74%↓)	74	-12,238
4 (base value × 2)	-227 (76%↓)	6	-8,845

The last part of the sensitivity analysis is on the adoption rates of GURTs. Figure 6-1 reports the changes of producer's surplus under various combinations of GURTs seed and traditional crop. From table 6-1 we find that if GURTs are introduced without any productivity increase, there will be a huge loss in producer's surplus. No rational producer would adopt GURTs in this scenario. The results of figure 6-1 are based on the GURT seeds with 16 per cent productivity increase. When GURTs seeds become 16 per cent more productive, which is similar to the case of the introduction of hybrid corn in the first five years, there might be some incentives for the farmers to adopt these more productive new GURTs seeds. However, as the adoption rates of GURTs increases, the producer's surplus deceases. When there is no adoption, the producer's surplus will decrease 20 per cent [5]; when the adoption rate of GURTs reaches 100 per cent, the producer's surplus will decrease 66 per cent, compared to the baseline value.

Figure 6-1 Potential Economic Impacts of GURTs (16% more productive) in Argentine Soybean Sector With Various Adoption Rates



6.2. Discussion

In this research, we have analyzed aggregate welfare effects of various IPR enforcement mechanisms, with a focus on GURTs in the soybean sector of Argentina. Our model results provide an indication of how a developing country, such as Argentina,

[5] In this scenario, the producers revert to plant non-RR seeds, which are less efficient than the RR seeds. Therefore, the producer's surplus will decrease.

which adopts the new technology, but ignores IPRs of the innovators, could be affected if various IPR enforcement mechanisms were put into place. In the GURTs scenario, firstly we assume that only GURTs seeds are available to farmers, and conduct the sensitivity analysis on productivity increase and supply elasticities. Our counterfactual scenario is therefore a complete adoption of GURT soybean seeds by producers, in which we estimate how the economic welfare would change in the soybean sector in Argentina. Note that this analysis is applicable to a scenario in which only GURT RR seeds are available to producers. Obviously if GURT traits were introduced into current generation RR seeds, then producers would have no economic incentives to adopt the GURT seeds - producers would continue using saved seeds or go back to plant conventional non-RR soybean seeds. In the last part of the analysis, we relax the assumption of only GURT seeds available to farmers. A range of combinations of GURTs and conventional seeds is considered to examine the changes in producer's surplus. The welfare results of GURTs in the first two parts of the sensitivity analysis (productivity increase and supply elasticities) are therefore to be understood as a counterfactual in which RR seeds were only ever available to Argentine producers in the form of a GURT seed. These results can also inform the debate about the future adoption of GM crops in developing countries. If GURTs are commercialized and bundled into GM crops, then potential adopting countries may not ever have the option of maintaining seed markets in which IPRs are not protected. The results of this model provide some insight into how such a scenario could affect an adopting country.

The implementation of the TRIPS agreement has allowed the host country of an innovating firm to request trade sanctions against a country by implementing tariffs or other trade measures (Kerr and Perdikis, 2003). If there was TRIPS cross-agreement retaliation authorized in the case of Argentinean soybeans in 2001, then the welfare loss of Argentina would be sizable. This loss could serve as a threat to the Argentine government to respect the IPRs of the biotechnology firms and provide a welcoming IPR environment to foreign innovators. However, this is the worst situation that the adopting country could face. First, the adopting country would try to channel more exports to other markets to minimize the loss of the trade sanction from the innovating country (Gaisford, 2007). Second, if there was an effective *sui generis* protection system in place, the counterfactual loss of trade, based on the revenue of the monopolist, would likely be of less value because the seed price under an effective *sui generis* protection system may be lower than the monopoly price (Cardwell and Kerr, 2008).

Besides the launch of WTO TRIPS agreement, agricultural technology innovators, such as Monsanto, have begun to seek alternative solutions to solve the IPR dilemma in their overseas seed markets. A GM levy has been negotiated with the Brazilian National Association of Seed Producers in Brazil (Reuters, 2005). If there was a similar size of levy charged in the Argentine soybean sector, the total welfare would decrease by approximately 400 million dollars, which is closer to the scenario of trade retaliation. So the seed innovators have designed the levy to capture similar amount rent as in the counterfactual monopoly scenario (which is discussed in chapters three and five: the amount of the trade retaliation is equal to the counterfactual monopoly rent). The results also show that GM levy is another powerful means to guarantee the innovators to capture rents from their R&D in seed development. Cardwell and Kerr (2008) find that the adopting country may gain by accepting a GM levy in the international environment of tightened IPRs, unlike this application to Argentina. The main reasons for this difference are different model assumptions. For example, in their study, Brazil is a big country and can affect the world soybean price. Cardwell and Kerr also use different price elasticities and counterfactual baselines. Their study uses a pre-GM scenario as a baseline and the benefit caused by cost-saving of GM crops offsets the loss due to the levy charges. This study's baseline is pirated GM technology.

In the analysis of the effects of GURT seeds, the level of innovation is treated as endogenous to the format of IPRs protection by modeling increased yields in response to tighter IPR protection. GURTs would provide perfect protection for the biotechnology innovator's IPRs, and give the life-science firms monopoly power to constrain output and charge higher prices. This could encourage more investment in seed R&D, which could result in more productive seeds. Developing countries could benefit from adopting GURTs, but only if increased productivity is big enough to offset the adverse effects of higher seed prices.

In this research, a range of yield improvements associated with GURTs are set to explore the potential impacts of introducing GURTs into the Argentinean RR soybean supply chain. The welfare changes in the adopting country are very sensitive to the introduction of GURTs. If there was no productivity increase coming along with GURTs, then the welfare loss of the adopting country could be large; producer's surplus would go down by three quarters of the baseline value. The losses are offset as seeds become more productive, and producers in the adopting country could gain when the new GURT seeds are approximately 90 per cent more productive than current GM varieties.

The results of sensitivity analysis on supply elasticities indicate that when the soybean supply is more elastic, the loss of the adopting country might be smaller after introduction of GURT seeds with no productivity increase. This is reasonable since when the supply elasticity increases, the supply curve becomes flatter, which means that the producers can adjust their plans more easily. If the seed company behaves as a monopoly to constrain the seed quantities after GURTs, the country with a flatter supply curve could lose less.

The results of sensitivity analysis on the adoption rates of GURTs vividly reveal the potential negative impacts of GURTs. It is very likely that farmers would go back to plant conventional soybean seeds if GURTs were introduced without any productivity increase.

The results of GURTs estimated in our study are similar as the results of previous studies. Using hybrid crops as a proxy and employing a diffusion model, Goeschl, and Swanson (2000) analyze the potential impact of GURTs on the yield improvement in developing countries. They find that if GURTs are widely adopted across all staple crops by the innovators, there will be a downward shift of agricultural productivity in developing countries because of restricted access to the innovations. As an extension, the results of their study published in 2003 demonstrate that the impacts of GURTs on yield improvement could vary considerably, depending on the yield gap between the developing country and the technology frontier.

The results of how complete adoption of GURTs can affect producers, consumers, innovators and the soybean industry as a whole in this study are very clear. GURTs could markedly reduce welfare in the adopting country, unless the higher degree of rent appropriability leads to vastly more productive seeds. GURT seeds have to be at least 90 per cent more productive than the current GM seeds. This is a relatively large yield increase for soybeans; and it may take a very long time to achieve this target. According to agronomists Volenec and Jackson (2004) the advance of soybean yields is much slower than corn, because of the genetic and physiological differences between these two crops and greater efforts put into corn research. The genetic makeup of the soybean plant is quite unique which makes the yield improvement of soybeans fall behind that of corn (Volenec and Jackson, 2004). First, it is more difficult to genetically cross soybeans than the corn genes. Second, the photosynthesis in soybeans is less efficient than that of corn. Third, under environment stresses, soybeans lose more grain than corns. Between 1930 and 2003, average corn yields have improved sevenfold; while average soybean yields only tripled (Volenec and Jackson, 2004). The rate of yield increase in soybeans is about 1 per cent per year (Wilcox, 2001). So, at the current pace, it could take about 90 years for GURTs seeds to achieve the goal of being 90 per cent more productive than the current GM seeds.

If there was a complete adoption of GURTs, innovators could capture full rents from their IPRs. Motivated by the enhanced ability to rent capture, the innovators may increase their investment in the R&D of yield improvement in developing countries, which would speed up the advance of yield increase in soybeans. It might take less than 90 years for GURTs seeds to become 90 per cent more productive with such incentives in place.

Chapter 7

Conclusions

7.1. Conclusions

The global area under GM crops grew rapidly in the first ten years of GM technology adoption. However, the protection of innovators' IPRs has remained controversial, especially in developing countries. The return from R&D is dependent on how well innovating firms' intellectual property is protected from pirating (Gaisford et al., 2002). Strong protection of IPRs can help to ensure that private companies earn profits from their innovations and stimulate their incentives to invest in R&D. There has been a long history and comprehensive legal systems and mechanisms to respect and protect IPRs in the US and other industrialised countries. In contrast, the IPRs of agricultural biological innovations are often poorly protected in developing countries because of the absence of legislation and institutions, and low incentives for local governments to protect IPRs of foreign companies (Levy, 2000).

Weak enforcement of IPRs in developing countries has generated significant market failures for biotechnology firms who are unable to fully capture their innovation rents from producers who "free ride" on their innovations. In order to strengthen IPR enforcement in developing countries, various IPR protection mechanisms have been established. These mechanisms include the WTO TRIPS agreement, GM technology levies, and GURTs. GURTs have been developed by agricultural biotechnology firms to restrict the unauthorized use of their innovations and protect their IPRs.

Based on farm-level survey data collected by Qaim and Traxler (2005), and data of production, consumption and elasticities from other sources, this research employs a synthetic partial-equilibrium model and a vertical linkage production model to estimate the welfare effects of GURTs and other IPR enforcement mechanisms applied in RR soybean production in Argentina. Sensitivity analysis is conducted on the productivity increase of GURT seeds, soybean supply elasticities, and adoption rates of GURTs to examine the potential economic impacts of GURTs on producer's surplus, seed price, and supply quantities. We set a range of yield improvement to analyze how much more productive GURTs seeds would have to be to offset the adverse effects that could result from innovating-firm market power in seeds. The economic surpluses of producers, consumers and the innovators are quantified and compared in various scenarios including a black market for seeds, TRIPS retaliation, a GM technology levy, and GURTs. The model's results vividly depict how a developing country with loose IPR regulations, such as Argentina, which adopts the new technology, could be affected if various IPR enforcement mechanisms were in place. In the GURTs scenario, first we consider the situation in which RR soybean seeds are only available with GURT traits. The negative welfare effects of the GURTs that are analyzed above imply that there would be no economic incentive for producers to adopt seeds with GURT traits if they had the option of continuing to use black market RR seeds. As such, the model's results are to be understood as a counterfactual scenario in which RR technology was only available with GURT traits. The model's results also inform the debate about inserting GURTs into future biotechnology crops. Countries that have not yet adopted GM technology may be faced with adopting crops that could be bundled with GURT traits.

The results of how GURTs can affect producers, consumers, innovators and the soybean industry in an adopting country are clear. GURTs could markedly reduce welfare in the adopting country, unless the higher degree of rent appropriability leads to vastly more productive seeds. As the soybean supply elasticity increases, the producers could lose more if GURTs are introduced without any productivity increase. When GURT seeds become 16 per cent more productive than the current GM crop, the producer's surplus still keeps falling as the adoption rate of GURTs increases. GURTs seeds have to be at least 90 per cent more productive than current GM seeds. This is a large yield increase for soybeans. The rate of yield increase in soybeans is slow relative to some other crops that are commonly grown in North and South America. For example, between 1930 and 2003, average yields of corn have been increased nearly seven fold; the average yields of soybeans have not quite tripled (Volenec and Jackson, 2004). An increase of 90 percent may take a long time to achieve. The rate of yield increase in soybeans is about 1 per cent per year during the last sixty years (Wilcox, 2001).

We conclude that complete adoption of GURTs by producers, associated with strengthened IPRs may reduce welfare of the adopting country and lead to higher technology prices. The reduction in welfare in the adopting country could be sizeable. Meanwhile, effective IPR enforcement can improve the innovator's ability to capture rents on R&D and may generate incentives to conduct more research into plant breeding that could benefit farmers in developing countries.[6]

The model's results also suggest that the hesitance with which GURT technology has been met with by other authors (Goeschl and Swanson, 2003; Lence and Hayes, 2005; Khachaturyan and Yiannaka, 2006) is warranted. Even if such protection systems led to higher seed productivity, GURTs are still very likely to have negative impacts on the welfare of the adopting countries at the initial transitional period of adoption. This period could be several years and the adopting country could experience significant welfare losses. Compared to GURTs, the levy on GM technology, also as suggested by Cardwell and Kerr (2008), is a better candidate for developing countries to fulfill international obligations of enforcing plant IPRs, in order to avoid trade retaliation under TRIPS agreement. Developing-country governments must weigh the potential benefits and the costs of welfare lost associated with strengthened IPRs in making licensing and regulations decisions related to crop biotechnology.

7.2. Limitations and Future Study

In our study, the model's results show that soybean yields would have to increase markedly for adopting-country producers to not be negatively affected by the presence of GURT traits. Within the maximum yield potentials, the increase in productivity is partially dependent on the efforts that innovating firms expend on R&D in plant breeding that is tailored to growing conditions in developing countries. The economic models

[6] The decision how much protection is required to elicit R&D investment is not modeled in this paper. See Gaisford et al. (2007) for a discussion of this issue.

employed in this study do not attempt to determine how large returns to R&D would have to be to generate sufficient investment to make such big yield gains. In future study, more research work will need to be done to answer this question.

This research treats the adopting country as a small country that is unable to affect commodity terms of trade. This assumption is appropriate for the period from which the baseline data is drawn for Argentina. Argentine soybean output is expanding, however, and future studies may have to reconsider the small country assumption. The small country assumption is also appealing in the context of this research because many countries who could be adversely affected by GURT seeds are not yet large players in global commodity trade.

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Appendix A: 2006 Monsanto Technology Agreement

2006 MONSANTO TECHNOLOGY/STEWARDSHIP AGREEMENT

(Limited Use License)

PLEASE MAIL THE SIGNED 2006 MONSANTO TECHNOLOGY/STEWARDSHIP AGREEMENT TO: Grower Licensing, Monsanto, 622 Emerson Road, Suite 150, St. Louis, MO 63141

GROWER INFORMATION (please print)

Please complete this section with your business information. To sign this Agreement you must be the operator/grower for all fields that will grow plants from Seed you obtain containing Monsanto Technologies (defined below). You represent that you have full authority to and do hereby bind to this Agreement yourself, all entities for which you obtain Seed, all individuals and entities having an ownership interest in any entities for which you obtain Seed, and that Monsanto Company has not barred any of those individuals or entities from obtaining this limited-use license. Your name must be filled in and must match the signature below.

Full Grower's Name (First/Middle/Last) Dr. Mr. Mrs. Ms. Suffix (Jr. Sr. II, III, etc.) Farm Business Name

Business Address (as listed with the FSA) Business City

State Zip Area Code Business Phone Fax

E-mail Address

PRIMARY SEED SUPPLIER

Business Name

Area Code Phone City State Zip

THIS SPACE FOR MONSANTO OFFICE USE ONLY, PLEASE LEAVE THIS SECTION BLANK:

Lic. #: Batch #: Date:

This Monsanto Technology/Stewardship Agreement is entered into between you (Grower) and Monsanto Company (Monsanto) and consists of the terms on this page and on the second page.

This Monsanto Technology/Stewardship Agreement grants Grower a limited license to use Roundup Ready® soybeans, YieldGard® Corn Borer corn, YieldGard® Rootworm corn, YieldGard® Rootworm with Roundup Ready® Corn 2, YieldGard® Plus corn, YieldGard® Plus with Roundup Ready® Corn 2, Roundup Ready® Corn 2, YieldGard® Corn Borer with Roundup Ready® Corn 2, Roundup Ready® cotton, Bollgard® cotton, Bollgard® with Roundup Ready® Cotton, Bollgard II® cotton, Bollgard II® with Roundup Ready® Cotton, Roundup Ready® Flex Cotton, Bollgard II® with Roundup Ready Flex Cotton, Roundup Ready® sugarbeets, Roundup Ready® Canola, and Roundup Ready® Alfalfa (Monsanto Technologies). This Agreement also contains Grower's stewardship responsibilities and requirements associated with the Monsanto Technologies.

GENERAL TERMS:

Grower's rights may not be transferred to anyone else without the written consent of Monsanto. If Grower's rights are transferred with Monsanto's consent or by operation of law, this Agreement is binding on the person or entity receiving the transferred rights. If any provision of this Agreement is determined to be void or unenforceable, the remaining provisions shall remain in full force and effect.

Grower acknowledges that Grower has received a copy of Monsanto's Technology Use Guide (TUG). To obtain additional copies of the TUG, contact Monsanto at 1-800-768-6387 or go to Farmsource.com. Once effective, this agreement will remain in effect until either Grower or Monsanto choose to terminate the Agreement. Information regarding new and existing Monsanto Technologies and any new terms will be mailed to you each year. Continuing use of Monsanto Technologies after receipt of any new terms constitutes Grower's agreement to be bound by the new terms. If any provision of this Agreement is determined to be void or unenforceable, the remaining provisions shall remain in full force and effect.

GROWER RECEIVES FROM MONSANTO COMPANY:

- A limited use license to purchase and plant seed containing Monsanto Technologies ("Seed") and apply Roundup agricultural herbicides and other authorized non-selective herbicides over the top of Roundup Ready crops. Monsanto retains ownership of the Monsanto Technologies including the genes (for example, the Roundup Ready gene) and the gene technologies. Grower receives the right to use the Monsanto Technologies subject to the conditions specified in this Agreement and for spring canola in a separate use agreement.
- Monsanto Technologies are protected under U.S. patent law. Monsanto licenses the Grower, under applicable patents owned or licensed by Monsanto, to use Monsanto Technologies subject to the conditions listed in this Agreement. This license does not authorize Grower to plant Seed in the United States that has been purchased in another country or plant Seed in another country that has been purchased in the United States. Grower is not authorized to transfer Seed to anyone outside of the U.S.
- Enrollment for particiaption in Roundup Rewards[sm] program.
- A limited use license to prepare and apply on glyphosate-tolerant soybean, cotton, alfalfa, or Canola crops (or have others prepare and apply) tank mixes of, or sequentially apply (or have others sequentially apply), Roundup agricultural herbicides or other glyphosate herbicides labeled for use on those crops with quizalofop, clethodim, sethoxydim, fluazifop, and/or fenoxaprop to control volunteer Roundup Ready corn in Grower's crops for the 2006 growing season. However, neither Grower nor a third party may utilize any type of co-pack or premix of glyphosate plus one or more of the above-identified active ingredients in the preparation of a tank mix.

PLEASE MAIL THE SIGNED 2006 MONSANTO TECHNOLOGY/STEWARDSHIP AGREEMENT TO: Grower Licensing, Monsanto, 622 Emerson Road, Suite 150, St. Louis, MO 63141. This Monsanto Technology/Stewardship Agreement becomes effective if and when Monsanto issues the Grower a license number from Monsanto's home office in St. Louis, Missouri. Monsanto does not authorize seed dealers or seed retailers to issue a license of any kind for Monsanto Technologies.

UNITED STATES PATENTS:

The licensed U.S. patents include: for YieldGard® Corn Borer corn – 5,484,956; 5,352,605; 5,424,412; 5,859,347; 5,593,874; 6,180,774; 6,331,665; for YieldGard® Corn Rootworm corn - 5,110,732; 6,174,724; 5,484,956; 5,352,605; 5,023,179; 6,063,597; 6,331,665; 6,501,009; for YieldGard® Plus corn - 5,023,179; 5,352,605; 5,484,956; 5,424,412; 5,859,347; 5,593,874; 6,063,597; 6,174,724; 6,331,665; for Roundup Ready® Corn 2 – 4,940,835; 5,188,642; 5,359,142; 5,196,525; 5,322,938; 5,164,316; 5,352,605; 5,554,798; 5,593,874; 5,859,347; 5,424,412; 5,633,435; 5,804,425; 5,641,876; 6,825,400; 5,717,084; 5,728,925; 6,083,878; 6,025,545; for Roundup Ready® corn - 4,940,835; 5,188,642; 6,025,545; 5,554,798; 6,040,497; 5,641,876; 5,717,084; 5,728,925; 6,083,878; for YieldGard Corn Borer with Roundup Ready® Corn - 5,484,956; 5,352,605; 5,424,412; 5,859,347; 5,593,874; 6,331,665; 4,940,835; 5,188,642; 5,359,142; 5,196,525; 5,322,938; 5,164,316; 5,554,798; 5,633,435; 5,804,425; 5,641,876; 5,717,084; 5,728,925; 6,083,878; 6,025,545; for Roundup Ready® soybeans – 4,940,835; 5,188,642; 5,352,605; 5,633,435; 5,530,196; 5,717,084; 5,728,925; 5,804,425; for Roundup Ready® cotton – 5,633,435; 5,352,605; 5,530,196; 5,188,642; 4,940,835; 5,804,425, 6,051,753; 6,018,100; 5,378,619; 6,174,724; 5,159,135; 5,004,863; 5,728,925; 5,717,084; 6,083,878; for Bollgard® cotton – 5,359,142; 5,352,605; 5,530,196; 5,322,938; 5,196,525; 5,164,316; 6,174,724; 5,880,275; 5,159,135; 5,004,863; for Bollgard® with Roundup Ready® cotton – 5,633,435; 5,359,142; 5,352,605; 5,530,196; 5,322,938; 5,196,525; 5,188,642; 5,164,316; 4,940,835; 5,717,084; 5,728,925; 6,051,753; 6,018,100; 5,378,619; 6,174,724; 5,159,135; 5,004,863; 6,083,878; 5,880,275 and 5,804,425; for Bollgard II® cotton – 6,489,542; 5,359,142; 5,352,605; 5,530,196; 5,322,938; 5,196,525; 5,164,316; 6,174,724; 5,880,275; 5,159,135; 5,004,863; 5,728,925; 5,717,084; 5,338,544; 5,659,122; 5,362,865; for Bollgard II® with Roundup Ready® cotton - 5,633,435; 6,489,542; 5,359,142; 5,352,605; 5,530,196; 5,322,938; 5,196,525; 5,188,642; 5,164,316; 4,940,835; 5,717,084; 5,728,925; 6,051,753; 6,018,100; 5,378,619; 6,174,724; 5,159,135; 5,004,863; 6,083,878; 5,880,275; 5,804,425; 5,338,544; 5,362,865; 5,659,122; for Roundup Ready® Canola – 6,051,753; 6,018,100; 5,378,619; 5,728,925; 5,776,760; 5,717,084; 5,804,425; 5,633,435; 5,188,642; 4,940,835; 5,463,175; 6,083,878; for Roundup Ready® sugarbeets – 5,378,619; 5,463,175; 5,776,760; 5,633,435; 5,164,316; 5,196,525; 5,322,938; 5,359,142; 5,352,605; 5,530,196; 4,940,835; 5,188,642; 5,717,084; 5,728,925; 6,018,100; 6,051,753; 6,083,878; 5,804,425; 6,174,724; for Roundup Ready® Alfalfa – 6,051,753; 6,018,100; 5,378,619; 5,362,865; 5,659,122; 5,717,084; 5,728,925; 5,633,435; 5,804,425; for Roundup Ready® Flex Cotton - 4,940,835; 5,004,863; 5,159,135; 5,188,642; 5,633,435; 5,717,084; 5,728,925; 5,804,425; 6,051,753; 6,083,878; 6,660,911; for Bollgard II® with Roundup Ready® Flex Cotton - 6,489,542; 5,359,142; 5,352,605; 5,530,196; 5,322,938; 5,196,525; 5,164,316; 6,174,724; 5,880,275; 5,159,135; 5,004,863; 5,728,925; 5,717,084; 5,338,544; 5,659,122; 5,362,865; 4,940,835; 5,004,863; 5,159,135; 5,188,642; 5,633,435; 5,717,084; 5,728,925; 5,804,425; 6,051,753; 6,083,878; 6,660,911; for YieldGard® Plus with Roundup Ready® Corn 2-5,023,179; 5,352,605; 5,484,956; 5,424,412; 5,859,347; 5,593,874; 6,063,597; 6,174,724; 6,331,665; 4,940,835; 5,188,642; 5,359,142; 5,196,525; 5,322,938; 5,164,316; 5,352,605; 5,554,798; 5,593,874; 5,859,347; 5,424,412; 5,633,435; 5,804,425; 5,641,876; 6,825,400; 5,717,084; 5,728,925; 6,083,878; 6,025,545; for YieldGard® Corn Borer with Roundup Ready® Corn 2 -5,484,956; 5,352,605; 5,424,412; 5,859,347; 5,593,874; 6,180,774; 6,331,665; 4,940,835; 5,188,642; 5,359,142; 5,196,525; 5,322,938; 5,164,316; 5,352,605; 5,554,798; 5,593,874; 5,859,347; 5,424,412; 5,633,435; 5,804,425; 5,641,876; 6,825,400; 5,717,084; 5,728,925; 6,083,878; 6,025,545; for YieldGard® Rootworm with Roundup Ready® Corn 2 - 5,110,732; 6,174,724; 5,484,956; 5,352,605; 5,023,179; 6,063,597; 6,331,665; 6,501,009; 4,940,835; 5,188,642; 5,359,142; 5,196,525; 5,322,938; 5,164,316; 5,352,605; 5,554,798; 5,593,874; 5,859,347; 5,424,412; 5,633,435; 5,804,425; 5,641,876; 6,825,400; 5,717,084; 5,728,925; 6,083,878; 6,025,545; for tank mix 6,239,072

ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS. Roundup Ready® crops contain genes that confer tolerance to glyphosate, the active ingredient in Roundup® agricultural herbicides. Roundup® agricultural herbicides will kill crops that do not contain Roundup Ready® genes. Roundup®, Roundup Ready®, Bollgard®, Bollgard II®, YieldGard®, and the Vine Symbol are trademarks of Monsanto Technology LLC. Roundup Rewardssm is a servicemark of Monsanto Technology LLC © 2001 Monsanto Company. Roundup Rewards applies only to Roundup branded and other specified Monsanto agricultural herbicides.

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GROWER AGREES:

- To direct grain produced from corn containing the YieldGard Rootworm trait and stacks that include the Roundup Ready Corn 2 and/or YieldGard Rootworm trait(s) to appropriate markets as necessary.
- If growing Roundup Ready alfalfa: to comply with the Seed and Feed Use Agreement, which is incorporated and part of this Agreement, to direct any product produced from a Roundup Ready alfalfa crop or seed, including hay and hay products, only to those countries where regulatory approvals have been granted, and not to plant Roundup Ready alfalfa for the production of sprouts. Refer to the Technology Use Guide for additional information.
- To accept and continue the obligations of this Monsanto Technology Stewardship Agreement on any new land purchased or leased by Grower that has Seed planted on it by a previous owner or possessor of the land; and to notify in writing purchasers or lessees of land owned by Grower that has Seed planted on it that the Monsanto Technology is subject to this Monsanto Technology Stewardship Agreement and they must have or obtain their own Monsanto Technology Stewardship Agreement.
- To implement an Insect Resistance Management program as specified in the applicable Bollgard/Bollgard II cotton and YieldGard corn sections of the most recent Technology Use Guide (TUG) and Insect Resistance Management (IRM) guides and to cooperate and comply with Insect Resistance Management programs.
- To use Seed containing Monsanto Technologies solely for planting a single commercial crop. Not to save any crop produced from Seed for planting and not to supply Seed produced from Seed to anyone for planting other than to a Monsanto licensed seed company.
- Not to transfer any Seed containing patented Monsanto Technologies to any other person or entity for planting.
- To plant Seed for Seed production, if and only if, Grower has entered into a valid, written Seed production agreement with a Seed company that is licensed by Monsanto to produce Seed. Grower must either physically deliver to that licensed Seed company or must sell or use as commodity grain all of the Seed produced pursuant to a Seed production agreement. Grower shall NOT plant any Seed Grower has produced or use or to allow others to use Seed containing patented Monsanto Technologies for crop breeding, research, or generation of herbicide registration data.
- To use on Roundup Ready crops only a labeled Roundup® agricultural herbicide or other authorized non-selective herbicide which could not be used in the absence of the Roundup Ready gene (see TUG for details on authorized non-selective products). Use of any selective herbicide labeled for the same crop without the Roundup Ready gene is not restricted by this Agreement. MONSANTO DOES NOT MAKE ANY REPRESENTATIONS, WARRANTIES OR RECOMMENDATIONS CONCERNING THE USE OF PRODUCTS MANUFACTURED OR MARKETED BY OTHER COMPANIES WHICH ARE LABELED FOR USE IN ROUNDUP READY CROP(S). MONSANTO SPECIFICALLY DISCLAIMS ALL RESPONSIBILITY FOR THE USE OF THESE PRODUCTS IN ROUNDUP READY CROP(S). ALL QUESTIONS AND COMPLAINTS ARISING FROM THE USE OF PRODUCTS MANUFACTURED OR MARKETED BY OTHER COMPANIES SHOULD BE DIRECTED TO THOSE COMPANIES.
- To read and follow the applicable sections of the TUG, which is incorporated into and is a part of this Agreement, for specific requirements relating to the terms of this Agreement, and to abide by and be bound by the terms of the TUG as it may be amended from time to time.
- To acquire Seed containing these Monsanto Technologies only from a seed company with technology license(s) from Monsanto or from a licensed company's authorized dealer.
- To pay all technology fees due to Monsanto that are a part of, associated with or collected with the Seed purchase price or that are invoiced for the seed.
- Upon written request, to allow Monsanto to review the Farm Service Agency crop reporting information on any land farmed by Grower including Summary Acreage History Report, Form 578 and corresponding aerial photographs, Risk Management Agency claim documentation, and dealer/retailer invoices for seed and chemical transactions.
- To allow Monsanto to examine and copy any records and receipts that could be relevant to Grower's performance of this Agreement.

GROWER UNDERSTANDS:

- Commodity Marketing: Grain/commodities harvested from YieldGard Plus corn, YieldGard Plus with Roundup Ready Corn 2, YieldGard Rootworm with Roundup Ready Corn 2, YieldGard Corn Borer with Roundup Ready Corn 2, Roundup Ready Canola, and YieldGard Rootworm corn are approved for U.S. food and feed use but not yet approved in certain export markets where approval is not certain to be received before the end of 2006. As a result, Grower must direct those grain/commodities to the following approved market options: feeding on farm, use in domestic feed lots, elevators that agree to accept the grain, or other approved uses in domestic markets only. Go to www.866sell.com for a list of Grain Handlers' positions on accepting transgenic corn. The American Seed Trade Association web site (www.amseed.org) includes a list of grain handlers' positions on accepting transgenic corn. You must complete and send to Monsanto a Market Choices® Grain Markeing Communication Plan. For additional information on grain market options or to obtain additional forms, call 1-800-768-6387.
- Regulatory approvals: Monsanto Technologies may only be used where the products have been approved for use by all required governmental agencies. For example, some Monsanto Technologies are not approved in all states. Check with your Monsanto representative if you have questions about the approval status in your state.
- Insect Resistance Management (IRM): When planting any YieldGard or Bollgard product, Grower must implement an IRM program including planting a non-Bt refuge according to the size and distance guidelines specified in the Bollgard cotton and YieldGard corn sections of the most recent Monsanto Technology Use Guide including any supplemental amendments (collectively "TUG") and the crop specific IRM guides. Grower may lose Grower's limited use license to use these products if Grower fails to follow the IRM program required by this Agreement.
- Crop Stewardship & Specialty Crops: Refer to the section on Coexistence and Identity Preservation in the TUG for information on crop stewardship and considerations for production of identity preserved crops

MONSANTO'S REMEDIES:

If Grower breaches this Agreement, in addition to Monsanto's other remedies, Grower's limited-use license will terminate immediately. Thereafter, Monsanto will not accept any application for a new Monsanto Technology/Stewardship Agreement unless Monsanto provides in writing an authorization specifically naming Grower. Any such purported agreement that does not contain Monsanto's express authorization (whether a license number has been issued or not) is void. Injunction; Infringement and Contract Damages. If Grower is found by any court to have infringed one or more of the U.S. patents listed below, Grower agrees that Monsanto will be entitled to a permanent injunction enjoining Grower from making, using, selling, or offering for sale Seed and patent infringement damages to the full extent authorized by 35 U.S.C. § 271 et.seq.. Grower will also be liable for all breach of contract damages. If Grower is found by any court to have infringed one or more of the U.S. patents listed below or otherwise to have breached this agreement, Grower agrees to pay Monsanto and the licensed Monsanto Technology provider(s) their attorneys' fees and costs.

Grower accepts the terms of the following NOTICE REQUIREMENT, LIMITED WARRANTY AND DISCLAIMER OF WARRANTY AND EXCLUSIVE LIMITED REMEDY by signing this Agreement and/or opening a bag of Seed containing Monsanto Technology. If Grower does not agree to be bound by the conditions of purchase or use, Grower agrees to return the unopened bags to Grower's seed dealer.

NOTICE REQUIREMENT:

As a condition precedent to Grower or any other person with an interest in Grower's crop asserting any claim, action, or dispute against Monsanto and/or any seller of Seed containing Monsanto Technologies regarding performance or non-performance of Monsanto Technologies or the Seed in which it is contained, Grower must provide Monsanto a written, prompt, and timely notice (regarding performance or non-performance of the Monsanto Technologies) and to the seller of any Seed (regarding performance or non-performance of the Seed) within sufficient time to allow an in-field inspection of the crop(s) about which any controversy, claim, action, or dispute is being asserted. The notice will be timely only if it is delivered 15 days or less after the Grower first observes the issue(s) regarding performance or non-performance of the Monsanto Technology and/or the Seed in which it is contained. The notice shall include a statement setting forth the nature of the claim, name of the Monsanto Technology, and Seed hybrid or variety.

LIMITED WARRANTY AND DISCLAIMER OF WARRANTIES:

Monsanto warrants that the Monsanto Technologies licensed hereunder will perform as set forth in the TUG when used in accordance with directions. This warranty applies only to Monsanto Technologies contained in planting Seed that has been purchased from Monsanto and seed companies licensed by Monsanto or the seed company's authorized dealers or distributors. <u>EXCEPT FOR THE EXPRESS WARRANTIES IN THE LIMITED WARRANTY SET FORTH ABOVE, MONSANTO MAKES NO OTHER WARRANTIES OF ANY KIND, AND DISCLAIMS ALL OTHER WARRANTIES, WHETHER ORAL OR WRITTEN, EXPRESS OR IMPLIED INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE.</u>

GROWER'S EXCLUSIVE LIMITED REMEDY:

THE EXCLUSIVE REMEDY OF THE GROWER AND THE LIMIT OF THE LIABILITY OF MONSANTO OR ANY SELLER FOR ANY AND ALL LOSSES, INJURY OR DAMAGES RESULTING FROM THE USE OR HANDLING OF SEED CONTAINING MONSANTO TECHNOLOGY (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, PRODUCT LIABILITY, STRICT LIABILITY, TORT, OR OTHERWISE) SHALL BE THE PRICE PAID BY THE GROWER FOR THE QUANTITY OF THE SEED INVOLVED OR, AT THE ELECTION OF MONSANTO OR THE SEED SELLER, THE REPLACEMENT OF THE SEED. IN NO EVENT SHALL MONSANTO OR ANY SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL, OR PUNITIVE DAMAGES.

Thank you for choosing our advanced technologies. We look forward to working with you in the future. If you have any questions regarding the Monsanto Technologies or this license, please call the Monsanto Customer Relations Center at: 1-800-ROUNDUP.

GOVERNING LAW: This Agreement and the parties' relationship shall be governed by the laws of the State of Missouri and the United States (without regard to the choice of law rules).

BINDING ARBITRATION FOR COTTON-RELATED CLAIMS MADE BY GROWER: Any claim or action made or asserted by a cotton Grower (or any other person claiming an interest in the Grower's cotton crop) against Monsanto or any seller of cotton Seed containing Monsanto Technology arising out of and/or in connection with this Agreement or the sale or performance of the cotton Seed containing Monsanto Technology other than claims arising under the patent laws of the United States must be resolved by binding arbitration. The parties acknowledge that the transaction involves interstate commerce. The parties agree that arbitration shall be conducted pursuant to the provisions of the Federal Arbitration Act, 9 U.S.C. Sec 1 et seq. and administered under the Commercial Dispute Resolution Procedures established by the American Arbitration Association ("AAA"). The term "seller" as used throughout this Agreement refers to all parties involved in the production, development, distribution, and/or sale of the Seed containing Monsanto Technology. In the event that a claim is not amicably resolved within 30 days of Monsanto's receipt of the Grower's notice required pursuant to this Agreement any party may initiate arbitration. The arbitration shall be heard in the capital city of the state of Grower's residence or in any other place as the parties decide by mutual agreement. When a demand for arbitration is filed by a party, the Grower and Monsanto/sellers shall each immediately pay one half of the AAA filing fee. In addition, Grower and Monsanto/sellers shall each pay one half of AAA's administrative and arbitrator fees as those fees are incurred. The arbitrator(s) shall have the power to apportion the ultimate responsibility for all AAA fees in the final award. The arbitration proceedings and results are to remain confidential and are not to be disclosed without the written agreement of all parties, except to the extent necessary to effectuate the decision or award of the arbitrator(s) or as otherwise required by law.

FORUM SELECTION FOR NON-COTTON-RELATED CLAIMS MADE BY GROWER AND ALL OTHER CLAIMS: THE PARTIES CONSENT TO THE SOLE AND EXCLUSIVE JURISDICTION AND VENUE OF THE U.S. DISTRICT COURT FOR THE EASTERN DISTRICT OF MISSOURI, EASTERN DIVISION, AND THE CIRCUIT COURT OF THE COUNTY OF ST. LOUIS, MISSOURI, (ANY LAWSUIT MUST BE FILED IN ST. LOUIS, MO) FOR ALL CLAIMS AND DISPUTES ARISING OUT OF OR CONNECTED IN ANY WAY WITH THIS AGREEMENT AND THE USE OF THE SEED OR THE MONSANTO TECHNOLOGIES, EXCEPT FOR COTTON-RELATED CLAIMS MADE BY GROWER.

THIS AGREEMENT CONTAINS A BINDING ARBITRATION PROVISION FOR COTTON RELATED CLAIMS PURSUANT TO THE PROVISIONS OF THE FEDERAL ARBITRATION ACT, 9 U.S.C. §1 ET SEQ., WHICH MAY BE ENFORCED BY THE PARTIES.

GROWER SIGNATURE & DATE REQUIRED

____ ____________________
Name Date

Appendix B: Selective V-GURTs And T- GURTs Type Patents

Selective V-GURTs And T- GURTs Type Patents Issued /Applied By Major Biotech Companies/Institutes

Company/ Institution	Patent (or application) number	Date issued/ filed	Remarks[a]
BASF (ExSeed/ Iowa State Univeristy)	WO9907211 Control germination using inducible	02/18/99	National phase entry to AU, CA, CN, NZ in 2000; withdrawn from EPO in 2004
Cornell Research Foundation	US 5,859,328 (WO9425613) female sterility in plants	01/12/99	PCT published in 1994; phase entry to AU; no phase entry to CA, EU
Delta&Pine Land/USDA	US 5,723,765 (WO9604393) Control plant gene expression	03/03/98	PCT published in 1996; phase entry to AT, AU, BR, CA, CN, EU, JP, TR, ZA in 1997 – 1998; AU patent granted in 1998; CN patent granted in 2003; HK patent granted in 2004; done with EPO in 2005
Delta&Pine Land/USDA	US 5,925,808 Control plant gene expression	07/20/99	
Delta&Pine Land/USDA	US 5,977,441 Control plant gene expression	11/02/99	
DuPont (Pioneer Hi-Bred)	US 5,859,341 Mediate fertility, method of use	01/12/99	Filed in 1995; continuation of patent US5,478,369
DuPont (Pioneer Hi-Bred)	US 6,297,426 Mediate female fertility in plants	10/02/01	Filed in 1998; continuation of patent US5,859,341
DuPont (Pioneer Hi-Bred)	US 6,265,640 Mediate fertility, method of use	07/24/01	Filed in 1998; continuation of patents US5,850,014 and US5,478,369
Monsanto	WO9744465 Control seed germination	11/27/97	No national phase entry data
Syngenta (Zeneca)	WO9403619A2 and A3 Improved plant germplasm	02/17/94	Filed in 1992; done with EPO in 2002; filed in US in 2005 (phase entry in 1995)
Syngenta (Zeneca)	US6,228,643 (WO9735983A2)	05/08/01	PCT published in1997; done with EPO in 2005;

	Promoter, containment of plant germination		lapsed in SE, GR, DK, PT in 2006; national phase entry to CA, KR, NZ in 1998
Syngenta (Zeneca)	WO9738106A1 Gene promoter sequence from banana	10/16/97	No phase entry to EU, Japan, CA
Syngenta (Zeneca)	US 5,808,034 Plant gene construct comprising male flower specific promoters	09/15/98	Filed in 1994
Syngenta (Zeneca)	US 6,172,279 Plant gene construct encoding a protein disrupting viable pollen	01/09/01	Continuation of patent US5,808,034
Syngenta (AstraZeneca)	US 6,700,039 (WO9906578) Controlling sprouting	03/02/04	PCT published in 1999; phase entry to AU, CA and CN in 1999 -2000
Syngenta (AstraZeneca)	WO9929881 Increasing yield, controlling flowering behavior	06/17/99	Filed in EPO, Japan, and phase entry to USA, AU, CA in 2000
Syngenta (AstraZeneca)	US6,683,230 (WO9942598) Hybrid seed production	01/27/04	PCT published in 1999; phase entry to AU, CA, CN, IL, KR in 1999; CN patent granted in 2005
Syngenta (AstraZeneca)	WO0009704 Gene switch	02/24/00	Phase entry to AU, CA in 2001
Syngenta (AstraZeneca)	WO0009708 Disrupt cell function	02/24/00	Phase entry to AU, CA, CN, IL in 2001
Syngenta (Novartis)	US5,880,333 Control gene expression	03/09/99	Done with EPO in 2005; lapse in SE in 2006
Syngenta (Novartis)	US6,018,104 Nucleic acid promoter	01/25/00	Filed in 1995
Syngenta (Novartis)	US6,018,105 (WO9732028) Promoters of plant protoporhyringen oxidase genes	01/25/00	PCT published in 1997; AU patent granted in 2000; withdrawn from EPO in 2004; no entry to CA
Syngenta (Novartis)	US6,031,153 (WO9829537) Method of protecting plant	02/29/00	Continuation of patent US5,780,469; phase entry to JP in 1999, EPO 1998; AU patent granted in 2000; RU patent granted in 2004; CN, HU patents granted in 2005; PL patent granted in 2006
Syngenta (Novartis)	US2002133846 Method of protecting plant	Filing published	Divisional continuation of patent US6,031,153

		09/19/02	
Syngenta (Novartis)	US6,057,490 Method for selecting disease resistant mutant plants	05/02/00	Filed in Dec. 1998; continuation-in-part of patent US5,792,904
Syngenta (Novartis)	US6,091,004 Signal transduction cascade leading to acquired resistance	07/18/00	Filed in 1997;
Syngenta (Novartis)	US2002152499 Signal transduction cascade leading to acquired resistance	Filing published 10/17/02	Continuation of patent US6,091,004
Syngenta (Novartis)	US6,147,282 Control the fertility of a plant	11/14/00	Filed in 1999; divisional continuation of patent US5,880,333
Syngenta (Novartis)	US6,107,544 Method for breeding disease resistance into plants	08/22/00	Filed in 1997; continuation-in-part of patent US5,792,904
Syngenta (Zeneca)	US6,362,394 (WO9713864) Control gene expression	03/26/02	PCT published in 1997; phase entry to CA, CN, JP in 1998; AU patent granted in 1999; deemed to be withdrawn from EPO in 2004
Syngenta	US6,610,828 Gene switch receptor protein	08/26/03	Filed in 2000; divisional continuation of patent US6,379,945
Syngenta	US6,605,754 (WO9321334) Chemically inducible gene expression	08/12/03	PCT published in 1993; phase entry to the US in 1998; done with EPO in 2001
Syngenta	US6,939,711 (WO9627673) Control of plant gene expression	09/06/05	PCT published in 1996; continuation of patent US6,147,282; phase entry to CA, JP in 1997; AU patent granted in 1999; done with EPO in 2005; lapse in SE in 2005
? (Jenkins &Wilson, PA, a patent firm)	US2004058369 Method for controlling gene expression	Filing published 03/25/04	Syngenta's inventor?

a: Capital letters are country abbreviations.
Sources: ETC group (2003), Warwick (2000),
USPTO database (http://www.uspto.gov/patft/index.html),
WIPO database (http://www.wipo.int/tools/en/databases.jsp),
CAMBIA patent database (http://www.bios.net/daisy/bios/50).