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Controversies Over the Adoption of Genetically Modified Organisms

Genetically Modified Organisms: Rights To Use Commodity Names and the Lemons Problem

Richard Gray* Charles B. Moss†

Andrew Schmitz‡

*University of Saskatchewan, grayr@duke.usask.ca

†University of Florida, cbmoss@ifas.ufl.edu

‡University of Florida, aschmitz@ifas.ufl.edu

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Richard Gray, Charles B. Moss, and Andrew Schmitz

Abstract

Genetically modified crops have met some consumer opposition domestically and abroad. This opposition has resulted in variety market and policy reactions with a large potential to disrupt trade and to become a focus of international negotiations. In this paper we consider the spillover from adopters to the non-adopters and non-consumers of GM technology. In the absence of any (organizational) transaction costs the assignment of property right to use the name corn will result in Pareto improving decisions with respect to the introduction of GM technology. However, in the presence of transaction costs the ability to use generic crop names such as corn, the adopters of GM technology have the implicit right and will impose costs on participants in the non-GM marketing channel, by creating a lemons problem. This assignment of property rights can result in the commercial introduction of GM despite potential losses in overall social welfare. If the property rights are reassigned such that the innovators are forced to segregate their GM products through labeling laws, this preempts welfare decreasing technology introduction. The relative efficiency of either allocation of property rights depends on the cost savings, rate of adoption, segregation costs, and consumers' preference for the GM crop in question. This suggests that assignment of property rights may be more effective if done on a case-by-case basis rather than a one size fits all policy.

KEYWORDS: GMOs, property rights

*Richard Gray is Professor of Agriculutral Economics, University of Saskatchewan, Saskatchewan, Canada. Charles B. Moss is professor in the Food and Resource Economics Department, Institute of Food and Agricultural Sciences University of Florida, Gainesville, Florida. Andrew Schmitz is professor and Ben Hill Griffin, Jr. III Eminent Scholar in the Food and Resource Economics Department, Institute of Food and Agricultural Sciences University of Florida, Gainesville, Florida.

1. Introduction

The wide-scale release of genetically modified (GM) crops in the 1990s raised a host of policy issues in the United States and in the rest of the world. These issues have centered around the environment (e.g., the impact of *Bt* corn on the Monarch butterfly in the United States), health concerns regarding the long-term consequences of the consumption of genetically modified organisms (GMOs), and the impact on consumer demand and trade flows. Governments have responded to these policy issues with a number of regulations, some of which have become the focus of trade disputes. In reaction to a World Trade Organization (WTO) ruling on the European Union's (EU) ban on GM crops in early 2003, the European Union introduced strict GM labeling and segregating requirements. Other countries, particularly less-developed countries, are concerned that new regulations will impose significant marketing costs and will act as nontariff trade barriers.

There is widespread agreement for the need to test and regulate the introduction of GM products for both environmental and health reasons. To do so, regulatory systems are well established in most countries of the world.[1] In addition to individual regulatory systems, the WTO has made provisions for trade policies to protect against real threats to both the environment and human health.

Regulatory systems in each country attempt to address fairly broad environmental and health concerns. However, these systems generally do not address consumer concerns regarding the relative risks, benefits, and costs associated with GM crops. One school of thought suggests that the market is the most appropriate mechanism through which to regulate GM crops. GM products will be developed, produced, marketed, and consumed only if they enhance net social welfare.[2] This reliance on the "market test" is based on the notion that there are no information externalities. Opponents to this view suggest that actions of the innovators, who introduce a product viewed inferior by some consumers,

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[1] In the United States, the U.S. Department of Agriculture (under 7 Code of Federal Regulations (CFR) Part 340), the U.S. Environmental Protection Agency (under 40 CFR Parts 152, 174, and 725), and the U.S. Food and Drug Administration (under 21 United States Code (USC) Chapter 9) regulate the release of GM crops.

[2] The adoption of GM crops will affect social welfare through four general groups: farmers who adopt GM crops, farmers who do not adopt GM crops, consumers who are indifferent between GM and non-GM crops, and consumers who prefer non-GM crops. As developed later in this article, non-GM producers and consumers will experience a welfare loss while GM producers and consumers who are indifferent between GM and non-GM crops gain from the introduction of GM commodities. A net social gain suggests that the gain to GM consumers and GM producers is larger than the loss to non-GM consumers and non-GM producers (ignoring for the moment segregation costs).

force these same consumers and those innovators who wish to sell to these same consumers, to spend additional resources to identify and segregate non-GM products. The introduction of segregation costs reduces total product demand (Moss, Schmitz, and Schmitz, 2004; Fulton and Giannakas, 2004). Further, opponents argue that because these additional transaction costs are external to the agents who produce GM products, the market test for product viability is no longer appropriate. As a result of this fundamental debate, policies made to deal with consumer demand differ by country and have lead to trade disputes.

In this article, we explore the conceptual issues surrounding consumer demand and product segregation in the presence of GM corn. We analyze alternative distributions of economic rents based on different property rights. This model can be modified to deal with a host of GM commodities (e.g., the distribution of economic rents) whose likelihood of GM adoption depends on who defines what can be marketed as corn. With the ability to use generic crop names such as corn, the adopters of GM technology have the implicit right and will impose costs on participants in the non-GM marketing channel by creating a 'lemons' problem: a group of consumers concerned about the uncertainty associated with the consumption of GM crops could perceive GM commodities as inferior goods. Hence, informational asymmetries give rise to incentives to fail to report GM content in the same manner as described in the market for 'lemons' problem addressed by Akerlof (1970). The property rights associated with the name of the commodity can be reassigned through labeling laws such that the innovators are forced to effectively rename their GM products. The relative efficiency of both assignments of property rights is compared under various economic scenarios. However, the economic costs imposed by these information costs must be viewed within the context of other economic effects of technological change. Apart from the introduction of information costs, the introduction of a new technology has significant implications for the distribution of economic rents between producers who do not adopt the GM-crop varieties, producers who adopt the GM-crop varieties, consumers who are indifferent between GM-crop and non-GM-crop varieties, and consumers who prefer non-GM-crop.

In the next section, we provide the context for the analysis by drawing on existing literature that explores the gains from research, the 'lemons' problem, and the New Institutional Economics. In the following section, we present a model of a GM-crop variety and illustrate the welfare effects of cost reduction and segregation costs. We then show that with organizational transaction costs, the assignment of property rights can affect the efficiency of the market outcome and can result in immiserizing technology adoption. Finally, we discuss the results and areas for which further research is required.

2. The Context

Agricultural research has provided significant benefits by genetically improving agricultural crops and animals so as to make nutritional food products more affordable. These returns have been well documented. The Alston et al. (2000) meta-analysis of 1,128 studies reported an average rate of return to public crop research of 81.3 percent per annum. In the case of a yield-increasing or cost-reducing technology, innovation will shift the supply curve downwardly, increasing the quantity produced and reducing the output price. The innovation will benefit consumers through lower product prices. Producers who adopt the technology are better off as long as the average per-unit of cost savings exceeds the price drop. Nonadopters are made worse off through the decrease in price. While the distribution of benefits will vary depending on the elasticity of the supply and demand curves, and while costs change yield-increasing or cost-reducing technology that a firm has an incentive to adopt, they both will increase the economic surplus generated by the industry.

Studies on the rates of return to research have also considered economic distortions and market failures. For example, Schmitz and Seckler (1970) show that there were high rates of return from developing the mechanical tomato harvester but there were also associated costs because of the displacement of farm labor. Murphy, Furtan, and Schmitz (1993) and Alston and Martin (1995) show that in the presence of government policy distortions, the gains from research could become negative leading to what is known as immiserizing technical change. Also the rates of return are affected when the innovators, who are granted Intellectual Property Rights, have market power. This can limit the adoption and overall gain from the innovation (e.g, Moschini and Lapan, 1997; Fulton and Giannakas, 2000). Other studies have examined the payoff to research in the presence of environmental and health externalities and have shown that these external costs or benefits can affect substantially the overall gain from agricultural research (e.g., Gray and Malla, 1998; Gray and Malla, 2001; Lutter and Tucker, 2002).

Studies are beginning to surface based on the impact of GM technology in the presence of segregation costs and farm subsidies. Schmitz, Moss, and Schmitz (2004) analyze the impact of GM soybeans and Moss, Schmitz, and Schmitz (2004) investigate B*t* corn, taking the above into account. In these cases, the payoff from GM technology is dependent on, among other things, the size of segregation costs. Furtan, Gray, and Holzman (2003) study GM wheat, showing that high segregation costs will reduce and can even eliminate the gains from the introduction of GM wheat. Taken as whole, these studies suggest that market externalities or distortions from a competitive equilibrium can change the impact of agricultural research.

On the demand side of the analysis, many of the above studies assume no change in the characteristics of the commodity bundle consumed. The economic impact of an innovation that involves a change in product quality is difficult to assess. The case in which product quality increases, economic surplus also increases because demand shifts upwardly. (This is the case explored by Gray and Malla, 1998 and 2001, when considering the positive nutritional aspects of GM canola.) This type of health-improving innovation will generally benefit producers in aggregate. Consumers will benefit from the consumption of a higher-quality product, offset to some extent by having to pay a higher price for the product. Often an innovation that affects product quality will also affect the cost of production. The innovation will be adopted only if the net impact of the shift in demand and the change in costs results in an increase in total economic surplus. For example, Ulrich, Furtan, and Schmitz (1987) explore the impact of higher-yielding lower-quality wheat in Canada, and show that a cost reduction would exceed a demand reduction and therefore the technology would be welfare enhancing. The economics of quality change is further complicated by the impact of informational costs.[3] The willingness to pay for a new quality level will be realized only if the buyer can distinguish the new product from the old. Additional costs necessary to segregate the products need to be incorporated into the welfare analysis.

Assessing the economic impact of the introduction of a GM crop involves a cost change, a quality change (or at least the perception of a change in quality), and additional product segregation costs. Many GM crop varieties have input traits such as herbicide tolerance or insect resistance that lower the cost of production, but, at the same time, crop demand is reduced because some consumers are averse to the technology. Many consumers in the United States and abroad want to be assured that the corn they are consuming is non-GM corn. Food processors, distributors, and retailers concerned about losing some of their customers have decided to segregate, label, and sell non-GM products. The additional costs associated with segregation and labeling are additional costs in the non-GM marketing channel. These costs, which must be borne by the producers and consumers of non-GM corn, become necessary as a result of the introduction of GM corn.

Given the existing laws in North America, segregation costs from the introduction of GM varieties are externalities (or spillovers) from GM producers

[3] As of 2004, the introduction of GM varieties has implied a reduction in the perceived quality of commodities. For the most part, these reductions are the result of uncertainties about the long-term health effects of foods made with GM crops. It is conceivable, however, that GM technologies may provide health advantages. In such scenarios, the informational costs developed in this study are reversed such that adopters are willing to pay the segregation costs to obtain a price premium. In the case of a price premium, the additional segregation costs are incentive compatible.

and GM consumers to non-GM producers and non-GM consumers. Furtan, Gray, and Holzman (2003) illustrate that the introduction of GM wheat into a commodity market imposes costs on non-GM adopters and non-GM consumers by introducing a 'lemon' into the wheat market. The same scenario ensues with the introduction of B*t* corn (Moss, Schmitz, and Schmitz, 2004). As long as the buyers are willing to pay a premium for non-GM products, the sellers of GM products have an incentive to misrepresent their product as a non-GM product. This incentive for misrepresentation is described by Akerlof (1970) as part of the 'Market for Lemons,' in which he argues that, in the absence of affordable means to distinguish between the higher-valued product and the lower-valued product (the 'lemon'), the lower-valued product will drive the higher-valued product out of existence. To prevent this occurrence, the buyer would be forced to spend resources on search costs, and sellers would be forced to spend resources to signal to the buyers that the product would be of higher value. These transaction costs associated with segregation are externalities to the adopters of the GM crop. Therefore, the presence of an externality suggests that the market may fail to achieve a Pareto-optimal allocation.

Given that GM technologies can create a segregation-cost externality, and given that previous research has shown that the presence of externalities can affect significantly the returns to research, external-segregation costs may be an important consideration. Accordingly, the development of policies mitigating segregation costs may have important implications for the economics of GM crops.

3. Institutions and Advantageous Misrepresentation

The development of institutions to mitigate transaction costs is at the center of the New Institutional Economics, which suggests that alternative private and public institutional arrangements will have different transaction costs associated with the governance of the economy, and those institutions associated with the lowest transaction costs will become eventually the dominant form of governance (Williamson, 2002).

There are a number of institutions that have been developed to handle the advantageous misrepresentation of product quality. In non-commodity markets, private brand names and trademarks are used to protect a firm's product against misrepresentation. In commodity markets there are typically thousands of supply sources, and products are mixed to economize on handling costs. Unlike Sony televisions, which are protected by a commodity trademark, private trademarks do not protect commodity names such as wheat and corn.[4] In the absence of these private property rights, a system of compulsory grading and a system of regulations prohibiting contamination are used to protect product quality. This is particularly evident in the food industry in which both food safety and product quality are carefully monitored by government agencies.

The property rights to use the name corn for GM corn are a classic case of an unvalued attribute (Barzel, 1997). According to Barzel, most goods have a multitude of attributes, but at a given point in time only some of these attributes have economic value. Typically, property rights are not defined using these attributes. When there is an economic change that creates value for a previously unvalued attribute, the attribute becomes part of the commons. What ensues is litigation and, in some cases, regulation to handle the market failure created by the incomplete property rights. Barzel argues that the property rights over the attribute will eventually become well defined, and markets will evolve to value and govern the attribute.

Prior to the existence of GM products, the non-GM attribute had no economic value. Once GM products were introduced, however this was no longer the case because some consumers preferred the non-GM attribute. Thus the non-GM attribute acquired value. As Barzel's framework foretold, one of three responses can ensue: 1) litigation, for example the lawsuit initiated by organic growers (Pratt, 2002); 2) regulation (e.g., the EU trade ban), or 3) EU labeling requirements. In each of these responses, the courts, domestic laws, and international trade agreements will need to define clearly the property-rights concept.

The assignment of property rights to use the name corn for GM products could represent an important choice. In the following sections, we use an economic model to show that, under plausible conditions, the introduction of GM crops can be immiserizing, and a reassignment of property rights could reverse this situation.

4. Modeling the Introduction of Genetically Modified Organisms into a Marketing Channel

The level and distribution of economic costs due to the introduction of GM crops is dependent on a variety of factors, including consumer acceptance, cost savings, and segregation costs in the marketing channel. To build up the notation and the basic intuition behind the model, first consider the case in which innovation lowers the marginal cost of production for a group of adopters but has no adverse

[4] The exception in this case is canola which is a trademark registered by the Canola Council of Canada. In order to use this trademark, the quality of the product must meet specific requirements.

impact on demand (Figure 1). In this case, the supply curve for GM adopters S_G shifts downwardly to S_G', while the supply curve for the non-GM adopters S_N does not shift. The result is a shift in the total supply curve S_T downwardly to S_T', and a decrease in the equilibrium price from P to P'. In this case, all

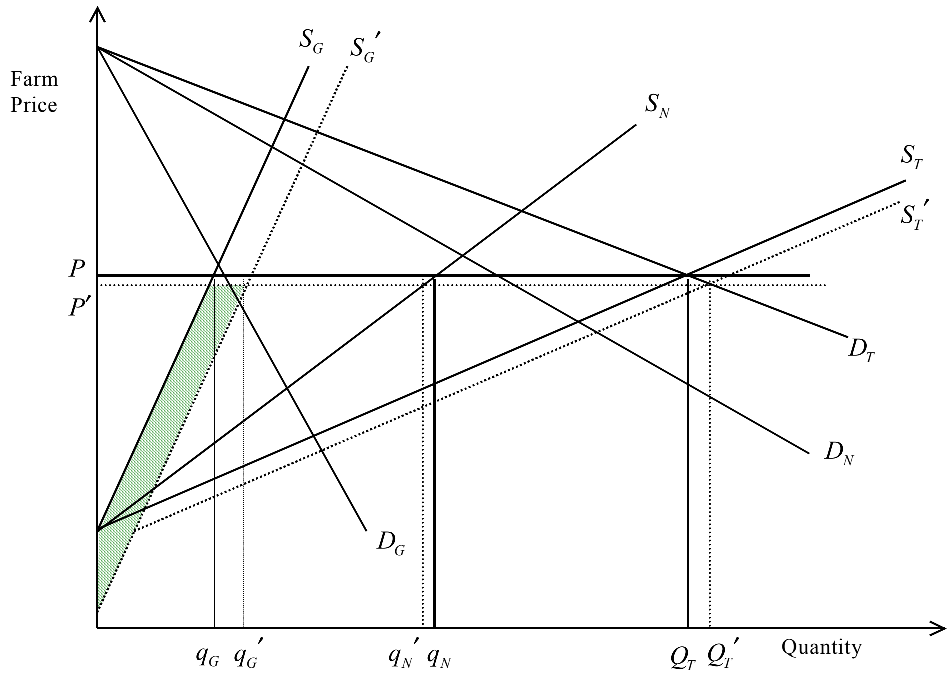

Figure 1: Economic Impacts of GM Crop Adoption without Consumer Resistance

consumers gain from the price decrease. Thus the nonadopters lose by the amount of the price decrease and the GM adopters gain by the net-cost savings minus the price savings. The loss of the non-GM adopters is referred to as a pecuniary externality, which is an adverse market impact that is not a source of market failure. Thus, as long as the markets are competitive, a cost-reducing innovation must lead to an increase in total economic surplus.

A more general case is one that follows the introduction of GM commodities. Some consumers will only consume the non-GM commodity that is segregated from the GM commodity and only a portion of the producers will adopt the GM technology.[5] As an example, the release of GM corn varieties will affect the economic equilibrium in the corn market in two ways (Moss, Schmitz, and Schmitz, 2004; Fulton and Giannakas 2004). First, the supply of corn for those farmers adopting GM technologies shifts outwardly. Second, additional segregation costs are imposed on the marketing channel for non-GM output that shifts total demand inwardly. If we assume at the new market equilibrium that the production of non-GM corn will exceed demand, both products will sell for a common price at the farm level. At the consumer level, the price of non-GM corn will exceed that of GM corn by the per-unit cost of segregation.

In Figure 2, the increased supply of corn from GM-adopting farmers shifts the GM-corn supply curve inwardly from S_G to S_G'. As a result of this shift, the total supply curve for corn shifts outwardly from S_T to S_T'. The introduction of GM corn causes the farm-level demand for non-GM corn users to shift downwardly from D_G to D_G', which reflects the segregation costs associated with satisfying the non-GM demand for corn. This shift in farm-level demand for non-GM corn users implies that the total demand for corn will shift inwardly from D_T to D_T'. Taken together, the outward shift in supply due to the adoption of GM technologies (the shift in GM supply from S_T to S_T') and the inward shift in demand associated with the increased segregation costs for non-GM users of corn cause the corn price to fall from P to P''. This change results from an increase in the quantity of GM corn demanded (from q_G to q_G') and an increase in the quantity of GM corn supplied (from q_G to q_g'). However, the quantity of non-GM corn demanded declines from Q_N to Q_N', primarily as a result of the increased identity preservation cost, and the quantity of non-GM corn supplied by the non-GM adopters decreases from q_N to q_N', due primarily to the overall decrease in the price of corn.

There are two groups potentially disadvantaged from the introduction of this technology. The non-GM adopters suffer the pecuniary externalities resulting from the greater supply of corn as well as they suffer from the contraction of farm-level demand. Thus consumers demanding a segregated non-GM product must incur a segregation cost. If the consumer demanding a segregated non-GM

[5] In the United States, the corn market is composed of two major components: (1) the demand for livestock feed (which is by far the largest component of demand); and (2) the demand for corn for human consumption (which includes products containing corn meal, such as corn chips). Within this market structure, the non-GM-commodity demand for corn increases within a sub-component of the demand for corn for human consumption.

product will benefit from the technology will depend on whether or not the segregation costs exceeded the drop in the farm-level price. These additional segregation costs in the non-GM marketing channel confounds general statements about welfare improvement. These costs are also external to agents making the decision to introduce GM products into the marketplace, thus they create a potential market failure. As shown in Figure 2, it is possible for GM-corn adopters to benefit from the GM technology and still experience an overall loss in economic surplus.

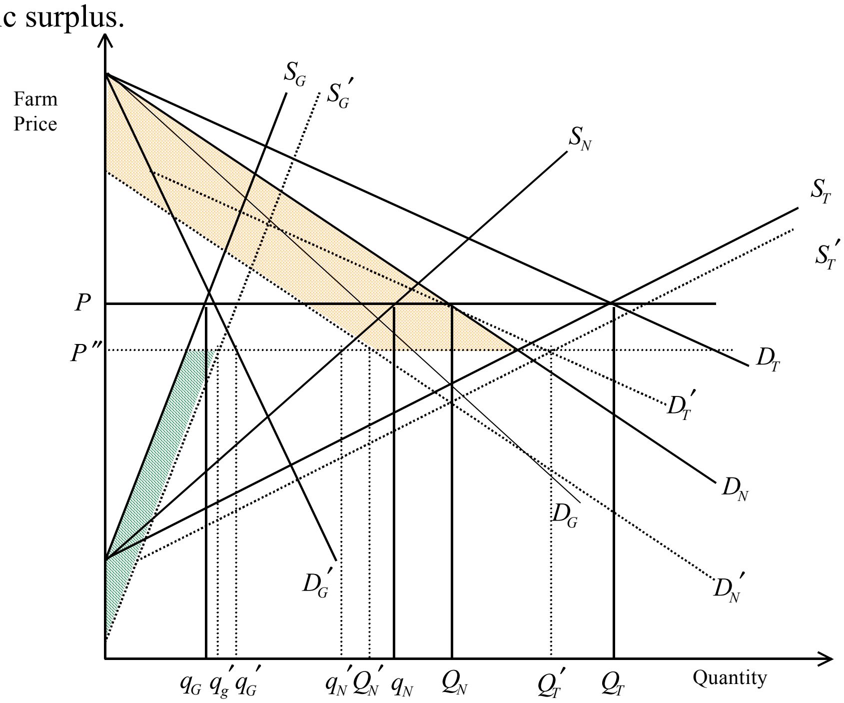

Figure 2: Economic Impact of GM Adoption with Segregation Costs

The net societal impact is the cost reduction due to innovation minus the additional segregation costs incurred. In the case of GM technology, the gross economic gain is approximately the product of the per-unit cost savings and the extent of adoption, represented by the lower shaded area in Figure 2, while the gross economic loss is the per-unit product of segregation costs multiplied by the quantity that has to be segregated, equal to the upper cross-hatched area in Figure 2. Given these relationships, the introduction of technology is likely to be welfare enhancing when per-unit cost savings are large and adoption rates are high, while segregation costs and the proportion of consumer resistance are small. The introduction of technology is likely to be welfare reducing when the cost savings and adoption rates are small, while the segregation costs and the proportion of consumer resistance is large.

5. Property Rights for Crops

The graphical model in the preceding section demonstrates that the adoption of GM technology can adversely affect nonadopters and nonconsumers of the GM product. Biotechnology redefines the agricultural output. Corn is no longer corn, but it is potentially a GM crop. This shift in definition then imposes an economic cost on non-GM adopters and non-GM consumers. Without the requirement to segregate their product, the producers of GM crops do not have to prove that their crops are GM products, but the producers of non-GM crops must now prove that their crops are not GM products. In essence, the adoption of a new technology has changed the property rights of the nonadopter, which has caused the producer of non-GM crops to bear an additional cost.

6. Coasian Approach to Plant Property Rights

One formulation of the property-rights question raised in the adoption of GM crops can be found in Coase’s development of externalities (Coase, 1960). Specifically, the adoption of GM crops by some producers results in an externality. The economic cost to a biotechnological innovation can be decomposed into the impact of an outward shift in the supply curve that is common to all adoption scenarios and an increased transaction cost that is specific to the redefinition of the property right. Following the Coasian discussion of externalities, the property right (specified as the ability to define what constitutes corn) can be allocated to the producers of non-GM corn or to those who adopt GM corn. In the absence of transaction costs in either case, the economy can reach an efficient solution through an appropriate series of side payments.

In Scenario 1, assume that the property rights to determine the definition of corn were to belong to the producers of the non-GM corn. The adopters would be asked to compensate the producers and consumers of the non-GM corn for the right to adopt the technology. If their production-cost savings due to the new technology were greater than their additional segregation costs such that total economic surplus increases, then the gainers would be able to afford to compensate the potential losers and the technology would be introduced. If, on the other hand, the production-cost savings were less than the segregation costs, then the gainers could not afford to compensate the losers and the immiserizing technology would be blocked (Figure 2). Thus with zero transaction costs, the assignment of the property right to non-GM adopters could lead to a Pareto-improving choice about technology.

In Scenario 2, with zero transaction costs, if the property right to use the name were to belong to the innovator (actually this case is the closest to reality because anyone has the ability to innovate and redefine corn), the net result would be similar to Scenario 1. Under Scenario 2, however, producers would adopt the GM technology unless the nonadopters would offer a sufficient bid to stop the innovation. If the production savings were to exceed the segregation costs, the innovation would proceed. An immiserizing technical change would be blocked only if the potential losers from the technology could afford to more than compensate the potential gainers to block the technology.

If transaction costs were significant, it would be difficult for gainers and losers to organize, negotiate, and make the required payments to arrive at an efficient outcome. How would the gainers and losers be identified? How is the free-ride scenario prevented? How would compensation be allocated among the gainers and losers? Where would the organizational resources come from to make these payments? These are all complex questions discussed throughout the public-choice literature. Since the payments to individual gainers and losers would likely be small, and the number of potential gainers and losers would likely be large, negotiation and transaction of side payments would be costly.

Since side payments would be unlikely, each economic agent (i.e., producers and consumers) would respond to individual incentives without regard to overall economic-welfare considerations. Therefore, the initial assignment of property rights would have overall economic implications.

If the property rights were granted such that the adopters of GM corn have the right to use the name, the segregation externality would exist. As was discussed above, in the absence of side payments from potential losers, the technology would be introduced even if the technical change were immiserizing. In this case, the market test would be insufficient to assess desirability of the technology. Allocating the property rights to control the use of the name corn with potential non-GM corn adopters also has a problem. If the group were identified correctly as potential losers, they could block approval of the technology unless a side payment would be forthcoming from the gainers. However, if the potential gainers were to face additional transaction costs, they may not be able to make the side payments to the losers and the technology would be blocked even if the production-cost savings would far exceed the additional segregation costs. Thus in the presence of transactions costs, property-right allocation may not lead to an efficient outcome.

7. Implications and the Need for Further Study

A decade ago, it was difficult to appreciate that the non-GM trait would have an economic value and that the introduction of GM products could disrupt supply chains and trade. The biotechnological revolution implies mixed results for the agricultural sector and for consumers. The latter are faced with added uncertainties associated with the consumption of food produced with GM crops. Further, some farmers do not benefit from the adoption of GM technologies. Thus, the biotechnological revolution does not imply a Pareto-improving change (i.e., there are losers). However, these types of technologies often meet the compensation test in that the gainers could actually compensate the losers. But there are cases in which even the compensation test would not be met (i.e., immiserizing technological change) even though some would gain from the adoption of GM crops. These welfare trade offs would be further complicated by the presence of externalities.

One of these externalities involves the segregation costs borne by nonadopters (i.e., those farmers that choose not to plant GM varieties). This externality combined with property rights that allow adopters of GM technology (those farmers that plant GM varieties) to use generic-commodity names, could lead to immiserizing-technical change under plausible economic conditions. (In this case, as is discussed above, not even the compensation test is met.) This unsatisfactory result (i.e., immiserizing technology) suggests the need to examine potential institutional alternatives such as changing the property rights implicit in the use of commodity names. For example, farmers planting GM varieties could be required to bear segregation costs as a condition to the approval of commercialization of a GM variety. Unfortunately, a similar mechanism failed in the case of StarLink™ (Schmitz, Schmitz, and Moss, 2004) because Aventis was unable to guarantee segregation of the GM corn.

More research is needed to understand the conditions under which segregation-cost externalities can lead to immiserizing-technical change. In this article, we constructed a theoretical model to show the conditions under which the impacts of GMOs would be immiserizing. More empirical research is needed, taking into account segregation costs, rates of adoption, government subsidies, and international trade dimensions in which domestic and import demands are made explicit. For example, the net payoff from the adoption of B*t* corn appears to be much less than for GM soybeans due partly to the relatively low rate of adoption for B*t* corn. As stated above, several studies have estimated the welfare effect of segregation costs and supply shifts associated with the introduction of GM crops. As a starting point, the numerical results of the studies may provide insights regarding the magnitude of the side payments required to satisfy the property-rights issues (i.e., to forestall the adoption of GM crops).

The exploration of alternative institutional arrangements could include the role of government when assessing the overall costs and benefits of GM technology and when making regulatory decisions. The analysis is this article suggests that, to be effective, the regulation and/or the assignment of property rights would have to be done on a case-by-case basis as cost savings, technological-adoption rates, segregation costs, and consumer acceptance would differ considerably by market and by crop. An overall acceptance of GM technologies would lead to some cases of immiserizing technical change and a simple rule of reject would forego opportunities for economic growth. Further analysis would be required to understand the incidence of existing policies and how this incidence would change under various policies.

A second alternative institutional arrangement is to allow industrial organizations, which are in the best position to asses the impacts and the distributional implications of the sector, a greater role in managing these new GM technologies. An example is the Canadian Flax Council's intervention to block the production of a GM flax seed.[6] In this case, the Canadian Flax Council had no legal authority to take this action yet they were effective in blocking the introduction of the GM technology. Obviously, there is a need to explore how industrial groups, organized to monitor the introduction of new GM commodities and the subsequent property rights, could be formed and what powers they should be granted.

Additionally, there is need to examine the impact of alternative international trade agreements that would allow domestic governments to handle segregation-cost issues. If trade agreements were to prevent domestic governments from dealing with segregation-cost issues, the result could be immiserizing technical change and/or trade disputes in those sectors and with those countries attempting to address the issue.

Economic-impact assessment involves quantifying the losers and gainers from new technologies. As we discuss, there can be losers from a new technology even in the absence of negative externalities. As a result, in the research of GM crops, both forces are at work; those due to segregation costs (negative externalities) and those due to the dynamics of supply response. In the absence of negative externalities, whether or not losers should be compensated is a value judgment, even for cases in which they can be identified. This is not a property-rights issue, rather it is the outcome of the efficient functioning of a market.

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[6] CDC Triffid, was a GM flax variety that was registered in the mid 1990s prior to other GM crops in Canada (Warick, 2001; McHughen, 2000). This variety was suited only to a small acreage because it was resistance to sulfonylurea, an herbicide used only in an unusual crop rotation. At the same time, most of the Canadian flax crop was exported to the European Union, which indicated the European Union would ban all Canadian shipments if the GM crop were introduced. In response to this potentially catastrophic situation, the Canadian flax organizations, including the Canadian Flax Council, went to the commercial-seed growers and bought their stocks of seed to prevent distribution. In 2001, the commercial seed stocks were crushed and the variety was deregistered.

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