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THE PRICE AND TRADE EFFECTS OF STRICT INFORMATION REQUIREMENTS FOR GENETICALLY MODIFIED COMMODITIES UNDER THE CARTAGENA PROTOCOL ON BIOSAFETY

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The Price and Trade Effects of Strict Information Requirements for Genetically Modified Commodities under the Cartagena Protocol on Biosafety

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Abstract

This paper assesses the global economic implications of the proposed strict documentation requirements on traded shipments of potentially genetically modified (GM) commodities under the Cartagena Protocol on Biosafety. More specifically, we evaluate the trade diversion, price, and welfare effects of requiring all shipments to bear a list of specific GM events (the “does contain” rule) in the maize and soybean sectors. Using a spatial equilibrium model with 80 maize- and 53 soybean-trading countries, we show that information requirements would have a significant effect on the world market for maize and soybeans. But they would have even greater effects on trade, creating significant trade distortion that diverts exports from their original destination. The measure would also lead to significant negative welfare effects for all members of the Protocol and nonmembers that produce GM maize, soybeans, or both. While non-GM producers in Protocol member countries would benefit from this regulation, consumers and producers in many developing countries would have to pay a proportionally much heftier price for such a measure.

Key words: Genetically modified food, international trade, Cartagena Protocol on Biosafety.

1. Introduction

The Cartagena Protocol on Biosafety (CPB), a supplementary agreement to the United Nations Convention on Biological Diversity introduced in 2000 (Secretariat of the COB 2000), entered into force in September 2003 with the goal of setting up a harmonized framework of risk assessment, risk management, and information sharing on the transboundary movements of living modified organisms (LMOs).[1] Within the Protocol, a number of rules focus on LMOs intended for direct uses as food or feed, or in food or feed processing (noted as LMO-FFPs), which are essentially unprocessed genetically modified (GM) agricultural commodities.[2]

Article 18.2(a) of the Protocol requires that each traded shipment of LMO-FFPs be labeled as "may contain" LMO-FFPs not intended for release in the environment, though the Convention also noted that a more specific rule on information requirements should be determined at a later date (Secretariat of the COB 2000). At a March 2006 meeting in Brazil, after a contentious debate, Protocol members agreed to adopt a two-option rule consisting of a more stringent option and the less stringent one that had previously been in effect (ICTSD 2006). Under the stringent option, shipments containing LMO-FFPs identified through means such as identity-preservation (IP) systems would be labeled as "does contain" LMO-FFPs and would include a list of all GM events present in each shipment. Shipments containing LMO-FFPs that are not well identified would follow previous practice and would be labeled as "may contain" LMO-FFPs. At the same time, a complete list of GM events commercialized in the exporting country would be available to importers via the Biosafety Clearing House (BCH), an internet database. At the same meeting, Protocol members also agreed that the two-option rule would be reconsidered, with the possibility of making the stringent "does contain" option mandatory for all countries (ICTSD 2006). At

[1] Also called genetically modified organisms.
[2] These products represent more than half the total import value of the four main GM commodities. Approximately 51 percent of the import value of soybeans and 88 percent of that of maize comes from unprocessed commodities (Gruère 2006).

the latest meeting of parties in October 2010 in Nagoya, Japan, discussion on the issue was postponed to leave time for data collection, but it is planned to get the topic back to the table in 2014.

While the benefits of this proposed change are highly debatable, its implementation would generate significant new costs (see, for example, Gruère and Rosegrant 2008; Kalaitzandonakes 2004; and Redick 2007). More specifically, under the “does contain” rule, countries that produce and export only non-GM products would be exempt from verifications and tests, while countries that export GM products would have to test each shipment to verify the accuracy of GM event identification. Importers that are ratifying parties of the CPB would also need to pay for the IP system or to conduct tests to confirm the validity of shipment statements in order to ensure enforcement of mandatory information requirements.

Previous studies have analyzed the economic implications of adopting the “does contain” rule in different countries, such as Argentina (Direccion Nacional de Mercados Agroalimentarios 2004), the United States (Kalaitzandonakes 2004), and Australia (Foster and Galeano 2006), reporting that the costs of such a change would be potentially significant. More recently, Huang et al. (2008) showed that the cost of implementation would be high globally but not really significant for China (their focus country). Gruère and Rosegrant (2008) assessed the potential implementation costs of article 18.2(a) on all member countries of Asia–Pacific Economic Cooperation (APEC)[3] and provided a range of cost estimates for exporters and importers, noting the disproportionate cost for developing countries that have been supportive of this measure. They also showed that it would effectively constitute a new entry cost for GM adoption and for Protocol membership in the APEC region.

Yet most of these studies provide short-run, partial-cost estimates of the strict rule in particular regions, leaving aside potential price and trade diversion effects. Huang et al. (2008) do did use a multiregion computable general equilibrium (CGE) model to assess the potential trade effects of this new measure, showing that it would affect the prices of maize and soybeans. But their approach focused only

[3] APEC is a regional trade body covering 21 countries located around the Pacific Ocean, from Chile to New Zealand, including large traders like Mexico, the United States, Canada, China, Japan, South Korea, Indonesia, and Australia.

on a few regions (China, the Americas, and the world), used the 2001 Global Trade Analysis Project (GTAP) database, and did not provide a detailed assessment of potential trade diversions. Furthermore, the CGE modeling approach prevents the appearance of new trade flows, leaving aside significant possibilities in trade diversion. While their results showed that the cost of implementation would be high for all but not really significant for China, they noted that other developing countries would likely pay a higher price.

The objective of this paper is to complement previous studies by providing a comprehensive global trade assessment of strict documentation requirements in all member countries of the Protocol. In particular, our analysis intends to evaluate the market effect it would have on developing countries that are members of the Protocol. To do so, we develop a spatial trade model and simulate scenarios to evaluate the trade diversion, price, and welfare effects of implementing the "does contain" rule on the maize and soybean sectors in all significant trading countries, using data from multiple sources in the reference period 1995–2005. The model incorporates transportation costs, uses a lower level of product analysis (four-digit codes of the Harmonized Commodity Description and Coding System [HS]), includes more countries than GTAP-based models include, and accounts for trade diversion and the creation of new trade flows.

The results of our policy simulation intend to provide an overview of the medium- to long-run effects of mandating the "does contain" rule to all members of the Protocol, ahead of future negotiations on the issue. Developing countries that are members of the CPB have been vocal supporters of using precautionary measures for trade of GM commodities, such as Article 18.2(a), but they may have underestimated the cost of such measures on their economies. Beyond the cost estimates and their geographic and product differentiation, our findings aim at giving an outlook of a possible future trade scenario for GM commodities in the presence of increasingly stricter trade regulations in specific trade blocs.

In the following section we provide a conceptual framework for analysis. We then present the simulation model, data, and policy scenarios. The fourth section presents and discusses the first results of our simulations, and we close the paper with some policy conclusions.

2. Conceptual Framework

While the "may contain" and "does contain" rules may share usefulness for regulatory purposes, their costs of implementation widely differ. Under the "does contain" rule, countries that export GM products would have to test each shipment to verify the accuracy of the list of GM events, whereas the "may contain" rule would not require additional tests beyond those to reject unapproved events in the importing countries. Even if all GM events were approved in all importing nations, the exporter would be required to provide precise information on each shipment. This could also include additional insurance costs for shippers against the rejection of shipments. On the importing side, CPB member countries would need to pay for the IP system or pay to conduct tests to confirm the validity of shipment statements in order to ensure enforcement of the requirements. Naturally, importers would also have to pay the price for the information, given the additional testing and insurance applied to shipments.

Given these considerations, we propose an analytical framework based on the characterization of Gruère and Rosegrant (2008) that categorizes countries to assess the cost of information requirements. More specifically, we divide countries into four groups according to their membership in the CPB and whether they produce GM maize or GM soybeans, as presented in Table 2.1.

Table 2.1—Characterization of the four groups by GM production status and CPB membership

Group	Produces GM?*	Member of the CPB	Example of country
1	Yes	No	Argentina, U.S.A.
2	No	Yes	Japan, Mexico
3	Yes	Yes	Brazil, South Africa
4	No	No	Russia

Source: Authors, based on Gruère and Rosegrant (2008).
Note: * In our case the question will be "Produces GM maize?" or "Produces GM soybeans?," depending on the commodity.

This categorization[4] is used to impose the effect of strict information on specific trade flows, that is, those flows that link groups of GM maize– or GM soybeans–producing countries to groups of CPB

[4] Naturally the groups will differ by commodity, depending on whether a country produces GM corn, GM soybeans, or both.

members. Two types of trade relationships are bound to be affected, those that will request testing at the import and export sides, linking GM producers (Groups 1 and 3) to CPB members (Groups 2 and 3), and those that would affect only exporters, linking CPB member GM-producing countries (Group 3) to non-CPB member countries (Groups 1 and 4).

We use this framework to set up a simplified partial equilibrium model of trade with four countries (*A*, *B*, *C*, and *D*) representing the four groups (1 to 4), to illustrate the potential price effect of such regulation. *A* and *C* produce GM, *B* and *D* do not, and *B* and *C* are members of the CPB while *A* and *D* are not. Each country *I* faces a linear supply S^I defined by the inverse relationship $p^I = c_k^I Q^I$, whose slope coefficient depends on whether the country adopts GM ($k = g$) or not ($k = n$). We assume that the slope coefficients are ranked as follows: $0 < c_g^A < c_g^C < c_n^B < c_n^D$, and that *A* and *C* are net exporters, while the two others are net importers. The demand in each country is linear and defined by the inverse demand equation $p^I = a^I Q^I + b^I$ where ($a^I < 0$). The equilibrium price is reached when all excess supply equals excess demand. The original world price (p_0^W) is

$$p_0^W = \frac{-\frac{b^A}{a^A} - \frac{b^B}{a^B} - \frac{b^C}{a^C} - \frac{b^D}{a^D}}{\frac{1}{c_g^A} + \frac{1}{c_g^C} + \frac{1}{c_n^B} + \frac{1}{c_n^D} - \frac{1}{a^A} - \frac{1}{a^B} - \frac{1}{a^C} - \frac{1}{a^D}}. \tag{1}$$

The proposed regulation is modeled as an additional transport cost for GM and non-GM products from *A* to *B*, from *A* to *C*,[5] and from *C* to *B*, for simplification.[6] Let us assume a per-unit cost of τ, applied as a relative tariff on the affected trade flows. At the equilibrium, there are two prices for commingled commodities: one with affected flows and the other with non affected. The affected equilibrium is going to be defined by the relationship between *A*, *B*, and *C*, while the non affected one will be defined by the relationship of *A* and *D*. Naturally *A* and *C* will only export to *B* and *D* under price arbitrage conditions.

The main equations are the following. The world price is

$$p^W = c_g^A Q^A = c_g^A \left(Q_{CPB}^A + Q_{OUT}^A \right) \tag{2}$$

[5] The basic transport costs are not included explicitly here, because we focus on the new costs associated with the regulation, but they are treated with care in the empirical application.
[6] We exclude trade flows from *C* to *C* and from *C* to *A* and *D*.

The trade volume of non affected (subscript *OUT*) and affected (subscript *CPB*) commodities are

$$Q_{OUT}^{A} = \frac{p_{OUT}^{W} - b^{A}}{a^{A}} + \frac{p_{OUT}^{W} - b^{D}}{a^{D}} - \frac{p_{OUT}^{W}}{c_{n}^{D}} \tag{3}$$

$$Q_{CPB}^{A} = \frac{p_{CPB}^{W} - b^{C}}{a^{C}} + \frac{p_{CPB}^{W} - b^{C}}{a^{C}} - \frac{p_{CPB}^{W}}{c_{n}^{B}} - \frac{p_{CPB}^{W} - \tau}{c_{g}^{C}} \tag{4}$$

The arbitrage condition for A to export in both market is:

$$\{\pi_{CPB}^{A} = \pi_{OUT}^{A}\} \Rightarrow \left\{\frac{\left(p_{OUT}^{W}\right)^{2}}{2c_{g}^{A}} = \frac{\left(p_{CPB}^{W} - \tau\right)^{2}}{2c_{g}^{A}}\right\} \tag{5}$$

Using these equations, we find that at the equilibrium, the price of the non affected area (subscript *OUT*), affected area (subscript *CPB*), and overall world prices are, respectively,

$$p_{OUT}^{W} = p_{CPB}^{W} - \tau \tag{6}$$

$$p_{CPB}^{W} = \frac{-\frac{b^{B}}{a^{B}} - \frac{b^{C}}{a^{C}} + \tau\left(\frac{1}{c_{g}^{A}} + \frac{1}{c_{g}^{C}}\right)}{\frac{1}{c_{g}^{A}} + \frac{1}{c_{g}^{C}} + \frac{1}{c_{n}^{B}} - \frac{1}{a^{B}} - \frac{1}{a^{C}}} \tag{7}$$

$$p^{w} = a^{A}\left(p_{CPB}^{W}\right) + p_{OUT}^{W}\left(\frac{1}{a^{D}} - \frac{1}{c^{D}}\right) + \frac{b^{B}}{a^{B}} + \frac{b^{A}}{a^{A}} \tag{8}$$

In this simplified case, the cost of the regulation acts as a wedge between the two prices—the higher the cost, the larger the difference between the two. The international price may or may not differ, but the local consumer price will increase in *B* and *C*, and may decrease in *A* and *D*. Therefore consumers in *A* and *D* may experience welfare gain, but because of the tariff-like effect, producers in *A*, *C*, and potentially *D* will lose, while producers in *B* will gain. In the long term, countries may decide to produce or abandon GM, while others may decide to join or abandon the CPB. If the effect on price is significant, *A* producers may try to avoid planting new GM crops, to lower additional losses.

Naturally the use of this aggregate trade model can only provide a crude, medium-term, and inaccurate appreciation of what information requirements will do. Not all GM producers are large exporters; not all importers are the same; and transport costs, tariffs, and the structure of supply and demand vary widely from one country to another, even within the same group. We will now turn to our simulation model to explore the observable effects of the strict option under specific scenarios in the case of GM maize and GM soybeans.

3. Model and Scenarios

We built a spatial trade equilibrium model (Samuelson 1952, Takayama and Judge 1971) of the international market for maize and soybeans, which includes N countries (80 and 53 for maize and soybeans, respectively), that produce, export, or import these two commodities. All countries are maximizing their welfare function subject to a set of spatial trade arbitration equations. The structure of the model is based on the application by Devadoss et al. (2005) in the case of trade of timber.[7] The objective function is a quasi-welfare function (QW) that Devadoss et al. (2005) called a net social monetary gain function, defined as

$$QW = \sum_{i=1}^{N}(\alpha_i - \beta_i y_i)y_i - \sum_{i=1}^{N}(\gamma_i - \delta_i x_i)x_i - \sum_{i=1}^{N}\sum_{j=1}^{N} x_{ij}t_{ij} - \sum_{i=1}^{N}\sum_{j=1}^{N}\left(\rho_j^D - \rho_i^S\right)x_{ij} + \sum_{i=1}^{N}\sum_{j=1}^{N}\left(\frac{\rho_j^D}{1+\varepsilon_{ij}} - \rho_i^S\right)x_{ij}, \tag{9}$$

where α_i, β_i, γ_i, and δ_i are the positive demand and supply coefficients, respectively; y_i is the quantity demanded and x_i the quantity produced in country i; t_{ij} is the transportation cost from i to j and x_{ij} the volume exported from i to j; ρ_j^D and ρ_i^S are the market supply and demand prices for maize (which accounts for constraints in and access to the international market); and ε_{ij} is the *ad valorem* tariff equivalent for an import of maize from i to j. The market prices should not be confused with the country prices, $\left(p_i^D, p_i^S\right)$, which are defined by the inverse demand and supply equations $p_i^D = \alpha_i - \beta_i y_i$ and $p_i^S = \gamma_i + \delta_i x_i$. This objective function is maximized subject to the following set of feasibility constraints, capacity constraints, and arbitrage conditions:

$$\forall i \in [\![1, N]\!] \qquad \sum_{j=1}^{N} x_{ij} \leq x_i \,, \tag{10}$$

[7] Sobolevsky, Moschini, and Lapan (2005) also used a spatial equilibrium model in the case of the GM soybeans, focusing on different actors in the chain in four regions, and used it to simulate different scenarios on segregation and GM import bans.

$$\forall i \in [\![1, N]\!] \quad \sum_{j=1}^{N} x_{ij} \leq x_i \tag{10}$$

$$\forall j \in [\![1, N]\!] \quad \sum_{i=1}^{N} x_{ij} \geq y_j \tag{11}$$

$$\forall i \in [\![1, N]\!] \quad \alpha_i - \beta_i x_i \leq \rho_i^D \tag{12}$$

$$\forall i \in [\![1, N]\!] \quad \gamma_i + \delta_i x_i \geq \rho_i^S \tag{13}$$

$$\forall (i, j) \in [\![1, N]\!]^2 \quad \left(1 + \varepsilon_{ij}\right)\left(\rho_i^S + t_{ij}\right) \geq \rho_j^D \tag{14}$$

$$\forall (i, j) \in [\![1, N]\!]^2 \quad \left\{x_i \geq 0, y_i \geq 0, x_{ij} \geq 0\right\} \tag{15}$$

Equations (10) and (11) imply that the total quantity exported by *i* does not exceed *I*'s production and that the total quantity imported by *j* is greater than or equal to *j*'s demand. Equations (12) and (13) state that the market demand price should not exceed the country demand price and that the market supply price should be greater than or equal to the country supply price. When these inequalities are binding, in the case of an interior solution, market and country prices are equal, and the country produces or consumes a nonzero quantity of maize. The fifth constraint, given by equation (14), relates the market supply price (accounting for transport costs and tariffs) to the market demand price, and the last condition, in equation (15), is that demand, supply, and trade are nonnegative.

Table 3.1—List of exporting and importing countries included in the model by group

	Group	Maize	Soybeans
Net exporters	**1**	Argentina, U.S.A.	Argentina, Canada, U.S.A.
	2	Austria, Bulgaria, China, France, Hungary, India, Namibia, Paraguay, Romania, Swaziland, Thailand, Uganda, Ukraine	Austria, Ecuador, India, Russia, Slovakia, Tanzania, Ukraine, Uganda, Vietnam
	3	Brazil, Czech Republic, South Africa	Brazil, Paraguay
	4	Moldova	Malawi, Moldova
Net importers	**1**	Canada, Uruguay	Uruguay
	2	Algeria, Bangladesh, Belgium–Luxembourg, Bolivia, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Ecuador, Egypt, El Salvador, Greece, Guatemala, Honduras, Indonesia, Iran, Italy, Japan, Jordan, Kenya, Lebanon, Libya, Malaysia, Mauritius, Mexico, Mozambique, Nigeria, Netherlands, North Korea, Panama, Peru, Saudi Arabia, Slovenia, South Korea, Sri Lanka, Sudan, Syria, Tanzania, Turkey, Venezuela, Vietnam, Yemen, Zambia,	Bolivia, Bulgaria, China, Colombia, Czech Republic, Croatia, Egypt, El Salvador, France, Germany, Guatemala, Greece, Honduras, Indonesia, Italy, Japan, Kenya, North Korea, Peru, Philippines, Poland, Romania, Slovenia, Spain, Sri Lanka, Thailand, Turkey, United Kingdom, Venezuela, Yugoslavia, Zambia, Zimbabwe

	Zimbabwe	
3	Germany, Philippines, Spain	Mexico, South Africa
4	Angola, Chile, Israel, Jamaica, Kuwait, Malawi, Morocco, Pakistan, Russia	Bosnia and Herzegovina

Source: Authors.
Note: The groups are based on the year 2009 for protocol membership and 2008 for GM maize production (James 2008).

Table 3.1 shows the list of countries retained for the simulation; this includes all countries with maize production, export, or import volume during the period 1995–2005 exceeding 0.1 percent of total volume, and for which key data were available. Because spatial trade models allow for only unidirectional bilateral trade flows, we distinguish net exporters from net importers based on United Nations Comtrade data at the HS four-digit level (HS-4 1005 for maize and 1201 for soybeans) from 1995 to 2005.

Table 3.2—Data sources for key parameters

Parameter	**Years**	**Sources of original data**
Production	1995–2005	FAOSTAT, UN Food and Agricultural Organization
Domestic prices	1995–2005	FAOSTAT, UN Food and Agricultural Organization
Consumer prices	1995–2005	FAOSTAT, UN Food and Agricultural Organization
Elasticities of supply	2001–2005	IMPACT model, International Food Policy Research Institute
Elasticities of demand	2001–2005	IMPACT model, International Food Policy Research Institute
Net trade flows	1995–2005	UN Comtrade 1005 and 1201 (HS-4) bilateral trade data
Transportation costs	2004–2006	Ocean freight rates from the International Grains Council
Ad valorem tariffs	2005	MAcMap database

Source: CEPII (2010), FAOSTAT (2010), International Grains Council (2010),Rosegrant et al (2008), UN COMTRADE (2010)

Table 3.2 summarizes the major sources of data used for key parameters. As noted above, we assume linear supply and demand in each country, with initial coefficients based on production data from the Food and Agricultural Organization (FAO) FAOSTAT database, and supply and demand elasticities obtained from the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) of the International Food Policy Research Institute (IFPRI). Transportation costs for each bilateral trade flow are estimated using reported ocean freight rates from the International Grains Council as references, and distances between ports are computed with data from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). Tariff rates are based on the MAcMap HS-6 database[8] of *ad valorem*–equivalent aggregate tariffs developed by the CEPII and the International Trade Centre (ITC). Producer and consumer prices are derived from above-listed data and consumer and producer support equivalents from IMPACT and the Organization for Economic Cooperation and Development (OECD).[9]

Because of the inconsistency across data sources and incomplete datasets for some of the parameters, we use cross-entropy methods to calibrate the data, following a procedure used by Robinson, Cattaneo, and El-Said (2001) and by You and Wood (2006). More specifically, the parameterization is completed in two stages. In the first stage, bilateral trade data are entered and rebalanced in order to respect two constraints: There is no bilateral trade flow between two countries and a country cannot simultaneously import from one partner and export to another one. In the second stage, transport costs are adjusted to fit with the rest of the data, in particular the trade data. In these two stages, the prior distributions of probabilities for the parameters of interest (bilateral trade flows and transport costs) are based on distributions of frequencies of trade volume per exporter and of transport costs directly derived from available data. The support used for these cross-entropy stages is therefore a uniform distribution. The third stage runs the model of quasi-welfare maximization in a standard fashion using a nonlinear solver in the General Algebraic Modeling System (GAMS).

[8] See Bouët et al. 2008.
[9] The complete procedures, though not presented here, are available from the authors.

Table 3.3—Definitions of scenarios

	Affected trade flows by group of countries	Additional cost imposed on trade flows (US$)			
		Base	**Scenario 1**	**Scenario 2**	**Scenario 3**
Set A	1→2, 1→3, 2→2, 2→3	$0	$1.50/ton	$6.50/ton	$13/ton
Set B	1→2, 1→3, 2→2, 2→3	$0	$1.50/ton	$6.50/ton	$13/ton
	3→1, 3→4	$0	$1/ton	$5/ton	$9/ton

Source: Authors, based on Gruère and Rosegrant (2008).

We run six scenarios of simulations by implementing marginal increases in transport costs of affected trade flows of potentially GM maize and soybeans. Table 3.3 presents each of the scenarios. Set A imposes additional transport costs only on flows between GM producers (Groups 1 and 3) and CPB members (Groups 2 and 3). Set B includes the same shocks but also includes additional costs for exports from GM-producing countries that are CPB members (Group 3) toward nonmembers (Groups 1 and 4). In other words, Set A provides a minimum (or pragmatic) implementation of the requirements by CPB members, and Set B shows the situation if CPB members implement the requirements to all their exports as long as they produce GM crops.

Under each set, the base scenario represents the initial situation, which can be interpreted as the "may contain" option. Scenario 1 introduces a small per-volume cost on affected trade flows, based on a sum of the export and import costs assumed by Gruère and Rosegrant (2008) but also consistent with the costs estimated by Huang et al. (2008) in the case of China. Scenarios 2 and 3 impose higher additional costs, following Gruère and Rosegrant (2008), who cite JRG Consulting Group (2004) and Kalaitzandonakes (2004), that represent less efficient testing systems[10] and that may be more representative of the costs for less developed trading countries. In each case, we focus on three key variables: the relative changes in trade volume, prices, and quantities in major countries. For notification

[10] JRG Consulting Group (2004) and Kalaitzandonakes (2004) studied the cases of major exporters of GM products, with very advanced infrastructure, and therefore their proposed costs may still be low compared with the actual transport costs for smaller, developing countries. But because they are much higher than those of Huang et al. (2008), which appear to be more precise, we take them as benchmark values for a possible high-end cost of implementation.

simplicity, the scenarios in Set A will be written A1, A2, and A3, and the scenarios in Set B will be designated B1, B2, and B3.

4. Simulation Results

Scenarios in Set A

Changes in Main Market Variables

Table 4.1—Relative changes (%) in world market variables compared to the Base in Set A.

	Maize			Soybeans		
Scenario	**A1**	**A2**	**A3**	**A1**	**A2**	**A3**
Aggregate quantity	-0.04%	-0.16%	-0.33%	-0.05%	-0.22%	-0.45%
Average p^S	+0.37%	+1.41%	+3.06%	+0.37%	+1.57%	+3.10%
Average p^D	+0.69%	+2.70%	+5.76%	+1.05%	+2.66%	+4.72%

Source: Derived from simulation results.

At the global level (Table 4.1), the additional cost imposed on the main affected trade flows decreases the total production of maize by 190,771 metric tons[11] (Scenario A1) to 1.6 million tons (A3) and the production of soybeans by 98,689 tons (Scenario A1) to 855,276 tons (A3). As expected, an increase in the cost of information requirements amplifies the effects the requirements have on the world market. The average country's supply price increases by up to 3.06 percent in Scenario A3 for maize and 3.1 percent for soybeans. The average country's demand price also increases, signifying a drop in demand, by up to 4.72 percent for soybeans and 5.76 percent for maize in Scenario A3. However, these results do not provide a good overview of the changes experienced at a lower level of aggregation. Since the shocks are implemented by group, it is useful to first analyze differences in groups, as shown in Table 4.2.

Table 4.2—Relative changes (%) in key variables compared to the base in each group of countries

	Group 1			Group 2			Group 3			Group 4		
Scenario	**A1**	**A2**	**A3**	**A1**	**A2**	**A3**	**A1**	**A2**	**A3**	**A1**	**A2**	**A3**
Maize												
Supply	-0.14	-0.69	-1.38	+0.09	+0.53	+1.0	-0.13	-0.63	-1.16	-0.05	-0.38	-0.73
Demand	+0.24	+1.22	+2.42	-0.19	-0.95	-1.86	-0.34	-1.37	-2.96	+0.09	+0.63	+1.22
Average p^S	-0.57	-2.85	-6.34	+0.63	+2.7	+5.7	-0.78	-4.16	-7.87	-0.06	-0.7	-1.39
Average p^D	-0.57	-2.85	-6.34	+0.89	+3.73	+7.9	+1.43	+5.44	+11.3	-0.27	-2.19	-4.25
Soybeans												
Supply	-0.79	-0.35	-0.69	+0.04	+0.18	+0.35	-0.06	-0.27	-0.55	+0.01	+0.05	+0.09

[11] All weights are given in metric tons.

Demand	+0.05	+0.21	+0.43	-0.15	-0.63	-1.27	-0.16	-0.72	-1.43	-0.04	-0.16	-0.31
Average p^S	-0.81	-3.51	-7.02	+0.5	+2.22	+4.43	-0.71	-3.08	-6.17	+0.8	+2.67	+4.34
Average p^D	-0.81	-3.51	-7.02	+0.6	+2.55	+5.09	+0.67	+2.9	+5.81	+0.63	+1.43	+1.24

Source: Derived from simulation results.

Group 1, including GM-producing countries whose exports are affected (see tables A1 and A2 in the appendix), does experience a decrease in supply and supply prices. Between Scenarios A1 and A3, the production of maize and soybeans declines by 285,345 tons to 2.8 million tons and 84,235 tons to 729,976 tons respectively, which are non-negligible amounts. In the case of maize, most of this decline is experienced by the United States (-271,375 to -2.65 million tons), but all Group 1 countries do reduce their production. With the average demand price decreasing by 0.57 to 6.34 percent for maize and by 0.8 to 7 percent for soybeans, internal demand does increase by about 433,993 to 4.3 million tons for maize and by 47,244 to 409,418 tons for soybeans, which have to come from a reduction of exports or an increase in imports.

Results for Group 2, which includes non-GM producers who are members of the CPB, are opposite in direction and amplitude. Countries in this group slightly increase their production of maize and soybeans due to the effect of the new tariff-like measures, but they decrease their demand because of an increase in consumer prices. This region is the largest consumer of maize, and a decline in demand of 1.86 percent for maize and 1.28 percent for soybeans in Scenario A3 translates into a reduction of consumption by about 4.3 million tons for maize and 747,615 tons for soybeans. This suggests that the region does increase its imports of maize and soybeans more than it increases its exports overall. However, the group includes a large number of countries that do not all share the same trend. India, Italy, France, and Nigeria experience large decrease in demand for maize (exceeding 230,000 tons), but China is the only country with a drop exceeding 1 million tons. On the supply side, China, France, Italy, and India lead the group in production increase of maize (ranging from 133,889 tons in Italy to 806,902 tons in China in Scenario A3). These increases suggest significant domestic changes, resulting in increased maize exports to countries of other groups. China and India also experience the largest decrease in demand for soybeans between Scenario A1 and A3 (exceeding 300,000 tons and 130,000 tons, respectively). On the supply side, China increases its production of soybeans from 6,953 tons to 60,271 tons; India and Bolivia also experience a large increase in their production of soybeans between A1 and A3 (from 3,967 tons to 34,392 tons and from 1,311 tons to 11,364 tons respectively).

Group 3 countries, which include GM producers that are CPB members, represent an intermediate situation for maize, with decreased supply and demand, a higher demand price, and a reduction in the supply price. But the drop in demand (from -180,775 tons in Scenario A1 to -1,568,318 tons in Scenario A3) largely exceeds the decrease in supply (from -83,438 tons to -732,749 tons), signifying a growing maize surplus. Most of the decline in demand is borne by Brazil (-946,456 tons in A3), South Africa (-291,435 tons), and Spain (-214227 tons). The decrease in supply is also experienced greatly by Brazil (-416,133 tons in A3) and, to a lesser extent, South Africa (-142,217 tons in A3), but much less by other countries in the group.

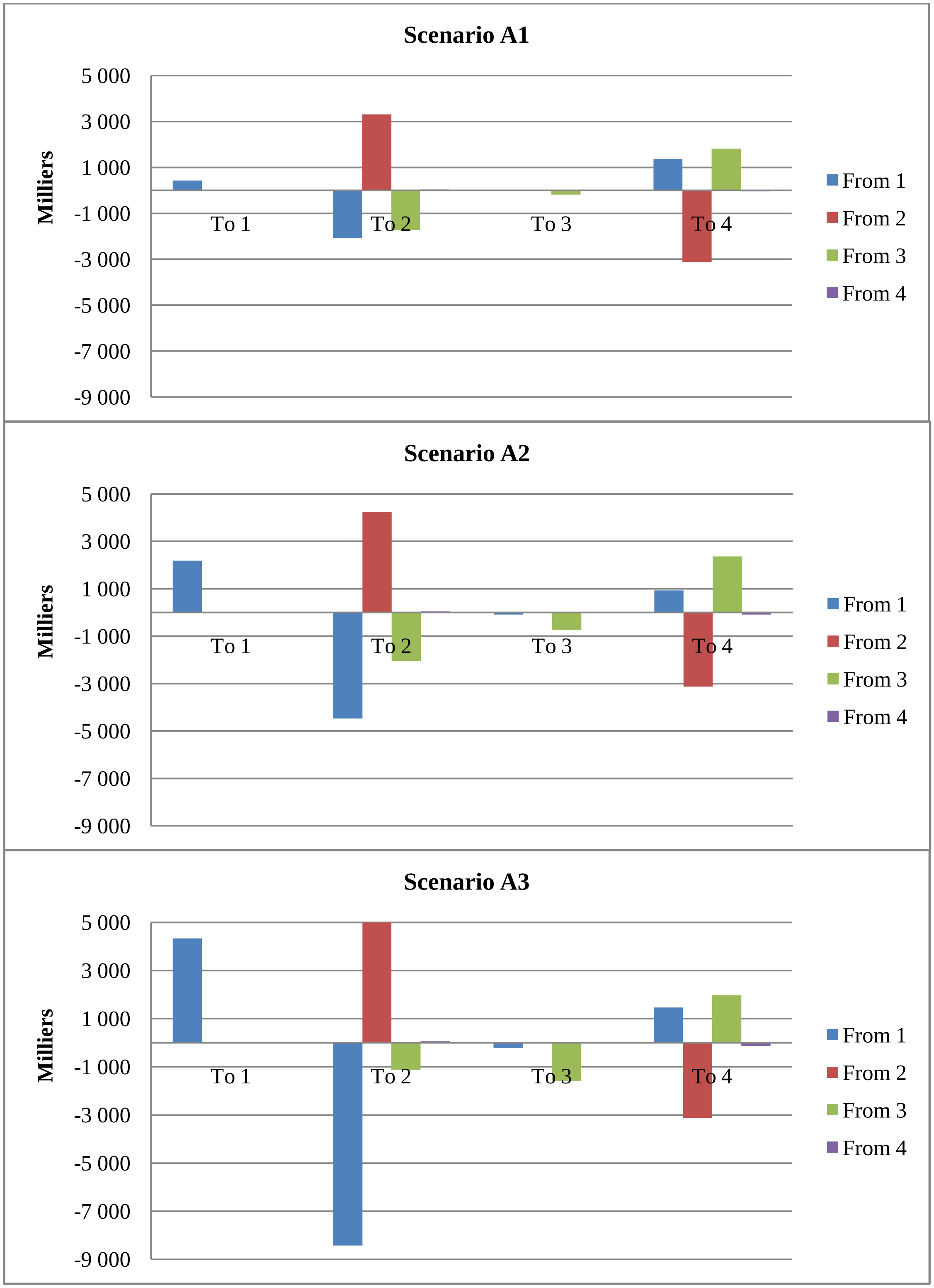
Similar results can be highlighted for soybeans in terms of variation of supply, demand, and prices. Soybeans also experience a growing surplus as evidenced by the drop in demand (from -59,311 tons in A1 to -514,072 tons in A3), which greatly exceeds the decrease in supply (from -29,310 tons to -254,000 tons between A1 and A3). Once again, Brazil experiences the larger decline in demand (from -57,214 tons in A1 to -495,896 tons in A3) and in supply (from -25,586 tons to -221,731 tons). To a lesser extent, Paraguay follows with a decrease in demand (-14,202 tons in A3) smaller than the decrease in supply (-30,176 tons in A3).

Lastly, Group 4, which includes non-GM producers that are not CPB members, has a distinct pattern with, on average, negligible changes in supply and demand, following the same pattern as Group 2. However, the minor observed decrease in demand is associated with a minor decrease in demand prices, suggesting the presence of heterogeneous effects in countries with differentiated demand elasticities. Indeed, unlike other groups, there is a significant variation of demand effects within Group 4. Moldova experiences lower maize demand (-1,636 tons in A1 to -14,858 tons in A3) while larger countries, like Chile (+41,126 tons in A3), Russia (+21,639 tons), and Pakistan (+16,305 tons), increase their demand for maize. Israel (+21,691 tons in A3) and, to a greater extent, Malawi (+55,225 tons) also experience a significant growth in demand. These variations are consistent with demand price fluctuations across countries. Significant variations are also observable on the supply side, with Moldova producing more maize (up to +13,847 tons) to take advantage of higher supply prices, while other countries decrease their production, especially larger countries such as Russia, Chile, and Pakistan. To a lesser extent, these results also apply to soybeans, with a slight decrease in demand (-3,065 tons in A3) and a growing supply (+3,839 tons) in Russia, while Bosnia and Herzegovina records the opposite trend.

Trade Effects

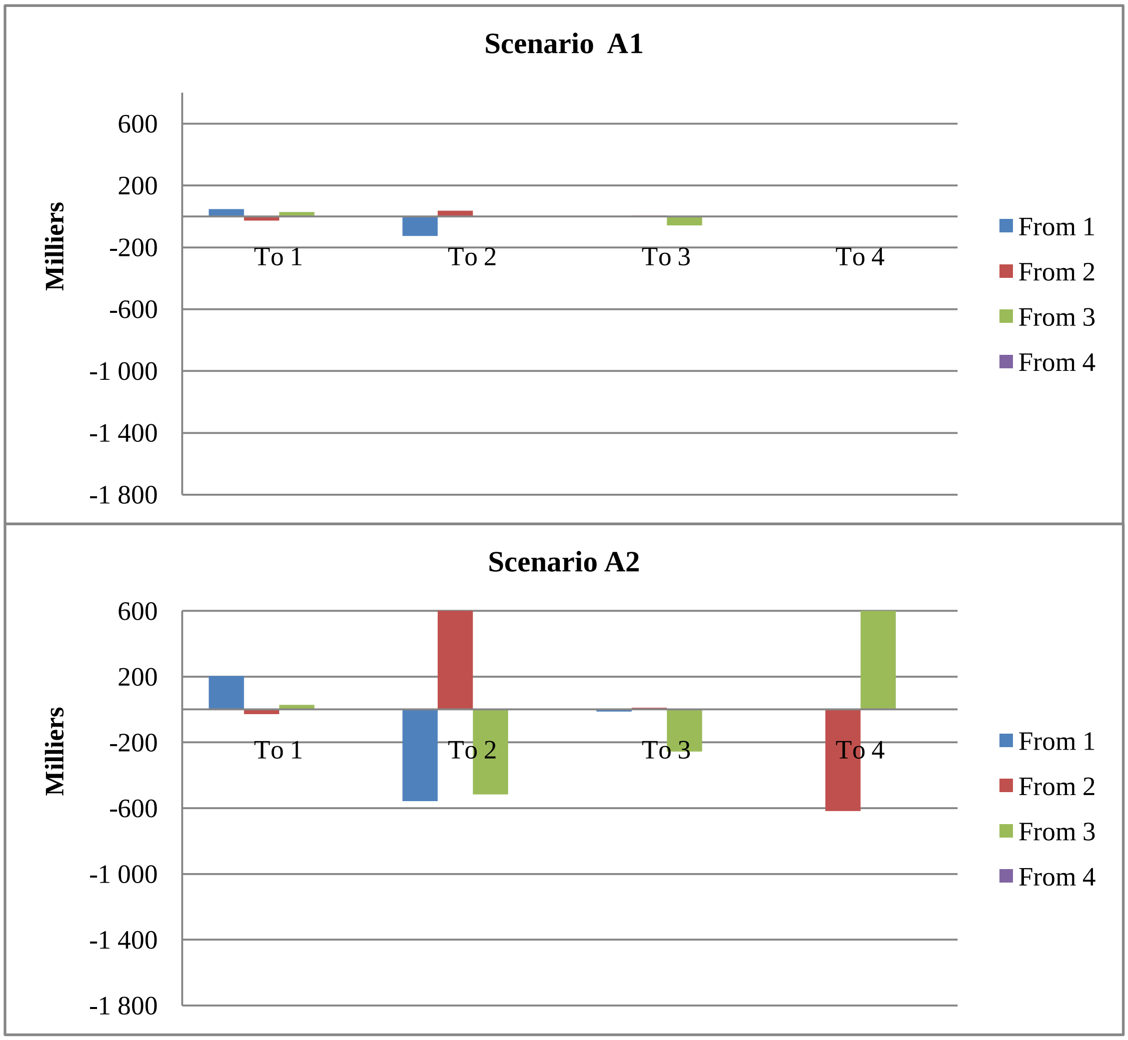
The simulation results on trade are generally consistent with our expectations; trade flows that bear additional costs are affected. But the magnitude of trade diversion is perhaps more significant than expected and varies across regions and scenarios. Figures 4.1 and 4.2 show a decomposition of aggregate bilateral trade flows by group under the three scenarios for the two crops, based on Tables A.3 (maize) and A.4 (soybeans) in the Appendix. The top 10 and bottom 10 variations of disaggregated bilateral trade flows are reported by scenario in Tables A.5, A.6, and A.7 in the Appendix.

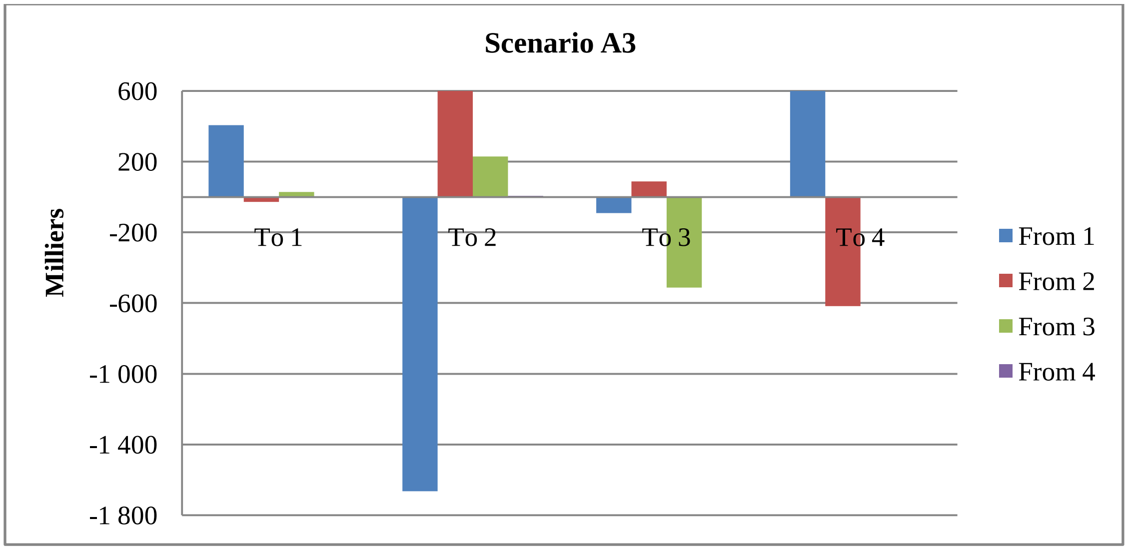
Figure 4.1—Changes in maize trade volume (metric tons) relative to the base under the three scenarios in Set A



Source: Created by authors based on simulation results.

Figure 4.2—Changes in soybean trade volume (metric tons) relative to the base under the three scenarios in Set A Source: Created by authors based on simulation results.





Source: Created by authors based on simulation results.

In Scenario A1, an additional cost is imposed on trade flows going from Group 1 and Group 3 to Group 2 and 3 (see Table 3.3). These trade flows are greatly reduced because of the additional transport cost. In particular, Groups 1 and 3 export around 3.7 million (124,000) tons of maize (soybeans) to Group 2, and 203,353 fewer tons of maize and 64,000 fewer tons of soybeans to Group 3 than in the base scenario. But these deficits are partially compensated for by exports from other groups; Groups 2 and 4 export 3.3 million tons of maize and 37,700 tons of soybeans to Group 2. A domino effect follows, with countries in affected groups (1 and 3) diverting their exports toward non-affected groups (1 and 4), and countries in compensating groups (2 and 4) reducing their exports to affected exporters (1 and 3). Still, in aggregate, the total net trade volume is reduced by 190,772 tons of maize and 98,690 tons of soybeans, and all groups import less maize and soybean than before. But only Group 1 reduces its total export of maize and soybeans because of the additional cost, as shown in Table 4.3.

Table 4.3—Changes in MAIZE AND SOYBEANS export volume (metric tons) relative to the base under the scenarios in Set A

	Group 1	Group 2	Group 3	Group 4	Total
			Maize		
A1	-718,557	162,866	84,097	3,162	-468,433

A2	-3,611,490	685,926	285,293	12,889	-2,627,381
A3	-7,017,858	1,497,366	734,081	28,705	-4,757,705
			Soybeans		
A1	-131,280	16,892	29,784	838	-83,765
A2	-568,851	73,204	129,084	3,632	-362,931
A3	-1,137,667	146,412	258,192	7,264	-725,799

Source: Created by authors based on simulation results.

The same general effects are observed on a larger scale under Scenarios A2 and A3 (Figures 4.1 and 4.2 and Table 4.3). Overall, compared with the base, the total trade volume of maize and soybeans decreases by 771,366 and 427,643 tons and 1.6 million (855,276) tons in scenarios A2 and A3 compared to the basis, respectively. Results from Scenario A2 are fully consistent with those from A1 but on a larger scale. Results from Scenario A3, however, do deviate minimally; instead of diminishing, exports of maize from Group 2 to Group 3 increase slightly by a non significant amount (+17,228 tons as shown in Table A.3 in the Appendix). This increase is more significant for soybeans (+87,644 tons) than for maize. This may be because exports to Group 2 are so much diminished (-9.5 million tons of maize from Groups 1 and 3, and -1.6 million tons of soybeans from Group 1) that compensating Group 2 sends an even larger volume to this group than to Group 3, creating an excess demand in Group 3 that may be met by minimal additional amounts from exporters in Group 2 (see Table A.4 in the Appendix).

At the country level, the largest changes are experienced by major trading countries in Groups 1 and 3, as expected. For instance, in Scenario A1, the United States decreases its trade balance of maize by about 694,465 tons overall, but it decreases mainly its exports to Japan (Group 2) and Spain (Group 3), by 2 million tons and 22,000 tons, respectively. Its exports of maize increase toward Group 4: Morocco (+509,259 tons) and Chile (+783,185 tons). In the same scenario, Brazil (Group 3), India (Group 2), and France (Group 2) export more maize overall (with the trade balance increasing by 53,544, 67,218, and 46,500 tons, respectively), but Brazil exports 44,000 and 11,000 fewer tons to Venezuela and Colombia, respectively (Group 2), which is compensated for by an increase in exports of 110,912 tons to Morocco

(Group 4). South Africa (Group 3) also decreases its exports of maize to various Group 2 countries by 33,819 tons but compensates by exporting 75,960 tons more to Russia (Group 4).

Results for soybeans are similar but with lower volumes, perhaps because of a lower flexibility in the market.[12] The United States experiences the largest decrease in net exports (-65,520 tons overall in Scenario A1), especially toward Group 2: China (-46,087 tons) and Japan (-17,392 tons). Brazil and Paraguay (Group 3) increase their exports (+69,219 tons overall in Scenario A1) toward countries of Group 2 (Japan, Zimbabwe, and Germany) and Group 1 (Uruguay).

Scenarios in Set B

Change in Main Market Variables

Table 4.4 shows the relative changes in prices and quantities at the global level. These results are almost identical to the ones under Set A when comparing the three scenarios (Table 4). In particular, the volume of production and the average of supply and demand prices experience identical relative changes. This may indicate that the additional changes have only minor effects on the market, given that they do not represent major trade flows.

Table 4.4—Relative changes (%) in world market variables under scenarios in Set B compared with the base

	Maize			**Soybeans**		
Scenario	**B1**	**B2**	**B3**	**B1**	**B2**	**B3**
Aggregate quantity	-0.04%	-0.16%	-0.33%	-0.05%	-0.22%	-0.45%
Average p^S	+0.4%	+1.4%	+3.1%	+0.38%	+1.58%	+3.10%
Average p^D	+0.7%	+2.7%	+5.8%	+0.50%	+2.13%	+4.20%

Source: Created by authors based on simulation results.

Table 4.5—Relative changes (%) in key variables in each group of countries under scenarios in Set B compared with the base

	Group 1			**Group 2**			**Group 3**			**Group 4**		
Scenario	**B1**	**B2**	**B3**	**B1**	**B2**	**B3**	**B1**	**B2**	**B3**	**B1**	**B2**	**B3**

[12] Soybean production and exports are concentrated in a few North and South American countries.

Maize												
Supply	-0.13	-0.7	-1.38	+0.07	+0.53	+0.99	-0.13	-0.63	-1.17	-0.01	-0.32	-0.69
Demand	+0.23	+1.2	+2.4	-0.17	-0.95	-1.86	-0.35	-1.37	-2.9	+0.06	+0.57	+1.2
Average p^S	-0.53	-2.86	-6.34	+0.65	+2.68	+5.7	-0.85	-4.36	-8.1	+0.02	-0.58	-1.3
Average p^D	-0.53	-2.86	-6.34	+0.9	+3.7	+7.9	+1.36	+5.24	+11	-0.1	-1.9	-4.08
Soybeans												
Supply	-0.08	-0.35	-0.7	+0.04	+0.18	+0.35	-0.06	-0.27	-0.5	+0.01	+0.05	+0.09
Demand	+0.05	+0.21	+0.43	-0.15	-0.63	-1.27	-0.16	-0.7	-1.4	-0.05	-0.22	-0.45
Average p^S	-0.8	-3.5	-7	+0.5	+2.2	+4.4	-0.7	-3.1	-6.2	+0.8	+2.67	+4.3
Average p^D	-0.8	-3.5	-7	+0.58	+2.54	+5.1	+0.7	+2.9	+5.8	+0.6	+1.4	+1.24

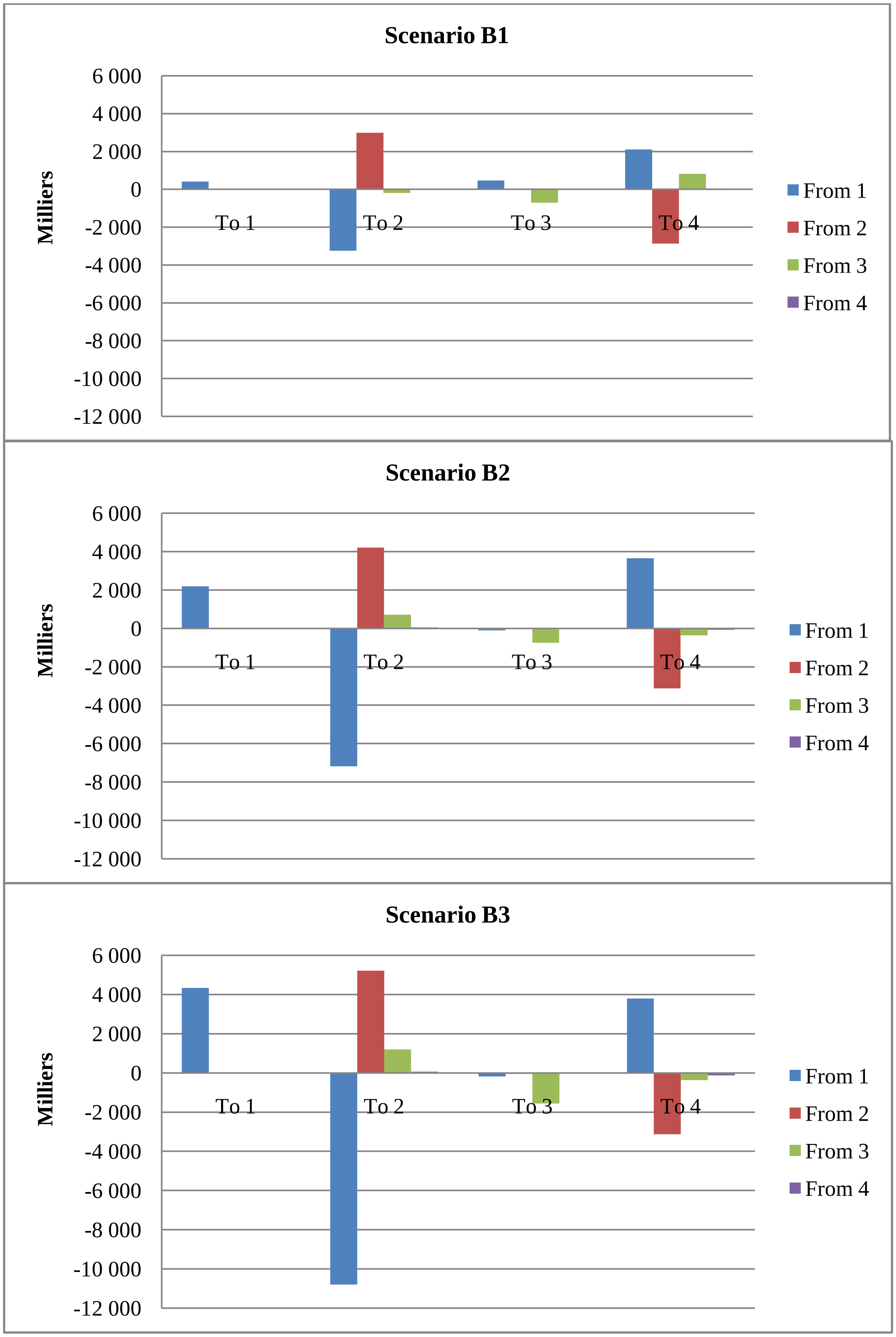
Source: Created by authors based on simulation results.

Table 4.5 presents the same relative changes by group. Once again, the results are similar to the ones obtained under Set A, in terms of both signs and quantitative relative changes from the base. A few changes appear for selected scenarios and variables, but never exceeding +/-0.2 percent. The only visible difference concerns Group 4 in the case of soybeans. This group, a relatively lower trader of soybeans than others, experiences additional costs for its imports from CPB members (countries of Group 3) compared with Set A. This results in slightly different effects on the demand side under scenarios B2 and B3, compared with A2 and A3. While Group 1 also witnesses the same changes for imports from CPB members, the effects of additional transport costs are negligible, because the group is made up of mostly net exporting regions, or regions that may compensate for their losses.

Trade Effects

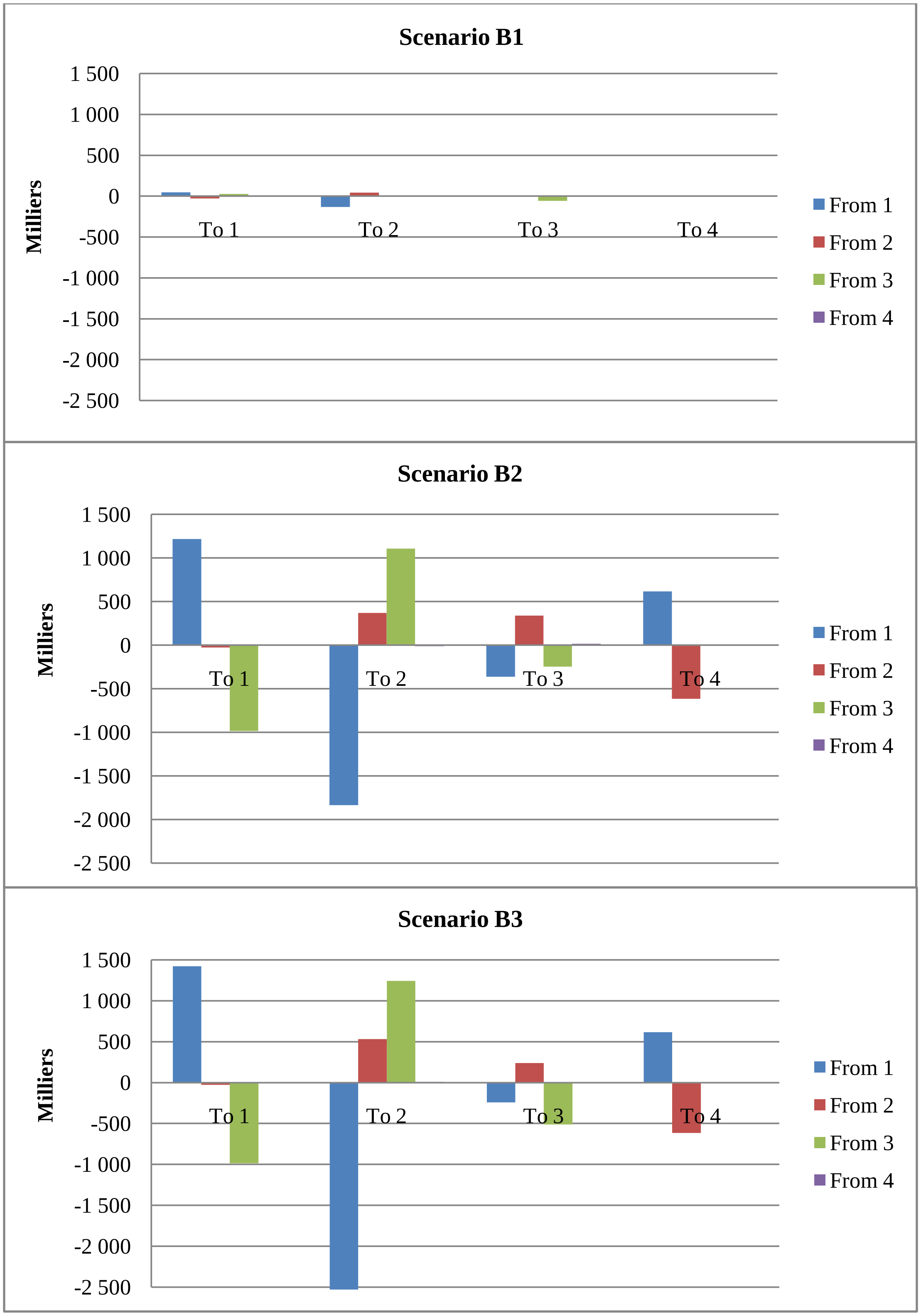
The trade effects of the shocks implemented under scenarios B1, B2, and B3 are presented in Figures 4.3 and 4.4 and Table 4.6 (total exports by group). In addition, detailed bilateral group flows are shown in Tables A.3 and A.4 in the Appendix, as was done in the case of Set A. At first view, the aggregate results of Table 4.6 appear quite similar to those observed in Table 4.3 (Set A). Total trade volume of maize is reduced by 468,433 tons and soybeans by 83,765 tons under B1; the reductions for the two commodities are 2.6 million tons and 362,931 tons under B2, and 4.8 million under B3 (725,799); slightly less than under A3. All groups reduce their imports, and only Group 1 reduces its exports. But in the detail, the amplitude and direction of intra- and intergroup trade change greatly, as visible in Figures 4.3 and 4.4.

Figure 4.3—Changes in maize trade volume (metric tons) relative to the base under the three scenarios in Set B



Source: Created by authors based on simulation results.

Figure 4.4—Changes in soybean trade volume (metric tons) relative to the base under the three scenarios in Set B



Source: Created by authors based on simulation results.

Table 4.6—Changes in maize and soybean export volume (metric tons) relative to the base under the scenarios in Set B

	Group 1	Group 2	Group 3	Group 4	Total
			Maize		
B1	-718,557	162,866	84,097	3,162	-468,433
B2	-3,611,490	685,926	285,293	12,889	-2,627,381
B3	-7,017,858	1,497,366	734,081	28,705	-4,757,705
			Soybeans		
B1	-131,280	16,892	29,784	838	-83,765
B2	-568,851	73,204	129,084	3,632	-362,931
B3	-1,137,667	146,412	258,192	7,264	-725,799

Source: Created by authors based on simulation results.

For maize and soybeans, Group 1 countries follow the same pattern as under Set A: They export much less to Groups 2 and 3, and compensate by exporting more to Groups 1 and 4. But the magnitude of these diversions is much greater than under Set A. In particular, Group 1 reduces its maize (respectively soybean) exports to Group 2 by 3.2 million (0.13 million tons) to 10.8 million tons (2.53 million tons), depending on the scenario, instead of 2 to 8 million tons (maize) and 0.12 million to 1.6 million tons (soybeans) under Set A. Interestingly, these changes happen despite the fact that Group 1 is not directly affected by the new transport costs. Group 2 also follows the same diversion pattern as under Set A, diverting its exports to Groups 2 and 3 to compensate for the losses due to Group 1's trade reductions. Group 2's overall imports and exports are very similar to those under Set A. On the import side, however, Group 2 experiences a much larger shift in maize suppliers, notably because of the much larger drop in exports from Group 1. But instead of making up the volume from itself and from Group 4 (as under Set A), it receives a large amount of maize (-188,151 tons to 1.2 million tons) and soybeans (2,300 tons to 1.2 million of tons) from Group 3.

Group 3 is in fact the most affected by these additional changes, as expected. It faces additional costs for all its maize and soybean exports, regardless of their destination, but with more costs imposed on trade to Group 2 and itself than to Group 1 and 4. Interestingly, however, these relatively smaller changes on exports to Groups 1 and 4 lead to a complete switch in export diversion for Group 3. Group 3 reduces its exports to Groups 1 and 4, and significantly increases its exports to Group 2 under Scenarios B2 and B3. This may be due to different market considerations, but likely mostly to trade preference factors, such as regular tariffs and transport costs, as well as Group 3 exporters' own competitiveness compared with that of other countries. The drastic drop in exports from Group 1 to Group 2 may also be a driver of this preference for exporting to Group 2, which has the largest set of importers. Despite these significant changes, the aggregate exports and imports under Set B scenarios are virtually identical to those under Set A scenarios (they are actually identical for soybeans). The effect is a simple and pure trade diversion. Lastly, trade from and to Group 4 is relatively unaffected by the new measure compared with the results for Scenario A. Its total imports do decrease more than under Set A but by relatively small volumes.

At the country level (Tables A.8, A.9, and A.10 in the Appendix), the largest changes can be seen in major trading nations of Group 1 and especially Group 3. For instance, in the case of Scenario B1, the United States (Group 1) reduces its maize exports by 4.16 million tons to Japan (Group 2). It also reduces its maize exports to Vietnam (-14,954 tons) and Turkey (-10,205 tons), both from Group 2. These reductions are compensated for by increased maize exports to Group 4: Morocco (+932,173 tons), Chile (+782,839 tons), Malawi (+590,932 tons), Kuwait (+403,115 tons), and to a smaller extent, Angola (+77,944 tons) and Bosnia and Herzegovina (+12,750 tons). The United States also experiences increased maize exports toward Group 2 countries by 1.17 million tons to Malaysia and by more than 600,000 tons each to Ecuador, Belgium, Bangladesh, Greece, Honduras, Libya, Mauritius, Italy, and Slovenia. Its exports to Germany (Group 3) also increase significantly, by 485,300 tons.[13]

Brazil (Group 3) significantly decreases its maize exports to Colombia and Cuba (Group 2) by 1.2 million tons and 853,414 tons, respectively, and to a smaller extent, toward Vietnam (Group 2) by about 87,600 tons. These decreases are compensated for by increased exports to other countries within Group 2: Tanzania (+717,000 tons), Sudan (+573,214 tons), Mozambique (+394,000 tons), Kenya (+

[13] Overall the United States does decrease its maize exports by about 650,200 tons in this scenario.

325,912 tons), and Yemen (+190,876 tons). South Africa reduces its exports to Germany (Group 3) by about 459,000 tons, and to Group 2 countries Ecuador (-116,806 tons); Belgium (-87,596 tons); Greece and Honduras (down more than 70,000 tons each); and to a lesser extent, Slovenia, Israel, Egypt, and Syria (down less than 4,000 tons each). These reductions are compensated for by exporting an additional 590,729 tons and 300,971 tons toward closer Japan and Bangladesh (Group 2), respectively. As expected, each of these changes is consistent with a cost-minimizing effort on behalf of the exporting country; substitutions are made only to countries at similar distance or closer, or those that have similar or not significantly different trade policies.

As with maize, the largest changes for soybeans can be seen in major trading nations of Group 1 and Group 3. Under Scenario B1, the United States (Group 1) decreases its soybean exports by more than 50,000 tons to China and Poland (Group 2), while Paraguay (Group 3) reduces its exports by 33,135 tons to Zimbabwe (Group 2) and by about 6,600 tons to Spain (Group 2). Brazil (Group 3) also decreases its exports to Group 2 countries Bolivia, Italy, and Spain by more than 4,000 tons each and compensates by additional exports of 24,480 tons and 19,654 tons of soybean exports to Uruguay (Group 1) and Japan (Group 2), respectively. Paraguay (Group 3) increases its exports to Germany (Group 2) by about 38,000 tons.

Discussion: From Markets to Welfare Effects

The results from the simulations have shown that implementing strict information requirements with the "does contain" option on maize and soybeans could have significant market and especially trade effects. However, although there is less trade and smaller volume of maize or soybeans, which constitute clear market losses, not all countries will experience similar welfare outcomes. In this section we look further by analyzing economic welfare for countries in different regions.

We use the slope and intercept coefficients and the supply and demand variables to compute Marshallian consumer and producer surpluses for each country and group in each scenario. Figures 4.5, 4.6, and 4.7 show the absolute changes in consumer surplus, producer surplus, and total surplus for each group compared with the base. Tables A.11 and A.12 in the Appendix provide the results by country for Scenario B3.

Figure 4.5—Change in consumer surplus (U.S. dollars per year) for each group under each scenario

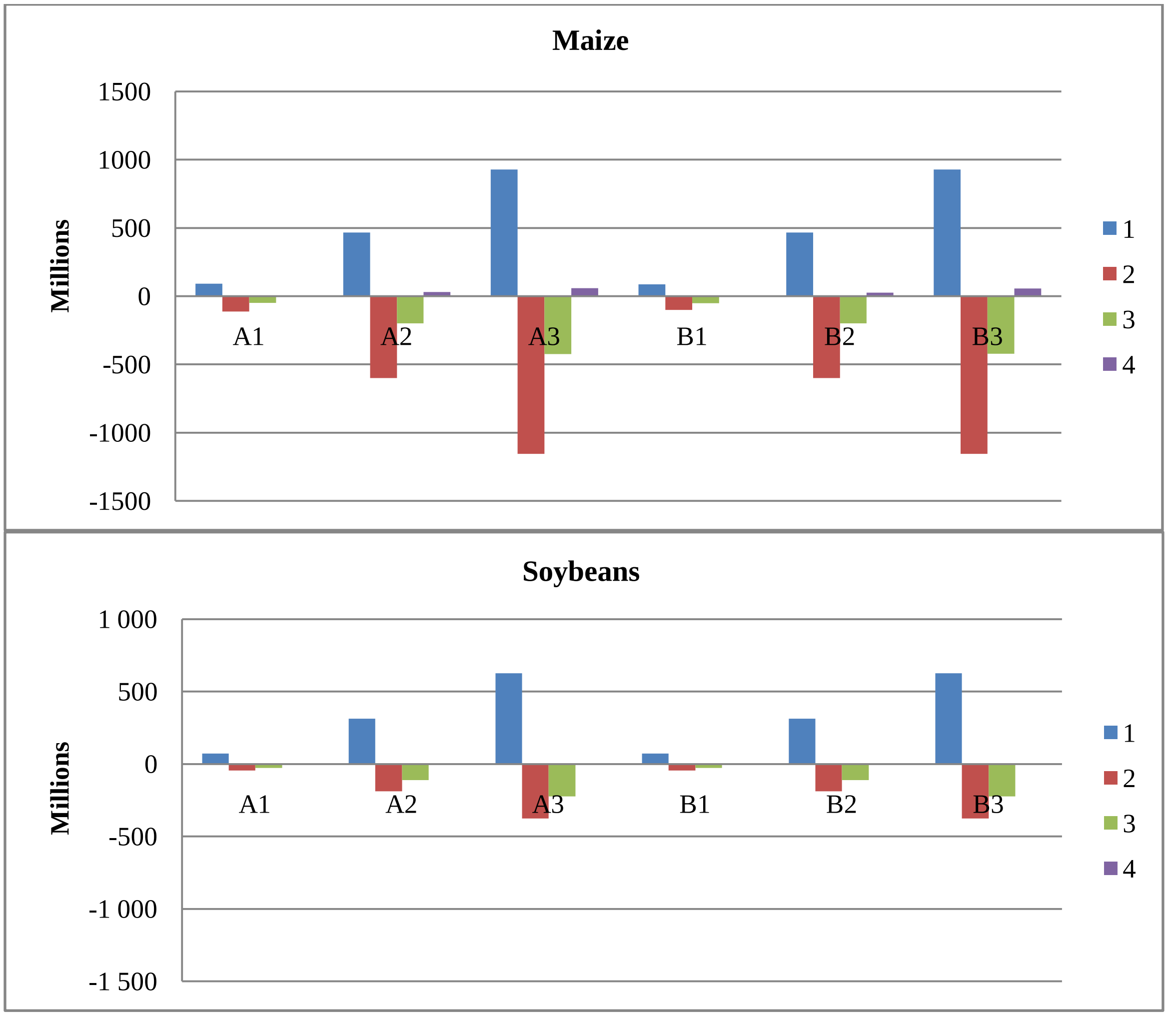


Figure 4.6—Change in producer surplus (U.S. dollars per year) for each group under each scenario

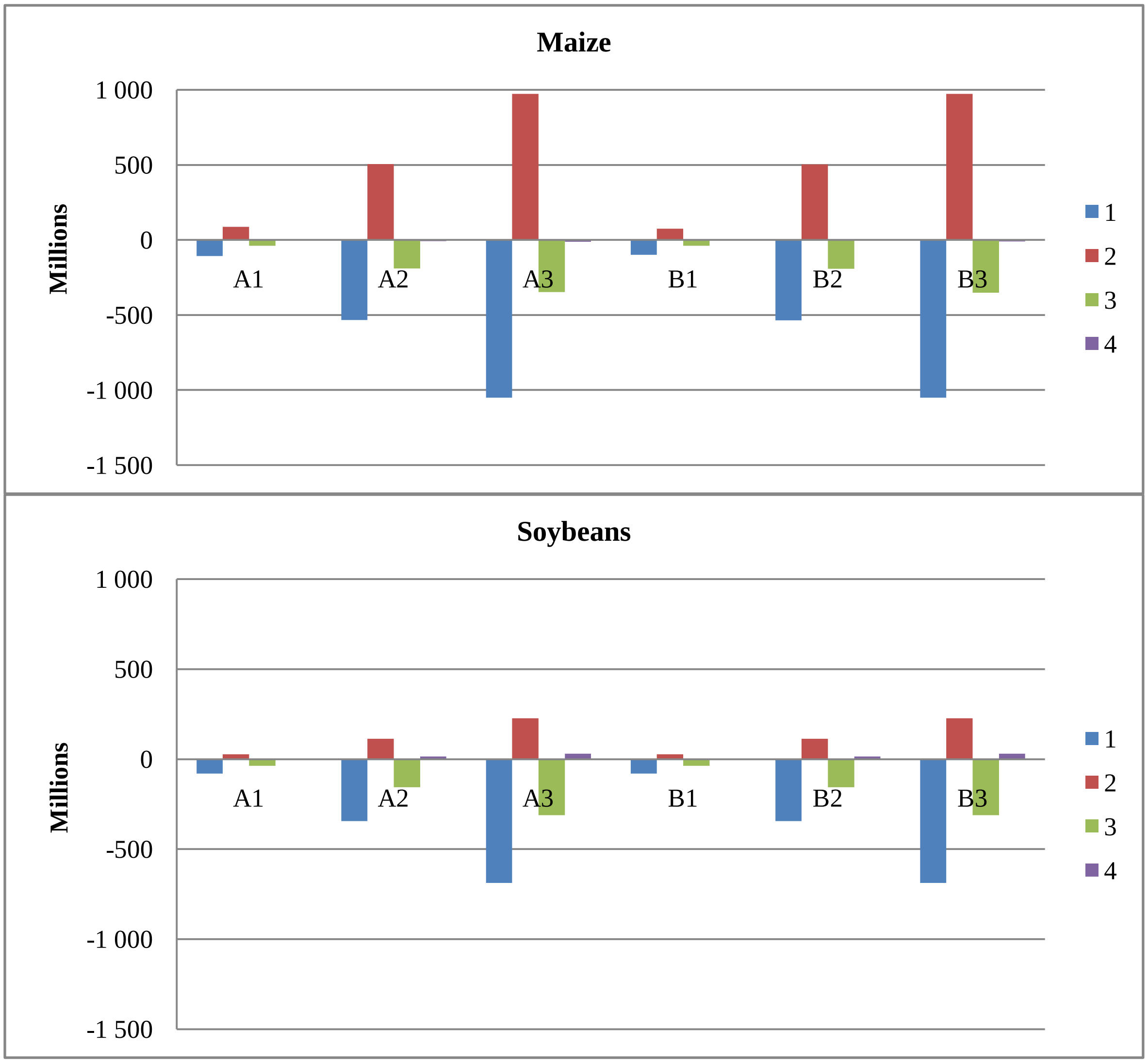
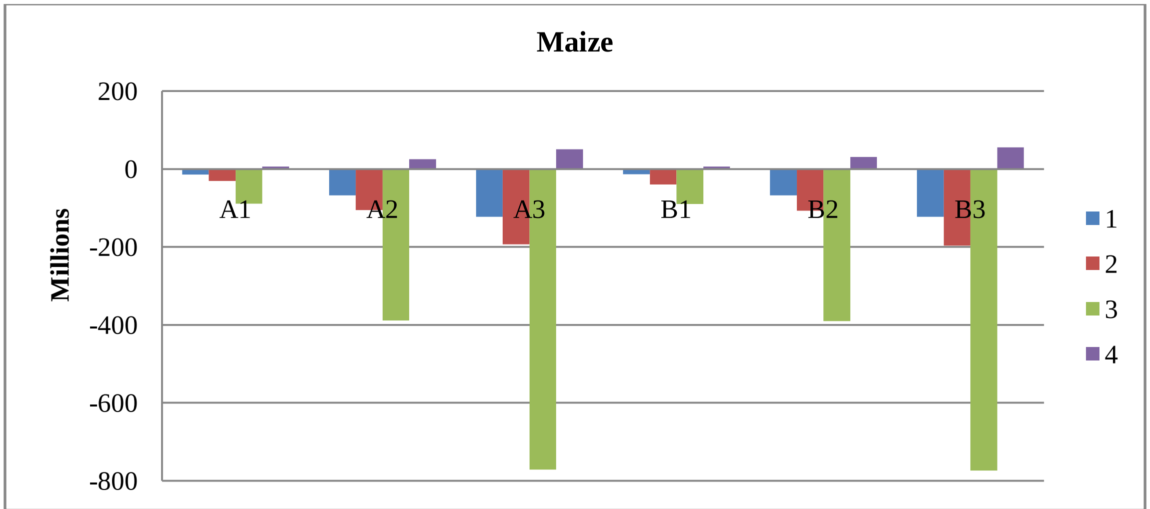
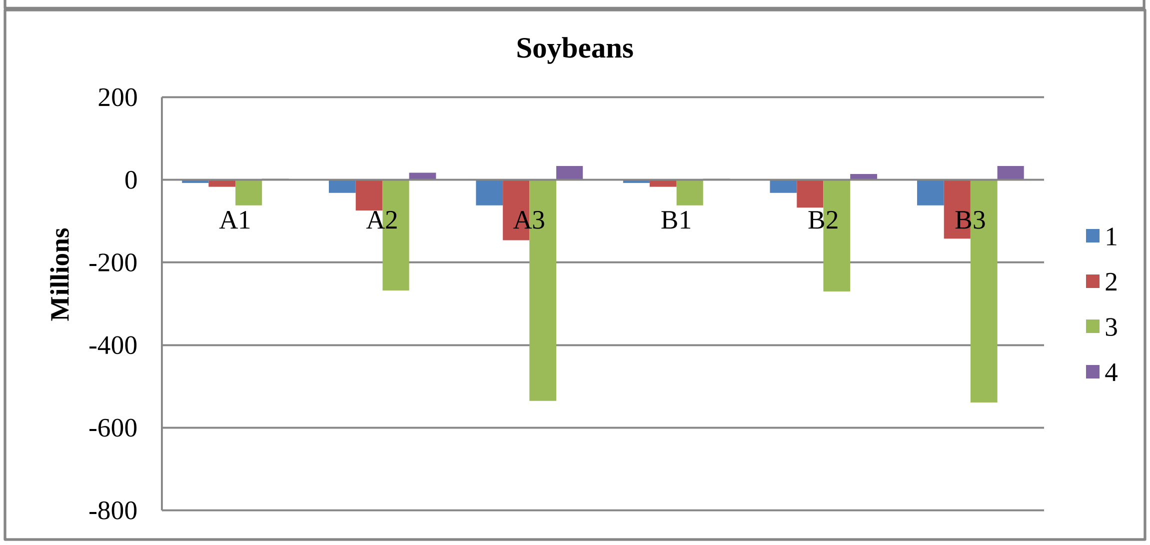


Figure 4.7—Change in total surplus (U.S. dollars per year) for each group under each scenario





The results show that the distribution of welfare effects for both maize and soybeans is indeed quite heterogeneous. Generally, the effects observed for maize are replicated in the case of soybeans at a smaller scale (except for Group 4); the main differences are observed across groups. On the consumer side, Group 1 is bound to gain from lower prices, while Groups 2 and 3 lose. These effects are amplified when moving toward more costly scenarios. On the producer side, Group 2 gains from increased trade costs imposed on competitors (which act like protectionist rents), and Groups 1 and 3 lose from loss of market access and price restrictions. The amplitude of these gains and losses also increases with more costly scenarios. On both sides, Group 4 experiences small changes in welfare, positive or negative, that increase with more drastic scenarios.

Still, when considering both producer and consumer surplus (Figure 4.7), Group 4 is the only one that derives net welfare gains, which grow from A1 to A3 and B2 to B3, with minimal losses under B1. In contrast, Group 3 does experience non-negligible net losses for maize from US$89 million[14] under Scenarios A1 and B1 to $773 million under Scenarios A3 and B3. To a smaller extent, the total welfare losses (which include lost tax revenues) are also quite significant for soybeans, from $62 million under Scenarios A1 and B1 to more than $535 million under Scenarios A3 and B3. Interestingly, Group 2 countries overall, representing CPB members, lose more than Group 1 countries, which are not members of the CPB, but that result is mostly because Group 2 countries together are net importers of maize and soybeans, and because consumers bear more of the surplus than do producers.

Overall, these results show that most countries (54 out of 80 countries for maize and 41 out of 53 for soybeans, as shown in tables A.11 and A.12 in Appendix) are bound to lose with strict information requirements, which confirms the conclusions of other studies. But they also shed light on some of the key supports for such requirements as the Cartagena Protocol. Nonmembers have only an indirect role to play in negotiation, so even if the large trading countries in Group 1 (like Argentina, Canada, or the United States) continue to push against it, they may not advance much. Group 4 countries are absent from discussions, as smaller traders and non-members. The core of the support obviously needs to come from member countries in Groups 2 and 3, groups that are both bound to lose overall, especially Group 3 countries for maize (Brazil and Romania are the biggest losers, as shown in Table A.11 in the Appendix) and Groups 2 and 3 countries for soybeans (Brazil and Japan are the biggest losers, as shown in Table A.12 in the Appendix). Yet member countries of these groups (especially Brazil, European countries, and African countries) have generally been very supportive of the strict requirements in meetings of the Protocol. So why do they support a measure that could be economically detrimental for them?

As in other political forums, a well-known result from the literature (Olson 1965) is that the best-organized groups are bound to be the most influential. In developed countries, the most influential or well-organized parties tend to be on the production side. Results presented in Figures 4.6 and 4.7 suggest

[14] All dollar amounts are in U.S. dollars.

that producers, especially in countries of Group 2, are bound to gain from this measure significantly. In other countries of Group 2, notably those in Africa, producers and consumers are typically not well represented, and the support for such measure has been seen from anti-GM organizations, which are pushing for any restriction in the marketing of GM food.

Yet these countries are bound to be directly affected by the measure, with potentially high losses at stake. Table 4.7 shows the welfare results for countries in Sub-Saharan Africa (SSA) in our study in the case of Scenario B3. Of the twelve CPB member SSA countries included in the study, only Uganda (maize and soybeans), Tanzania (soybeans), Namibia (maize), and Swaziland (maize) would experience welfare gains overall, due to production gains and the small number of consumers in the first three countries, and due to the gains of consumers in a small producing country in the third country. Consumers in Group 4 countries (Angola and Malawi) would gain. But at the same time, eight countries, and especially Nigeria and South Africa, would bear nontrivial welfare losses.

Table 4.7—Change in welfare effects in Sub-Saharan African countries under Scenario B3 compared with the base scenario, in U.S. dollars per year

Group	Country	Maize			Soybeans		
		Consumer surplus (USD$)	Producer surplus (USD$)	Total surplus (USD$)	Consumer surplus (USD$)	Producer surplus (USD$)	Total surplus (USD$)
2	**Kenya**	-16,863,690	14,953,707	-1,909,983	0	0	0
2	**Mozambique**	-11,424,342	8,616,742	-2,807,600	n.a.	n.a.	n.a.
	Mauritius	-4,337,626	0	-4,337,626	n.a.	n.a.	n.a.
2	**Namibia**	0	12,780,857	12,780,857	n.a.	n.a.	n.a.
2	**Nigeria**	-31,825,904	0	-31,825,904	n.a.	n.a.	n.a.
2	**Senegal**	-5,052,061	862,223	-4,189,838	n.a.	n.a.	n.a.
2	**Swaziland**	-453,620	12,915,522	12,461,902	n.a.	n.a.	n.a.
2	**Tanzania**	-19,693,684	14,974,529	-4,719,155	0	9,332,821	9,332,821
2	**Uganda**	-5,153,379	17,194,193	12,040,814	-770,629	9,551,946	8,781,316
2	**Zambia**	-8,312,453	3,308,317	-5,004,136	-3,864,878	88,967	-3,775,911
2	**Zimbabwe**	-12,215,160	7,929,417	-4,285,743	-4,462,323	502,835	-3,959,488
3	**South Africa**	-50,317,745	-43,092,970	-93,410,716	-4,878,721	-954,005	-9,515,636
4	**Angola**	4,864,907	-1,813,459	3,033,795	n.a.	n.a.	n.a.
4	**Malawi**	10,282,904	-6,995,551	3,287,353	0	9,306,972	9,306,972

Source: Created by authors based on simulation results.

Note: n.a. = Not available—countries not included in the soybean model.

While small producers in SSA countries (mostly in Group 2) do not always connect to the market (an implicit assumption here), urban consumers are immediately affected by price increases, as observed during the food price increase of 2008. This means that the presumed gains for producers may be overestimated here while consumers' losses may be underestimated. Producers in Groups 3 and 4 that are connected to the market will also lose. Even South Africa will experience large losses for both producers and consumers. All these groups will probably pay a much larger proportional price than consumers in developed nations of Groups 2 and 3, given their resources, or even producers in some of the most productive countries of Group 3.

Naturally, these welfare effects would change if countries were to change their group. Countries like Kenya, Tanzania, and Uganda are part of a large public–private partnership to develop drought-tolerant GM maize, and if they adopted this promising crop, they would join Group 3 and would thus bear welfare losses for both producers and consumers. This "penalty effect" for GM adoption provides a rationale for why the measure is so strongly supported by anti-GM groups. If in place, it could further discourage developing countries in Africa that are already subject to external influence (see, for example, Paarlberg 2008) from moving toward GM crop adoption.

5. Conclusions

In this paper we investigate the economic effects of implementing a strict information requirement ("does contain LMO-FFPs" with a list of specific GM events) under Article 18.2(a) of the Cartagena Protocol on Biosafety. More specifically, our analysis focuses on evaluating the effect on prices, trade, and welfare of implementing this regulation at the global level.

Using a simple analytical model, we first show that such regulation would create price tension with losers and winners. We then use an empirical model to validate our hypothesis in the case of maize and soybeans. We find that under relatively conservative cost assumptions, information requirements would have a significant effect on the world market for both maize and soybeans. But they would have even greater effects on trade, creating significant trade distortion that diverts exports from their original destination. In particular, nonmember countries that produce GM products would reduce their exports to Protocol members, and GM-producing countries that are part of the Protocol would also divert their exports to new destinations, depending on the scenario. The measure would reduce world trade and production in maize and soybeans, with significant welfare effects.

At the global level, under the more costly scenario, total welfare effects (consumer and producer surplus plus tax revenue) would decline by up to $1.036 billion annually for maize and by up to $716 million annually for soybeans, with significant heterogeneity across countries and agents. While non-GM producers in Protocol member countries would benefit from increased protection, consumers and producers in selected countries of SSA would proportionately pay a much heftier price for the regulation. Even those that derive gains from new protectionist rents would lose if they decided to adopt potentially beneficial GM crops currently under development, like drought-resistant maize. This situation calls for governments in African and other affected countries to reconsider their support for this new regulation, which does not present any clear benefit for regulators but, if implemented, would be associated with significant costs for generations to come.

Appendix: Additional Tables

Table A.1—Change in export volume (metric tons) relative to the base under the six scenarios for maize

	A1	A2	A3	B1	B2	B3
Argentina	-24,093	-121,090	-235,302	-22,557	-121,304	-235,450
USA	-694,465	-3,490,400	-6,782,556	-650,195	-3,496,566	-6,786,838
Austria	7,437	30,317	67,518	7,762	30,272	67,486
Bulgaria	1,678	14,052	31,294	1,827	14,031	31,280
France	46,502	189,577	422,199	48,538	189,296	422,004
Hungary	14,882	60,669	135,114	15,533	60,579	135,052
India	67,218	265,288	541,286	69,609	264,955	541,054
Namibia	75	304	677	78	304	677
Paraguay	3,617	14,748	32,844	3,776	14,726	32,828
Swaziland	944	3,849	8,571	985	3,843	8,567
Thailand	3,110	36,174	99,858	551	36,097	99,804
Uganda	6,565	26,765	59,607	6,853	26,725	59,580
Ukraine	10,838	44,184	98,399	11,312	44,118	98,354
Brazil	53,544	190,792	530,323	60,579	189,821	529,649
Czech Republic	851	1,521	3,073	189	377	1,664
Romania	8,073	23,333	51,467	9,145	23,183	51,363
South Africa	21,629	69,647	149,218	23,845	69,339	149,004
Moldova	3,162	12,889	28,705	3,300	12,870	28,692

Source: Created by authors based on simulation results.

Table A.2—Change in export volume (metric tons) relative to the base under the six scenarios for soybeans

	A1	A2	A3	B1	B2	B3
Argentina	-58,748	-254,564	-509,113	-58,748	-254,564	-509,113
Austria	87	378	756	87	378	756
Brazil	31,628	137,072	274,166	31,628	137,072	274,166
Canada	-7,011	-30,381	-60,760	-7,011	-30,381	-60,760
Ecuador	146	633	1,266	146	633	1,266
India	15,872	68,781	137,566	15,872	68,781	137,566
Moldavia	37	159	318	37	159	318
Malawi	5	20	41	5	20	41
Paraguay	-1,844	-7,988	-15,974	-1,844	-7,988	-15,974
Russia	797	3,452	6,905	797	3,452	6,905
Slovakia	9	39	79	9	39	79
Tanzania	0	2	4	0	2	4
Uganda	39	170	340	39	170	340
Ukraine	492	2,131	4,262	492	2,131	4,262

U.S.A.	-65,520	-283,906	-567,794	-65,520	-283,906	-567,794
Venezuela	3	12	25	3	12	25
Vietnam	238	1,031	2,062	238	1,031	2,062
Zambia	6	26	53	6	26	53

Source: Created by authors based on simulation results.

Table A.3—Change in trade volume (metric tons) relative to the base under the six scenarios for maize

		To 1	To 2	To 3	To 4	Total
A1	From 1	433,993	-2,066,237	-22,724	1,369,623	-285,345
	From 2	0	3,312,822	-4,026	-3,126,336	182,460
	From 3	0	-1,716,922	-180,629	1,814,113	-83,438
	From 4	0	39,281	0	-43,730	-4,449
	Total	433,993	-431,056	-207,379	13,670	-190,772
		To 1	To 2	To 3	To 4	Total
A2	From 1	2,181,258	-4,466,579	-85,498	936,668	-1,434,151
	From 2	0	4,239,306	-14,689	-3,126,336	1,098,281
	From 3	5	-2,033,984	-731,929	2,367,559	-398,349
	From 4	0	49,008	0	-86,158	-37,150
	Total	2,181,263	-2,212,248	-832,116	91,734	-771,367
		To 1	To 2	To 3	To 4	Total
A3	From 1	4,335,510	-8,426,293	-216,570	1,470,409	-2,836,944
	From 2	0	5,155,959	17,228	-3,126,336	2,046,851
	From 3	-526	-1,120,165	-1,583,204	1,971,145	-732,750
	From 4	0	64,824	0	-136,463	-71,639
	Total	4,334,984	-4,325,675	-1,782,546	178,756	-1,594,481
		To 1	To 2	To 3	To 4	Total
B1	From 1	406,854	-3,238,347	461,436	2,102,902	-267,155
	From 2	0	2,990,845	30,006	-2,870,562	150,289
	From 3	-526	-188,151	-706,715	816,163	-79,229
	From 4	0	39,419	0	-40,274	-855
	Total	406,328	-396,234	-215,273	8,228	-196,951
B2		To 1	To 2	To 3	To 4	Total

	From 1	2,185,643	-7,178,650	-99,770	3,656,093	-1,436,684
	From 2	0	4,208,457	14,253	-3,126,336	1,096,374
	From 3	-526	712,501	-744,823	-366,637	-399,485
	From 4	0	48,989	0	-79,915	-30,926
	Total	2,185,117	-2,208,702	-830,340	83,205	-770,720
		To 1	**To 2**	**To 3**	**To 4**	**Total**
B3	**From 1**	4,338,328	-10,799,805	-176,226	3,798,926	-2,838,777
	From 2	0	5,211,903	-39,272	-3,126,336	2,046,295
	From 3	-526	1,198,826	-1,565,476	-366,637	-733,813
	From 4	0	64,811	0	-132,545	-67,734
	Total	4,337,802	-4,324,265	-1,780,974	173,409	-1,594,028

Source: Created by authors based on simulation results.

Note: Shaded cells represent affected trade flows.

Table A.4—Change in trade volume (metric tons) relative to the base under the six scenarios for soybeans

		To 1	To 2	To 3	To 4	Total
A1	**From 1**	47,045	-126,280	-5,000	0	-84,235
	From 2	-27,281	36,882	4,783	-17	14,367
	From 3	27,480	2,304	-59,095	0	-29,311
	From 4	0	838	0	-349	489
	Total	47,244	-86,256	-59,311	-366	-98,690
		To 1	**To 2**	**To 3**	**To 4**	**Total**
A2	**From 1**	203,852	-557,040	-11,811	0	-364,999
	From 2	-27,281	695,544	10,872	-616,875	62,260
	From 3	28,144	-515,931	-256,089	616,871	-127,005
	From 4	0	3,632	0	-1,532	2,100
	Total	204,715	-373,796	-257,028	-1,535	-427,644
		To 1	**To 2**	**To 3**	**To 4**	**Total**
A3	**From 1**	407,692	-1,665,099	-89,522	616,954	-729,976
	From 2	-27,281	681,036	87,644	-616,875	124,525

	From 3	29,008	229,184	-512,194	0	-254,002
	From 4	0	7,264	0	-3,087	4,177
	Total	409,418	-747,615	-514,072	-3,008	-855,276
		To 1	**To 2**	**To 3**	**To 4**	**Total**
B1	**From 1**	47,045	-130,918	-361	0	-84,234
	From 2	-27,281	41,520	145	-17	14,384
	From 3	27,480	2,304	-59,095	0	-29,311
	From 4	0	838	0	-349	489
	Total	47,244	-86,256	-59,311	-366	-98,672
B2		**To 1**	**To 2**	**To 3**	**To 4**	**Total**
	From 1	1,216,747	-1,835,457	-363,161	616,871	-365,000
	From 2	-27,281	368,224	338,192	-616,875	62,260
	From 3	-984,751	1,105,826	-248,079	0	-127,004
	From 4	0	-12,388	16,020	-1,532	2,100
	Total	204,715	-373,796	-257,028	-1,535	-427,644
B3		**To 1**	**To 2**	**To 3**	**To 4**	**Total**
	From 1	1,421,451	-2,528,565	-239,816	616,954	-729,976
	From 2	-27,281	530,743	237,938	-616,875	124,525
	From 3	-984,751	1,242,943	-512,194	0	-254,002
	From 4	0	7,264	0	-3,087	4,177
	Total	409,418	-747,615	-514,072	-3,008	-855,276

Source: Created by authors based on simulation results.

Note: Shaded cells represent affected trade flows.

Table A.5—Change in export volume (metric tons) relative to the base under Scenario A1: Top 10 and bottom 10 trade flows

	Maize					Soybeans				
	Exporter	**Gp.**	**Importer**	**Gp.**	**A1**	**Exporter**	**Gp.**	**Importer**	**Gp.**	**A1**
Bottom 10	U.S.A.	1	Japan	2	-2,043,532	U.S.A.	1	China	2	-46,087
	Uganda	2	Morocco	4	-931,942	Argentina	1	Poland	2	-27,622
	Czech Rep.	3	Nigeria	2	-669,621	India	2	Uruguay	1	-27,281
	France	2	Chile	4	-603,303	Ecuador	2	Germany	2	-25,808
	France	2	Pakistan	4	-568,343	U.S.A.	1	Japan	2	-17,392
	Czech Rep.	3	Sri Lanka	2	-484,336	Argentina	1	Un. Kingdom	2	-12,848
	Hungary	2	Iran	2	-460,190	Paraguay	3	Zimbabwe	2	-12,806
	France	2	Russia	4	-452,677	Brazil	3	Zimbabwe	2	-9,720
	Swaziland	2	Iran	2	-451,490	Argentina	1	Colombia	2	-7,394
	Austria	2	Bosnia-Herz.	4	-282,808	Canada	1	Japan	2	-7,011
Top 10	Czech Rep.	3	Bosnia-Herz.	4	283,154	India	2	Hungary	2	5,469
	U.S.A.	1	Morocco	4	509,259	India	2	Philippines	2	5,469
	France	2	Sri Lanka	2	531,194	India	2	Poland	2	5,469
	Czech Rep.	3	Russia	4	546,623	Ecuador	2	Un. Kingdom	2	5,469
	Swaziland	2	Nigeria	2	582,529	India	2	Un. Kingdom	2	5,469
	Czech Rep.	3	Pakistan	4	594,509	Russia	4	Colombia	2	6,882
	U.S.A.	1	Chile	4	783,185	Paraguay	3	Germany	2	17,447
	Hungary	2	Japan	2	896,275	Ecuador	2	Poland	2	21,876
	France	2	Iran	2	950,620	India	2	Zimbabwe	2	22,426
	Uganda	2	Japan	2	1,098,893	Brazil	3	Japan	2	24,292

Source: Created by authors based on simulation results.

Table A.6—Change in export volume (metric tons) relative to the base under Scenario A2: Top 10 and bottom 10 trade flows

	Maize					Soybeans				
	Exporter	**Gp.**	**Importer**	**Gp.**	**A2**	**Exporter**	**Gp.**	**Importer**	**Gp.**	**A2**
Bottom 10	U.S.A.	1	Japan	2	-4,159,330	Brazil	3	Bolivia	2	-501,060
	Thailand	2	China	2	-1,199,270	Uganda	2	Bosnia-Herz.	4	-432,243
	Uganda	2	Morocco	4	-931,942	India	2	Turkey	2	-234,542
	Argentina	1	Malaysia	2	-841,513	India	2	Bosnia-Herz.	4	-184,632
	Czech Rep.	3	Nigeria	2	-727,999	India	2	Egypt	2	-182,532
	Argentina	1	Libya	2	-653,104	Argentina	1	Poland	2	-162,159
	France	2	Chile	4	-603,303	U.S.A.	1	Thailand	2	-130,349
	Hungary	2	Philippines	3	-574,536	Ukraine	2	China	2	-123,903
	France	2	Pakistan	4	-568,343	Ecuador	2	Zimbabwe	2	-104,966
	U.S.A.	1	Egypt	2	-564,026	U.S.A.	1	China	2	-80,452

Top 10	Czech Rep.	3	Pakistan	4	607,664	Russia	4	Colombia	2	20,346
	Romania	3	Libya	2	632,932	Brazil	3	Uruguay	1	28,144
	Argentina	1	Venezuela	2	704,129	Brazil	3	Japan	2	95,385
	Argentina	1	Japan	2	719,280	Ukraine	2	Thailand	2	117,054
	Brazil	3	Morocco	4	789,684	Ecuador	2	Poland	2	146,735
	U.S.A.	1	Chile	4	805,020	India	2	Zimbabwe	2	158,979
	U.S.A.	1	Malaysia	2	838,654	Uganda	2	Egypt	2	179,617
	France	2	Iran	2	932,177	Uganda	2	Turkey	2	230,674
	Uganda	2	Japan	2	1,119,093	India	2	Bolivia	2	488,289
	Hungary	2	Japan	2	1,312,283	Brazil	3	Bosnia-Herz.	4	616,871

Source: Created by authors based on simulation results.

Table A.7—Change in export volume (metric tons) relative to the base under Scenario A3: Top 10 and bottom 10 trade flows

	Maize					**Soybeans**				
	Exporter	**Gp.**	**Importer**	**Gp.**	**A3**	**Exporter**	**Gp.**	**Importer**	**Gp.**	**A3**
Bottom 10	U.S.A.	1	Japan	2	-4,159,330	Argentina	1	Un. Kingdom	2	-595,491
	Thailand	2	China	2	-1,857,582	Uganda	2	Bosnia-Herz.	4	-432,243
	Uganda	2	Morocco	4	-931,942	Argentina	1	Poland	2	-295,261
	Argentina	1	Malaysia	2	-820,895	U.S.A.	1	China	2	-284,820
	U.S.A.	1	Greece	2	-780,970	India	2	Turkey	2	-234,542
	Czech Rep.	3	Nigeria	2	-727,999	U.S.A.	1	Japan	2	-196,367
	U.S.A.	1	Croatia	2	-692,480	India	2	Bosnia-Herz.	4	-184,632
	France	2	Chile	4	-603,303	India	2	Egypt	2	-182,532
	Hungary	2	Philippines	3	-574,536	Ecuador	2	Zimbabwe	2	-147,764
	France	2	Pakistan	4	-568,343	Ukraine	2	China	2	-123,903
Top 10	Argentina	1	Angola	4	562,121	Brazil	3	Bolivia	2	82,944
	Czech Rep.	3	Russia	4	582,496	Ukraine	2	South Africa	3	87,644
	India	2	Croatia	2	605,554	Russia	4	Colombia	2	89,544
	South Africa	3	Greece	2	645,414	India	2	Zimbabwe	2	115,147
	U.S.A.	1	Chile	4	716,828	Uganda	2	Egypt	2	176,701
	France	2	Iran	2	790,355	Uganda	2	Turkey	2	226,806
	France	2	Japan	2	797,160	Ecuador	2	Poland	2	244,635
	Swaziland	2	Nigeria	2	823,567	Brazil	3	Japan	2	256,635
	Uganda	2	Japan	2	1,151,935	India	2	Un. Kingdom	2	583,537
	Hungary	2	Japan	2	1,386,728	Argentina	1	Bosnia-Herz.	4	616,954

Source: Created by authors based on simulation results.

Table A.8—Change in export volume (metric tons) relative to the base under Scenario B1: Top 10 and bottom 10 trade flows

	Maize					Soybeans				
	Exporter	**Gp.**	**Importer**	**Gp.**	**B1**	**Exporter**	**Gp.**	**Importer**	**Gp.**	**B1**
Bottom 10	U.S.A.	1	Japan	2	-4,159,330	U.S.A.	1	China	2	-50,798
	U.S.A.	1	Egypt	2	-2,011,723	Argentina	1	Poland	2	-50,567
	Namibia	2	Nigeria	2	-1,782,003	Ecuador	2	Germany	2	-46,359
	Argentina	1	Malaysia	2	-1,276,783	Paraguay	3	Zimbabwe	2	-33,135
	Brazil	3	Colombia	2	-1,206,428	India	2	Uruguay	1	-27,281
	Uganda	2	Morocco	4	-931,942	U.S.A.	1	Japan	2	-12,752
	Brazil	3	Cuba	2	-853,414	Canada	1	Japan	2	-7,011
	Austria	2	Tanzania	2	-734,536	Paraguay	3	Spain	2	-6,595
	Argentina	1	Libya	2	-653,104	Brazil	3	Italy	2	-4,733
	France	2	Chile	4	-603,303	Brazil	3	Bolivia	2	-4,292
Top 10	Argentina	1	Cuba	2	851,836	India	2	Bolivia	2	1,574
	Argentina	1	Peru	2	917,556	Uganda	2	Bosnia-Herz.	4	1,604
	U.S.A.	1	Morocco	4	932,173	Russia	4	Colombia	2	2,334
	Uganda	2	Japan	2	1,053,263	Vietnam	2	Thailand	2	2,764
	U.S.A.	1	Malaysia	2	1,170,383	Ukraine	2	China	2	3,642
	Argentina	1	Colombia	2	1,194,559	Brazil	3	Japan	2	19,654
	Austria	2	Iran	2	1,378,181	Brazil	3	Uruguay	1	27,480
	Ukraine	2	Nigeria	2	1,386,112	Paraguay	3	Germany	2	37,887
	Namibia	2	Japan	2	1,782,081	India	2	Zimbabwe	2	38,918
	France	2	Egypt	2	1,907,269	Ecuador	2	Poland	2	49,369

Source: Created by authors based on simulation results.

Table A.9—Change in export volume (metric tons) relative to the base under Scenario B2: Top 10 and bottom 10 trade flows

	Maize					Soybeans				
	Exporter	**Gp.**	**Importer**	**Gp.**	**B2**	**Exporter**	**Gp.**	**Importer**	**Gp.**	**B2**
Bottom 10	U.S.A.	1	Japan	2	-4,159,330	Brazil	3	Uruguay	1	-984,751
	Thailand	2	China	2	-1,196,722	Canada	1	Japan	1	-684,717
	Uganda	2	Morocco	4	-931,942	Argentina	1	Un. Kingdom	1	-595,491
	Argentina	1	Libya	2	-653,104	Uganda	2	Bosnia-Herz.	1	-432,243
	Namibia	2	Nigeria	2	-649,368	Argentina	1	South Africa	1	-371,394
	U.S.A.	1	Greece	2	-628,664	Argentina	1	Poland	1	-241,376
	U.S.A.	1	Egypt	2	-627,508	India	2	Turkey	1	-234,542
	France	2	Chile	4	-603,303	U.S.A.	1	Japan	1	-196,367
	France	2	Pakistan	4	-568,343	India	2	Bosnia-Herz.	1	-184,632
	Austria	2	Peru	2	-541,620	India	2	Egypt	1	-182,532

Top 10	Czech Rep.	3	Nigeria	2	601,630	Brazil	3	Bolivia	1	94,726.1
	U.S.A.	1	Pakistan	4	604,281	Ecuador	2	Zimbabwe	1	135,266.7
	Namibia	2	Japan	2	649,672	Uganda	2	Egypt	1	179,616.7
	Romania	3	Libya	2	651,622	Uganda	2	Turkey	1	230,674.1
	Swaziland	2	Peru	2	744,549	India	2	Poland	1	294,988.5
	France	2	Iran	2	932,213	Ukraine	2	South Africa	1	322,172.2
	U.S.A.	1	Morocco	4	937,208	India	2	Un. Kingdom	1	606,368.7
	Hungary	2	Japan	2	958,186	Canada	1	Bosnia-Herz.	1	616,871.4
	Uganda	2	Japan	2	1,119,053	Argentina	1	Uruguay	1	1,012,896
	Austria	2	Japan	2	1,347,846	Brazil	3	Japan	1	1,039,526

Source: Created by authors based on simulation results.

Table A.10—Change in export volume (metric tons) relative to the base under Scenario B3: Top 10 and bottom 10 trade flows

	Maize					**Soybeans**				
	Exporter	**Gp.**	**Importer**	**Gp.**	**B3**	**Exporter**	**Gp.**	**Importer**	**Gp.**	**B3**
Bottom 10	U.S.A.	1	Japan	2	-4,159,330	Brazil	3	Uruguay	1	-984,751
	U.S.A.	1	Egypt	2	-2,025,745	Argentina	1	Un. Kingdom	2	-595,491
	Thailand	2	China	2	-1,857,582	Argentina	1	South Africa	3	-583,634
	Uganda	2	Morocco	4	-931,942	Argentina	1	Poland	2	-507,527
	U.S.A.	1	Greece	2	-780,970	Uganda	2	Bosnia-Herz.	4	-432,243
	U.S.A.	1	Croatia	2	-692,480	Vietnam	2	Indonesia	2	-426,121
	Czech Rep.	3	Nigeria	2	-654,687	Austria	2	Japan	2	-403,471
	Romania	3	Italy	2	-652,705	Argentina	1	Colombia	2	-370,125
	Argentina	1	Libya	2	-610,167	U.S.A.	1	China	2	-368,575
	France	2	Chile	4	-603,303	Russia	4	Hungary	2	-354,721
Top 10	Argentina	1	Morocco	4	567,779	India	2	Hungary	2	314,520.2
	U.S.A.	1	Bosnia-Herz.	4	574,425	U.S.A.	1	South Africa	3	343,371.8
	India	2	Croatia	2	614,018	Russia	4	Colombia	2	365,690.8
	South Africa	3	Greece	2	683,471	Austria	2	Indonesia	2	404,226.8
	U.S.A.	1	Chile	4	830,764	Vietnam	2	Thailand	2	428,183.8
	Swaziland	2	Egypt	2	849,990	Ecuador	2	Poland	2	479,653.3
	Czech Rep.	3	Egypt	2	921,275	India	2	Un. Kingdom	2	598,088.5
	Uganda	2	Japan	2	1,151,908	Argentina	1	Bosnia-Herz.	4	616,954
	Hungary	2	Japan	2	1,386,666	Brazil	3	Japan	2	666,545.5
	France	2	Japan	2	1,432,215	Argentina	1	Uruguay	1	1,013,759

Source: Created by authors based on simulation results.

Table A.11—Welfare effects for maize (Scenario B3 compared with base) by country in decreasing order of total surplus, in U.S. dollars per year

	Group	Consumer Surplus (USD$)	Producer Surplus (USD$)	Total Surplus (USD$)
France	2	-45,070,877	70,382,039	25,311,162
India	2	-77,003,315	95,668,532	18,665,217
Hungary	2	-34,203,209	50,622,027	16,418,819
Ukraine	2	-25,388,278	40,027,374	14,639,096
Austria	2	-8,931,600	23,321,346	14,389,746
Bulgaria	2	-8,214,527	21,333,467	13,118,941
Moldova	4	-8,061,054	21,031,769	12,970,715
Namibia	2	0	12,780,857	12,780,857
Swaziland	2	-453,620	12,915,522	12,461,902
Uganda	2	-5,153,379	17,194,193	12,040,814
Thailand	2	-22,255,120	34,071,475	11,816,355
Paraguay	2	-3,321,440	13,590,844	10,269,404
Morocco	4	5,214,748	-554,835	4,659,913
Israel	4	4,488,106	0	4,488,106
Chile	4	8,597,715	-4,374,424	4,223,291
Malawi	4	10,282,904	-6,995,551	3,287,353
Jamaica	4	3,272,035	0	3,272,035
Kuwait	4	3,139,964	0	3,139,964
Angola	4	4,864,907	-1,813,459	3,051,448
Uruguay	1	3,818,429	-887,761	2,930,669
Pakistan	4	9,459,700	-6,959,766	2,499,934
Bosnia & Herzegovina	4	5,219,822	-2,878,746	2,341,076
Russia	4	9,598,192	-7,279,777	2,318,415
Canada	1	17,631,074	-17,465,876	165,198
Indonesia	2	0	0	0
Mexico	2	0	0	0
South Korea	2	-770,675	320,610	-450,065
Vietnam	2	-17,994,403	16,635,835	-1,358,568
Kenya	2	-16,863,690	14,953,707	-1,909,983
Mozambique	2	-11,424,342	8,616,742	-2,807,600
China	2	-316,930,047	313,699,946	-3,230,101
Italy	2	-68,848,536	65,568,770	-3,279,767
Croatia	2	-17,133,267	13,776,914	-3,356,353
Bolivia	2	-7,863,384	3,912,010	-3,951,374
Sudan	2	-4,211,087	108,605	-4,102,483
Sri Lanka	2	-4,301,331	186,266	-4,115,065
Belgium-Luxembourg	2	-5,365,103	1,179,088	-4,186,015
Senegal	2	-5,052,061	862,223	-4,189,838

Zimbabwe	2	-12,215,160	7,929,417	-4,285,743
Mauritius	2	-4,337,626	0	-4,337,626
Yemen	2	-4,693,129	173,332	-4,519,797
Bangladesh	2	-5,246,789	616,462	-4,630,327
Lebanon	2	-4,655,887	15,818	-4,640,069
Cyprus	2	-4,666,032	0	-4,666,032
Tanzania	2	-19,693,684	14,974,529	-4,719,155
Honduras	2	-8,028,624	3,220,785	-4,807,840
Slovenia	2	-7,230,180	2,261,006	-4,969,174
Panama	2	-5,402,121	430,733	-4,971,388
Jordan	2	-5,075,638	93,294	-4,982,344
Zambia	2	-8,312,453	3,308,317	-5,004,136
Libya	2	-5,066,729	8,511	-5,058,218
Costa Rica	2	-5,421,085	119,126	-5,301,960
El Salvador	2	-9,059,598	3,607,092	-5,452,507
Ecuador	2	-8,310,395	2,386,726	-5,923,669
Greece	2	-20,496,971	14,139,394	-6,357,577
Cuba	2	-6,562,586	0	-6,562,586
Guatemala	2	-11,682,662	4,967,934	-6,714,728
Peru	2	-13,113,143	6,258,229	-6,854,914
Algeria	2	-7,671,730	3,406	-7,668,324
Netherlands	2	-8,669,929	977,389	-7,692,539
Syria	2	-7,911,981	0	-7,911,981
Venezuela	2	-15,698,768	7,711,697	-7,987,071
Turkey	2	-24,084,676	16,034,538	-8,050,138
Saudi Arabia	2	-8,359,529	151,557	-8,207,972
Colombia	2	-16,650,701	7,662,577	-8,988,125
Malaysia	2	-10,363,537	349,630	-10,013,907
Iran	2	-15,293,149	4,883,617	-10,409,531
Egypt	2	-52,555,962	38,927,681	-13,628,281
Czech Republic	3	-2,194,608	-12,101,598	-14,296,206
Argentina	1	22,709,989	-47,099,824	-24,389,835
Nigeria	2	-31,825,904	0	-31,825,904
Germany	3	-23,256,453	-13,052,688	-36,309,141
North Korea	2	-39,569,164	0	-39,569,164
Japan	2	-40,103,626	0	-40,103,626
Spain	3	-37,066,976	-18,195,357	-55,262,332
Philippines	3	-34,583,943	-24,878,740	-59,462,683
South Africa	3	-50,317,745	-43,092,970	-93,410,716
USA	1	884,791,079	-986,061,468	-101,270,389
Romania	3	-69,400,487	-53,422,320	-122,822,807

Brazil	3	-205,837,242	-185,974,222	-391,811,464

Source: Created by authors based on simulation results.

Table A.12— Welfare effects for soybeans (Scenario B3 compared with base) by country in decreasing order of total surplus, in U.S. dollars per year

	Group	Consumer Surplus (USD$)	Producer Surplus (USD$)	Total Surplus (USD$)
India	2	-31,333,891	43,529,664	12,195,773
Ukraine	2	-712,144	10,248,947	9,536,803
Moldova	4	0	9,440,711	9,440,711
Austria	2	-217,046	9,583,355	9,366,309
Tanzania	2	0	9,332,821	9,332,821
Slovakia	2	-51,195	9,371,420	9,320,226
Vietnam	2	-986,436	10,237,045	9,250,609
Russia	4	-2,151,588	11,131,251	8,979,663
Ecuador	2	-425,826	9,404,555	8,978,729
Uganda	2	-770,629	9,551,946	8,781,316
Uruguay	1	7,583,946	-727,801	6,856,145
Bosnia & Herzegovina	4	2,115,105	-19,665	2,095,439
Kenya	2	0	0	0
Venezuela	4	0	24,517	0
Malawi	2	0	9,306,972	0
Romania	2	-4,177,058	1,001,095	-3,175,964
Sri Lanka	2	-3,317,201	8,441	-3,308,759
El Salvador	2	-3,535,429	12,577	-3,522,853
Poland	2	-3,667,056	527	-3,666,529
Bolivia	2	-11,016,874	7,304,446	-3,712,428
Zambia	2	-3864878	88967	-3775911
Germany	2	-3809443	4395	-3805048
Bulgaria	2	-3864116	25280	-3838836
Czech Republic	2	-3870776	30931	-3839845
Hungary	2	-4103575	262728	-3840847
Slovenia	2	-3843806	566	-3843240
Yugoslavia	2	-5088723	1214110	-3874613
Croatia	2	-4315811	436330	-3879481
United Kingdom	2	-3948360	0	-3948360
Zimbabwe	2	-4462323	502835	-3959488
Peru	2	-3974962	14977	-3959985
Colombia	2	-4370028	366736	-4003293
Honduras	2	-4050602	21288	-4029314

Guatemala	2	-4247123	204975	-4042148
France	2	-5448555	1237356	-4211200
Egypt	2	-4421879	187015	-4234863
Greece	2	-4320172	22261	-4297912
Philippines	2	-4351975	7373	-4344602
Turkey	2	-4717451	308842	-4408609
Italy	2	-8979589	4310612	-4668977
Indonesia	2	-11481954	6590847	-4891108
South Africa	3	-4878721	-954005	-5832726
Spain	2	-6309439	31406	-6278033
South Korea	2	-7525700	760536	-6765164
Thailand	2	-9155722	1839736	-7315986
Canada	1	13545563	-24910303	-11364740
Mexico	3	-10563844	-842515	-11406359
China	2	-102190929	87415271	-14775658
USA	1	475362089	-496772896	-21410807
Argentina	1	129875487	-165597097	-35721609
Paraguay	3	-18537941	-31789362	-50327303
Japan	2	-89364565	1097388	-88267177
Brazil	3	-189163459	-278298108	-467461567

Source: Derived from simulation results.

References

Bouët, A., Y. Decreux, L. Fontagné, S. Jean, and D. Laborde. 2008. "Assessing Applied Protection across the World." *Review of International Economics* 16 (5): 850–863.

Centre d'Etudes Prospectives et d'Information Internationales (CEPII). 2009. MacMaps Database consulted December 2009.
Available online. http://www.cepii.fr/anglaisgraph/bdd/macmap.htm

Devadoss, S., A. H. Aguiar, S. Shook, and J. Araji. 2005. "A Spatial Equilibrium of U.S.–Canadian Disputes on the World Softwood Lumber Market." *Canadian Journal of Agricultural Economics* 53 (2 & 3): 177–192.

Direccion Nacional de Mercados Agroalimentarios. 2004. *Contexto y Opciones Para La Exportacion Segregada de Maiz y Soja OVM y No OVM en Condiciones de Bioseguridad, Conforme al Protocolo de Cartagena.* Proyecto FAO/SAGPYA TCP/ARG 2903. Rome: UN Food and Agriculture Organization.

FAOSTAT .2010. Database available Online<http://faostat.fao.org/faostat/collections?subset=agriculture>.

Foster, M., and D. Galeano. 2006. *Biosafety Protocol-Implications of the Documentation Regime.* ABARE eReport 06.2. Canberra, Australia: Australian Bureau of Agricultural and Resource Economics.

Gruère, G. P. 2006. An Analysis of Trade Related Regulations of Genetically Modified Food and their Effects on Developing Countries. EPT Discussion Paper 147, Washington DC: International Food Policy Research Institute.

Gruère, G. P., and M. W. Rosegrant. 2008. "Assessing the Implementation Effects of the Biosafety Protocol's Proposed Stringent Information Requirements for Genetically Modified Commodities in Countries of the Asia Pacific Economic Cooperation." *Review of Agricultural Economics* 30 (2): 214–232.

Huang, J., D. Zhang, J. Yang, S. Rozelle, and N. Kalaitzandonakes. 2008. "Will the Biosafety Protocol Hinder or Protect the Developing World? Learning from China's Experience." *Food Policy* 33 (1): 1–12.

ICTSD (International Centre for Trade and Sustainable Development). 2006. "Constructive Ambiguity Saves LMO Labelling Discussions at MOP-3." 2006. *Bridges Trade BioRes* 6 (5): 1–3.

International Grains Council. 2010. Ocean Freight Rates. Available online http://www.igc.int/en/grainsupdate/igcfreight.aspx

James, C. 2008. *Global Status of Commercialized Biotech/GM Crops: 2008.* ISAAA Brief No. 39. Ithaca, NY: International Service for the Acquisition of Agri-Biotech Applications.

JRG Consulting Group. 2004. "Economic Assessment of the Ratification of the Cartagena Protocol, Based on the Outcome of the 1st Meeting of Parties." Final Report Prepared for Agriculture and Agri-Food Canada, Ottawa.

Kalaitzandonakes, N. 2004. *The Potential Impacts of the Biosafety Protocol on Agricultural Commodity Trade.* IPC Technology Issue Brief. Washington, DC: International Food and Agricultural Trade Policy Council.

Olson, M. 1965. *The Logic of Collective Action*. Cambridge, MA, US: MIT University Press.

Paarlberg, R. 2008, *Starved for Science. How Biotechnology is Being Kept Out of Africa*. Harvard University Press, Cambridge, MA.

Redick T. P. 2007. The Cartagena Protocol on Biosafety: Precautionary Priority in Biotech Crop Approvals and Containment of Commodities Shipments. *Colorado Journal of International Environmental Law and Policy* 18(Winter 2007):51–116.

Rosegrant, M.W., S. Msangi, C. Ringler, T.B. Sulser, T. Zhu and S.A. Cline (2008). "International Model for Policy Analysis of Agricultural Commodities and Trade (Impact): Model Description." Washington, D.C.: International Food Policy Research Institute.

Robinson, S., A. Cattaneo, and M. El-Said. 2001. "Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods." *Economic Systems Research* 13 (1): 47–64.

Samuelson, P. 1952. "Spatial Price Equilibrium and Linear Programming." *American Economic Review* 21: 283–303.

Secretariat of the COB (Convention on Biological Diversity). 2000. *Cartagena Protocol on Biosafety to the Convention on Biological Diversity: Text and Annexes.* Montreal, Canada: Secretariat of the Convention on Biological Diversity.

Sobolevsky, A., G. Moschini, and H. Lapan. 2005. "Genetically Modified Crops and Product Differentiation: Trade and Welfare Effects in the Soybean Complex." *American Journal of Agricultural Economics* 87 (3): 621–644.

Takayama, T., and G. Judge. 1971. *Spatial and Temporal Price Allocation Models*. Amsterdam: North Holland.

UN Comtrade . 2010. New York : United Nations Available at: http://comtrade.un.org/db/dqBasicQuery.aspx

You, L., and S. Wood. 2006. "An Entropy Approach to Spatial Disaggregation of Agricultural Production." *Agricultural Systems* 90 (1–3): 329–347.