Global welfare and trade-related regulations of GM food: Biosafety, markets and politics

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Abstract

This paper presents an overview of current and upcoming trade related regulations of genetically modified (GM) food, and analyzes their effects on trade, consumers, and producers. Using a three country analytical model of welfare and political interests, the study assesses the economic effects and motivation behind the adoption of import approval regulations, information requirements for GM commodity shipments, and GM food marketing policies. The results of the analysis show that in a non-GM producing country, trade-related regulations will benefit producers, but not necessarily consumers. Thus, while consumers may play a role in supporting import approval regulations, producers' support is likely to be instrumental to the adoption of all other types of regulations. Outside pressure groups will play the role of swing voters in cases where consumers and producers do not agree, such as on mandatory labeling of GM food, information requirements, or potentially to support GM-free private standards.

Key words: Genetically modified food, international trade, regulations, political economics.

1. Introduction

During the last fifteen years, genetically modified (GM) crops have been produced, consumed, and traded in an increasing number of countries. Still, only a few GM crops have been commercialized, and even fewer have been produced at a large scale- soybeans, cotton, maize, and canola still represent the almost entirety of global GM crop area. An increasing number of GM events have been commercialized for each of these crops, but few of the same traits have been used to improve other crops. This specialization coupled with the continued growth in adoption has resulted in an increasing share of these four crops

being GM. Today most of soybeans, half of maize, about a third of global cotton production and an increasing share of canola are likely GM.[1]

Because these four crops are major agricultural commodities, GM products have been largely traded internationally,[2] but the presence of diverging importers' preference and heterogeneous trade-related regulations have resulted in a double segmentation of the international market. First, geographical differences in national, regional and international regulations, in association with GM-free private standards, have contributed to the separation of markets for products that contain or may contain GM from their conventional counterparts purely based on non-GM material (with the purity level depending on each product, regulation, or standard). Second, each GM event[3] has been approved for production or import only in a limited set of countries, whereas many other countries have not adopted any regulations on the use of GM products.

This double division (geographic and event-based) has required an increased sophistication of food marketing systems worldwide. In particular, traceability and identity preservation systems have been developed to separate and track specific GM and/or non-GM products from the field to their end uses. Several examples illustrate this complexity. Brazil exports large volume of GM soybeans to China, which does not allow the use of GM soybeans, and therefore segregates its GM imports from non-GM domestic soybeans. South Africa produces GM and non-GM maize, imports GM maize from Argentina but not from the United States, and exports milled GM maize and non-GM maize grains to specific Southern African countries, but not others (Gruere and Sengupta 2010). The United States exports large quantities of GM maize to countries like Mexico and the Philippines, but also non-GM soybean products to Japan and non-GM maize to South Korea.

[1] For instance, the production of corn and soybeans in GM adopting countries represented 56% and 84% of the global production in 2005, respectively (own calculations based on FAOSTAT), and probably much more in 2010.
[2] GM soybean adopting nations covered over 94% of total soybean export volume and value in 2005, while GM corn adopting nations represented 80% of total volume and 77% of total value of corn the same year (estimates based on UN Comtrade).
[3] A GM event is a unique crop/trait combination commercialized (e.g., MON 810 Bt corn).

While the marketing system has adapted relatively quickly, it has also faced new challenges. On the seed side, some GM crops approved for particular purposes have moved to other countries or marketing channels without approval, creating trade tensions and regulatory reactions.[4] Moreover, several GM varieties that were being tested but not approved for use in any country have been unintentionally found in domestic and foreign markets. For example, two types of unapproved GM rice that were field tested in China and the United States were detected there and in the European Union (EU) - creating a series of import bans despite limited risks involved (Ledford 2007).

In this setting, trade-related regulations of GM food are key factors in understanding the dynamic of adoption of GM crops and the contribution of these technologies to global welfare. They affect exporters, importers, but can also have spillover effects on the regulatory and adoption decisions of countries that do not produce nor consume GM products (e.g., Paarlberg 2008). While officially designed for public goals, these regulations may also serve less laudable political goals, and have unwanted market effects (either domestically or internationally).

The purpose of this paper is to present an overview of current and upcoming trade-related regulations of GM food, and to analyze their effects on trade, consumers, and producers in a comprehensive manner. More specifically, we review the effects of import approval authorization, the possible impact of documentation requirements for GM commodities, and the effects of GM food labeling and GM-free private standards. Each type of regulation is analyzed based on available evidence from the literature, a qualitative assessment of key political actors and their role, and an analytical model assessing their main trade and welfare effects and the possible rationale for their existence.

Past literature on GM food and international trade has mostly focused on three issues: a) the choice of import regulations, b) the export side or the economic effects of trade-related regulations, and c) the issue of global competition and GM technology adoption (Smale et al. 2009). More specifically, most published papers used simulation models to evaluate the potential effects of GM crop adoption in various

[4] Starlink corn, for example, was intended for animal feed, not human consumption.

regions under different regulatory and competition scenarios.[5] Other ex-ante analyses focus on the optimal choice of regulations (e.g., Plastina and Giannakas 2007), or on positive evaluations of introducing new trade-related regulations (e.g., Gruere and Rosegrant 2009). Fewer studies provide ex-post analyses, perhaps because of insufficient time series data available. Among those, a few papers analyze the observed trade effects of GM adoption in the presence of existing regulations (Purcell and Kalaitzandonakes 2004; Smyth, Kerr, and Davey 2006, Vigani et al. 2009), while others try to explain the current pattern of regulations (Anderson and Jackson 2003, Graff et al. 2009, Gruere et al. 2009).

This paper aims to add to the very last category and provide a primer on trade-related regulations of GM food. While referring to the results other studies, the paper aims to be a positive analysis of current and upcoming regulations. Unlike previous contributions, the goal is to assess trade-related regulations in a comprehensive manner, and provide the reader with a synthetic and political economic outlook of the growing complexity of the GM trade regulatory world.

In what follows, we define GM food as raw and processed products derived from GM crops and used for food and/or animal feed.[6] To our knowledge, there are no trade-related regulations on non-food or non-feed products from GM crops (e.g., cotton fibers derived from GM cotton),[7] so we do not consider those. The paper is organized as follows. After defining our model, we first look at import approval, then consider traded shipment requirements, and market regulations and standards in the importing country. We conclude on the current and future challenges of adapting to an increasingly complex trading environment.

2. The basic model

[5] See Smale et al. (2009) for a list of recent papers that include developing countries.
[6] These products represented an average trade value of $42 billion/year for 2000-2004 (Gruere 2006).
[7] Cotton is however subject to GM-free private standards like organic or fair trade labeling.

We use a three-country partial equilibrium model to represent the present situation for a food or feed crop. Because most of the current GM crop producers are also exporters,[8] we separate the GM exporter from two types of non-adopting importers. Let country A be producing GM and non-GM variants of the product and exporting both to the world. More specifically, A produces two GM events, a past event g_1 and a new event g_2 of the same product. Based on export market requirements, A can also produce a conventional non-GM version *n* which can be separated from the GM marketing channel using a costly identity preservation system at cost c_s. Country B, which will be the main focus of our analysis, produces *n* but is also a net importer of products from A and has specific regulations for GM crops. Country C is another importer of products from A without specific regulations for GM or non-GM.[9]

To assess the welfare effect of each regulation, we make some simplifying assumptions. In Country A, we focus on exporting producers. In country B, we assess the effects of new regulation on domestic producers and on three groups of consumers: non-GM consumers, indifferent consumers that disregard the presence of GM or non-GM in their purchasing choices, and switching consumers with a propensity to change their purchasing decision according to the labeling policy (Bansal and Gruere 2010). In country C, we will evaluate the effects of regulations on producers and consumers.

Regulations in country B are the results of political decisions, which indirectly depend on welfare effects of the main pressure groups. We use the framework of Gruere et al. (2009) on GM food labeling as a basis of analysis, with the addition of food safety as a public goal. Three main groups are represented: agricultural producers *AP*, consumers/voters *CV* (which includes the three subgroups), and non-governmental bodies *NO* (that represent anti and pro-GM groups). While producers and consumers' positions are determined by economic welfare, *NO*'s welfare depends on the balance of forces on the ground- if the anti-GM forces dominate they will push for a non-GM agenda, and conversely.

[8] See Footnote 2.
[9] These countries could be representing regions, such as North America and Argentina (A), European and Asian nations with GM regulations and low or no GM adoption (B), and many of the remaining developing nations (C).

In each group *l*, an individual voting member *k* prefers regulating (*R*) to not regulating (*NR*) if and only if: $W^l(R) \geq W^l(NR)+\sigma^{kl}$ where $W^l(.)$ is the welfare function associated with the regulation, and σ^{kl} is an idiosyncratic parameter representing voter *k*'s belief. For simplicity we assume that σ^{kl} is drawn from a uniform distribution, on a range centered on zero, i.e., $\sigma^{kl} \rightarrow U[-1/(2\varphi^l), 1/(2\varphi^l)]$ (with $\varphi^l>0$). In each group, the indifferent member (or swing voter) is defined by the parameter σ^l so that $\sigma^l = W^l(R) - W^l(NR)$. Any voter *k* such that $\sigma^{kl} < \sigma^l$ prefers regulating, and conversely any individual voter *k* such that $\sigma^{kl} > \sigma^l$ opposes regulating.

Each group determines his position according to a vote equivalent. The intensity of the message delivered by each group depends on the proportion of members approving it. The adoption decision by policymakers will be made according to the weighted sum of support of each group. We compute the probability of voting or the proportion of vote equivalents for a particular regulation *R* as: $V(R)=\sum \gamma^l F(\sigma^l)$ where $F(.)$ is the cumulative density function (c.d.f.) of σ and γ^l is the political weight of group *l*. Substituting the c.d.f of the Uniform distribution, this gives:

$$V(R) = \sum \gamma^l \varphi^l (\sigma^l + (1/2\varphi^l)) = \tfrac{1}{2} + \sum \gamma^l \varphi^l \sigma^l \qquad (1)$$

To obtain a majority of vote equivalents for the regulation, the second term has to be positive: $\sum \gamma^l \varphi^l \sigma^l \geq 0$. Thus, three factors affect the outcome: the weight given to each group in the final decision (γ^l), the degree of homogeneity in each group (φ^l), and the welfare change associated with the new policy for each group (σ^l).

At the end, the policymaker will balance the will of its constituents $V(R)$ with his own assessment of safety related matters, which is represented by the relative difference in perceived safety ΔS with the regulation compared to the status quo $\Delta S=(S(R)-S(NR))/S(NR)$. The utility score of the decision maker for a particular regulation is assumed to be the following:

$$U_{DM}(R) = \Delta S + (1 - \Delta S) V(R) \qquad (2)$$

Because ΔS and $V(R)$ are set to be in [0,1], this function is also within [0,1], and it is set up to ensure that perceived safety effects dominate constituents' preference. This "total utility score" will lead to a yes decision for any score greater or equal to ½.

While the weight and concentration parameters depend on the country and group, the welfare effects σ^j will be computed in the respective groups (producers *AP*, consumers *CV*) in each country. For simplification, we assume a linear supply and demand in the three countries with the following functional forms for product i in country j: $p_i^j = c_i^j Q_i^j$ on the supply side and $p_i^j = a^j Q_i^j + b^j + \Psi_i(\lambda)$ on the demand side. Unless specified for particular scenarios, we assume that $\forall j \in \{A, B, C\} \quad a^j < 0,\ b^j > 0,$ $0 < c_{g_2} < c_{g_1} < c_n^j$. $\Psi_i(\lambda)$ represents the utility shifter for the quality component of the product as perceived by consumers of country B. It depends on the type of consumers and labeling regulations as defined in Table 1. For simplicity, we assume that non-GM consumers will always try to avoid GM products and switching consumers will only buy non-GM with mandatory labelling.[10]

Table 1. Product consumed and quality function $\Psi_k(\lambda)$ for the three consumer groups in country B

Type of consumers	Non-GM	Switching	Indifferent
No labeling	Mixed / -λ	Mixed/ 0	Mixed/0
Voluntary labeling	Non-GM / λ	GM/0	GM/0
Mandatory labeling	Non-GM/ λ	Non-GM/ λ	GM/0
GM-free private standards	Non-GM/ λ	Non-GM/ 0	Non-GM/0

Prices are obtained by setting excess supply equal to excess demand in the world market for each specific product. Producer welfare in all countries is defined by profits $\Pi_i = p_i Q_i - C_i(Q_i)Q_i$ where p_i and Q_i are the prices and quantities, and $C_i(Q) = c_i Q_i/2$ is the unit cost function for variant i. Consumer welfare is equal to the Marshallian consumer surplus (*CS*) in countries A and C. In country B, we define it as:

[10] More flexible models could be used to capture changes in variants- e.g., see Gruere et al. (2008).

$$U^B(R) = (\sum_t \alpha_t CS_t - T(R))(1 - \Delta S) \quad (3)$$

where *T(R)* is the possible tax imposed with each regulation and α_t is the share of consumers of group *t* (Non-GM noted *NG*, switching *S*, indifferent *I*). The model is solved by a) determining the price(s) at equilibrium, b) computing the welfare effects, c) assessing the majority of vote equivalent in B, and d) determining the decision maker's utility score.

3. Regulating imports: import approval and low level presence

The first and most important regulation is the authorization to import a specific GM event in a given country. There are two distinct issues: importing seeds or planting material for experiment or crop production, and importing GM products or processed products derived thereof. Since we focus on commodity trade of GM food products, we will only treat of the approval for products intended for processing, food or feed.

Not all countries have implemented import regulations for GM products, but those that have typically require an application with food or feed safety data from the developer for each new GM product (Gruere 2006). The product then goes through an evaluation by a scientific body giving an opinion, but the final approval decision depends on policymakers. Although the exact modalities differ across countries, the food safety data requirements tend to be relatively similar, following OECD and Codex Alimentarius principles, even if the assessment may be more or less strict. Carter and Gruere (2006) provide a review of the approval processes in Japan, Australia and New Zealand, and the European Union (EU). They note that the observed differences are mainly at the policy level, where different layers of political representations are involved.

While most developed countries have functional import regulatory systems, other countries can be divided into those that have not enforced their regulations, those with no regulations, and those with

official bans of GM products (Gruere 2006). Very few countries have official bans of GM products, and they are mostly in Southern Africa (Gruere and Sengupta 2010). Most developing countries have no regulation, but may apply some regulations in the future, following guidance under the Cartagena Protocol on Biosafety (CPB) to which they are members. Among others, the CPB allows rejecting imports even in the absence of proven risk, but this bears the risk of being in violation of countries' WTO obligations (Winham 2003).

Even among developed countries, several regulations have been slow to become functional, and still face political challenges. A key example is that of the EU, which applied a moratorium on new GM varieties from 1998 to 2003. This moratorium was the object of a WTO dispute launched by Canada, Argentina and the United States in 2003. The 2006 ruling by the WTO Dispute Settlement Body did not provide any qualified opinion on scientific matters, but did found that the EU violated the Sanitary and Phytosanitary (SPS) Agreement (WTO 2006) and requested the EU members to change their regulations and stop the moratorium. If the EU revised its regulatory system to a certain extent, several EU members still have to comply with this decision.[11]

The main issue of an importing regulating country is to ensure the safety of incoming products. Therefore the goal is to reject all unapproved material at the border, regardless of quantities, but this proves to be challenging if not unrealistic in a globalized economy. In principle, a country would prefer to have a 0% tolerance for non-approved GM events. However, because GM products are largely traded commodities in a bulk marketing system, accidentally mixing frequently occur, and is often unavoidable, resulting in low level presence of different types of GM events in commodity shipments.[12] The multiplication of approval of GM events in large exporting countries associated with lengthy approval

[11] Since then, Canada has concluded an agreement the EU to settle the dispute. The United States has also been discussing a similar agreement with the EU (ITCSD 2009).

[12] In fact, the accidental presence of non approved material is a well known reality- for instance the presence of non-grain organic material (animal and plant waste) is commonly accepted in traded shipments below 2%.

processes at importers has resulted in an increasing pressure on regulating importers to lift their 0% tolerance.

This phenomenon, called asynchronous approval of GM events, has created a number of incidents where the importing countries had to reject large shipments of grains or oilseeds, because of minute traces of unapproved GM material at the port (Gruere 2009, Stein et al. 2009). As a consequence, importers had to substitute for other non-GM products at a higher cost, sometimes paying a significant premium to avoid traces of unapproved GM events.

Economically, while approval regulations will be beneficial to all consumers if they do increase the safety of imported food, they bear two types of costs. First, obtaining approval in each country of import is a fixed cost for biotech developing companies in the exporting country. While these companies had to obtain approval for production in the country, each importer has slightly different testing and documentation requirements, that add to the overall cost of marketing a product. Second, if the importing country's approval decision happens after the commercialization in the exporting country (assuming a 0% tolerance level), the importers face a temporary tariff equivalent, in the sense that they have to procure a substitute for the original mixed GM commodity at a higher price until approval is granted. This tariff equivalent also applies to commodities transported in the same fashion- e.g., soybean or wheat shipments can be found to contain trace levels of unapproved maize.

This temporary barrier is eliminated when the import authorization is granted, but it can also remain in place indefinitely if it is used as pretext for regulatory reform. South Africa provides a key example (Gruere and Sengupta 2010). In 2003, under pressure by domestic maize producers, the GM import authorization procedure (called commodity clearance) was eliminated, and since then imports have been subject to the regular procedure for a new GM crop planting approval. Thus, no GM product can be imported unless it shows no environmental risk and a significant agronomic advantage for farmers. This decision, which was highly contested by the animal feed industry, has resulted in the blocking of U.S.

imports of maize that may contain a GM maize event resistant to corn rootworm, because this GM event does not provide any agronomic advantage in South Africa.

The use of zero percent tolerance levels by major importing countries has also created a disincentive to the development and use of publically developed GM crops especially in developing countries. The fact that a minimum trace of unapproved GM event in countries of the EU or Japan can trigger bans or penalties creates new challenges for public biotech research organizations. To avoid this situation, public sector developers would need to obtain approval in all major countries, a significant additional cost they may not always be able to bear. In some cases, these organizations can also face a rejection by domestic authorities if potential export risks are considered in an approval decision. South Africa recently rejected the commercialization of the first publically-developed GM potato variety intended solely for small-scale non-exporters, mostly because of the fear of export loss of the commercial potato industry.

Past studies have tried to track the effect of GM regulations on trade and found a relatively small effect (Cadot et al. 2003, Parcell and Kalaitzandonakes 2004, Smythe et al 2008). These studies generally did not separate the effects by type of regulation, and it is therefore difficult to assess the effect of import approval. Nonetheless, while focusing on transatlantic exchanges, they tend to find that trade was not affected significantly by GM policies in the recent past, even if trade diversion may have occurred because of GM regulations. In a different setting, however, cases where a domestically unapproved GM event did enter the global commodity chain, like Starlink, or the more recent Liberty Link Rice 601, did have significant market effects (Carter and Smith 2007). These cases generated series of bans of commodities in many countries at a huge cost for domestic producers.

To assess the potential welfare implications of these regulations, we compare five scenarios, defined in Table 2.[13] Each scenario represents a step in the approval procedure of new GM events in Country A, with different regulatory response in country B.

Table 2. Scenarios with import approval

Country	A	B	C
Scenario 0: No regulation	Exports g_1	Imports g_1	Imports g_1
Scenario 1: B bans g_1	Exports g_1 and n	Imports n at a cost c_s	Imports g_1
Scenario 2: B approves g_1	Exports g_1	Imports g_1	Imports g_1
Scenario 3: A approves g_2	Exports g_1 and g_2	Imports g_1 at a cost c_s	Imports g_2
Scenario 4: g_2 approved in B	Exports g_2	Imports g_2	Imports g_2

Table 3. Equilibrium prices under the five scenarios.

Scenario	Countries A and C	Country B
0	$p_0^W = \frac{-\frac{b^A}{a^A}-\frac{b^C}{a^C}-\frac{b^B}{a^B}+\frac{\alpha_{NG}\lambda}{a^B}}{\frac{1}{c_{g_1}}+\frac{1}{c_n^B}+\frac{1}{c_n^C}-\frac{1}{a^A}-\frac{1}{a^B}-\frac{1}{a^C}}$	
1	$p_g = \frac{-\frac{b^A}{a^A}-\frac{b^C}{a^C}}{\frac{1}{c_{g_1}}+\frac{1}{c_n^C}-\frac{1}{a^A}-\frac{1}{a^C}}$	$p_n = \frac{-\frac{b^B}{a^B}-\frac{\alpha_{NG}\lambda}{a^B}+\frac{c_s}{c_n^A}}{\frac{1}{c_n^A}+\frac{1}{c_n^B}-\frac{1}{a^B}}$
2	$p_2^W = \frac{-\frac{b^A}{a^A}-\frac{b^B}{a^B}-\frac{b^C}{a^C}+\frac{\alpha_{NG}\lambda}{a^B}}{\frac{1}{c_{g_1}}+\frac{1}{c_n^B}+\frac{1}{c_n^C}-\frac{1}{a^A}-\frac{1}{a^B}-\frac{1}{a^C}}$	
3	$p_{g_2} = \frac{-\frac{b^A}{a^A}-\frac{b^C}{a^C}}{\frac{1}{c_{g_2}}+\frac{1}{c_n^C}-\frac{1}{a^A}-\frac{1}{a^C}}$	$p_{g_1} = \frac{-\frac{b^B}{a^B}+\frac{\alpha_{NG}\lambda}{a^B}+\frac{c_s}{c_{g_1}}}{\frac{1}{c_{g_1}}+\frac{1}{c_n^B}-\frac{1}{a^B}}$
4	$p_4^W = \frac{-\frac{b^A}{a^A}-\frac{b^C}{a^C}-\frac{b^B}{a^B}+\frac{\alpha_{NG}\lambda}{a^B}}{\frac{1}{c_{g_2}}+\frac{1}{c_n^B}+\frac{1}{c_n^C}-\frac{1}{a^A}-\frac{1}{a^B}-\frac{1}{a^C}}$	

[13] We assume that A will produce non-GM under scenario 1, which will only happen with a sufficiently small cost of segregation. If it is prohibitive, the price of non-GM is the autarky price in B.

Setting up demands and supplies, we obtain the equilibrium prices shown in Table 3. Comparative statics show that, under our assumptions, $p_0^W = p_2^W > p_4^W$, $p_{g_2} \leq p_g$, and $p_{g_1} \leq p_n$. Under most likely conditions,[14] $p_g \leq p_n$ and $p_{g_2} \leq p_{g_1}$. The comparisons between the world prices and p_g or p_{g_2} are much more ambiguous and depend on demand and supply parameters. If the supply effect dominates, the price of GM in scenarios 1 or 3 will be higher than the price without trade restriction (scenarios 0, 2 and 4). If the drop in demand dominates, the price of GM will be lower than world prices with the same technology. Nonetheless, this partial comparison can help rank scenarios for welfare as shown in Table 4.

Table 4. Comparison of scenarios in terms of welfare in the three countries.

	Producer welfare	**Consumer welfare**
Country A	Example (scenario 0): $\Pi_0^A = \left(1/2\, c_{g_1}\right)(p_0^w)^2$ Due to segregation costs, 1 and 3 less beneficial, 4 is better than 2 and 0.	Example (scenario 0): $U_0^A = -(b^A - p_0^w)^2/2a^A$ Best outcome under scenarios 3 or 4.
Country B	Example (scenario 1): $\Pi_1^B = (1/2c_n^B)(p_n)^2$ Most likely ranking: 1 >3 >2 ≥ 0 >4.	Example (scenario.1): $U_1^B = \left[\frac{(1-\alpha_{NG})(b^B-p_n)^2}{2a^B} + \frac{\alpha_{NG}(b^B+\lambda-p_n)^2}{2a^B} + T(R)\right](1 - S(R))$ Overall, 4 better than 2, which is better than 0. 3 is the worst market outcome, 1 is best for non-GM consumers.
Country C	Example (scenario 2): $\Pi_2^C = (1/2c_n^C)(p_2^W)^2$ Better off under 0 or 2, compared to 4. 1 is better than 3.	Example (scenario 2): $U_2^C = -(b^C - p_2^w)^2/2a^C$ Best market outcome under 3 or 4, but it depends on additional risk with g_2.

[14] Especially-but not only- if the share of non-GM consumers is important, that they are strongly opposed to GM and/or if the cost of segregation is non-trivial.

While approval regulations can be beneficial to guarantee the safety of consumers (scenario 2 is better than 0), delayed approval processes (scenario 3) can be expensive and detrimental to consumers, particularly those that are not adamantly opposed to GM. Consumers in C may gain from such situation (scenario 3), if the exporter's product approval has been sufficiently rigorous and the product does not represent additional risks. On the supply side, B producers naturally benefit from stricter regulations on imports, while producers in A may lose if the segmentation under (1 or 3) is costly, and C producers can win or lose depending on structural parameters.

In vote equivalents, in country B, a sufficient condition for $\sum \gamma^l \varphi^l \sigma^l \geq 0$ is that all groups benefit from the regulations, i.e. $\sigma^l \geq 0$. Producers will have positive welfare gains compared to the status-quo (scenario 0) in scenarios 1, 2 and 3. Of these, 1 and 3 may lead to positive or negative welfare effects for consumers, while 2 is positive for both consumers and producers. This means that, assuming the non-governmental group *NO* is not strictly opposed to an approval regulation,[15] $V(R) > 1/2$.

Overall, given these results, if the decision maker believes that an import approval procedure increases (or does not decrease) consumer safety ($\Delta S > 0$), he will pass a regulation as $U_{DM}(R) \geq \Delta S + \frac{1-\Delta S}{2} > \frac{1}{2}$. A ban (scenario 1) may occur if the decision maker is convinced that any GM is risky despite contradicting scientific evidence, if producers have a strong political weight (γ^{AP}),[16] and/or if non-GM consumers largely dominate the population ($\alpha_{NG} \approx 1$) with a very high willingness to avoid GM (λ). A non-tariff barrier (scenario 3) can appear if the imports are low, and the local producers have a strong representation, a higher voice than consumers ($\gamma^{AP} > \gamma^{CV}$), and are potentially supported by anti-GM groups.

[15] This is unlikely given that B does not produce GM.

[16] For instance, in Zimbabwe, where consumers have no voice, domestic producer lobbies have been strong supporter of a GM maize ban, despite expected disastrous consequences (Gomo 2010). In Zambia, the president did ban imports in 2002 largely to support domestic producers' interest (Gruere and Sengupta 2009a).

4. Information requirements on shipments under the Protocol

The Cartagena Protocol on Biosafety (CPB) 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). Among the key measures of the Protocol, there are specific rules for LMOs intended for direct uses as food, feed or processing (noted LMO-FFPs), which are essentially unprocessed GM commodities. These products represent more than half of total import values of the four main GM commodities (Gruere 2006).[17]

In particular, 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 it also noted that a more specific rule on information requirements should be determined at a later date. At a March 2006 meeting in Brazil, 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. 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 precise 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 in 2010, with the possibility of making the stringent "does contain" option mandatory for all countries in 2012 (Gruere and Rosegrant 2009).

While the benefits of this proposed regulatory change are not clear, its implementation would generate significant new costs (e.g., Gruere and Rosegrant 2009). More specifically, under the "does contain" rule, countries that export GM would have to test each shipment to verify the accuracy of GM-

[17] Approximately 51% of soybeans and 88% of maize import value comes from unprocessed commodities (Gruere 2006).

event identification. Even if the GM-producing countries export a non-GM commodity, they would still have to conduct additional tests in order to make sure the quantity of GM crops in the shipment was lower than the potential threshold levels set up by importers. Importing CPB member countries 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 these requirements.

Previous studies have analyzed the likely 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) or Australia (Foster and Galeano 2006), reporting that the costs of such change would be potentially significant. Using a multi-region computable general equilibrium model, Huang et al. (2008) show that it would affect the prices of maize and soybeans, increasing world prices overall. While their results show that the cost of implementation would be large globally, but not really significant for China (their focus country), they note that smaller developing countries would likely pay a higher price. Gruere and Rosegrant (2009) assess the potential implementation costs of article 18.2.a on all countries member of the Asia Pacific Economic Cooperation, and provide a range of cost estimates for exporters and importers, noting the disproportional cost for less developing countries that have been supportive of this measure. They also show that it would effectively constitute a new entry cost for GM adoption and for Protocol membership in this region.

Economically, the benefits are difficult to measure, simply because they are not obvious, unless one counts the use a GM event list as justification for a ban, for the benefit of a policy maker's popularity. As long as there are at least two GM events being exported, the measure will act as a selective tariff that depends on testing requirement and the degree of enforcement by importers. This technical barrier will likely apply to all products, whether GM or not, coming from GM producing countries, but unlike scenario 3, it will be a lasting and limited tariff, not a temporary potentially prohibitive one. Furthermore, it will apply to many more countries, because many developing countries without regulations are CPB members.

The proposed regulation is modeled as an additional transport cost for GM and non-GM for A to B and C, assuming that B and C are CPB members. We use an alternative to scenario 4 as the basis of analysis. In scenario 4, A only produces and exports g_2 to A and B, but here we assume that g_1 is still present in the commodity chain (as a residual presence or due to stocks) when the measure enters into force. All shipments have to be tested to know whether there is g_1 or not. Assuming a per unit cost τ, we obtain the following new price for the world:

$$p_5^W = \frac{-\frac{b^A}{a^A} - \frac{b^C}{a^C} - \frac{b^B}{a^B} + \frac{\alpha_{NG}\lambda}{a^B} + \frac{\tau}{c_{g_2}}}{\frac{1}{c_{g_2}} + \frac{1}{c_n^B} + \frac{1}{c_n^C} - \frac{1}{a^A} - \frac{1}{a^B} - \frac{1}{a^C}}$$

Naturally, we find that $p_5^W > p_4^W$. For B, it will slightly increase the cost of imports and raise domestic prices, for C it will include new costs for consumers. A exporters will all lose. The rent will go to testing companies present in A, B and C. The situation is slightly different if C is not member: the price of the good may fall in C to the benefit of consumers and at the detriment of producers.

The observed support among CPB members for this new regulation is singular, as it is essentially unrelated to safety (Gruere and Rosegrant 2009) and therefore seems to be mostly driven by anti-GM sentiments. Assuming that the decision maker does not consider it a safety related matter, his decision function simplifies to: $U_{DM}(R) = V(R) = ½ + \sum \gamma^l \varphi^l \sigma^l$. Knowing that consumers will lose, B's decision maker will support it ($\sum \gamma^l \varphi^l \sigma^l \geq 0$) only if producers vocally push for it (large $\gamma^{AP} \varphi^{AP} \sigma^{AP}$) with support from anti-GM lobbies and minimum opposition from consumers (e.g., assuming τ is relatively small or that they are uninformed about this technical measure).

At the international level, Country C may or may not support the decision, depending on the voice of consumers. A lot of developing countries (especially in Africa) have let their environmental representatives support this measure as an additional restriction to what they see as potentially hazardous products, that need to be labeled as such, without accounting for unaware consumers and the effect it would have on prices (Gruere and Rosegrant 2009).

5. Marketing regulations and standards

Three types of marketing policies have trade-related implications: traceability, GM labeling, and GM-free private standards. This section will only briefly discuss the EU traceability requirements, to mainly focus on labeling policies and private standards, and their role on affecting demand, prices and market access.

Traceability is an important regulatory requirement for GM traded products, but it is only applied in the EU since 2004. The main differences between traceability and other marketing policies are its focus on safety and the fact that its implementation cost focus solely on GM products and suppliers. Labeling policies are not designed as safety measure (Gruere and Rao 2007). Moreover, in most cases, the cost of labeling will be borne by non-GM providers, either because exporters want to signal their non-GM status (voluntary labeling/private standard) or because they want to avoid a GM label (mandatory labeling) in markets adverse to GM. On the one hand, this GM-target is justified by the fact that traceability is designed to help conduct recall in cases of food safety crises. On the other hand, this regulatory requirement adds a new cost of entry to the EU for GM products only, which may be beneficial to domestic non-GM producers that represent a very large majority of producers in the EU. Essentially traceability can be modeled as a safety measure with a significant fixed cost (setting up a tracking system) plus some smaller variable costs (labor, tests, documentation, archives) that are applied solely to GM imports. While industrialized or large-scale exporters may be able to comply with it without much difficulty, traceability may prevent others to export GM products to the EU, as observed in other markets.

In contrast, many countries have adopted GM food labeling policies. The economic implications of GM labeling have been largely discussed in the literature; this section will only focus on labeling and trade. While a large number of labeling policies have been adopted over the world (Gruere and Rao 2007), there is a clear dichotomy in labeling approaches between voluntary labeling and mandatory labeling (e.g., Runge and Jackson 2000).

Mandatory labeling requires food companies to display the presence of certain GM ingredients (or ingredients derived from GM crops) on food products over a specific threshold level. Each regulation has a different coverage and different exemptions. While developed countries have relatively well enforced regulations, virtually all developing countries still have to enforce their regulations (Gruere and Rao 2007). Unlike other consumer regulations, mandatory labeling directly applies to decisions for food companies, not consumers, and therefore does not guaranty consumer choice (Gruere et al. 2008). Still, the companies' decision to use GM ingredients is indirectly related to consumer preference. The cost structure of labeling and its effect on demand by food companies (and ultimately consumers) are primordial in its ultimate market effect. Together with the degree of enforcement, these factors largely predict what the effect of labeling will be in a particular market (Bansal and Gruere 2010).

Consequently, the trade effect of labeling also depends on these three factors. So far, the evidence has shown that companies have been keen to avoid labeling their products as GM in virtually all countries with enforced mandatory labeling regulation. China is the only confirmed exception where GM labeling resulted in all targeted products being labeled as GM (with a limited demand shift see Lin et al. 2008).

While there is evidence that trade considerations play a role in explaining labeling regulations (Gruere et al. 2009, Vigani et al. 2009), introducing a mandatory labeling policy does not guarantee market access. Having a domestic labeling policy in the exporting country may be reassuring for importers, assuming the labeling is actually enforced. But labeling domestic consumer goods will generally not be sufficient to obtain market access to a labeling country. For instance, introducing GM labeling in India would not help basmati rice exporters keep their non-GM market in Europe, while it would bear significant costs to an entire country (Bansal and Gruere 2010). Regardless of the domestic labeling policy, these exporters will need to ensure that their rice is non-GM. A more convincing explanation relates to trade agreements and political influence; in a bipolar regulatory world,

memberships to free trade agreements seem to be increasingly used to support a particular position (precautionary or science-based) on GM regulations.[18]

The case of voluntary labeling is fundamentally different in that it is a bottom-up approach. Companies may or may not decide to label their products as GM or non-GM; non-labeling is an option. In a perfectly competitive market with no political distortion, voluntary labeling may lead to exactly the same outcome as mandatory labeling for consumers (Bansal and Ramaswami 2007). But its outcome will be more directly linked to consumer demand than mandatory labeling (Gruere et al. 2008).

Currently, voluntary labeling schemes apply to non-GM products in market in the presence of consumers willing to pay to avoid GM products. A large share of the non-GM products available in retail market is in fact organic before being non-GM. Still, non-GM, non-organic grains are traded internationally. For instance, the Japanese Tokyo Grain Exchange does have a quote for non-GM soybeans that are sold for a significant price premium.[19]

In certain countries like Japan or South Korea, non-GM claims have long been displayed on numerous products, despite the existence of a mandatory labeling policy, as publicity and potentially a support for stricter standards than those in the official mandatory labeling policy.[20] The growing market presence of non-GM labels in these countries demonstrates the low informative value of mandatory labeling of GM food. Non-GM labels would appear without mandatory labeling in these countries, but it would not prevent other GM products to appear on the retail shelves (Gruere et al. 2008).

Voluntary labeling claims are generally supported by GM-free private standards that are set up by food companies, traders or retailers (Knight et al. 2008). But while these standards can use labeling as a selling argument, not all GM-free private standards are associated with non-GM labels. A number of large

[18] Certain countries in Asia were reportedly encouraged to adopt mandatory labeling of GM food as a precursor to discussing free trade agreements (FTAs) with the EU (personal conversation with national Codex representatives on labeling, February 2009), while others (like Malaysia or South Korea) had to balance their interest for FTAs with the United States with their labeling regulations (Ahn 2008, Merrett 2007).

[19] Gruere (2009) shows that the average premium for non-GM soybean sold in this market were about 24% in 2008.

[20] The same trend is occurring in Europe where non-GM claims have recently been allowed.

food companies use blanket GM-free private standards (often on all products), without using it as a selling point. For instance, General Mills and Frito-Lay apply non-GM policies without non-GM claims in the United States (Gruere et al. 2008). McDonalds' decision to reject GM potatoes has resulted in the abandonment of Bt potato in North America (Gruere and Sengupta 2009a). The rationale for such standard may be a combination of brand and reputation insurance at a low cost.

While set up privately and therefore not official "regulations", these standards increasingly decide what product gains market access. Before mandatory labeling was fully enforced in the EU, several retailers companies had already set up GM-free policies (Bernauer 2003, Gruere and Sengupta 2009a). With market concentration, these standards rapidly started to affect the type of GM products sold in countries of Europe, Australia, New Zealand, Japan or South Korea, in the favor of animal feed.[21] There is also evidence that GM-free private standards at importers have played a significant role in biosafety policy making in developing countries (Gruere and Sengupta 2009a).

The model is used to assess the welfare effects and rationale for these different approaches. Three scenarios are considered, as shown in Table 5. Country B's demand differs according to the group of consumers and the standards (following Table 1). We assume that mandatory labeling results in a small share of GM products, not a corner solution with only non-GM, but scenario 8 represents a case with a corner solution. Segregation costs differ according to the specific policy, with voluntary labeling bearing an additional marketing cost *K* (following Gruere et al. 2008). Lastly, we assume that A will export non-GM to B in the three scenarios, which will only occur if it is at least as profitable as GM for these producers.[22]

[21] Labeling may have generalized this phenomenon in these markets to filter only products exempted from regulatory requirements.
[22] More flexible models could address this issue; here, we focus on the current market situation with coexistence in most exporters.

Table 5. Scenarios with marketing standards

Country	A	B	C
Scenario 6: Voluntary labeling in B	Exports g_2 and n	α_{NG} consume non-GM	Imports g_2
Scenario 7: Mandatory labeling in B	Exports g_2 and n	α_{NG}+ α_S consume non-GM	Imports g_2
Scenario 8: GM-free private standards in B	Exports g_2 and n	All consume non-GM	Imports g_2

Table 6. Equilibrium prices in the three scenarios.

Scenario	GM (sold in A, B, and C)	Non-GM (sold in B)
6. Voluntary labeling	$p_g^{VL} = \frac{-\frac{b^A}{a^A} - \frac{b^C}{a^C} - (\alpha_I + \alpha_S)\frac{b^B}{a^B}}{\frac{1}{c_{g_2}} + \frac{1}{c_n^C} - \frac{1}{a^A} - \frac{\alpha_I + \alpha_S}{a^B} - \frac{1}{a^C}}$	$p_n^{VL} = \frac{-\frac{\alpha_{NG}(b^B+\lambda)}{a^B} + \frac{c_S+K}{c_n^A}}{\frac{1}{c_n^A} + \frac{1}{c_n^B} - \frac{\alpha_{NG}}{a^B}}$
7. Mandatory labeling	$p_g^{ML} = \frac{-\frac{b^A}{a^A} - \frac{b^C}{a^C} - \alpha_I\frac{b^B}{a^B}}{\frac{1}{c_{g_2}} + \frac{1}{c_n^C} - \frac{1}{a^A} - \frac{\alpha_I}{a^B} - \frac{1}{a^C}}$	$p_n^{ML} = \frac{-\frac{(\alpha_{NG}+\alpha_S)(b^B+\lambda)}{a^B} + \frac{c_S}{c_n^A}}{\frac{1}{c_n^A} + \frac{1}{c_n^B} - \frac{(\alpha_{NG}+\alpha_S)}{a^B}}$
8. GM-free private standard	$p_g^{PS} = \frac{-\frac{b^A}{a^A} - \frac{b^C}{a^C}}{\frac{1}{c_{g_2}} + \frac{1}{c_n^C} - \frac{1}{a^A} - \frac{1}{a^C}}$	$p_n^{PS} = \frac{-\frac{b^B}{a^B} - \frac{\alpha_{NG}\lambda}{a^B} + \frac{c_S+K}{c_n^A}}{\frac{1}{c_n^A} + \frac{1}{c_n^B} - \frac{1}{a^B}}$

The equilibrium prices are shown in Table 6. While the price of GM is always inferior to the price of non-GM, the comparison across scenario is more ambiguous. The price of non-GM will be the highest under the private standard policy if the demand shift dominates.[23] Voluntary labeling may also generate a higher non-GM price than mandatory labeling if the cost of labeling is large and the proportion of switching consumers relatively small (two realistic assumptions).[24] The price of GM will be the lowest under the private standard scenario, but the ranking of the two others will depend on demand and supply parameters. If the demand shift dominates,[25] voluntary labeling will generate a higher GM price than

[23] In particular: $p_n^{VL} \le p_n^{PS} \leftrightarrow \alpha_{NG}\left(\frac{1}{c_n^A}(c_s + K) - \lambda/a^B\right) \le (b^B - \lambda)\left(\frac{1}{c_n^A} + \frac{1}{c_n^B}\right)$.

[24] More specifically: $p_n^{ML} \le p_n^{VL} \leftrightarrow -\frac{\alpha_S}{a^B}\left(b^B - \left(\left(-\frac{\alpha_{NG}(b^B+\lambda)}{a^B} + \frac{(c_S+K)}{c_n^A}\right)\Big/\left(\frac{1}{c_n^A} + \frac{1}{c_n^B} - \frac{\alpha_{NG}}{a^B}\right)\right)\right) \le \frac{K}{c_n^A}$.

[25] More specifically: $p_g^{ML} \le p_g^{VL} \leftrightarrow -\frac{1}{a^A}\left(\frac{b^A}{b^B} - 1\right) - \frac{1}{a^C}\left(\frac{b^C}{b^B} - 1\right) \le \frac{1}{c_{g_2}} + \frac{1}{c_n^C}$.

mandatory labeling. Comparing these prices with the case of scenario 4, with a non-differentiated market, we find that under plausible parameters, prices of non-GM will be higher, while the price of GM may be lower or higher than the unified price. To sum up, we find that the most likely rankings will be: $p_4^W \lessgtr p_g^{PS} \leq p_g^{ML} \leq p_g^{VL}$ and $p_4^W \leq p_n^{ML} \lessgtr p_n^{VL} \leq p_n^{PS}$. Using these qualitative ranking we compare the welfare effects of each policy in Table 7.

Table 7. Welfare effects under the three scenarios.

Country	Producer welfare	Consumer welfare
A	Example (scenario 6): $\Pi_6^A = \left(\frac{1}{2c_{g_2}}\right)\left(p_g^{VL}\right)^2 + \left(\frac{p_n^{VL}}{2c_n^A}\right)\left(p_n^{VL} - c_s - K\right)$ If non-GM is a market niche, scenario 6 is the best outcome and may be better than 4.	Example (scenario 6): $U_6^A = \frac{\left(b^A - p_g^{VL}\right)^2}{2a^A}$ Scenario 8 will be better than scenarios 6 and 7. The comparison between 8 and 4 is ambiguous.
B	Example (scenario 7): $\Pi_7^B = (1/2c_n^B)(p_n^{ML})^2$ Unambiguous ranking: 8 ≥ 6 ≥ 7 >4	Example (scenario 7): $U_1^B = \left[-\alpha_I \frac{-\left(b^B - p_g\right)^2}{2a^B} - (1-\alpha_I)\frac{\left(b^B + \lambda - p_n\right)^2}{2a^B} + T(R)\right]$ α_{NG}, α_I, and λ are critical in the ranking: marketing regulations are better than 4 if α_{NG} is sufficiently large, and if *T(R)* is small compared to λ, 7 will be preferred. In contrast, if α_I is large, the ranking becomes: 4≥ 6≥ 7≥ 8.
C	Example (scenario 8): $\Pi_8^C = \left(\frac{1}{2c_n^C}\right)\left(p_g^{PS}\right)^2$ Scenarios 6 and 7 are better than 8 and 4.	Example (scenario 8) : $U_8^C = \frac{\left(b^C - p_g^{PS}\right)^2}{2a^C}$ Same ranking as consumers in A.

Voluntary labeling appears to be potentially welfare enhancing regulations for producers of A and C, and has a low effect on these countries' consumers, which may explain why it is rare to see voluntary

labeling measures in regulating countries that do not produce GM. In contrast, country B's producers and consumers (if largely in favor of non-GM, and assuming low tax rate), will prefer mandatory labeling, which will reduce consumer welfare in A and C. Private standards are preferred by producers in B and potentially consumers in A and C.

Interestingly, the results show that the main gains of mandatory labeling (with or without a corner solution)[26] are obtained by the domestic producers in any labeling country that does not produce GM. In effect, whether labeling results in a demand shift towards non-GM or if it only creates additional costs to import GM products (that are in fact mixed GM/non-GM), domestic producers cannot lose and may gain substantial rents. This protectionist effect is unambiguous and may be visible in the push for mandatory labeling in non-GM food producing countries. For example, in India, the push for a strict mandatory labeling policy in India in 2006 was vocally supported by domestic producers of vegetable oils that wanted to limit imports and increase the domestic price of their products at a time of low world prices (Bansal and Gruere 2010).

At the decision making level, assuming it is non-safety related (as argued in EU and elsewhere),[27] $U_{DM}(R) = ½ + \sum \gamma^l \varphi^l \sigma^l$ and strict mandatory labeling in the EU and other countries can be explained by a consensus between domestic producers ($\sigma^{AP} > 0$), market dominating non-GM consumers (that would drive σ^{CV} to be large and positive) and anti-GM organizations (large $\gamma^{NO}\varphi^{NO}\sigma^{NO}$), that dominate the public debate.[28] In importing countries with less vocal civil society and/or consumer concerns (small γ^{CV} and γ^{NO}), domestic producers may be sufficient to the introduction of mandatory labeling, as seen in some transition developing countries.

GM-free standards are in principle driven by consumer aversion to GM, but the results suggest that non-GM consumers may not gain as much as domestic producers from such policy. Given that these

[26] Scenario 8 is equivalent to mandatory labeling reaching a corner solution with no GM product sold in B.
[27] Gruere and Rao (2007).
[28] This is consistent with Gruere et al. (2009)

standards are set up by food companies rather than governments, we cannot apply the same decision making model. But it is interesting to see that food companies may raise the cost of their non-GM inputs by setting up these standards. Anti-GM and "green" organizations probably play a key role in pushing companies to go GM-free (especially via their targeted internet campaigns against GM products).

Until recently, avoiding GM products in food items was not excessively costly, because of the small share of potentially GM ingredients in food products, and the wide availability of non-GM substitutes. But recent developments in the international food markets have demonstrated that prices matter in these decisions. While they were avoiding GM maize, the spike in maize prices in 2007-08 did result in certain Korean and Japanese companies processing maize to switch back to GM maize. The recent declarations by executives in European food companies, on the potential role of GM in food production, seem to indicate a possible change of direction in the future (Gruere and Sengupta 2009b).

6. Conclusion: the challenges of an increasingly complex trading environment

This paper provided a synthesis of current trade related regulations of GM food, from import authorization to market access and commercialization. A simplified welfare and political economic model was developed to assess the welfare effects of each type of regulation and analyze their possible adoption. The results of the analysis show that in a non-GM producing country, trade-related regulations will benefit producers, but not necessarily consumers. An import authorization that increases safety without raising costs significantly (i.e., with measures to avoid asynchronous approvals) will benefit consumers and producers. The effect of labeling regulations on consumers is ambiguous and depends on the share of GM averse and indifferent consumers, and the willingness to pay of the former to avoid GM products. A developing country with low consumer aversion and/or willingness to pay will be much better off with voluntary labeling than mandatory labeling. Lastly, proposed information requirements under the CPB do not provide any benefit to consumers, regardless of their characteristics.

Based on this welfare analysis, we assessed the political support needed for an importing country to introduce each regulation. While consumers may play a role in supporting an import approval process, provided it does not result in a ban, producers' support is likely to be instrumental to push for a ban, for information requirements on shipments, or for mandatory labeling of GM food products. Outside pressure groups will play the role of swing voters in cases where consumers and producers do not agree, such as on mandatory labeling, information requirements, or potentially to support GM-free private standards.

The model also illustrates the fact that trade-related regulations are likely to affect third countries via price transmission effects. But in reality the spillover effects of trade regulations are much broader. These regulations have played a critical role in limiting the market to few GM crops in few countries. In particular, the fear of export losses to countries with GM regulations has been a key constraint in the use of public-driven GM crops particularly in developing countries. Market access considerations have also resulted in decisions by biotech companies to shelve new GM crops, like wheat or rice.

More generally, export-related considerations are now progressively entering decision-making in an increasing number of countries. The multiplication of import rejections due to the presence of unapproved GM events in shipments is pushing exporting countries toward more caution. On the one hand, in view of the huge losses incurred to non-adopting producers in past cases of accidental commingling (e.g., LL601 rice), considering export risk before release appears to be a justified and welcome decision. On the other hand, the management of market risk needs to be done rationally in a case-by-case basis. Precautionary measures based on hypothetical or irrational risks are bound to be detrimental to consumers and producers (e.g. potatoes in South Africa).

While export concerns appear to increasingly matter, there has also been a gradual shift in power between exporters and importers in the last few years. For most of the last decade, exporters had to adapt to market requirements on GM food and had no word to say. But the increasingly rapid pipeline of new GM products has made regulations challenging for importers, especially those with zero percent tolerance

levels. In these countries, buyers are starting to call for changes of regulation, towards more practical and less precautionary measures, something that had never happened before.

Ultimately, the future global welfare effects of GM crops will depend on the evolution of trade related regulations. The most important challenge of regulators will remain to ensure that new GM food products are safe for consumers in any importing country. The second challenge will be to manage export risks associated with new GM events in an increasingly complex international regulatory system. Harmonization in risk assessment and management procedures would greatly facilitate tackling these two challenges. On the other hand, the use of non-safety related information regulations, including mandatory labeling, should be assigned a lower priority, and such regulations are only justified if they are supported by market and consumer preferences. Whether countries can address these three issues successfully will depend on their capacity to integrate biosafety, markets, and political considerations constructively.

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