

Discussion Paper

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## **Asynchronous Approvals of GM Products and the Codex Annex: What Low Level Presence Policy for Vietnam?**

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# Table of Contents

|   |    |
|---|----|
| Table of Contents .....   | 3  |
| Abstract .....  | 4  |
| 1. Vietnam and the low level presence of unapproved GM events ..... | 6  |
| Status of import regulation and development.....                    | 6  |
| An importer of GM crops: evidence.....                              | 8  |
| Short term versus long term considerations.....                     | 12 |
| 2. Expected economic effects of alternative LLP policies.....       | 14 |
| Analytical model: The case of a small importer.....                 | 15 |
| Total surplus effect.....   | 15 |
| Risk and perceived safety .....                                     | 19 |
| Cost of implementation .....  | 19 |
| Identifying the key parameters .....                                | 19 |
| Application to Vietnam .....  | 21 |
| Short run costs : the 5 developed country clause .....              | 22 |
| Long run effects of different LLP options .....                     | 23 |
| 3. Trade considerations: the case of maize.....                     | 27 |
| 4. Conclusions .....  | 30 |
| References .....  | 33 |
| Appendix. ....  | 36 |
| Text of The Codex Annex.....  | 36 |

## Abstract

This paper analyzes the economic effects of policy options under the Codex Annex on Low Level Presence (LLP) to manage the risk of trade disruption with asynchronous approval of genetically modified (GM) products, focusing on Vietnam, a significant GM feed importer in the process of introducing its biosafety regulations. An analytical model is built and helps identify the tolerance level, delays in approval and in LLP approval, and trust in the exporter's regulatory framework as critical factors for policy implementation. Empirical applications show that Vietnam's proposed rapid authorization of GM events approved in five developed country would cost \$7million more than if applied to three or fewer countries. Furthermore, maintaining a zero tolerance level for unapproved GM events would impose significant annual welfare costs for Vietnam, from \$3.6 million for maize to \$57million for soymeals. Any non-zero tolerance level would reduce these costs significantly, especially a 5% tolerance level.

At the side of China and India, a number of small Asian developing countries are in the process of developing their biosafety regulatory frameworks. Most of them have continued to trade genetically modified (GM) commodities or the products derived thereof with no or limited specific regulatory requirements,<sup>1</sup> while developing guidelines and regulations on imports of GM commodities. Many of these countries have conducted research on GM crops in the past (Runge and Ryan 2004), and several have recently expressed a growing interest in moving towards commercial planting of GM crops in the near future.

For these countries, implementing regulatory frameworks may create several trade related challenges that other countries do not face. First, introducing case-by-case regulatory authorization of GM events for use as food or feed will inevitably result in cascades of approvals that will be difficult to handle at once. Second, given their relative small market size, biotech companies may not have the economic incentive to automatically submit an import approval dossier to their regulatory authority for each new GM event they introduce in foreign countries. Third, as price takers, they will lose in competitiveness from the adoption of GM crops by larger competitors if they export (e.g. Bouet and Gruere 2011), and will not affect the world market for GM products if they reject GM imports. At the same time, their likely adoption of currently used productivity enhancing GM events may help them reduce commodity imports (Gruere, Bouet and Mevel, 2011) or increase exports with low risks of trade disruption in target markets, assuming import authorizations are being renewed by companies.

Because of these specificities, they may be more likely to face the presence of unauthorized new GM events in import shipments, but export regulatory barriers, such as import approval requirements, for GM crops they adopt may not matter as much. In other words, asynchronicity of approvals may have different implications for these countries than for large exporters or importers of GM products with pre-existing biosafety systems that have been the subject of other studies -like the EU , North America, or the other case studies undertaken as part of this project on China and Latin America. Vietnam fits in this category of countries. While it has progressed towards a regulatory system in the past, it is in the process of introducing a new comprehensive biosafety regulatory system with import authorization procedures for GM products. Assuming it is fully enforced, the new regulation will have an impact, as Vietnam has imported significant volumes of GM commodities (corn, soybean, cotton) mostly for non-food uses (USDA-FAS 2009) from large GM producers that use multiple GM events (USA, Canada, Argentina, Brazil) these last few years without any formal regulatory control.<sup>2</sup> At the same time, Vietnam has developed a research capacity in biotech research and development since the 1990s (e.g., Ngo 2003) and is now interested in the use of current GM crops for planting.<sup>3</sup> In particular, in 2010 Vietnam conducted its first field trial of a GM crop (GM corn) and has other crops in the pipeline.<sup>4</sup>

1 Certain countries have adopted requirements that are not fully implemented- e.g. mandatory labeling for GM food in Indonesia and Thailand (Gruere and Rao 2007).

2 GM testing has been conducted on imports by the Institute of Agricultural Genetics (AGI), revealing that “most animal feeds contain some portion of GM derived products” (Vu, 2004)- but the tests are not being used to control imports. GM testing is also used to satisfy export requirements on a voluntary basis (e.g., in the case of shrimp food and coating of finished products, see UNIDO 2007:13). SPRING Singapore(2010) reports that imports of GM products need to be accompanied by biosafety certificates, but there is no clarity as to whether this is a mandatory requirement.

3 Maize, soybeans, cotton (USDA FAS 2009) and others have been in development at the AGI (Tran 2004).

4 There are also reports that Bt cotton has been planted unofficially in Vietnam for several years (Vu 2004) with a reported adoption rate exceeding 80% (USDA FAS 2008); Vietnam is a large importer of cotton but not a significant producer. Vu (2004) also reports the unofficial use of other GM crops- maize, soybeans and rice.

This paper aims to complement other studies by providing a policy analysis of asynchronous approvals and applications of the Codex Annex - an amendment in annex to the Codex Alimentarius standard on GM food safety assessment, which elicits a set of simplified risk assessment guidelines on the temporary approval for the low level presence of GM products approved by the exporter but not yet approved by importers<sup>5</sup>- in small developing countries with an application on Vietnam. The objectives of the paper are 1) to identify the main parameters of choice for policymakers and 2) to assess the likely economic consequences of different regulatory options. A simple analytical framework is developed and applied to the case of Vietnam using past bilateral trade flow data, to assess the economic effects of potential trade disruption due to the LLP of unapproved GM in imported shipments of maize or soybeans. An international spatial equilibrium model of trade is also used to illustrate the trade diversion effects of such disruption and its consequence for Vietnam. This policy analysis aims to serve as a primer for many other developing countries that are small market actors, informally importing GM crops, and in the process of implementing their biosafety regulations.

The remaining part of the paper is organized in four sections. The first section introduces the regulatory and trade situation in Vietnam to assess the likelihood of low level presence. Second, an analytical model is developed using a specific importer as benchmark to identify the main policy constraints and variables and then applied to the case of Vietnam. Third we explore some of the trade implications. We close the papers with a few conclusions.

## **1. Vietnam and the low level presence of unapproved GM events**

### *Status of import regulation and development*

Biosafety legislation in Vietnam was built progressively in several iterations (Than Nan 2009). Following its accession to the Cartagena Protocol on Biosafety in April 2004, a legal framework was introduced under the Prime Minister Decision No. 212/2005/Qd-TTg of August 26, 2005 (Prime Minister of Vietnam 2005). It laid the basic framework to regulate the use of GM crops and the products derived thereof, following general principles under the Cartagena Protocol on Biosafety. However, the layout of this decision created overlap among the main ministries, and its enforcement was reportedly not effective (Than Nan 2009), with only one ministry (Ministry of Agricultural and Rural Development) effectively operational with implementing regulations on field trials<sup>6</sup> as of early 2010 (USDA-FAS 2010).

In 2008, Vietnam adopted a Biodiversity Law (VM 5062) which includes a section (chapter 5, Part 3) on the use of GM organisms (USDA-FAS 2009). To implement this section, the Government drafted a new Biosafety Decree in 2009, which has since become the new biosafety regulation (USDA-FAS 2009). This document, which replaces the Prime Minister Decision 212/2005 is the Decree on Biosafety for Genetically Modified Organisms, Genetic Specimens and Products of Genetically Modified Organisms of June 21, 2010 (Socialist Republic of Vietnam, 2010). In this decree, Chapter VI pertains to GM organisms for use as food or animal feed. As explained in Section I, Article 27, GM organisms used in food can only be allowed if they have been the subject of an authorization -a certificate of eligibility for use as food- by the Ministry of Health. There are two alternatives to obtain this authorization; an applicant can:

1. obtain a certificate from the GM food safety council, under a food safety application process

5 See appendix for the full text of the Annex.

6 Circular 69/2009/TT-BNNPTNT, published October 27 2009 and Circular 72/2009/TT-BNNPTNT, published November 17, 2009, according to USDA-FAS (2010).

similar to that in other countries, or

2. demonstrate that the GM product has been permitted by at least five developed countries for use as food and no risk has been seen in these countries.

The latter clause (Article 27.2) is singular to Vietnam, and useful in the context of import approval; an applicant does not have to provide safety data if the product has been approved and safely used in five developed countries.<sup>7</sup> There are still uncertainties as to what country is considered a “developed country” and what an applicant would need to demonstrate that the product has been approved and used safely in such country, but this particular regulatory pathway could help Vietnam move quickly towards authorizing the most commonly used GM products for import.

Article 28 provides further explanation on the regulatory approval process. Applicants for GM approval under Article 27.1 need to submit a form and a report on human health risk assessment of the GMO under consideration, as well as a payment. The authority will send an acknowledgment of receipt within 7 days, and after consultation of the GM Food Safety Council,<sup>8</sup> a ruling will be published within 180 days, including a public consultation (maximum of 30 days). Every GM product approved for food use will be included in a publically available list.

Thus, an applicant should expect a decision within 180 days, or approximately 6 months. During this time and at any time before the certificate is granted, no product can be used or imported (Article 38), i.e., under this Biosafety Decree, there is a zero tolerance level for unapproved products. In contrast, applications for GM approval under Article 27.2 should receive a determination within 60 days. Despite a similar condition to that proposed under the Codex Annex on low level presence, there is no specification of a tolerance level for those GM food products approved in other nations, i.e., there is also a zero tolerance level for GM food products approved in other countries.<sup>9</sup> In other words both Article 27.2 and the Codex Annex make adjustments for situations when a product has been approved outside of the importing country (either in 5 developed countries or in the exporter); even though 27.2 leads to a full authorization whereas the Codex Annex to a preliminary one and allows countries to set up a threshold for low level presence (without specifying any level),

Section 2 of the same chapter focuses on approval for use as animal feed, a category that likely represents a very large share of imported products (USDA-FAS, 2010). The exact same system is outlined, with two alternatives to obtain a safety certificate (Art 32.1.a, for general applications, and 32.1.b, faster system if approved for feed in at least five developed countries), and similar delays. The only differences listed on the decree<sup>10</sup> are that the risk assessment data requirement naturally focuses on animal safety and that any application is managed by the Ministry of Agriculture and Rural Development rather than the Ministry of Health (as done in Japan, see Carter and Gruere 2006). As explained in Article 39, any GM event included in animal feed has to be associated with a certificate or be listed to be used in Vietnam, i.e., there is no low level presence policy for animal feed (unlike

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7 To our knowledge, no other country has formally adopted this type of developed country exemption.

8 The GM Food Safety Council includes representatives from the Ministries of Industry and Trade, Science and Technology, Agriculture and Rural Development, Natural Resources and Environment, Health and some experts.

9 This does not prevent country officials to consider using a low level presence policy as stipulated under the Codex Annex, as noted during a USAID sponsored workshop on low level presence in Hanoi on 03/23/2010.

10 This will probably change, as there are discussions that food and feed safety would be both managed by MARD (Personal communication with the PBS country coordinator in Vietnam, July 7 2011).

Japan)- once again a zero tolerance level is applied.<sup>11</sup>

Apart from approval, Article 43 of the Decree requires that all marketed GM goods be labeled as such, if the GM component exceeds 5% of any constituent of the product. While this may not have an immediate impact on import of animal feed (animal products are a priori excluded), if forcefully implemented, it could create shifts in demands for products with GM ingredients, as observed in other countries like China (Gruere and Rao 2010). Still, the most likely outcome will be only few GM labeled products on the market (potentially direct imports of US and Canadian processed products), at least until a GM crop used for food is produced domestically.

Under Article 47, the Decree was supposed to take effect on August 10, 2010. However there are indications that it still had not been fully implemented as of July 2011.<sup>12</sup> Vietnam did notify the World Trade Organization Committee on Sanitary and Phytosanitary Measures of new safety and labeling requirements on genetically modified food on 25 March 2011(WTO SPS 2011), which presumes that implementation is upcoming. Still, using the existing framework under the former biosafety regulation (Decision 212/2005), Vietnam conducted its first field trials for a GM crop in 2010, for Bt corn. There are reports that GM cotton and GM soybeans (Bt soybeans) may follow (USDA-FAS 2010). The Government of Vietnam has long had ambitious plans for biotechnology, including the goal of commercializing locally grown and/or developed GM crops in 2010 (USDA FAS 2008), but no GM crop had moved towards actual commercialization as of July 2011.

We will now review past data and trends to see whether Vietnam would be potentially affected by the presence of unapproved GM events if/when it enforced the Ministerial Decree.

### *An importer of GM crops: evidence*

There is no international database tracking movements of GM versus non-GM commodities and products. However one can use existing bilateral trade data as well as regulatory differences and GM adoption patterns to induce the share of trade that is likely GM.<sup>13</sup> For instance, assessing the volume of maize imports from GM producing countries that mostly produce mixed (non-segregated) GM/non-GM commodities can be used as a proxy for volumes of likely GM imports in a country like Vietnam.

In our case we focus on imports<sup>14</sup> of maize (HS classification code 100590), canola (HS 151490), soybeans (HS 120100) and soymeals (HS 230400), using data from the UN Comtrade database taken from 1999 to 2010.<sup>15</sup> To cope with asymmetries in trade reports (reported exports to Vietnam are different from reported imports in Vietnam), and the fact that import and export data can be distorted by the reporters, we use two trade matrix balancing methods. The first method uses import data from Vietnam as a primary source and completes it with export data from partners (consistent with Feenstra et al. 2005). The second method focuses on reports on exporters to Vietnam and

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11 Japan applies a 1% tolerance level for unapproved GM events that have been approved at exporters only in the case of animal feed (USDA-FAS 2003). This regulation was introduced with new safety requirements for animal feed on April 1<sup>st</sup> 2003, not long after the beginning of the StarLink corn market disruption (Carter and Gruere, forthcoming).

12 Personal communication with N.C. Dang, Program for Biosafety Systems country coordinator in Vietnam, 07/2011.

13 As done in the case of South Africa by Gruere and Sengupta (2010).

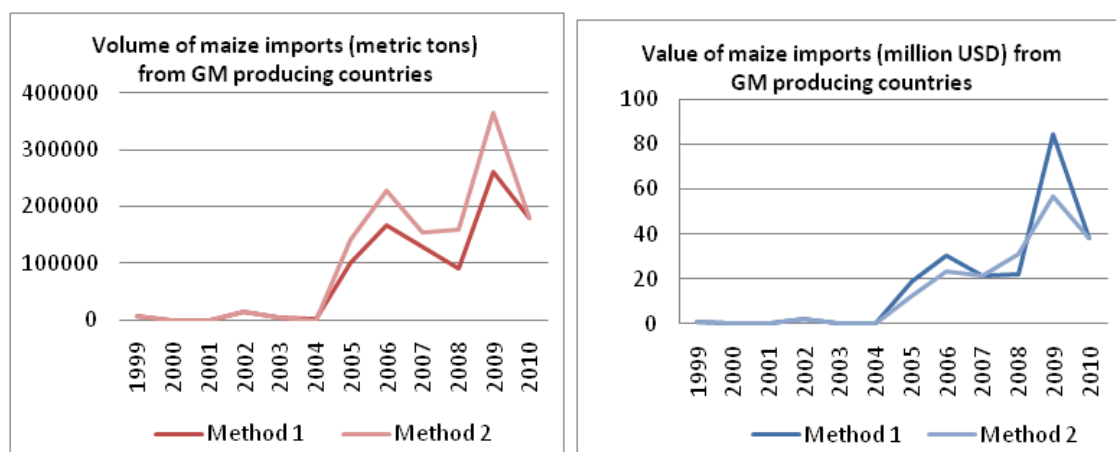
14 Vietnam is a significant net importer of the four main GM crops- so we focus on imports. Given the well substantiated opposition to the introduction of GM rice (Gruere and Sengupta 2009) and probably other export commodities, export considerations would only occur if it adopted a new GM corn or soybean event.

15 We do not include cotton lint, because as a non food and feed product, that is not a living modified organism, it will not face the same regulatory issues and should continue to be freely traded to Vietnam.

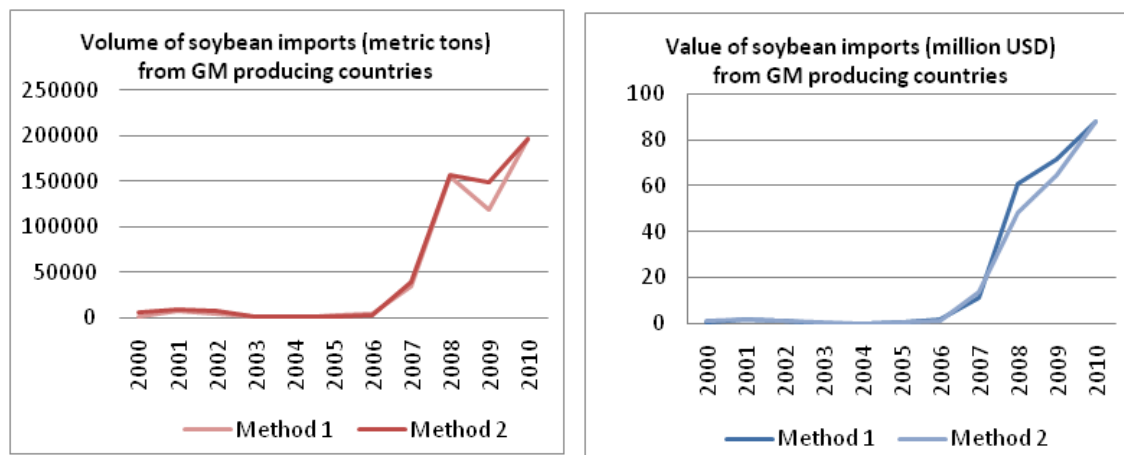
completes missing trade flows with import data. We also use adoption years for each GM commodity from the International Service for the Acquisition of Agri-biotech Applications (ISAAA) to ensure that only annual exports from GM adopting nations are considered likely GM. The results are presented graphically in terms of volumes and values in Figure 1, 2, 3 and 4 for the four commodities.

Figure 1 shows that the import volume of potentially GM maize increased sharply from zero before 2005 to over 200,000 metric tons in 2010 (worth over \$40 million). A similar pattern of quasi exponential growth is observed for soybeans, with imports of likely GM soybeans jumping from 0 to 200,000 metric tons (\$80million) starting after 2005. GM derived soymeal imports increase in a more linear fashion and at a larger scale from 100,000 in 1999 to around 750,000 tons in 2010 (\$250 million) with a 2009 peak exceeding 1 million metric tons (\$500 million). Lastly, Vietnam imported around 1,000 tons of GM canola in 2000 and then from 200 to 500 tons (worth \$400 to 700 thousand), a rather negligible volume.

**Figure 1. Volume and value of likely GM maize imports in Vietnam, 1999-2010**



**Figure 2. Volume and value of likely GM soybean imports in Vietnam, 1999-2010**



*Author's derivations from UN Comtrade data*

Thus, the trends across the main GM commodities are similar in shape even if different in value. Vietnam has increasingly imported GM grains and oilseeds over the years, especially starting in 2004/05. This may be due to changes in trade policy, following Vietnam's accession to the World Trade Organization in 2007, but also to economic growth and increasing demand for animal products. As seen in Figure 5, animal product supply in Vietnam has been booming for the past decade, with the doubling of pigmeat and fish/seafood products in only eight years. Local production of soybeans in

Figure 3. Volume and value of likely GM soymeal imports in Vietnam, 1999-2010

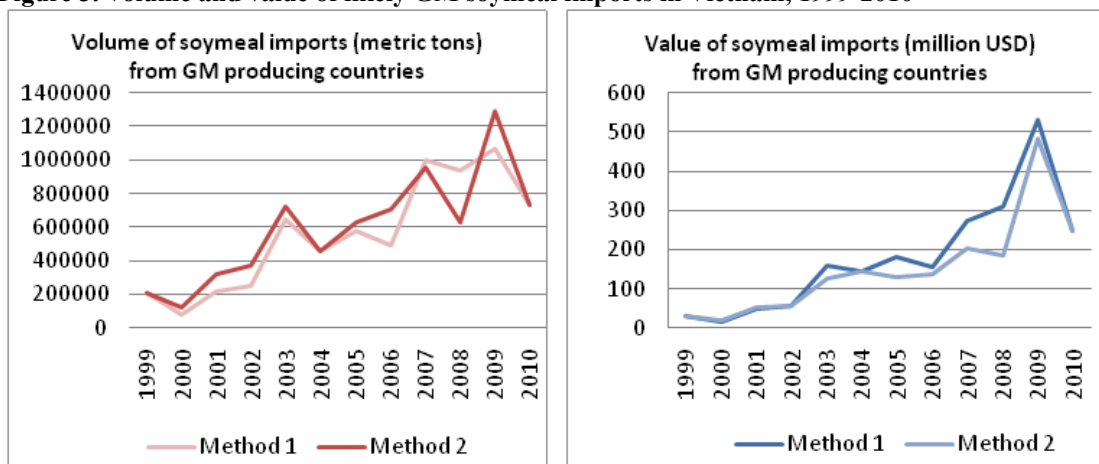
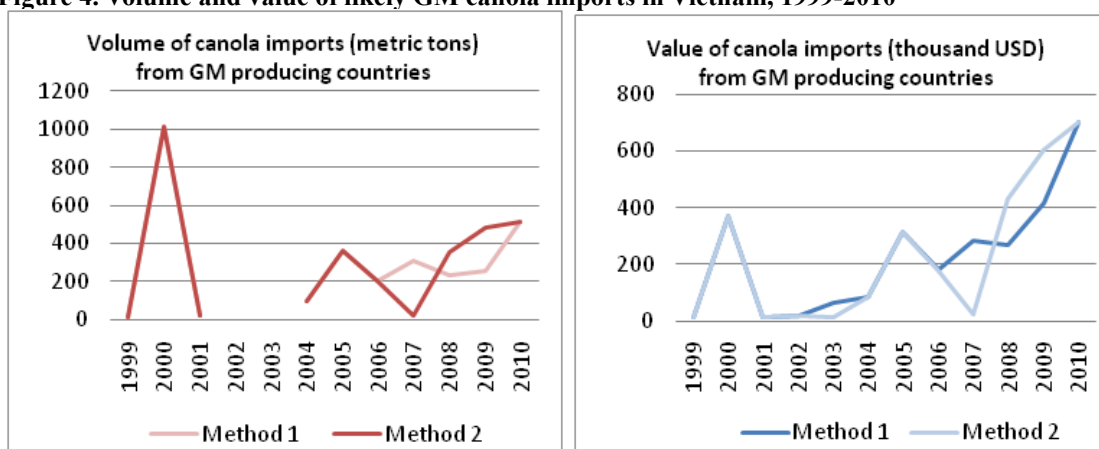
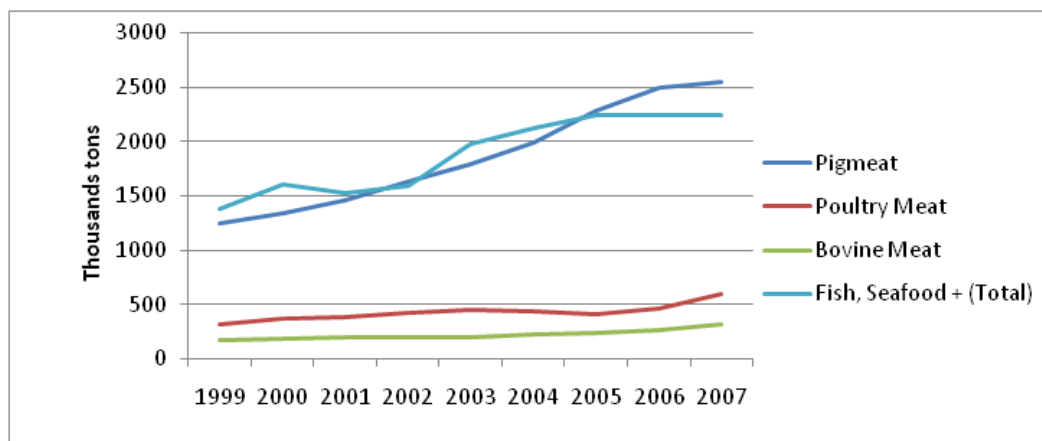


Figure 4. Volume and value of likely GM canola imports in Vietnam, 1999-2010



Author's derivations from UN Comtrade data

Figure 5. Supply of animal products in Vietnam 1999-2007

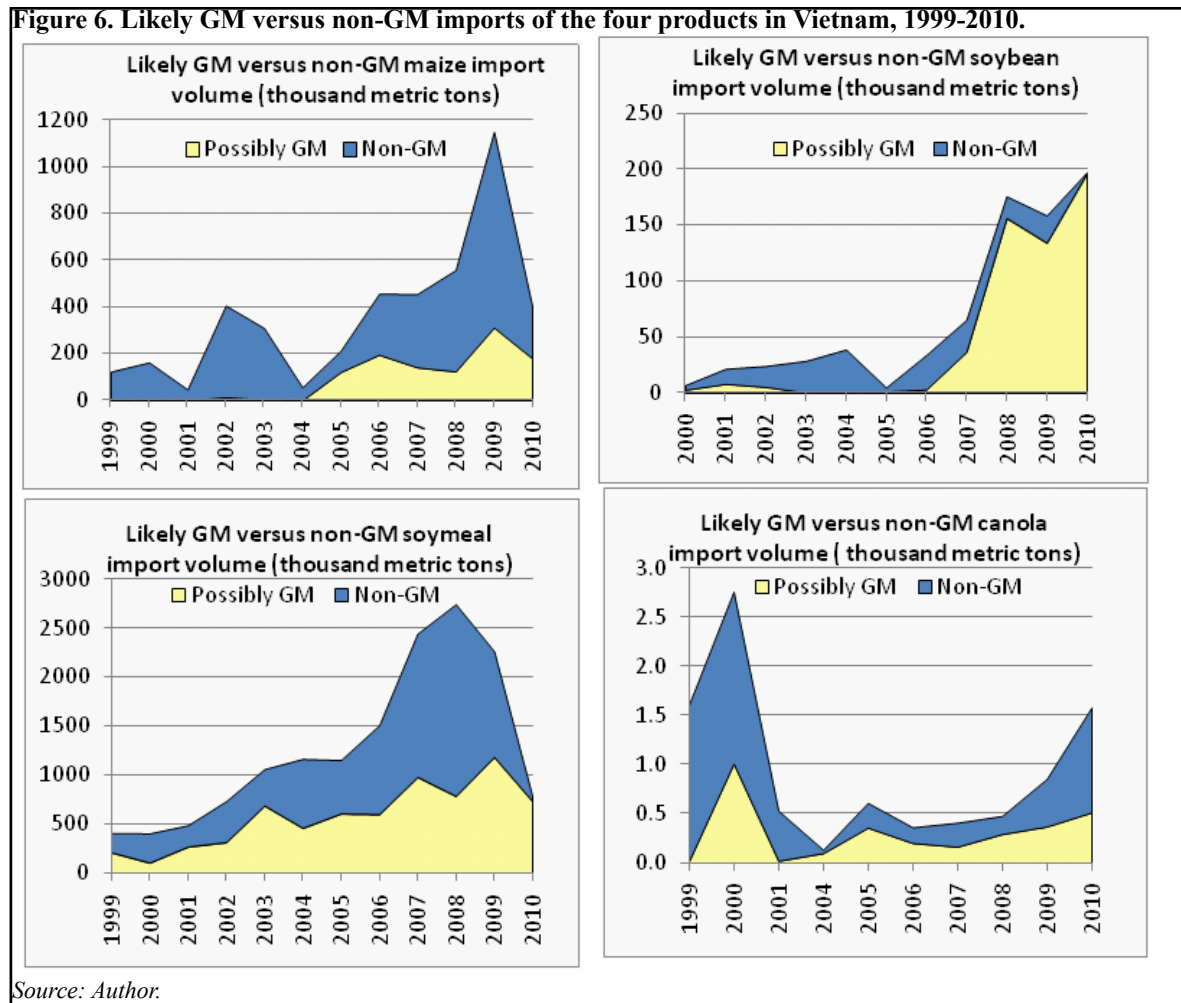


Source: FAOSTAT.

particular has remained low, and focused on food products (USDA-FAS 2010), resulting in increasing imports of soybeans and especially soymeal for animals. Because of the lack of significant crushing facilities,<sup>16</sup> soymeal has been largely imported (USDA-FAS 2010).

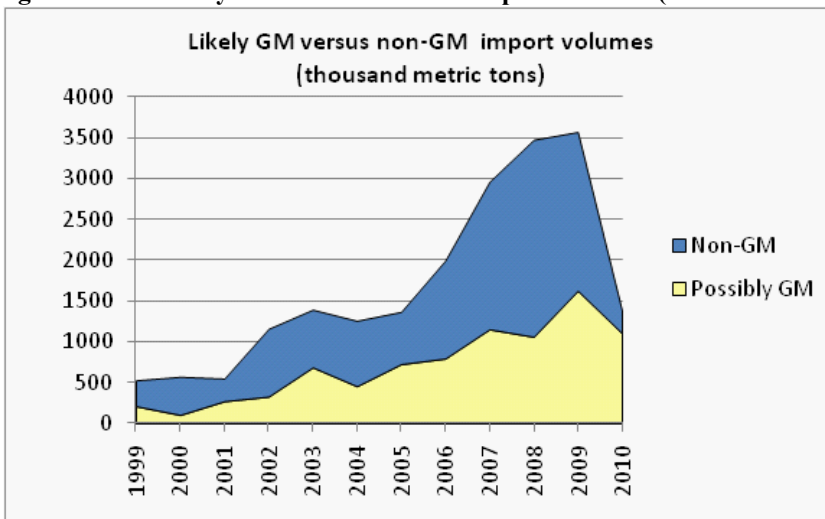
16 A large crushing facility is being built in the South and is supposed to be operational as of the summer of 2011 (USDA-FAS 2010).

Figure 6 provides the trend of GM and non-GM products overtime for the four products. The figure presents two patterns: one for maize/soymeal and canola and the other for soybeans. In the first case, likely GM product imports represent a growing share of total imports, and follow the general trend in imports, but imports from non-GM exporters remain significant. GM maize only entered the country in 2005, but non-GM imports have continued to dominate. The share of GM maize varied between 0% in 2000 and 58% in 2005 with an average of 26%.<sup>17</sup> The share of GM soymeal imports varied from



Source: Author.

**Figure 7. Total likely GM versus non-GM import volumes (thousand metric tons) 1999-2010.**



Source: Author

10% (2005) to over 90% (2010) with an average of 45%, especially because of the importance of non-GM soymeal imports from India (USDA-FAS 2010). GM canola represented in average 40% of total imports. In contrast, GM soybeans represent a much higher share of total soybeans imports (73% in average) and starting in 2006 almost all imports of soybeans (up to 99.7% in 2010).

These figures indicate that Vietnam has imported significant quantities of likely GM products, especially since 2004/05, and that the share of GM products is increasingly important especially for soybeans. As shown in the aggregate Figure 7, in average, at least 670,000 tons (worth \$190 million) of GM products have been imported annually between 1999 and 2010. In 2010, this total reached 1.1 million tons (worth \$375 million) and the share of GM imports exceeded 80% of total imports after ten years of fluctuation between 20% and 50% (Figure A2 in appendix). These are non trivial amounts, and are bound to continue to grow (e.g., USDA-FAS 2010). Issues surrounding authorization and unapproved GM events are therefore likely to be significant when Vietnam starts to enforce its new regulation.

### *Short term versus long term considerations*

As noted in the introduction, when Vietnam introduces its regulation, it will face a cascade of approvals. This may create trade disruption in the short run, as long as all existing and used GM events are not approved. Still, as noted above, the new biosafety system set up in Vietnam allows for an accelerated approval process for GM events authorized and safely used in at least five developed countries. If this system worked efficiently, and was able to clear all these exceptions within two months, will any GM event remain unapproved in the process? In other words, are all GM events currently used in the commodity system approved in at least 5 developed countries?

To respond to this question, we looked at GM maize, soybeans and canola events currently approved in the United States (maize and soybeans) and Canada (canola), two of the main exporters of likely GM commodities to Vietnam where virtually all GM events currently used in these commodities have been approved first.<sup>18</sup> Tables A1, A2, and A3 in the appendix provide a detailed listing of events and approvals per country. We assume that the definition of developed countries includes nations with functioning regulatory systems that are members of the OECD (i.e. Australia, Canada, European Union countries, Japan, Korea, Switzerland, and the United States). We further assume that GM crops only approved in USA and Canada are not used on the international market. The GM events that are in use and not approved in five developed countries are the remaining ones. Table 1 below summarizes the findings.

**Table 1. GM event approvals passing the 5 developed country authorization threshold.**

| Commodity    | GM events approved in at least 5 developed countries | GM events approved in less than 5 developed countries |                                  | Total GM events planted in the USA (maize& soybeans) or Canada (canola) |
|--------------|--|---|----------------------------------|---|
|              |  | Likely used in production                             | Probably not used or limited use |   |
| Maize        | 14   | 7   | 8                                | <b>29</b>   |
| Soybeans     | 4  | 3   | 2                                | <b>9</b>  |
| Canola       | 6  | 3   | 4                                | <b>13</b>   |
| <b>Total</b> | <b>24</b>  | <b>13</b>   | <b>14</b>                        | <b>51</b>   |

*Source: Based on Tables A1, A2 and A3, compiled from CERA (2010).*

As shown in Table 1, twenty-four of the fifty-one GM events approved for planting in North America would qualify for the rapid approval system under the Vietnamese Biosafety Decree. In contrast, thirteen GM maize, soybean and canola events would not qualify and yet be likely present in traded shipments arriving in Vietnam. Thus, regulators should expect to produce rapid reviews for twenty-

<sup>18</sup> Several GM cotton events also originate from India and China, but we have excluded cotton from this analysis.

four GM events, and full approval will be needed for at least thirteen GM events. Handling thirteen applications together may take some time, and will at a minimum require companies to provide full applications at the same time in order to avoid trade disruption. Table 2 provides a complete list of the thirteen events by crop and company.

**Table 2. List of currently used GM events not eligible for rapid approval under the Biosafety Decree**

| <b>Crop</b>    | <b>GM event</b>  | <b>Current company<br/>(original company)</b> | <b>Approved in</b>  |
|----------------|--|---|---|
| <b>Maize</b>   | DAS-Ø6275-8 (DAS-06275-8)  | Dow Agrosience                                | Canada, Japan, USA  |
|                | DP-Ø9814Ø-6 (Event 98140)  | DuPont Pioneer                                | Canada, Korea, USA  |
|                | MON809   | DuPont Pioneer                                | Canada, Japan (feed), USA   |
|                | DKB-8979Ø-5 (B16 (DLL25))  | Monsanto (Dekalb Genetics Corporation)        | Canada, Japan, Philippines, Korea, Taiwan, USA                    |
|                | MON-89Ø34-3 x DAS-Ø15Ø7-1 x MON-88Ø17-3 x DAS-59122-7 (MON89034 x TC1507 x MON88017 x DAS-59122-7) | Monsanto                                      | Canada, Japan, Korea, USA<br>Mexico, Philippines, Taiwan          |
|                | REN-ØØØ38-3 (LY038)  | Monsanto                                      | Australia (food), Canada, Japan, Mexico, Philippines, Russia, USA |
|                | SYN-E3272-5 (Event 3272)   | Syngenta                                      | Australia (food), Canada, Mexico, Philippines, Russia, USA        |
| <b>Soybean</b> | ACS-GMØØ6-4 (A5547-127)  | Bayer CropScience                             | Brazil, Canada, Japan, , Mexico, USA                              |
|                | DP-3Ø5423-1 (DP-305423)  | DuPont Pioneer                                | Australia (food), Canada, Mexico, USA                             |
|                | DD-Ø26ØØ5-3 (G94-1, G94-19, G168)  | DuPont Canada                                 | Australia (food), Canada, Japan, USA                              |
| <b>Canola</b>  | HCN10  | Bayer Crop Science(Aventis)                   | Canada, Japan, USA  |
|                | ACS-BNØ11-5 (OXY-235)  | Bayer CropScience Aventis                     | Australia (food), Canada, China, Japan, USA (food)                |
|                | MON89249-2 (GT200)   | Monsanto                                      | Canada, Japan, USA  |

Source: see Tables A1-A3 in the appendix.

These thirteen GM events belong to five of the six largest agricultural biotech companies: Bayer CropScience, Dow Agrosience, DuPont Pioneer, Monsanto and Syngenta. DuPont Pioneer, Monsanto and Syngenta have a specific interest in Vietnam as they do plan to commercialize GM crops in the near future, so they will likely comply with the requirements. Whether all other companies do is uncertain. Even if they do, the time to get an approval from the date of implementation will at the very least take the expected process length of 6 months, even if it is likely that more time will be required to process them all. During this period there will be a zero tolerance for unapproved events, which is likely to create significant trade disruption.

Interestingly, Table 2 also shows that all the GM events not eligible for rapid approval have been approved in at least three developed countries (Canada, USA and at least another country). This means that if the decree had used a lower threshold, e.g., that a GMO event would need to be approved in three developed countries, all currently used GM events would go through the rapid

process and the likelihood of trade disruption in the short run would be reduced to zero after the two month process. Knowing that the government did insist that new regulations would not prevent imports of GM products for animal feed before their introduction (USDA-FAS 2008:3),<sup>19</sup> it is surprising that the threshold for rapid approval is set up to such a high standard. On the other hand, one can also question whether using 3, 4, or 5 country approvals is valid, if those countries have differing authorization processes, or whether it means that Vietnam does not trust the regulatory approval of non-developed countries, including those in Asia, like China, Taiwan or the Philippines, that have approved a number of them.

In the longer term, the presence of unapproved GM events in import shipments will depend on the relevant biotech companies' (or other developers') willingness to submit applications for new GM events to be used in food and/or feed to Vietnam before commercialization. Their incentive to do so will depend on the pressure from traders of the specific grains and indirectly their economic stake in keeping access to the Vietnamese market. Even if export volumes may not be as large as for other Asian countries (China, Japan, Korea), corn and especially soybeans growers' and/or processors' associations in North America may encourage these companies to file applications in Vietnam. Even if export volumes may not be as large as for other Asian countries (China, Japan, Korea), corn and soybeans growers' and/or processors' associations in North America may encourage these companies to file applications in Vietnam. If, however, one company decided not to submit an application, and the event was found in traces in the shipment leading to its rejection, traders in major GM crop adopting countries would lose, and Vietnam would have to find imports in other countries or purchase substitutes at a potentially significant price premium.

We will now explore the economic effects of this zero percent tolerance and alternative low level presence policies under the Codex Annex to assess what cost different options would have in Vietnam.

## 2. Expected economic effects of alternative LLP policies

As noted in the overview paper, the WHO/FAO Codex Alimentarius Commission adopted an amendment in annex to its standard on GM food assessment,<sup>20</sup> which elicits a set of simplified risk assessment guidelines on the temporary approval for the low level presence of GM products approved by the exporter but not yet approved by importers (Codex Alimentarius Commission 2008, Korves 2008). These new simplified guidelines, commonly called the "Codex Annex", aim to encourage countries to adopt simplified and more rapid procedures for any new GM event to be approved temporarily at low levels in commodity shipments while waiting for full approval. At the same time, the Codex Annex encourages the setting up of new data sharing mechanism on the testing and approval of new GM products, to facilitate information exchange between exporters and import regulators.

In principle, the Codex Annex satisfies exporters and importers but it leaves a lot of room to countries with regard to implementation options. First, it considers different categories of products: processed products, grains whose GM part is small in final consumption goods, and whole produce, like fruits or vegetables, without specifying whether the rule should apply to each category in a similar manner. Second, and more critically, the Annex does not define what "low level presence" means. It leaves the discretion to countries to define what may be considered low level presence (LLP). But it also opens a wide range of possible options that will ultimately determine whether the procedure will be useful, feasible, and able to fulfill its goals of accommodating safety concerns and marketing realities.

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19 See USDA-FAS (2008), page 3: "*Both MARD [Ministry of Agriculture and Rural Development] and VFA [Vietnam Food Administration] have confirmed that their regulations will not affect imports of bulk commodities like cotton, soybean meal or corn for the feed industry.*"

20 See appendix for the full text of the Annex.

The new regulation in Vietnam does not include such a LLP policy as presently written, but it could be amended accordingly. The fact that the Biosafety Decree already includes a rapid authorization process for GM food and feed used in at least five developed countries demonstrates the government's willingness to consider practical trade realities. It also implicitly supports the fact that a GM event approved and safely used for food or feed in other countries might not need to be subject to a new full approval procedure. Still, as noted below, the Biosafety Decree does not account for the scenario of a new GM event approved in the exporting country but not yet approved in Vietnam, nor does it consider the potential delay in approving GM events not approved in five developed countries, two cases where the Codex Annex guideline could prove useful. In the following subsections, we build a simplified analytical model and then apply it using empirical trade data.

### *Analytical model: The case of a small importer*

Let us assume, that at time  $t_0$ , a country A is importing product X from a GM producing country B. At time  $t_1$ , a new GM variety of X is approved in country B, but not yet in A. B is also a country where GM commodities are mixed in the system. In the absence of approval, until time  $t_2$ , and assuming a zero tolerance level, A has to find another version of the good, either in country B or another country to satisfy its need. For simplicity we assume that it has to purchase a non-GM good<sup>21</sup> at a higher price than the GM mixed commodity it was previously purchasing from B. Because A is a small country, it is assumed to be a price taker on the international market. Assume a linear inverse demand for X in country A,  $p=aQ+b$ , ( $a<0$ ) and a linear supply  $p=cQ+d$  ( $c>0$ ). We also assume that from the perspective of the regulator, the probability of a safety outbreak from the new GM event is well defined with a distribution  $N(\sigma, \nu)$ . Lastly, we assume perfect enforcement as a benchmark (enforcement issues are discussed later).

Country A makes its decision according to a social welfare function that includes consumer and taxpayer welfare  $W$ , taken within a production period:

$$W= w+ (b-p)/Q+cQ^2/2 - \sigma DQ - CI(Q) \quad (1)$$

Where:  $w$ = basic welfare derived from good consumption,  $b$  = demand parameter,  $c$ = supply parameter,  $p$ = expected price under adopted policy,  $Q$ = quantity,  $\sigma$  = expected probability of potential damage per unit,  $D$ = damage per unit,  $CI$ = cost of implementation.

This expression can be decomposed into three components: first, the Marshallian consumer and producer surpluses, traditionally defined; second, the expected damage from importing a possibly or perceived unsafe good;<sup>22</sup> and third, the public costs of a regulation. These three terms will be extended in more details below.

Most of the parameters depend on the regulatory choice. For simplicity, we will assume three possible regulatory scenarios for country A, that will be the main options of small developing country importers : i) 0 percent low level presence (LLP), ii)  $\tau$  percent tolerance to LLP ( $0\% < \tau < 100\%$ ) , and iii) let everything pass ( $\tau = 100\%$ ). We separate scenarios with zero or 100 percent tolerance to single out the effect of implementing a LLP policy.

### *Total surplus effect*

The consumer surplus is derived based on prices and quantities. The expression is not subject to regulatory change but the prices of the imported good will vary according to the regulation. In

21 It could be a GM substitute available at a higher price due to transportation, differences in competitiveness, etc.

22 This second terms addresses possible safety issues from the perspective of a regulator, but can also be interpreted as the perceived risks of a new product imported in the country.

particular, the variable (p) can be defined as the expected price, and depends on the proportion of non-GM products in imports ( $k_g$ ), the probability of rejection of shipments ( $\pi$ ) defined as:

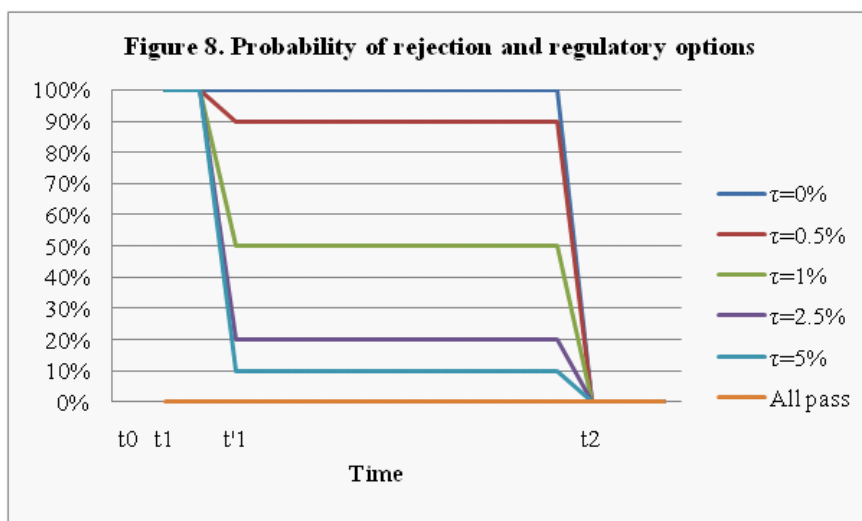
$$p = k_g p_o + (1 - k_g)(\pi p_n + (1 - \pi) p_0) \tag{2}$$

where  $p_n$  is the price of non-GM counterpart and  $p_0$  the price of the GM/mixed good (originally the price of the good). Assume  $p_n = p_0(1 + \Delta)$ , i.e. there is a proportional price premium  $\Delta$  when one avoids the original undifferentiated mixed GM good, and equation (2) can be simplified to:

$$p = p_0(1 + \pi(1 - k_g)\Delta) \tag{2}$$

Note that this probability of rejection ( $\pi$ ) can be interpreted as the probability of B traders not sending a shipment to country A because of the risk of rejection, and/or because the insurance cost that would make their good non competitive. Thus the “rejection” rate may not mean an actual rejection; what matters is that the expected price is a weighted average of GM and its non-GM substitute.

This probability of rejection depends on the tolerance level  $\tau$ , on the expected (average) concentration of non-approved GM events ( $\mu$ ) and on the timing of approval also within the country of export and import. Indeed there is more chance that a shipment will be rejected at a low tolerance level than at a high tolerance level for any shipment, and that a shipment with a lower likelihood of presence of unapproved events will be accepted for any tolerance level. The timing of approval obviously matters, since no rejection will occur if approvals in A and B are synchronous. The longer it takes to undertake a risk assessment, the longer shipments will be rejected. As time increases beyond a production season, the concentration of the new GM event is likely to increase, so the probability of rejection should also increase. Figure 8 shows an illustrative schedule of rejection probabilities within a production season under different regulatory options for a shipment where the expected original concentration ( $\mu$ ) is close to a few percent.



Source: Author

In this figure, the following notations are used to represent the timing of decisions:

$t_0$ : time of production approval in B,

$t_1$ : after production, export from B,

$t_1'$ : LLP approval,<sup>23</sup>

23 Note that we place  $t_1'$  before  $t_1$  but a better situation would occur if it was placed after  $t_1$ , i.e., that LLP approval occurred before export. In such case there would not be a period during which all shipments will be

$t_2$ : import approval

As shown in figure 8, a zero percent LLP policy (as proposed in Vietnam) results in a 100% rejection rate until approval is granted. A no-policy approach lets everything go, therefore meaning a 0% rejection rate. And a LLP policy with a non-zero tolerance level, is an intermediate approach, and results in a non-zero, non-one probability of rejection.

If testing was perfect, and the shipments were homogenous of known concentration ( $\mu$ ), the schedule of rejection for a non-zero tolerance level would be simpler to determine. Either ( $\tau \geq \mu$ ) and no shipment is rejected, or ( $\tau < \mu$ ) and all shipments are rejected. Thus to avoid any incident, traders would adjust the concentration of new GM events to the threshold in place. But the reality of bulk commodity trade (as described in the overview paper) and of testing make it impossible to be in such simplified situation in grains trading. First and most importantly, in a mixed commodity system, there is no known homogenous concentration in grains or products. Second, given the volume under consideration, traders do not know the concentration of events and can rarely control them (except under perfect identity preservation). Third, testing is not perfect, nor perfectly replicable.

A few papers have looked at testing probabilities, using existing cases where testing protocols have been established and used extensively. The case of Starlink corn may be the best illustration; the U.S. government set up a testing protocol with the multiple use of ELISA lateral flow strip tests<sup>24</sup> to avoid rejection of shipments in Japan (USDA-GIPSA 2006). The tradeoff faced by regulators was to balance the number of samples and sample sizes which together decrease the probability of errors, with the cost and time of testing (e.g., see Stave 2002). Johnson and Lin (2004) provided an economic analysis of testing for biotech grains, using the Starlink example. They noted that tests for biotech corn presence in this case, with discrete results (0 or 1), involve the use of Binomial distributions; the probability of staying under a set level depends on the concentration in the sample but also the sample size and the number of samples tested. In the case of Starlink, the US Department of Agriculture set up a testing protocol with three samples of 800 kernels being tested; under this plan, if no positive result from any of the presence tests is allowed, there is a 99% confidence that the actual concentration does not exceed 0.19% (Johnson and Lin 2004). More recent testing protocols involved more precise techniques, based on PCR, such as the one set up by the Canadian Grain Commission for flaxseed exported to Japan for feed or industrial use (Canadian Grain Commission 2010). In this procedure, 50kg are taken from shipments exceeding 500 tons; of these, 2.5 kg are taken, and four 60 g sub-samples are extracted. One DNA extraction is conducted for each sub-sample, and two PCR analyses are carried out for each. A lot is negative when all four subsample test negative within the 1% tolerance (Canadian Grain Commission 2010).

Given these considerations, determining a precise schedule of rejection probability per tolerance level is impossible without some information on at least the probability distribution of the concentration of the new GM event and the testing protocols adopted. But assuming that agencies will adopt testing protocols to minimize the actual likelihood of unwanted rejection while respecting regulatory requirements<sup>25</sup>- the main issue remains the concentrations and the tolerance level. Past experience with unapproved GM events like Starlink have shown that a) minimal traces can be found in most shipments even if production is limited to a small area and conducted during only one season, signifying a large variance in concentration, b) the presence of GM events can persist for a long

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rejected.

24 These tests are the most rapid and least expensive format of ELISA tests (Demeke et al. 2005). For more on ELISA test in the case of Starlink, see Stave (2002) and USDA-GIPSA (2006).

25 As seen in the StarLink case or others in North America, trade agencies especially on the exporting side do put effort into ensuring that shipments will pass the required test at exporters.

time in the commodity chain at trace levels. These two considerations help demonstrate the near impossibility of maintaining zero tolerance without segregation systems.

Figure 1 also shows that the timing is critical, because if  $t_1$  nears  $t_2$  there is no significant trade disruption. The extent to which there is asynchronicity in approval matters. So does the delay to approve a new GM event for LLP. Furthermore, if the Codex Annex is applied, a simplified procedure is used, but this procedure will only be effective if it is conducted quickly and if it is effectively faster than the full approval procedure.<sup>26</sup> Taking this in consideration, there are three key timing related parameters:

$T_1 = t_1' - t_1$  : delay for LLP approval,

$T_2 = t_2 - t_1$  : delay for full approval,

$T_3 = T_2 - T_1$  : difference in speed between the LLP and full procedure.

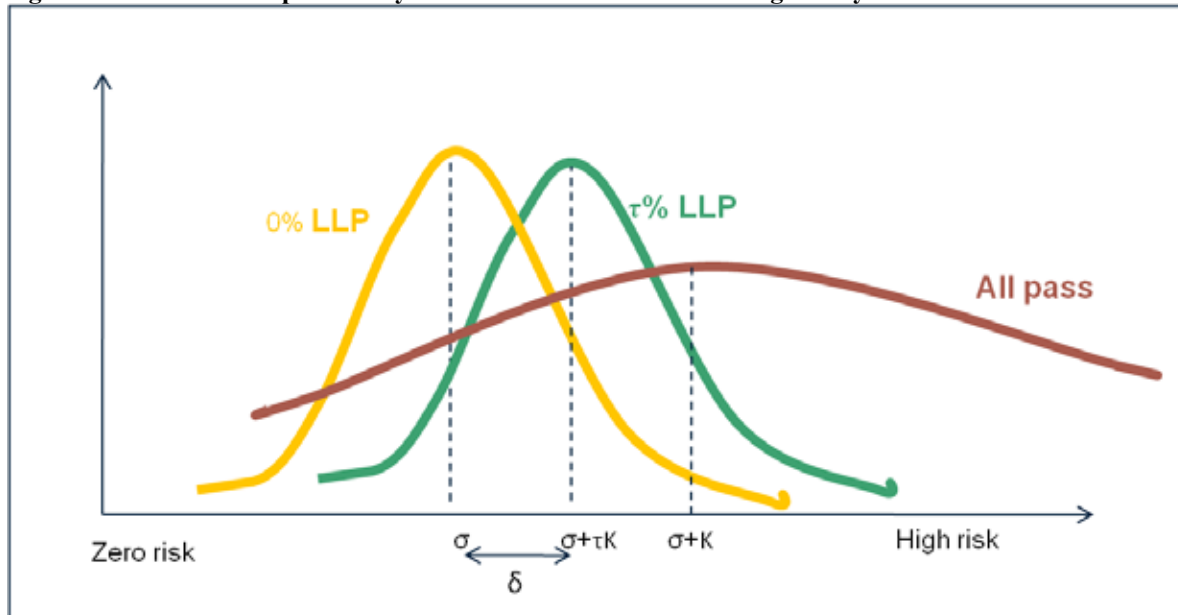
These three parameters can already be singled out as relevant to policy discussions, as they could also affect the surpluses by affecting the probability of rejection.

For the surplus calculations, we use Marshallian welfare measurements (see Figure A3 in appendix and main derivations). Higher prices due to trade restrictions will result in higher consumer price and lower consumer surplus. On the supply side, a higher domestic price, due to restrictions on GM imports can result in a supply response and higher producer surplus. However in an importing country, with linear and supply demand, this effect will not compensate for the loss in consumer surplus.

### *Risk and perceived safety*

The second factor that affects welfare relates to safety and its proxy from the standpoint of the regulator, perceived safety. The goal of biosafety regulations for imported consumption goods for

**Figure 9. Perceived risk probability distributions under different regulatory scenarios.**



Source: author

26 A regulatory expert recently noted that the differences between the complete and simplified procedures were not “very large”. If so, the effectiveness of a rapid system would be based on the implementation specifics: the review of data may be quicker or less detailed, and conducted by only a few people to accelerate the process.

food, feed or processing, is to limit risks for consumers. Perceived risks however do matter especially in the presence of uncertainty. It is the most difficult factor to quantify without looking at a case by case basis.

In our analysis we model risk using an exposure and damage framework. Because of uncertainties we assume that the exposure is modeled as a probability distribution of potential damage per unit consumed. Figure 9 shows our interpretation of risk probabilities under different regulations.

We assume that regulations affect both the mean and variance of the probability distribution of risks, but they do not completely eliminate risks. A 0% LLP policy in the short run does provide some certainty as to food risks but does not eliminate risk (enforcement could leave some uncertainty, but more generally any food item is associated with nonzero inherent risks). A nonzero percent tolerance level is modeled as a shift in mean probability of risks compared to 0%, but we assume that the variance remains the same (at least at rates under 10%). This shift reflects the perceived possible risk associated with importing trace levels of a still unapproved GM product. Lastly, no import policy does shift the mean and largely increases uncertainties about the perceived safety of imported products.

In this figure we see that the shift, modeled as  $\delta = \tau K$  is the crucial determinant of the perceived risk increase with a change in tolerance levels LLP for unapproved GM.  $K$  can be seen as the maximum expected risk increase from non-GM to 100% GM. The shift parameter  $K$  will depend on the type of product (processed vs. fresh), the intended use of the product (animal feed versus human consumption), and on the perceived value of the exporter's regulatory framework. If a country has a strong trust in the exporter's regulations, it will not fear new unknown risk with LLP in shipments at a nonzero rate. If, however, the exporter's regulatory body is not considered credible, the importer will fear any possible intrusion of non approved GM material. Generally speaking, if some of the developed country exporters have advanced regulation in place, they differ relatively significantly. Furthermore, some developing countries that export GM do not have fully functional/enforced regulatory systems.

### *Cost of implementation*

The cost of implementation is defined as:  $CI(Q) = (C1(\tau) S(\tau) + C2) Q$ , where  $C1(\tau) S(\tau)$  corresponds to the total testing costs (testing and sampling), and  $C2$  the equipment and inspectors. Both components are considered variable costs because they depend on total quantity imported. The first term depends on the tolerance level, as it is generally assumed that:  $C1(\tau < 1\%) > C1(1\% < \tau < 5\%) > C1(\tau > 5\%)$ , given detection level requirements.  $S(\tau)$ , defined as the sampling factor, is directly dependent on the tolerance level. A high tolerance level does not require as large a sample for a given concentration level.

### *Identifying the key parameters*

The problem described above is very much like a standard utility maximization problem. A rational and benevolent decision maker will choose the best regulatory options to maximize total welfare. There are four choice variables: the tolerance level, the two timing variables  $T1$  and  $T2$ , which correspond to the maximum time lapse before a decision of processing a LLP application and authorizing (or rejecting) the application, and the shift parameter  $K$  representing the lack of confidence in a given exporter's regulations.

While marginal effect parameters would need to be estimated to provide a possible solution, comparative statics can be used to determine what effect each of these parameters would have on total welfare. Table 3 shows the basic price and welfare effects of an increase in each parameter by component and in total. We subtract the producer surplus here, as we focus on the case of a small country net importer, with negligible production. The price effect is separated both to explain changes in consumer surplus and as an indicator of whether a specific regulatory choice would have

an inflationary price effect.

**Table 3. Effect of an increase in each key parameter on the total welfare of a LLP policy**

| Increase in | Price  | Consumer surplus | Risk avoidance/<br>perceived safety | Cost of implementation | Total welfare |
|-------------|--------|------------------|-------------------------------------|------------------------|---------------|
| $\tau$      | ↓      | ↑                | ↓ or →                              | ↓                      | ↓ or ↑        |
| $T_1$       | ↑ or → | ↓ or →           | →                                   | ↑ or →                 | ↓ or →        |
| $T_2$       | ↑      | ↓                | →                                   | ↑                      | ↓             |
| $K$         | →      | →                | ↓                                   | →                      | ↓             |

Source: Author

Simple derivations show that:

- A higher tolerance level, by reducing rejection rates, does decrease the expected price of the imported good, which therefore increases consumer surplus and total surplus (ceteris paribus). At the same time, the tolerance level either maintains or decreases the risk avoidance factor/ perceived safety of the regulation (depending on  $K$ ), and it decreases the cost of implementation. As a result, the effect on total welfare is ambiguous, and could be negative or positive, balancing perceived safety and consumer surplus and costs.
- A rise in the LLP processing delay increases expected price except if the tolerance level is zero, and therefore either maintains or decreases consumer surplus. The risk avoidance effect is similar, and the cost of implementation may increase or remain unchanged. As a result the total welfare effect is either negative or zero.
- Similarly, but regardless of the tolerance level, a longer delay in LLP approval will decrease consumer surplus and increase implementation cost with a resulting decrease in welfare.
- Lastly, increasing  $K$ , the lack of trust in the exporters' regulation, will only reduce the risk avoidance effect of any LLP policy and therefore reduce total welfare.

These results suggest that decision makers will always benefit from reducing approval delays and increasing confidence in exporters' regulation. This latter point is of relevance to Vietnam- as noted above, if the threshold for rapid approval of used events were lower (3 countries or less) the country's welfare would be enhanced, assuming such an approach were acceptable. Adopting a Codex Annex type of regulation for future new events, relying only on the exporter would also help. Still, reducing delays may or may not affect the marginal benefit of a LLP policy versus no LLP policy. If the maximum delay of LLP approval is too long, the policy will not provide any benefit and will just replicate a regular authorization.

But the results also show that setting up the tolerance level is not a simple decision; it involves both risk perceptions and economic considerations. Setting up a higher tolerance level can be summarized as trading lower transaction costs and prices for higher potential perceived risks. A decision on such key parameter needs to take into consideration benefits and costs.

Lastly Table 2 shows that prices may increase with long delays especially in LLP approvals, and with lower tolerance levels. In both cases, importers will have to purchase more expensive products, either authorized GM from another source or pure non-GM for a premium. Furthermore, a lower threshold (associated with higher rejection uncertainties) will also result in higher insurance for shipments, which will likely translate into the price of imported commodities. The next section uses this framework to provide an empirical application of the model in the case of Vietnam.

## Application to Vietnam

The goal of the application is to illustrate the conceptual framework, and to provide benchmark estimates of the effects of different regulatory options for low level presence of unapproved GM. The application focuses on maize, soybeans, and soymeals, the three main GM products imported in Vietnam, as noted in section 1b. We use the general assumptions of the analytical framework, with perfect enforcement and non-GM used as an alternative to GM within a partial equilibrium setting, and evaluate the effects of the presence of unapproved events in the short run and long run. In the short run, we use the analysis above to determine the cost of not including GM events that are not approved in five developed countries. In the long run, we compare three general options: a) a zero percent tolerance level (as suggested in the decree), b) all pass (current case), c) LLP policy with differing threshold levels.

We use the model described in section 2a) to compute an estimate of the cost of implementation and consumer surplus associated with different scenarios. Because of large uncertainties and the lack of reliable data on risk perceptions, we do not compute the risk avoidance term of the welfare function. Instead we compare the costs and economic surplus effects of different regulatory option to provide a first estimate of what risk perception differences a particular option would imply for welfare maximization.

**Table 4. Sources of data for the basic parameters.**

| Parameter                         | Source  |
|-----------------------------------|---|
| Production                        | FAOSTAT, average 2005-09, zero for soymeal  |
| Original price                    | Ratio of total trade value over total trade quantity, based on FAOSTAT data 2005-09   |
| Elasticities of supply and demand | IMPACT model projection 2005-09   |
| Total imports                     | COMTRADE data used in section 1, for 2005-09  |
| Share of affected imports         | Derived from COMTRADE data (used in section 1) for 2005-09 evaluated under different scenarios  |
| Price premium                     | Derived from the difference between the trade value/quantity ratios for GM and non-GM producers, FAOSTAT data, for 2005-09.                           |
| Cost of testing/volume            | Assumed to follow the following schedule per tolerance level: 5%: \$0.1/ton, 2.5%: \$0.5/ton, 1% and 0.9%: \$1/ton, 0.5%: \$1.5/ton, and 0.1%: \$2.5. |

*Source: as indicated.*

Table 4 provides a summary of the sources of the basic data used for computation. We focus on 2005-09 because of the observed pattern of imports of maize and soybeans in Vietnam- Vietnam has been importing increasing amounts of GM grains since 2005. For alternative to GM, we use actual market premium, as computed based on trade data from FAOSTAT. More specifically, we collect the trade values and volumes for all the GM producers of maize and soybeans between 2005 and 2009. We then identify for each year the GM producing countries, and differentiate the GM price and non-GM price for the three products. The difference between the two is a premium, of which we take the average value between 2005 and 2009. For instance we find average premia of 26.1% for maize, 25.8% for soybeans and 24% for soymeals, accounting for all GM producers. For the cost of testing  $CI(Q)$  we assign cost values between \$0.1 and \$2.5/ton depending on the scenario, based on Gruere and Rosegrant (2008). These are not precise estimates and would need to be more specifically measured with actual testing costs, but their contribution to the welfare effect is always small compared to the main market effects.

### Short run costs : the 5 developed country clause

Our model allows to compare the minimum costs of the “five developed country” trigger for rapid approval as suggested under the Biosafety decree to alternative less stringent options. To do so, we assume that GM events under the short run clause are approved within 2 months, as stipulated in the decree, while others are approved within 6 months. The four month difference extends the zero tolerance level on unapproved events especially in the US and Canada and thus results in changes in rejection probability and prices, We first calculate the annual economic effects of a zero tolerance level a) for all GM producing countries and b) for US and Canada and then report those to the number to the months of application. The results are shown in Table 5.

The total economic cost of the proposed system in the short run, not accounting for safety improvement is estimated to be at US\$18.6 million for the three products. This means that compared to a laissez faire policy, the approval system will result in economic costs around \$19 million not accounting for public enforcement cost. Assuming all GM events could be processed within two months if eligible, we find that this total is reduced to \$11.4 million if all GM events were eligible for rapid approval. Thus the cost of having a clause with five developed countries (rather than three developed countries, or three countries) is estimated to be \$7.2 million. The question one should ask is whether adding the experience of two countries is worth \$7.2 million in terms of improved perceived safety. If not, the cost will exceed the public benefits.

**Table 5. Economic analysis of the two tier approval system (in million US\$).**

|                                 | Crop     | Rapid approval process for<br>24 GM events |              | Delay for 13 US and Canada<br>GM events |              | Total<br>effects |
|---------------------------------|----------|--|--------------|---|--------------|------------------|
|                                 |          | Annualized                                 | For 2 months | Annualized                              | For 4 months |                  |
| Consumer surplus<br>effect      | Maize    | -65.0                                      | -10.8        | -9.1                                    | -3.0         | -13.8            |
|                                 | Soybeans | -20.2                                      | -3.4         | -19.4                                   | -6.5         | -9.9             |
|                                 | Soymeals | -47.9                                      | -8.0         | -3.7                                    | -1.2         | -9.2             |
| Producer surplus<br>effect      | Maize    | +59.2                                      | +9.9         | +8.1                                    | +2.7         | +12.6            |
|                                 | Soybeans | +16.0                                      | +2.7         | +15.3                                   | +5.1         | +7.8             |
|                                 | Soymeals | 0  | 0            | 0                                       | 0            | 0                |
| Total surplus<br>effect         | Maize    | -5.8                                       | -1.0         | -1.1                                    | -0.3         | -1.3             |
|                                 | Soybeans | -4.2                                       | -0.7         | -4.1                                    | -1.4         | -2.1             |
|                                 | Soymeals | -47.9                                      | -8.0         | -3.7                                    | -1.2         | -9.2             |
| Cost of<br>implementation       | Maize    | -1.3                                       | -0.2         | -2.6                                    | -0.9         | -1.1             |
|                                 | Soybeans | -0.2                                       | -0.04        | -0.3                                    | -0.09        | -0.1             |
|                                 | Soymeals | -9.1                                       | -1.5         | -10.0                                   | -3.3         | -4.8             |
| Total welfare<br>change         | Maize    | -7.1                                       | -1.2         | -3.7                                    | -1.2         | -2.4             |
|                                 | Soybeans | -4.5                                       | -0.7         | -4.3                                    | -1.4         | -2.1             |
|                                 | Soymeals | -57.0                                      | -9.5         | -13.8                                   | -4.6         | -14.1            |
| <b>TOTAL THREE<br/>PRODUCTS</b> |          | <b>-68.6</b>                               | <b>-11.4</b> | <b>-21.8</b>                            | <b>-7.2</b>  | <b>-18.6</b>     |

Source: Author's derivations.

### Long run effects of different LLP options

We now consider the longer term effect of a zero tolerance level policy, compared to no policy and a LLP policy as specified under the Codex Annex. To consider the case of intermediate low level presence policies, as discussed above, we focus on uncertainties and variances in concentration of

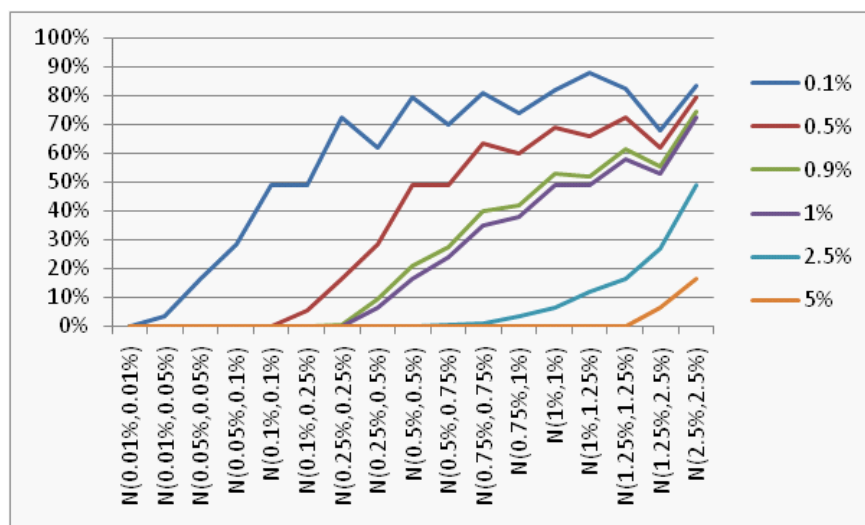
shipments, assuming testing is done to minimize errors. To set up a schedule of rejection probabilities, we conducted a mathematical simulation. We assumed that the observed concentration in a traded shipment was following one of seventeen normal distributions defined by distinct mean and standard deviations parameters between 0.01% to 2.5% , and truncated at zero to ensure that all concentration is positive. Under each distribution we drew 1,000 successive numbers, and compared these numbers to six given tolerance levels: 0.1% ,0.5%, 0.9%, 1%, 2.5%, and 5%.<sup>27</sup> Each time the concentration was above the tolerance level, the shipment was rejected. By counting the number of iterations where the shipments were rejected and dividing by 1000, we obtained probability of rejection for a given tolerance level and concentration distribution.

Figure 10 shows the results. On the horizontal axis, the seventeen Normal distributions are presented with mean concentrations ranging from 0.01% to 2.5% (from left to right), and variances varying within the same range. We decided to have distributions with mean equal variances and with variances exceeding the means step by step to represent various cases.<sup>28</sup> The results confirm that acceptance largely vary by tolerance level, but also help us determine the maximal mean and variance of concentration under which there will be no rejection for each tolerance level. This schedule is then used to set up probabilities of rejection under different tolerance levels for a given concentration.

To keep the results tractable, we pick four distributions of concentrations: N(0.1%,0.1%), N(0.5%,0.5%), N(1%,1%) and N(2.5%, 2.5%) to represent possible cases of concentration, potentially following each other overtime ((with increased adoption). The schedule of rejection probability is shown in Table 6. We then run the surplus computations under three scenarios for each product as noted in Table 7.

**Table 6. Probability of rejection by concentration and tolerance level**

**Figure 10: Probability of rejection by concentration distribution and tolerance level**



Source: Author; based on simulations

|            | N(0.1%,0.1%) | N(0.5%,0.5%) | N(1%,1%) | N(2.5%,2.5%) |
|------------|--------------|--------------|----------|--------------|
| $\tau=0\%$ | 1            | 1            | 1        | 1            |

27 These levels represent the range of options discussed at the policy level, with the EU adopting a 0.1% despite calls for a higher number, Japan applying 1% for animal feed, and the US and Canada in favor of a 5% system. We also include 0.9% because, as the labeling standard in Europe, it is often referred to in the discussions, and it helps show the difference between two close tolerance levels (0.9% versus 1%).

28 This means that the distributions are not strictly ordered in the axis, explaining the hills and valleys on the curves.

|              |       |      |      |      |
|--------------|-------|------|------|------|
| $\tau=0.1\%$ | 0.488 | 0.79 | 0.82 | 0.84 |
| $\tau=0.5\%$ | 0     | 0.49 | 0.69 | 0.79 |
| $\tau=0.9\%$ | 0     | 0.21 | 0.53 | 0.74 |
| $\tau=1\%$   | 0     | 0.17 | 0.49 | 0.73 |
| $\tau=2.5\%$ | 0     | 0    | 0.06 | 0.49 |
| $\tau=5\%$   | 0     | 0    | 0    | 0.17 |
| All pass     | 0     | 0    | 0    | 0    |

Source: Author's derivations

**Table 7. Scenarios of approval.**

|            | Maize                                       | Soybeans                                    | Soymeals                                    |
|------------|---|---|---|
| Scenario A | GM events from US+Canada affected           | GM events from US+Canada affected           | GM events from US+Canada affected           |
| Scenario B | GM events from US+Canada+Argentina affected | GM events from US+Canada+Argentina affected | GM events from US+Argentina+Brazil affected |
| Scenario C | GM events from all countries affected       | GM events from all countries affected       | GM events from all countries affected       |

Source: Author

For simplification, we assume that there is no delay for LLP ( $T_1=0$ ) and that the approval takes the entire year, but more complex scenarios could be simulated using zero tolerance during part of the year, and the LLP approval during another part. The results are presented in terms of total welfare effects defined as change in total surplus and cost of implementation, both in aggregate and per unit, knowing that the detailed results can be available from authors (prices, quantities). Table 8, 9 and 10 present the total results for maize, soybeans and soymeals, respectively. The same results are presented by unit (per ton) in the appendix tables A4, A5, and A6.

**Table 8. Total welfare effects (\$million/year) in the case of maize under different scenarios**

| Scenario | Concentration     | $\tau=0\%$ | $\tau=0.1\%$ | $\tau=0.5\%$ | $\tau=0.9\%$ | $\tau=1\%$ | $\tau=2.5\%$ | $\tau=5\%$ |
|----------|-------------------|------------|--------------|--------------|--------------|------------|--------------|------------|
| <b>A</b> | <b>N(0.1,0.1)</b> | -3.69      | -1.90        | -0.85        | -0.57        | -0.57      | -0.28        | -0.06      |
|          | <b>N(0.5,0.5)</b> | -3.69      | -2.18        | -1.35        | -0.79        | -0.74      | -0.28        | -0.06      |
|          | <b>N(1,1)</b>     | -3.69      | -2.21        | -1.55        | -1.12        | -1.07      | -0.35        | -0.06      |
|          | <b>N(2.5,2.5)</b> | -3.69      | -2.23        | -1.64        | -1.33        | -1.32      | -0.80        | -0.24      |
| <b>B</b> | <b>N(0.1,0.1)</b> | -6.47      | -3.80        | -0.85        | -0.57        | -0.57      | -0.28        | -0.06      |
|          | <b>N(0.5,0.5)</b> | -6.47      | -4.98        | -3.34        | -1.74        | -1.50      | -0.28        | -0.06      |
|          | <b>N(1,1)</b>     | -6.47      | -5.07        | -4.20        | -3.31        | -3.11      | -0.65        | -0.06      |
|          | <b>N(2.5,2.5)</b> | -6.47      | -5.13        | -4.58        | -4.20        | -4.16      | -2.90        | -1.05      |
| <b>C</b> | <b>N(0.1,0.1)</b> | -7.10      | -4.43        | -0.85        | -0.57        | -0.57      | -0.28        | -0.06      |
|          | <b>N(0.5,0.5)</b> | -7.10      | -5.78        | -4.01        | -2.09        | -1.78      | -0.28        | -0.06      |
|          | <b>N(1,1)</b>     | -7.10      | -5.88        | -5.02        | -4.04        | -3.80      | -0.76        | -0.06      |
|          | <b>N(2.5,2.5)</b> | -7.10      | -5.95        | -5.44        | -5.07        | -5.02      | -3.61        | -1.35      |

**Table 9. Total welfare effects (\$million/year) in the case of soybeans under different scenarios**

| Scenario | Concentration     | $\tau=0\%$ | $\tau=0.1\%$ | $\tau=0.5\%$ | $\tau=0.9\%$ | $\tau=1\%$ | $\tau=2.5\%$ | $\tau=5\%$ |
|----------|-------------------|------------|--------------|--------------|--------------|------------|--------------|------------|
| <b>A</b> | <b>N(0.1,0.1)</b> | -4.34      | -2.42        | -0.13        | -0.09        | -0.09      | -0.04        | -0.01      |
|          | <b>N(0.5,0.5)</b> | -4.34      | -3.55        | -2.34        | -1.10        | -0.89      | -0.04        | -0.01      |

|          |                   |       |       |       |       |       |       |       |
|----------|-------------------|-------|-------|-------|-------|-------|-------|-------|
|          | <b>N(1,1)</b>     | -4.34 | -3.64 | -3.12 | -2.48 | -2.31 | -0.35 | -0.01 |
|          | <b>N(2.5,2.5)</b> | -4.34 | -3.70 | -3.48 | -3.27 | -3.23 | -2.28 | -0.84 |
| <b>B</b> | <b>N(0.1,0.1)</b> | -4.46 | -2.50 | -0.13 | -0.09 | -0.09 | -0.04 | -0.01 |
|          | <b>N(0.5,0.5)</b> | -4.46 | -3.66 | -2.43 | -1.14 | -0.93 | -0.04 | -0.01 |
|          | <b>N(1,1)</b>     | -4.46 | -3.75 | -3.23 | -2.57 | -2.39 | -0.37 | -0.01 |
|          | <b>N(2.5,2.5)</b> | -4.46 | -3.82 | -3.59 | -3.38 | -3.34 | -2.37 | -0.88 |
| <b>C</b> | <b>N(0.1,0.1)</b> | -4.46 | -2.50 | -0.13 | -0.09 | -0.09 | -0.04 | -0.01 |
|          | <b>N(0.5,0.5)</b> | -4.46 | -3.66 | -2.43 | -1.15 | -0.93 | -0.04 | -0.01 |
|          | <b>N(1,1)</b>     | -4.46 | -3.75 | -3.23 | -2.57 | -2.39 | -0.37 | -0.01 |
|          | <b>N(2.5,2.5)</b> | -4.46 | -3.82 | -3.59 | -3.38 | -3.35 | -2.37 | -0.88 |

Source: Author's derivations

**Table 10. Total welfare effects (\$million/year) in the case of soybeans under different scenarios**

| Scenario | Concentration     | $\tau=0\%$ | $\tau=0.1\%$ | $\tau=0.5\%$ | $\tau=0.9\%$ | $\tau=1\%$ | $\tau=2.5\%$ | $\tau=5\%$ |
|----------|-------------------|------------|--------------|--------------|--------------|------------|--------------|------------|
| <b>A</b> | <b>N(0.1,0.1)</b> | -13.80     | -6.88        | -3.03        | -2.02        | -2.02      | -1.01        | -0.20      |
|          | <b>N(0.5,0.5)</b> | -13.80     | -8.02        | -4.86        | -2.81        | -2.64      | -1.01        | -0.20      |
|          | <b>N(1,1)</b>     | -13.80     | -8.12        | -5.62        | -4.02        | -3.86      | -1.24        | -0.20      |
|          | <b>N(2.5,2.5)</b> | -13.80     | -8.19        | -6.00        | -4.81        | -4.77      | -2.86        | -0.85      |
| <b>B</b> | <b>N(0.1,0.1)</b> | -54.18     | -27.30       | -3.03        | -2.02        | -2.02      | -1.01        | -0.20      |
|          | <b>N(0.5,0.5)</b> | -54.18     | -40.74       | -25.34       | -11.78       | -9.71      | -1.01        | -0.20      |
|          | <b>N(1,1)</b>     | -54.18     | -41.87       | -34.32       | -26.28       | -24.38     | -3.92        | -0.20      |
|          | <b>N(2.5,2.5)</b> | -54.18     | -42.73       | -38.69       | -35.57       | -35.13     | -23.52       | -8.14      |
| <b>C</b> | <b>N(0.1,0.1)</b> | -57.05     | -28.79       | -3.03        | -2.02        | -2.02      | -1.01        | -0.20      |
|          | <b>N(0.5,0.5)</b> | -57.05     | -43.10       | -26.84       | -12.44       | -10.23     | -1.01        | -0.20      |
|          | <b>N(1,1)</b>     | -57.05     | -44.29       | -36.40       | -27.90       | -25.88     | -4.12        | -0.20      |
|          | <b>N(2.5,2.5)</b> | -57.05     | -45.21       | -41.04       | -37.79       | -37.32     | -25.03       | -8.68      |

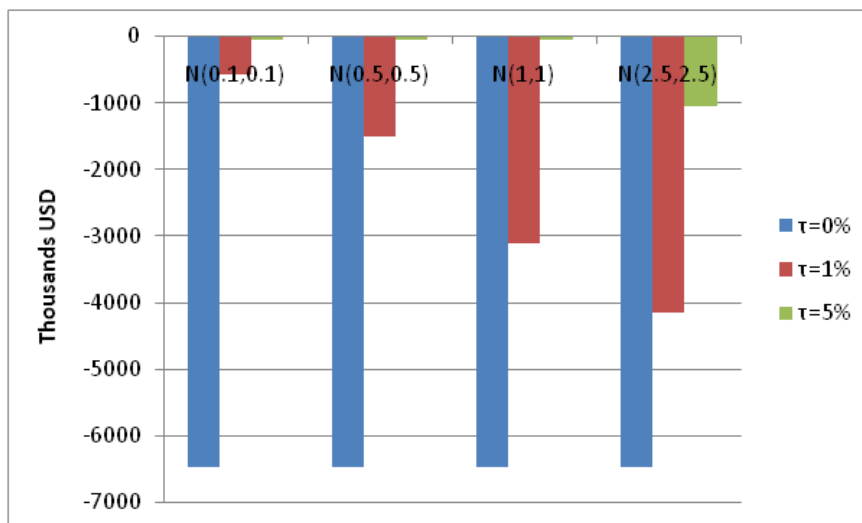
These tables show that results do vary by crop, scenario, tolerance and concentration. Welfare costs vary from -\$10,000 (soybeans, 5% tolerance level due to no rejection) up to over \$57 million (soybeans, zero percent tolerance where all GM are rejected). As expected, the effect of an unapproved soybean event, which would affect the soybean and soybean markets together is much greater than that

Source: Author's derivations

of a GM maize event. Furthermore, increasing the concentration, number of countries affected, or decreasing the tolerance would increase the welfare costs as expected. Overall, the main lesson is that zero tolerance is quite costly: the costs found for maize range from \$3.7 to \$7 million, which translates into \$7 to \$28/ton of imported maize; the cost for soybeans are around \$4 million or over \$80/ton, and they vary from \$14 to 57 million per year, which translates into \$7 to 31/ton for soybean.

Using these three dimensional tables, one can look at individual cases, and compare the effects of different tolerance levels. First, assume there is a new GM maize event that is rapidly adopted in the US, Canada and Argentina (scenario B). What would be the difference between a 0% versus a 5% tolerance as time goes by (with increasing concentration)? Figure 11 provides the results. The cost of maintaining a zero tolerance level would be around \$6.5 million per year. Adopting a 1% tolerance would reduce the cost significantly, but the difference with zero tolerance would diminish as the presence of the GM event increases (between \$568,000 and 4.1 million). In contrast, the use of a 5% tolerance level low level presence would keep the cost minimal (\$56,000- equal to the testing cost) for low concentrations, going to \$1 million under the highest concentration. Thus, the use of a

**Figure 11 Welfare effects for an unapproved GM maize event in US, Canada and Argentina**

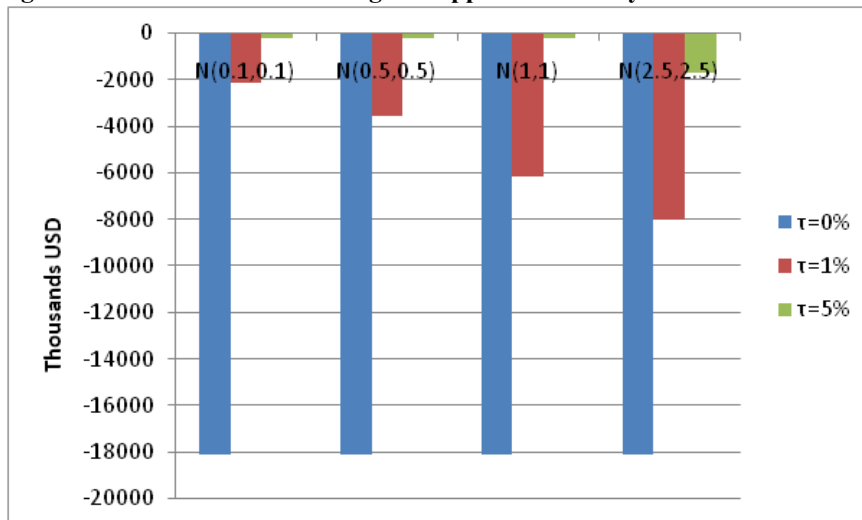


Source: Author's derivations

5% tolerance LLP would leave time to allow the government to clear the product without raising costs for importers and consumers.

As a second case study, assume that a new GM soybean event is being approved in the US and Canada, but not anywhere else. What would it mean for Vietnam? Figure 12 provides the results. A very similar pattern is found, simply because the schedule of rejection rate is the same for the similar concentration, but the values largely differ. Because soymeal imports are concerned, even if the disruption only concerns fewer countries, the effects are much larger. The cost of maintaining a zero tolerance level reaches \$18 million per year. With a 1% this cost ranges only from 2 million to 8 million. With a 5% tolerance level, the cost remains minimal (approximately \$200,000) with only under \$2million for the highest concentration. In average, a zero tolerance level cost \$18million, a 1% tolerance 4.1million, and a 5% tolerance \$580,000 per year. So the question for a policy maker is the following: is maintaining a zero tolerance level that costs \$14 million in order to address perceived safety concerns better than a 1% presence of an unapproved event that has gone through safety authorization in the country of export? Is it worth \$17 million more than a 5% level? The same computation can also be done with lower tolerance levels. In particular, using a 0.1% tolerance level results in an average cost of \$11 million, which is \$7million less than with a zero percent tolerance. Is

**Figure 12 Welfare effects of a single unapproved GM soybean event in the United States and Canada**



Source: Author's derivations

maintaining zero tolerance worth \$7million more than a 0.1% tolerance?

Many other scenarios can be applied with this framework, and one could also put off the costs of implementation, to find similar results: a zero tolerance level will cost a lot more than any other tolerance for any concentration, especially for a country like Vietnam that imports significant amounts of maize, soybeans and soymeals. We will now provide a few illustration of the trade effects of a zero tolerance level, using a different model focusing on maize.

### 3. Trade considerations: the case of maize

The model used above is very comprehensive and can capture a lot of detailed assumptions, but it is set with an international exogenous price, and based on past import flows. In particular it does not look at the possible trade diversion that a zero tolerance level could result in or at the effects of changes in trade flows on international prices. This section will briefly review some preliminary results from a trade model applied in the case of maize as a complement.

The original model used is a spatial equilibrium model of trade with 80 maize trading countries. The full specification of the model are available in Bouet, Gruere and Leroy (2011). The model was used previously to assess the effects of information requirements under the Cartagena Protocol on Biosafety. Here we make a few modification, because we focus on Vietnam and because membership to the Protocol is not an issue. We use a simplified calibration, without the maximum entropy framework used by Bouet et al (2011), to ensure that in the original trade matrix, Vietnam does import maize. We then shock the model by shutting down bilateral trade flows from GM producing countries. Table 11. Groups of countries used in the model.

| Group   | Description   | Countries  |
|---------|---|--|
| Group 1 | Country of focus  | Vietnam  |
| Group 2 | GM producing countries  | Argentina, Brazil, Canada, Spain, the Philippines, South Africa, Uruguay, USA  |
| Group 3 | Countries potentially future GM producers and potentially affected by LLP | China, Mexico  |
| Group 4 | Non-GM producing countries  | Algeria, Angola, Austria, Bangladesh, Belgium-Luxemburg, Bolivia, Bulgaria, Chile, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Ecuador, Egypt, El Salvador, France, Germany, Greece, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kuwait, Lebanon, Libya, Malawi, Malaysia, Mauritius, Moldova, Morocco, Mozambique, Namibia, Nigeria, Netherlands, North Korea, Panama, Pakistan, Paraguay, Peru, Romania, Russia, Saudi Arabia, Slovenia, South Korea, Sri Lanka, Sudan, Swaziland, Syria, Tanzania, Thailand, Turkey, Uganda, Ukraine, Venezuela, Yemen, Zambia, Zimbabwe |

Source: Author.

To simplify the scenarios, we define three groups of countries in addition to Vietnam, as shown in Table 11. The first group is constituted of Vietnam, the second group includes GM maize producing countries, the third group includes other countries of interest that could grow GM maize, and the fourth group includes non-GM producers. Table 12 shows the three scenarios. The shocks are implemented by adding a prohibitive cost of trade for the targeted bilateral trade flows.

**Table 12. Scenarios implemented**

|            | Trade flows impacted (zero tolerance like)   |
|------------|--|
| Scenario 0 | Base- no shock   |
| Scenario 1 | From Group 2 (GM) to Group 1 (Vietnam)   |
| Scenario 2 | From Group 2(GM) to Group 1 (Vietnam), and from Group 3 to Group 1 (Vietnam)                           |
| Scenario 3 | From Group 2 (GM) to Group 1 (Vietnam), from Group 3 to Group 1 (Vietnam), and from Group 2 to Group 3 |

Source: Author.

**Table 13. Effects of trade simulations on supply and demand per group**

| Variable | Group         | Scenario 1 | Scenario 2 | Scenario 3 |
|----------|---------------|------------|------------|------------|
| Demand   | Vietnam (VNM) | -8.2%      | -8.2%      | -12.1%     |
|          | GRP2          | 0.3%       | 0.3%       | 2.8%       |
|          | GRP3          | 0.1%       | 0.1%       | -3.8%      |
|          | GRP4          | -0.3%      | -0.3%      | -1.0%      |
| Supply   | Vietnam (VNM) | 0.4%       | 0.4%       | 2.5%       |
|          | GRP2          | -0.1%      | -0.1%      | -1.2%      |
|          | GRP3          | 0.0%       | 0.0%       | 0.3%       |
|          | GRP4          | 0.5%       | 0.5%       | 2.6%       |

Source: Simulations' results.

**Table 14. Effects of trade simulations on demand and supply prices per group**

| Variable          | Group         | Scenario 1 | Scenario 2 | Scenario 3 |
|-------------------|---------------|------------|------------|------------|
| Demand price (Pd) | Vietnam (VNM) | 17.9%      | 17.9%      | 26.2%      |
|                   | GRP2          | -0.6%      | -0.6%      | -3.1%      |
|                   | GRP3          | -0.5%      | -0.5%      | 21.0%      |
|                   | GRP4          | 0.7%       | 0.7%       | 2.4%       |
| Supply price (Ps) | Vietnam (VNM) | 1.9%       | 1.9%       | 12.8%      |
|                   | GRP2          | 0.4%       | 0.4%       | 3.8%       |
|                   | GRP3          | 1.3%       | 1.3%       | 9.2%       |
|                   | GRP4          | 1.3%       | 1.3%       | 8.5%       |

Source: Simulations' results.

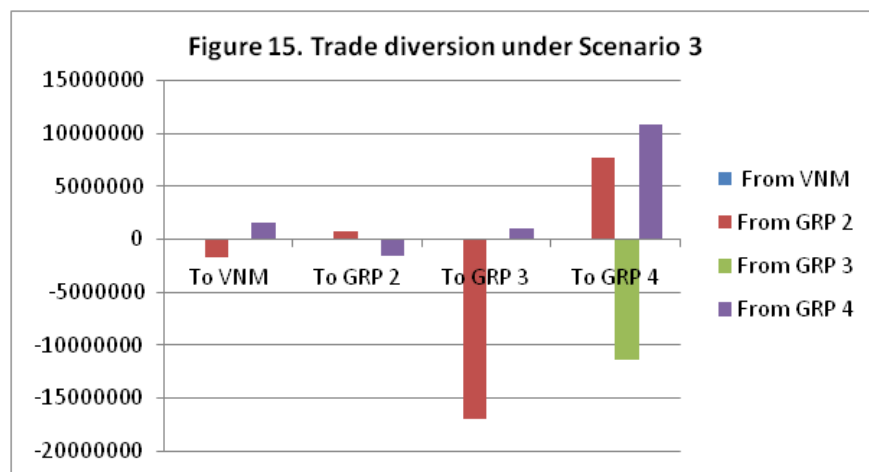
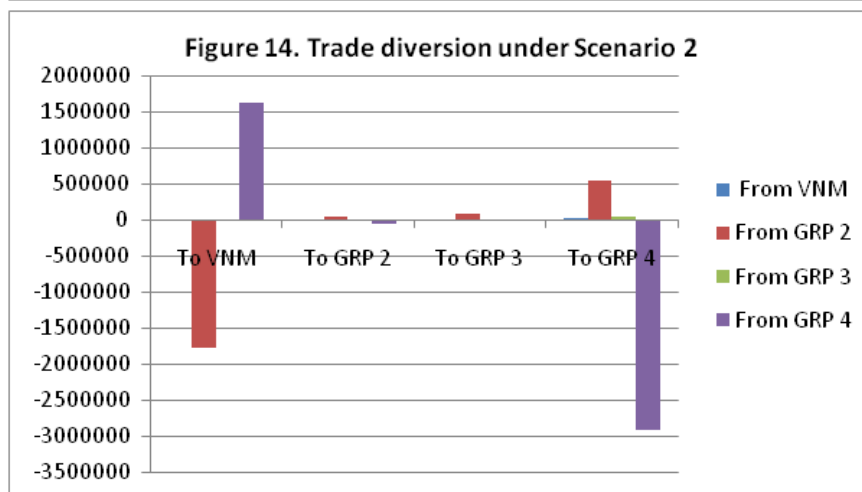
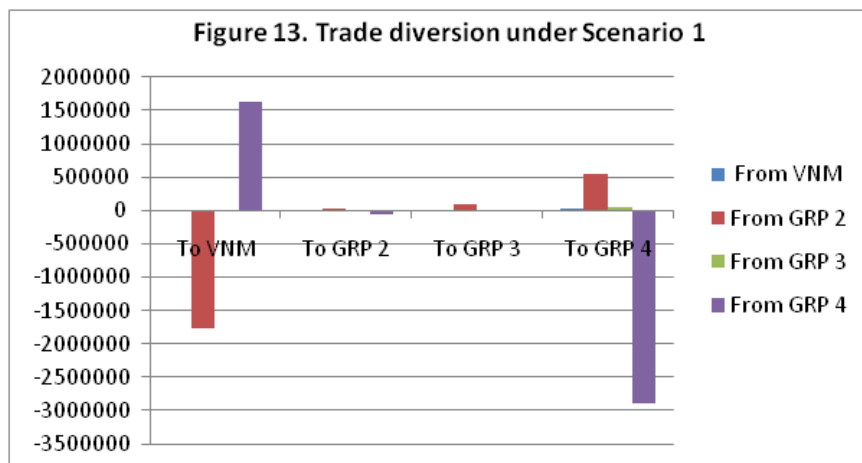
The results are shown in variations from Scenario 0. The relative price and quantity effects are shown in Table 13 and 14. As expected, Vietnam is the most affected by the three scenarios. It is slightly more affected by scenario 3, where large countries are also facing LLP. As expected, and as found with the other model, restricting GM access results in significant costs for consumers of the imported commodities, while suppliers gain from an increase in price, and increase their production.

Figures 13, 14 and 15 show the changes in trade flows across groups. In these figures Vietnam is noted VNM. While the absolute values may look large, it is the direction of trade diversion that is of interest. Under Scenario 1, Vietnam does not import any GM maize from Group 2 countries (Argentina and USA), and this is compensated by non GM maize from Group 4 countries. To do so, Group 4 countries also reduce their exports to other members and Group 1 compensates for its loss by sending more maize to Group 4. A similar pattern is observed when Group 3 cannot export to Vietnam, simply because these countries are not at present maize exporters. Lastly when one adds zero tolerance barriers in Group 3 countries for GM producers, there is a much larger volume of trade diversion across Groups 2, 3 and 4. Group 2 diverts its exports to Group 4. Group 3 stops exporting to Group 4 to compensate for the loss of imports. Group 4 make adjustment to its trade going to the

three other groups, including Vietnam.

**Table 15. Relative welfare effects under the three scenarios**

| Variable         | Group         | Scenario 1 | Scenario 2 | Scenario 3 |
|------------------|---------------|------------|------------|------------|
| Producer surplus | Vietnam (VNM) | 0.73%      | 0.72%      | 5.05%      |
|                  | GRP2          | -0.25%     | -0.25%     | -2.33%     |
|                  | GRP3          | 0.16%      | 0.16%      | 1.08%      |



Source: Simulations' results.(Figures 13 - 15)

|                  |               |         |         |         |
|------------------|---------------|---------|---------|---------|
| Consumer surplus | GRP4          | 0.81%   | 0.81%   | 4.79%   |
|                  | Vietnam (VNM) | -15.81% | -15.80% | -22.71% |
|                  | GRP2          | 0.63%   | 0.63%   | 5.66%   |
| Total surplus    | GRP3          | 0.08%   | 0.08%   | -3.08%  |
|                  | GRP4          | -0.41%  | -0.41%  | -2.18%  |
|                  | Vietnam (VNM) | -15.55% | -15.55% | -22.31% |
|                  | GRP2          | 0.62%   | 0.62%   | 5.57%   |
|                  | GRP3          | 0.08%   | 0.08%   | -3.05%  |
|                  | GRP4          | -0.41%  | -0.41%  | -2.17%  |

Source: Results from the simulation.

Based on these figures, and structural assumptions in the model, we can calculate the basic welfare implications of the three shocks in all the groups. The results are in Table 15. Unsurprisingly, Vietnam is most affected, especially Vietnamese consumers. Consumer surplus is reduced by 15 to 23%, while producer surplus is only marginally affected. Overall, total surplus is also reduced by 15 to 22% for Vietnam. There is no clear winner. Consumers in Group 2 do gain from trade restrictions especially under scenario 3, because of a lower price, but these relative gains are small (5%). Producers in the same countries do lose. Producers in Group 4 gains from increased restrictions.

While these results are not fully comparable and less realistic<sup>29</sup> than the ones obtained with the partial equilibrium model, they are qualitatively similar. Zero tolerance will have a significant effect on importers, even if applied only to one commodity for certain countries, and even in the presence of trade diversion. In the case of Vietnam, the animal industry would be the most affected, as it would have to feed a growing population of animals with more expensive feeds. In a vertically coordinated industry, with balance of power, prices would be transmitted, and the price of meat would increase and become unaffordable for a significant share of the population. But the Vietnamese industry may not fit this categorization and it is likely that a significant share of the loss will be borne by the farmers.

## 4. Conclusions

In this paper, we model the economic effects of different implementation options of low level presence (LLP) policies as proposed the Codex Annex and apply it to the case of Vietnam. We first describe the Vietnamese regulatory situation, and find that the new Biosafety Decree of 2010 does imply a zero tolerance for unapproved GM. We then show that Vietnam has been increasingly importing GM commodities these last few years. In 2010, 1.1 million tons (worth \$375 million) of likely GM products were imported, representing over 80% of total imports of maize, soybeans and soymeals. We explore the potential effects of a rapid approval system suggested for events approved in at least five developed countries, and show that it will not help clear all the events that will need to be assessed at the day of implementation.

We then develop a simple analytical model to identify factors for consideration in the design of regulations. We find that three factors will matter for a benevolent regulator: the market effects, the risk avoidance effect (perceived safety) and the implementation costs. Each of these factors will depend on the regulatory approach. Table16 provides a summary of the general effects and conclusions under three different approaches: a zero percent LLP policy, a nonzero percent LLP policy and no regulation (all passes).

29 Because of the spatial equilibrium model's calibration, based on older data, and strong assumptions needed to balance a matrix of 80 countries international trade, the country model, that relies on more recent and less structured data, is bound to provide a closer representation of actual effects.

**Table 16. Summary of the main effects of each regulatory option**

| Option                         | Probability of rejection | Price effect        | Risk effect                   | Cost effect      | Conclusions   |
|--------------------------------|--------------------------|---------------------|-------------------------------|------------------|---|
| <b>Zero tolerance</b>          | 1                        | High until approval | Larger variance               | Very high        | Valid if high perceived risk and no trust in export |
| <b><math>\tau\%</math> LLP</b> | Moderate                 | Moderate            | Larger variance and mean      | Moderate to high | Best solution from trade's perspective              |
| <b>All pass</b>                | 0                        | 0                   | Much larger variance and mean | None             | Valid if prices matter more than anything else      |

Source: Author.

An LLP policy with a 0% tolerance level is the most costly option, as it greatly exacerbates issues arising from synchronous approvals. It is only justified if the perceived risks exceed the temporary costs, and/or if there is no trust in the exporter's regulation. A laissez-faire approach is only justified if prices and costs largely exceed perceived risks. Lastly, the use of a nonzero tolerance level LLP policy, as proposed by the Codex Annex, is the best from trader's perspective in that it balances risks and cost considerations.

Low level presence policies are therefore valid intermediates between GM bans and no regulations. That may explain why all countries at the Codex approved such guideline. But our model also shows that the specific characteristics of the policies critically matter. In particular we find three significant factors that will determine whether a LLP policy will be effective and efficient: the tolerance level, the delay for LLP approval, the delay for full approval and the degree of trust in exporter's regulations. If reducing regulatory delays and increasing confidence unambiguously increase total welfare, the choice of the tolerance level will balance perceived risks and costs, and needs to be selected based on local specificities.

We then apply our model to the case of Vietnam, to assess the potential economic implications of the regulations as defined under the Biosafety decree in comparison with other options. In the short run, we derive the total cost of having a rapid approval for an incomplete list of events that we estimate at \$18 million, including \$7 million for the events not approved in at least five developed countries. In other words, had the decree been more inclusive, allowing events approved in three instead of five developed countries, it would have saved \$7 million. Naturally, adopting the suggested policy as stated in the Codex Annex would also help in the short run to avoid zero tolerance while a cascade of new GM events are going through the approval process.

In the longer term, we use the model to derive the changes in cost of implementation and consumer surplus associated with the use of different tolerance levels compared to no regulation in the case of a new GM event interrupting trade in maize, soybeans and soymeals. We find a range of results depending on the product, the number of exporting countries concerned, the concentration of unapproved GM events, and naturally the tolerance level adopted. But the most striking result we find is that, consistently with Table 16 above, zero tolerance level costs a lot more than any non-zero tolerance level, with additional costs ranging from a few million to over \$50million per year.

In particular, if a new GM soybean event approved only in the US and Canada was found in shipments in Vietnam, using a zero tolerance level would cost a minimum \$7million more than a LLP policy with a 0.1% tolerance level, \$14million more than a LLP policy with a 1% tolerance and \$17million more than with a 5% tolerance level. This raises the question of whether the temporary complete avoidance of

this new US approved soybean is worth pursuing. Are the benefits (improved perceived safety) worth the cost for the Vietnamese livestock producers?

Lastly, we provide the first results from a spatial equilibrium model of 80 maize trading countries, and confirm that a zero tolerance policy will be costly for consumers, with an increase in consumer price, lower demand, and a decrease in consumer surplus exceeding 15%.

Given all these considerations, the way ahead will be for small countries like Vietnam to design, introduce, and implement regulations that are pragmatic, credible and efficient. More specifically, the following four recommendations provide elements of guidance as to the choice of a tolerance level, limitations in regulatory delays and increased confidence in regulatory systems.

1. Vietnam and other similar countries should include an extended rapid approval system that allows for GM events approved and used in three countries to be assessed more rapidly.
2. They should choose a nonzero tolerance level to avoid the cost they generate. Practically, the levels should be greater than detection level and compatible with other tolerance levels. If the use of a nonzero tolerance level is a sensitive issue, countries may choose different thresholds by type of product based on level of risk: a) fresh food, b) grains for processing or processed food, c) animal feed. Such three-tier approach will lead to new transaction costs but can lead to better results than 0% for all.
3. To reduce regulatory delays, it would be better if LLP dossiers are aligned with exporter's approval. There should be a rapid information flow via a workable and reliable database. And if there is a low capacity, regions should rely on group of countries' expertise or use an integrated regional clearance system.
4. Lastly, to increase confidence in exporters' regulations, countries should try to use the same Codex guidelines. In some cases, integration and group decisions could be used to combine expertise. Ultimately, the development of some kind of international clearance system may be necessary to avoid over regulatory burden with hundreds of new GM events.

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## Appendix.

### *Text of The Codex Annex.*

#### **ANNEX 3: FOOD SAFETY ASSESSMENT IN SITUATIONS OF LOW-LEVEL PRESENCE OF RECOMBINANT-DNA PLANT MATERIAL IN FOOD**

##### **SECTION 1 – PREAMBLE**

1. An increasing number of recombinant–DNA plants are being authorized for commercialization. However, they are authorized at different rates in different countries. As a consequence of these asymmetric authorizations, low levels of recombinant DNA plant materials that have passed a food safety assessment according to the Codex Guideline for the conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Plants (CAC/GL 45-2003) (CodexPlant Guideline) in one or more countries may on occasion be present in food in importing countries in which the food safety of the relevant recombinant-DNA plants has not been determined.

2. This Annex describes the recommended approach to the food safety assessment in such situations of low-level presence of recombinant-DNA plant material or in advance preparation for such potential circumstances.<sup>1</sup>

3. This Annex also describes data and information sharing mechanisms to facilitate utilization of the Annex and to determine whether it should apply.

4. This Annex can be applied in two different dietary exposure situations:

a. That involving commodities, such as grains, beans or oil seeds, in which exposure to food from a variety not authorized in the importing country would likely be to dilute low level amounts at any one time. This would likely be the more common situation of low-level presence of recombinant-DNA plant material. Because any food serving of grains, beans or oil seeds would almost necessarily come from multiple plants, and because of how these types of commodities generally are sourced from multiple farms, are commingled in grain elevators, are further commingled in export shipments, at import and when used in processed foods, any inadvertently commingled material derived from recombinant-DNA plant varieties would be present only at a low level in any individual serving of food.

b. That involving foods that are commonly consumed whole and undiluted, such as some fruits and vegetables like potatoes, tomatoes, and papaya, in which exposure would be rare but could be to an undiluted form of the unauthorized recombinant-DNA plant material. While the likelihood of consuming material from such an unauthorized variety would be low and the likelihood of repeated consumption would be much lower, any such consumption might be of an entire unauthorized fruit or vegetable.

5. In both cases, the dietary exposure will be significantly lower than would be considered in a food safety assessment of the recombinant-DNA plant according to the Codex Plant Guideline. As a result, only certain elements of the Codex Plant Guideline will be relevant and therefore are included in this Annex.

6. This Annex does not:

- address risk management measures; national authorities will determine when a recombinant-DNA plant

material is present at a level low enough for this Annex to be appropriate;

- preclude national authorities from conducting a safety assessment according to the Codex Plant Guideline; countries can decide when and how to use the Annex within the context of their regulatory

<sup>1</sup> This guidance is not intended for a recombinant-DNA plant that was not authorized in an importing country as a result of that country's food safety assessment.

systems; or

- eliminate the responsibility of industries, exporters and, when applicable, national competent authorities to continue to meet countries' relevant import requirements, including in relation to unauthorized recombinant- DNA plant material.

## **SECTION 2 – GENERAL AND OTHER CONSIDERATIONS**

7. For the food safety assessment in situations of low-level presence of recombinant DNA plant materials in food, sections 4 and 5 of the Codex Plant Guideline apply as amended as follows. The applicable paragraphs are specifically indicated. Those paragraphs of the Codex Plant Guidelines that are not listed can be omitted from consideration.

### **DESCRIPTION OF THE RECOMBINANT-DNA PLANT**

8. Paragraph 22 of the Codex Plant Guideline applies.

### **DESCRIPTION OF THE HOST PLANT AND ITS USE AS A FOOD**

9. Paragraphs 23, 24 and 25 of the Codex Plant Guideline apply.

### **DESCRIPTION OF THE DONOR ORGANISM(S)**

10. Information should be provided on the donor organism(s) and, when appropriate, on other related species. It is particularly important to determine if the donor organism(s) or other closely related members of the family naturally exhibit characteristics of pathogenicity or toxin production, or have other traits that affect human health. The description of the donor organism(s) should include:

- A. its usual or common name;
- B. scientific name;
- C. taxonomic classification;
- D. information about the natural history as concerns food safety;
- E. information on naturally occurring toxins and allergens; for microorganisms, additional information on pathogenicity and the relationship to known pathogens; and,
- F. information on past and present use, if any, in the food supply and exposure route(s) other than intended food use (e.g., possible presence as contaminants)<sup>2</sup>.

### **DESCRIPTION OF THE GENETIC MODIFICATION(S)**

11. Paragraphs 27, 28 and 29 of the Codex Plant Guideline apply.

### **CHARACTERIZATION OF THE GENETIC MODIFICATION(S)**

12. Paragraphs 30 and 31 of the Codex Plant Guideline apply.

13. Information should be provided on any expressed substances in the recombinant-DNA plant; this should include:

- A) the gene product(s) (e.g. a protein or an untranslated RNA);
- B) the gene product(s)' function;
- C) the phenotypic description of the new trait(s);
- D) the level and site of expression in the plant of the expressed gene product(s), and the levels of its metabolites in the edible portions of the plant; and
- E) where possible, the amount of the target gene product(s) if the function of the expressed sequence(s)/gene(s) is to alter the accumulation of a specific endogenous mRNA or protein.<sup>3</sup>

<sup>2</sup> The text of this paragraph was adapted from paragraph 26 of the Codex Plant Guideline.

<sup>3</sup> The text of this paragraph was adapted from paragraph 32 of the Codex Plant Guideline.

14. Paragraph 33 of the Codex Plant Guideline applies.

## **SAFETY ASSESSMENT**

### **Expressed Substances (non-nucleic acid substances)**

#### **Assessment of possible toxicity**

15. The safety assessment should take into account the chemical nature and function of the newly expressed substance and identify the concentration of the substance in the edible parts of the recombinant-DNA plant, including variations and mean values.<sup>4</sup>

16. Information should be provided to ensure that genes coding for known toxins present in the donor organisms are not transferred to recombinant-DNA plants that do not normally express those toxic characteristics. This assurance is particularly important in cases where a recombinant-DNA plant is processed differently from a donor plant, since conventional food processing techniques associated with the donor organisms may deactivate, degrade or eliminate toxicants.<sup>5</sup>

17. Paragraph 37 of the Codex Plant Guideline applies.

18. In the case of proteins, the assessment of potential toxicity should focus on amino acid sequence similarity between the protein and known protein toxins as well as stability to heat or processing and to degradation in appropriate representative gastric and intestinal model systems. appropriate oral toxicity studies<sup>6</sup> may need to be carried out in cases where the protein present in the food is not similar to proteins that have previously been consumed safely in food, and taking into account its biological function in the plant where known.<sup>7</sup>

19. Paragraphs 39 and 40 of the Codex Plant Guideline apply.

#### **Assessment of possible allergenicity (proteins)**

20. Paragraphs 41, 42 and 43 of the Codex Plant Guideline apply.

### **Analyses of Key Toxicants and Allergens**

21. Analyses of key toxicants<sup>8</sup> and allergens are important in certain cases of foods from recombinant-DNA plants (e.g., those that are commonly consumed whole and undiluted, such as potatoes, tomatoes, and papaya). Analyses of concentrations of key toxicants and allergens of the recombinant-DNA plant typical of the food should be compared with an equivalent analysis of a conventional counterpart grown and harvested under the same conditions. The statistical significance of any observed differences should be assessed in the context of the range of natural variations for that parameter to determine its biological significance. The comparator(s) used in this assessment should ideally be the near isogenic parental line. In practice, this may not be feasible at all times, in which case a line as close as possible should be chosen. The purpose of this comparison is to establish that substances that can affect the safety of the food have not been altered in a manner that would have an adverse impact on human health.<sup>9</sup>

22. The location of trial sites should be representative of the range of environmental conditions under which the plant varieties would be expected to be grown. The number of trial sites should be sufficient

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4 The text of this paragraph was adapted from paragraph 35 of the Codex Plant Guideline.

5 The text of this paragraph was adapted from paragraph 36 of the Codex Plant Guideline.

6 Guidelines for oral toxicity studies have been developed in international fora, for example, the OECD Guidelines for the Testing of Chemicals.

7 The text of this paragraph was adapted from paragraph 38 of the Codex Plant Guideline.

8 Key toxicants are those toxicologically significant compounds known to be inherently present in the plant, such as those compounds whose toxic potency and level may be significant to health (e.g. solanine in potatoes if the level is increased).

9 The text of this paragraph was adapted from paragraph 44 of the Codex Plant Guideline.

to allow accurate assessment of key toxicants and allergens over this range. Similarly, trials should be conducted over a sufficient number of generations to allow adequate exposure to the variety of conditions met in nature. To minimize environmental effects, and to reduce any effect from naturally occurring genotypic variation within a crop variety, each trial site should be replicated. An adequate number of plants should be sampled and the methods of analysis should be sufficiently sensitive and specific to detect variations in key toxicants and allergens.<sup>10</sup>

### **Evaluation of Metabolites**

23. Some recombinant-DNA plants may have been modified in a manner that could result in new or altered levels of various metabolites in the food. In certain cases of foods from recombinant-DNA plants (e.g., those that are commonly consumed whole and undiluted), consideration should be given to the potential for the accumulation of metabolites in the food that would adversely affect human health. Food safety assessment in situations of low level presence of recombinant-DNA material in foods from such plants requires investigation of residue and metabolite levels in the food. Where altered residue or metabolite levels are identified in foods, consideration should be given to the potential impacts

on human health using conventional procedures for establishing the safety of such metabolites (e.g. procedures for assessing the human safety of chemicals in foods).<sup>11</sup>

### **Food Processing**

24. The potential effects of food processing, including home preparation, on foods derived from recombinant-DNA plants should also be considered. For example, alterations could occur in the heat stability of an endogenous toxicant. Information should therefore be provided describing the processing conditions used in the production of a food ingredient from the plant. For example, in the case of vegetable oil, information should be provided on the extraction process and any subsequent refining steps.<sup>12</sup>

### **POTENTIAL ACCUMULATION OF SUBSTANCES SIGNIFICANT TO HUMAN HEALTH**

25. Some recombinant-DNA plants may exhibit traits (e.g. herbicide tolerance) which may indirectly result in the potential for accumulation of pesticide residues, altered metabolites of such residues, toxic metabolites, contaminants, or other substances which may be relevant to human health. In certain cases of foods from recombinant-DNA plants (e.g. those that are commonly consumed whole and undiluted), the risk assessment should take this potential for accumulation into account. Conventional procedures for establishing the safety of such compounds (e.g. procedures for assessing the human safety of chemicals) should be applied.<sup>13</sup>

### **USE OF ANTIBIOTIC RESISTANCE MARKER GENES**

26. Paragraphs 55, 56, 57 and 58 of the Codex Plant Guideline apply.

### **SECTION 3 – GUIDANCE ON DATA AND INFORMATION SHARING**

27. In order for Codex Members to use this Annex, it is essential that they have access to requisite data and information.

28. Codex Members should make available to a publicly accessible central database to be maintained by FAO information on recombinant-DNA plants authorized in accordance with the Codex Plant Guideline. This information should be presented in accordance with the following format:

- a. name of product applicant;
- b. summary of application;

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10 The text of this paragraph was adapted from paragraph 45 of the Codex Plant Guideline.

11 The text of this paragraph was adapted from paragraph 46 of the Codex Plant Guideline.

12 The text of this paragraph was adapted from paragraph 47 of the Codex Plant Guideline.

13 The text of this paragraph was adapted from paragraph 54 of the Codex Plant Guideline.

- c. country of authorization;
- d. date of authorization;
- e. scope of authorization;
- f. unique identifier;
- g. links to the information on the same product in other databases maintained by relevant international organizations, as appropriate;
- h. summary of the safety assessment, which should be consistent with the framework of food safety assessment of the Codex Plant Guideline;
- i. where detection method protocols and appropriate reference material (non-viable, or in certain circumstances, viable) suitable for low-level situation may be obtained<sup>14</sup>; and
- j. contact details of the competent authority(s) responsible for the safety assessment and the product applicant.

29. This process should facilitate rapid access by importing Codex Members to additional information relevant to the assessment of food safety assessment in situations of low-level presence of recombinant-DNA plant material in foods in accordance with this Annex.

30. The authorizing Codex Members should make available complementary information to other Codex Members on its safety assessment in accordance with the Codex Plant Guideline, in conformity with its regulatory/legal framework.

31. The product applicant should provide further information and clarification as necessary to allow the assessment according to this Annex to proceed, as well as a validated protocol for an event-specific or trait-specific detection method suitable for low level situations and appropriate reference materials (non-viable, or in certain circumstances, viable). This is without prejudice to legitimate concerns to safeguard the confidentiality of commercial and industrial information.

32. As appropriate, new scientific information relevant to the conclusions of the food safety assessment conducted in accordance with the Codex Plant Guideline by the authorizing Codex member should be made available.

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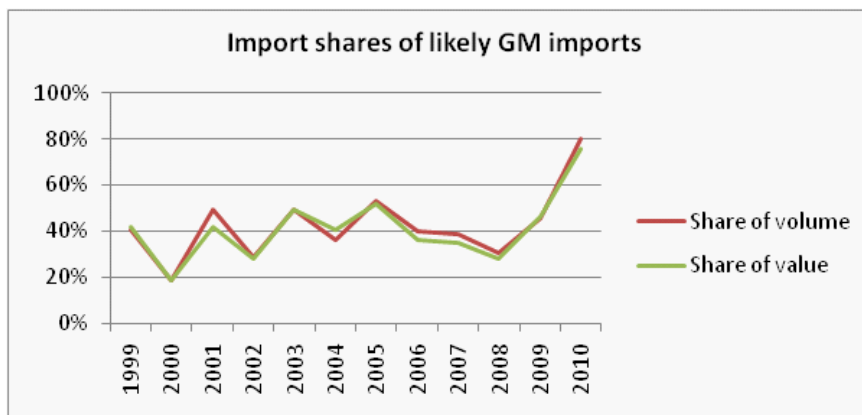
14 This information may be provided by the product applicant or in some cases by Codex members.

Figure A1. Import shares of likely GM commodities over time



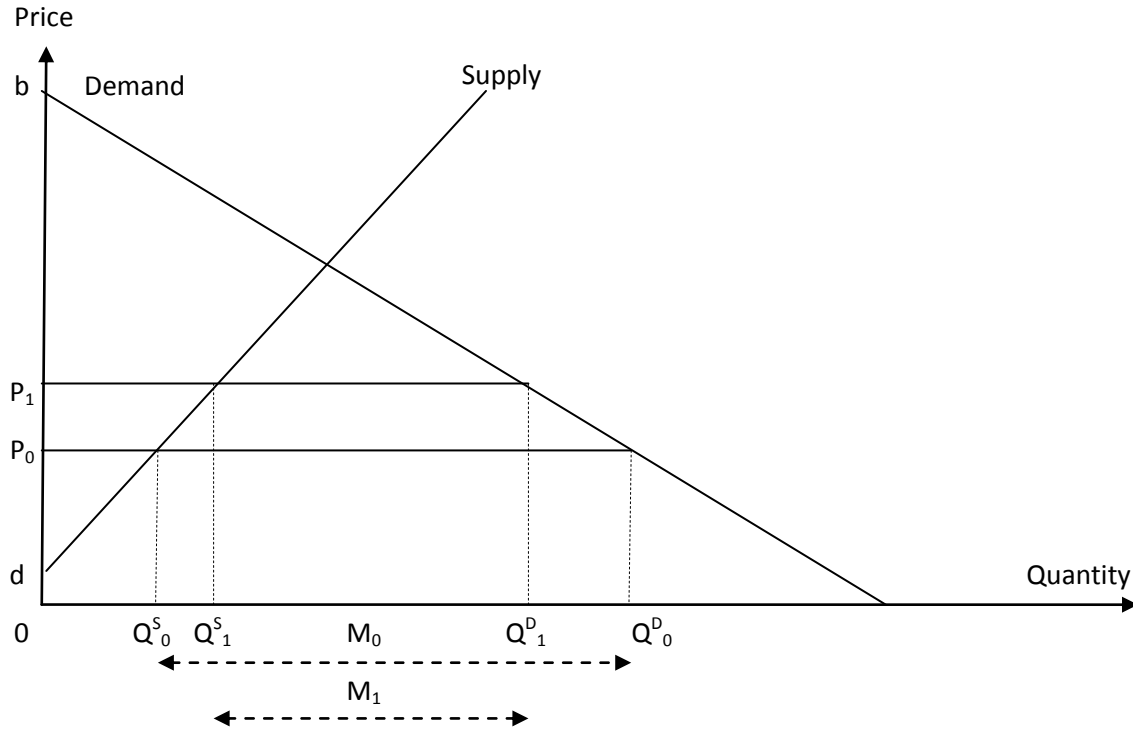
Source: Author's derivations from UN Comtrade data

Figure A2. Import share of like GM products between 1999 and 2010.



Source: Author's derivations from UN Comtrade data

**Figure A3. A partial equilibrium framework**



**Main expressions used in the computations**

Exogenous parameters

Price ( $p_0$ ), Quantity produced domestically ( $Q_0^S$ ), Volume of imports ( $M_0$ ), Elasticities of supply and demand ( $\varepsilon, \eta$ ), Proportion of GM in imports ( $k_g$ ) per scenario, Probability of rejection ( $\pi$ ) per concentration ( $\mu$ ) and tolerance level ( $\tau$ ), Price premium ( $\Delta$ ), Cost of testing per unit and per tolerance level  $Cl(\tau)$ .

Prices and quantities

$$p_n = p_0(1 + \pi(1 - k_g)\Delta)$$

$$Q_0^D = Q_0^S + M_0$$

$$Q_1^D = (p_1 - p_0(1 - (1/\eta))) / (p_0/(\eta \cdot Q_0^D)) = Q_0^D(1 + \eta \cdot \pi(1 - k_g)\Delta)$$

$$Q_1^S = (p_1 - p_0(1 - (1/\varepsilon))) / (p_0/(\varepsilon \cdot Q_0^D)) = Q_0^S(1 + \varepsilon \cdot \pi(1 - k_g)\Delta)$$

Consumer and producer surplus

$$CS = (b - p)Q^D/2$$

$$PS = c(Q^S)^2/2$$

$$TS = CS + PS$$

**Table A1. Food or feed approval for the 29 GM maize events approved for environmental release in the USA. Shaded rows indicate those with approval in at least five developed countries. (continues to next page)**

| <b>GM Maize event</b>                    | <b>Company</b>              | <b>Food and/or feed approval in developed countries</b>      | <b>Food and/or feed approval in other countries</b>  |
|--|-----------------------------|--|--|
| SYN-EV176-9 (176)                        | Syngenta                    | Australia(food) , Canada, EU, Japan, Korea, Switzerland, USA | Argentina, China, Philippines, South Africa, Taiwan (food)   |
| 676, 678, 680                            | Pioneer                     | USA  |  |
| DKB-89790-5 (B16 (DLL25))                | Dekalb Genetics Corporation | Canada, Japan, Korea (food), USA                             | Philippines, Taiwan (food)   |
| SYN-BT011-1 (BT11 (X4334CBR, X4734CBR))  | Syngenta                    | Australia (food), Canada, EU, Japan, Korea, Switzerland, USA | Argentina, Brazil, China, Colombia, Mexico, Philippines, Russia (food), South Africa, Taiwan (food), Uruguay |
| SYN-BT011-1, SYN-IR162-4 (BT11 x MIR162) | Syngenta                    | USA (environment/ registration expires in 2011)              |  |
| BT11 x MIR162 x MIR604                   | Syngenta                    | USA (environment/ registration expires in 2011)              |  |
| ACS-ZM004-3 (CBH-351)                    | Aventis                     | USA (feed)   |  |
| DAS-06275-8 (DAS-06275-8)                | Dow Agrosience              | Canada, Japan, USA   |  |
| DAS-59122-7 (DAS-59122-7)                | Dow Agrosience              | Australia (food), Canada, EU, Japan, Korea, USA              | China, Mexico, Philippines, Taiwan (food)  |
| DKB-89614-9 (DBT418)                     | Dekalb Genetics Corporation | Australia (food), Canada, Japan, Korea, USA                  | Argentina, Philippines, Taiwan   |
| SYN-E3272-5 (Event 3272)                 | Syngenta                    | Australia (food), Canada, USA                                | Mexico, Philippines, Russia (food)   |
| DP-098140-6 (Event 98140)                | Pioneer                     | Canada, Korea, USA   |  |
| MON-00021-9 (GA21)                       | Syngenta                    | Australia (food), Canada, EU, Japan, Korea, USA              | Argentina, Brazil, China, Mexico, Philippines, Russia, South Africa, Taiwan (food)                           |
| REN-00038-3 (LY038)                      | Monsanto                    | Australia (food), Canada, Japan, USA                         | Mexico (feed), Philippines, Taiwan (food)  |
| SYN-IR162-4 (MIR162)                     | Syngenta                    | Australia (food), Canada, Japan, Korea, USA                  | Argentina, Brazil, Colombia, Mexico, Philippines, Taiwan (food)  |

|  |                   |  |  |
|--|-------------------|--|--|
| SYN-IR604-5 (MIR604)   | Syngenta          | Australia (food), Canada, Japan, Korea, USA                  | China, Mexico, Philippines, Russia, Taiwan (food)  |
| MON80100   | Monsanto          | USA  |  |
| MON802   | Monsanto          | Canada, USA  |  |
| MON809   | Pioneer           | Canada, Japan (feed), USA                                    |  |
| MON-00810-6 (MON810)   | Monsanto          | Australia (food), Canada, EU, Japan, Korea, Switzerland, USA | Argentina, Brazil, China, Colombia, Mexico, Philippines, South Africa, Taiwan (food), Uruguay            |
| MON-00863-5 (MON863)   | Monsanto          | Australia (food), Canada, EU, Japan, Korea, USA              | China, Mexico, Philippines, Taiwan (food).   |
| MON-88017-3 (MON88017)   | Monsanto          | Australia (food), Canada, EU, Japan, Korea, USA              | China, Mexico, Philippines, Taiwan (food).   |
| MON-89034-3 (MON89034)   | Monsanto          | Australia (food), Canada, EU, Japan, Korea, USA              | Brazil, Colombia, Philippines, Taiwan(food).   |
| MON-89034-3 x DAS-01507-1 x MON-88017-3 x DAS-59122-7 (MON89034 x TC1507 x MON88017 x DAS-59122-7) | Monsanto          | Canada, Japan, Korea, USA                                    | Mexico, Philippines, Taiwan  |
| ACS-ZM001-9 (MS3)  | Bayer CropScience | Canada, USA  |  |
| ACS-ZM005-4 (MS6)  | Bayer CropScience | USA  |  |
| MON-00603-6 (NK603)  | Monsanto          | Australia (food), Canada, EU, Japan, Korea, USA              | Argentina, Brazil, China, Colombia, El Salvador, Mexico, Philippines (feed), South Africa, Taiwan (food) |
| ACS-ZM002-1 / ACS-ZM003-2 (T14, T25)   | Bayer CropScience | Australia, Canada, EU, Japan, Korea, USA                     | Argentina, Brazil, China, Mexico, Philippines, South Africa, Taiwan (food)                               |
| DAS-01507-1 (TC1507)   | Mycogen/Pioneer   | Australia (food), Canada, EU, Japan, Korea, USA              | Argentina, Brazil, China, Colombia, El Salvador, Mexico, Philippines, South Africa, Taiwan (food)        |

Note: Approvals by EU members are not included in the table if the EU has approved the event.

Source: CERA (2010).

**Table A2. Food or feed approval for the 9 GM soybean events planted in the USA. Shaded rows indicate those with approval in at least five developed countries.**

| GM soybean event                           | Company              | Food and/or feed approval in developed countries             | Food and/or feed approval in other countries   |
|--|----------------------|--|--|
| ACS-GM005-3 (A2704-12, A2704-21, A5547-35) | Bayer<br>CropScience | Australia, Canada, EU, Japan, Korea, USA                     | Brazil, China, Mexico, Philippines, South Africa, Taiwan.  |
| ACS-GM006-4 (A5547-127)                    | Bayer<br>CropScience | Canada, Japan, USA   | Brazil, Mexico   |
| DP-305423-1 (DP-305423)                    | DuPont<br>Pioneer    | Australia (food), Canada, USA                                | Mexico   |
| DP-356043-5 (DP356043)                     | DuPont<br>Pioneer    | Australia (food), Canada, Japan, Korea, USA                  | Mexico, Philippines, Taiwan (food).  |
| DD-026005-3 (G94-1, G94-19, G168)          | DuPont<br>Canada     | Australia (food), Canada, Japan, USA                         |  |
| MON-04032-6 (GTS 40-3-2)                   | Monsanto             | Australia (food), Canada, EU, Japan, Korea, Switzerland, USA | Argentina, Brazil, China, Colombia, Mexico, Paraguay, Philippines, Russia, South Africa, Taiwan (food), Uruguay. |
| ACS-GM003-1 (GU262)                        | Bayer<br>CropScience | USA  |  |
| MON-89788-1 (MON89788)                     | Monsanto             | Australia, Canada, EU, Japan, Korea, USA                     | China, Mexico, Philippines, Taiwan (food)  |
| ACS-GM001-8, ACS-GM002-9 (W62, W98)        | Bayer<br>CropScience | USA  |  |

Note: Approvals by EU members are not included in the table if the EU has approved the event.

Source: CERA (2010)

**Table A3. Food or feed approval for the 13 GM canola events planted in Canada. Shaded rows indicate those with approval in at least five developed countries.**

| GM canola event                             | Company             | Food and/or feed approval in developed countries | Food and/or feed approval in other countries |
|---|---------------------|--|--|
| 23-18-17, 23-198                            | Monsanto            | Canada, USA                                      |  |
| 45A37, 46A40                                | Pioneer             | Canada   |  |
| 46A12, 46A16                                | Pioneer             | Canada   |  |
| MON89249-2 (GT200)                          | Monsanto            | Canada, Japan, USA                               |  |
| MON-00073-7 (GT73, RT73)                    | Monsanto            | Australia (food), Canada, EU, Japan, Korea, USA  | China, Mexico, Philippines                   |
| HCN10                                       | Aventis CropScience | Canada, Japan, USA                               |  |
| ACS-BN007-1 (HCN92)                         | Bayer Crop Science  | Australia (food), Canada, EU, Japan, Korea, USA  | China, Mexico, South Africa                  |
| ACS-BN004-7 x ACS-BN001-4 (MS1, RF1 =>PGS1) | Aventis CropScience | Australia, Canada, EU, Japan, Korea, USA         | China, South Africa                          |
| ACS-BN004-7 x ACS-BN002-5 (MS1, RF2 =>PGS2) | Aventis CropScience | Australia, Canada, EU, Japan, Korea, USA         | China, South Africa                          |
| ACS-BN005-8 x ACS-BN003-6 (MS8xRF3)         | Bayer Crop Science  | Australia, Canada, EU, Japan, Korea, USA         | China, Mexico, South Africa                  |
| NS738, NS1471, NS1473                       | Pioneer             | Canada   |  |
| ACS-BN011-5 (OXY-235)                       | Aventis CropScience | Australia (food), Canada, Japan, USA (food)      | China  |
| ACS-BN008-2 (T45 (HCN28))                   | Bayer Crop Science  | Australia (food), Canada, EU, Japan, Korea, USA  | China, Mexico                                |

Note: Approvals by EU members are not included in the table if the EU has approved the event.

Source: CERA (2010).

**Table A4. Annual economic effects per unit (\$/ton) in the case of maize under different scenarios**

| Scenario | Concentration     | $\tau=0\%$ | $\tau=0.1\%$ | $\tau=0.5\%$ | $\tau=0.9\%$ | $\tau=1\%$ | $\tau=2.5\%$ | $\tau=5\%$ |
|----------|-------------------|------------|--------------|--------------|--------------|------------|--------------|------------|
| <b>A</b> | <b>N(0.1,0.1)</b> | -7.01      | -3.46        | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -7.01      | -4.09        | -2.46        | -1.41        | -1.32      | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -7.01      | -4.14        | -2.87        | -2.05        | -1.96      | -0.62        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -7.01      | -4.18        | -3.08        | -2.47        | -2.45      | -1.47        | -0.43      |
| <b>B</b> | <b>N(0.1,0.1)</b> | -19.49     | -8.38        | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -19.49     | -13.08       | -7.37        | -3.35        | -2.83      | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -19.49     | -13.53       | -10.36       | -7.47        | -6.87      | -1.17        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -19.49     | -13.89       | -12.01       | -10.67       | -10.50     | -6.41        | -1.99      |
| <b>C</b> | <b>N(0.1,0.1)</b> | -27.72     | -10.65       | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -27.72     | -18.04       | -9.64        | -4.16        | -3.45      | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -27.72     | -18.82       | -14.21       | -10.02       | -9.14      | -1.39        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -27.72     | -19.44       | -16.93       | -15.02       | -14.75     | -8.69        | -2.62      |

**Table A5. Annual economic effects per unit (\$/ton) in the case of soybeans under different scenarios**

Source: Author's derivations

| Scenario | Concentration     | $\tau=0\%$ | $\tau=0.1\%$ | $\tau=0.5\%$ | $\tau=0.9\%$ | $\tau=1\%$ | $\tau=2.5\%$ | $\tau=5\%$ |
|----------|-------------------|------------|--------------|--------------|--------------|------------|--------------|------------|
| <b>A</b> | <b>N(0.1,0.1)</b> | -81.87     | -34.13       | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -81.87     | -59.00       | -33.10       | -13.72       | -10.90     | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -81.87     | -61.38       | -48.95       | -35.76       | -32.60     | -4.14        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -81.87     | -63.24       | -57.64       | -52.72       | -51.85     | -32.28       | -10.30     |
| <b>B</b> | <b>N(0.1,0.1)</b> | -86.55     | -35.66       | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -86.55     | -62.09       | -34.62       | -14.29       | -11.33     | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -86.55     | -64.64       | -51.43       | -37.46       | -34.12     | -4.30        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -86.55     | -66.64       | -60.70       | -55.47       | -54.55     | -33.82       | -10.75     |
| <b>C</b> | <b>N(0.1,0.1)</b> | -86.63     | -35.69       | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -86.63     | -62.14       | -34.65       | -14.30       | -11.34     | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -86.63     | -64.69       | -51.47       | -37.49       | -34.15     | -4.30        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -86.63     | -66.70       | -60.75       | -55.52       | -54.59     | -33.84       | -10.75     |

Source: Author's derivations

**Table A6. Annual economic effects per unit (\$/ton) in the case of soymeals under different scenarios**

| Scenario | Concentration     | $\tau=0\%$ | $\tau=0.1\%$ | $\tau=0.5\%$ | $\tau=0.9\%$ | $\tau=1\%$ | $\tau=2.5\%$ | $\tau=5\%$ |
|----------|-------------------|------------|--------------|--------------|--------------|------------|--------------|------------|
| <b>A</b> | <b>N(0.1,0.1)</b> | -6.88      | -3.42        | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -6.88      | -3.99        | -2.42        | -1.39        | -1.31      | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -6.88      | -4.04        | -2.80        | -2.00        | -1.92      | -0.62        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -6.88      | -4.08        | -2.99        | -2.39        | -2.37      | -1.42        | -0.42      |
| <b>B</b> | <b>N(0.1,0.1)</b> | -29.43     | -14.13       | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -29.43     | -21.70       | -13.11       | -5.94        | -4.88      | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -29.43     | -22.35       | -18.10       | -13.65       | -12.61     | -1.95        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -29.43     | -22.86       | -20.60       | -18.84       | -18.60     | -12.17       | -4.09      |
| <b>C</b> | <b>N(0.1,0.1)</b> | -31.20     | -14.94       | -1.50        | -1.00        | -1.00      | -0.50        | -0.10      |
|          | <b>N(0.5,0.5)</b> | -31.20     | -23.07       | -13.93       | -6.29        | -5.15      | -0.50        | -0.10      |
|          | <b>N(1,1)</b>     | -31.20     | -23.77       | -19.28       | -14.54       | -13.43     | -2.05        | -0.10      |
|          | <b>N(2.5,2.5)</b> | -31.20     | -24.32       | -21.96       | -20.12       | -19.85     | -13.00       | -4.37      |

Source: Author's derivations

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The International Food & Agricultural Trade Policy Council promotes the role of trade in creating a more open, equitable, productive and sustainable global food & agricultural system. IPC makes pragmatic trade policy recommendations to help solve the major challenges facing the global food & agricultural system in the 21st century—the need to promote global food security, to sustainably increase productivity, and to contribute to economic growth and development.

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