Trade Impact of European Measure on GMOs Condemned by the WTO Panel

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Trade Impact of European Measures on GMOs Condemned by the WTO Panel

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***Abstract* - In May 2003, the United States, Canada and Argentina launched a World Trade Organization (WTO) case against the European Union concerning its authorization regime for biotech products. In November 2006, the WTO condemned this regime. Using a gravity equation, we estimate the reduction of exports from the complainants to the European Union for potentially affected products. Our results suggest that the European moratorium and product-specific measures have a negative effect on trade, as well as safeguard measures adopted by Germany, Italy and Greece.**

***Keywords* - Genetically modified organisms, WTO dispute settlement, gravity equation.**

I. INTRODUCTION

From the beginning of the 90s, the European Union (EU) implemented a legislation on genetically modified organisms (GMOs), which was however challenged by major GM producer and exporting countries: In May 2003, the United States (US), Canada and Argentina launched a case at the World Trade Organization (WTO) against the EU. For the three complainants, the EU policy on GMOs reduced their exports to the EU market. In September 2006, the WTO panel stated in its report that the EU applied a general *de facto* moratorium on the approval of GMOs since June 1999 and undue delays in the processing of product specific applications, and consequently violated its obligations under the Sanitary and Phytosanitary (SPS) Agreement. Besides, the report concluded to the inconsistency of the national safeguard measures put in place by certain EU Members on biotech products that have already been approved as safe by the EU.

The purpose of this paper is to study the trade impact of EU measures on GMOs in the perspective of the WTO complaint. Quite surprisingly, to date no research has been carried out to measure and quantify in monetary terms the potential export losses faced by Argentina, Canada and the US in the EU market. Our paper provides two contributions to the literature : First, we focus on the main GM products being grown commercially and potentially affected by EU measures and provide an estimation of losses in term of exports by product, exporting country and measure at stake. To conduct this analysis, we make use of most recent advances in gravity equation estimation. In particular, we try to avoid most usual misspecifications and other mistakes present in the literature relying on the traditional simplest gravity framework [1]. We also use the Poisson estimator [2]. The authors show that in the presence of heteroskedasticity, ordinary least squares (OLS) method can yield biased estimates. The second contribution is to investigate, for comparison, the impact of moratoria or non-approvals of GM products adopted by other countries, such as New Zealand, Switzerland and Norway.

This research is related to the broader literature on the economic effects of the introduction of GM products and the costs induced by regulations on authorization and labelling aiming the segregation and identity preservation of non-GM grains from GM ones. A first paper investigates how these costs affect American seed producers, farmers and grain handlers and how they depend on standards defining goods as non-GM [3]. The authors show that most of the costs faced by farmers come from the production process itself, while handlers' main cost is the cost of dedicating equipment to either GMOs or non-GMOs but never both. Those that wish to sell non-GM food are likely to bear costs of segregation and identity preservation [4]. This aspect has not been fully recognized in the public policy debate. The costs of segregation and identity preservation could also be introduced in a partial-equilibrium, two-country trade model [5]. In the model, seeds of a new GM product are produced by a home country monopolistic innovator and sold to a competitive farming industry. Consumers in the foreign country can choose between GM and non-GM products and view GM products as inferior in quality. Due to the presence of segregation and identity preservation costs, the introduction of GM products can lower welfare. Furthermore, regulations on imports of GM products, such as labelling requirements or bans, will affect the income distribution among trading partners. A last paper distinguishes between GM, conventional and organic food and analyses the effects of the introduction of GM products within a partial equilibrium, multi-market model of the EU agricultural sector [6]. Organic and conventional products, which exist prior the introduction of GMOs, are horizontally differentiated, while GM and conventional goods are vertically differentiated (GMOs are quality inferior to conventional food). On the supply side, the model accounts for segregation and identity preservation costs. The model shows that, due to the associated segregation costs for non-GM products, the introduction of GMOs reduces welfare. However, this introduction benefits producers of organic food.

The next section provides some statistics on the world production and trade of GM products. It also reviews EU legislation on GMOs and summarizes the dispute between the US, Canada and Argentina on the one hand, and the European Communities (EC) and its Member States on the other. In section 3, we describe our data and detail our econometric specification. Estimation results are reported in section 4. Section 5 concludes.

II. Background

A. *World production and trade of GM products*

To date, GM technology was used to develop crops that benefit farmers, such as insect resistant and herbicide tolerant crops. Insect resistance means that pests can be controlled without insecticide application, while herbicide tolerance means that weeds can be destroyed by applying the herbicide to which the plant is tolerant. In 2006, GM herbicide tolerant crops account for 68% of global GM plantings, while GM insect resistant crops account for 19% and stacked herbicide tolerant and insect resistant crops represent 13% of global GM plantings [7]. Researchers are now developing new GM products that make food production easier (for example altered salmon growing up three to five times faster than non-GM counterparts) or that have improved quality and nutritional values (e.g. cattle and pigs with lower fat). Non-food uses of GM plants and animals are also explored, with a particular focus on medical applications (e.g. the xenotransplantation, which consists in using tissues and organs from animals to humans). This new generation of GM products is likely to generate strong debate on its relative costs and benefits [8].

The first commercial GM crops were planted in 1994. In 1996, GM crops were sowed on less than two million hectares, nearly all in the US. Since 1996, world areas of GM crops have increased dramatically. Table 1 presents the trends in GM crop plantings at the world scale and for the main countries since 1996. In 2006, areas reach 102 million hectares in 22 countries. The US are the main producer country with 53% of the total areas, followed by Argentina, Brazil, Canada, India, China and Paraguay. All other countries[1] cultivate GM crops on less than 2 million hectares.

Table 1: Global GM plantings. World and main producer countries, 1996-2006 (million hectares)

Year	1996	1998	2000	2002	2004	2006
World	*1.7*	*27.8*	*44.2*	*58.7*	*81.0*	*102.0*
US	1.4	19.3	28.2	37.5	44.8	54.6
Argent.	0.04	4.8	9.6	13.6	15.9	18.0
Brazil	0	0.5	1.3	1.7	5.0	11.5
Canada	0.1	2.2	3.3	3.3	5.1	6.1
India	0	0	0	0.04	0.5	3.8
China	0	0.3	1.2	2.1	3.7	3.5
Paraguay	0	0	0.09	0.5	1.2	2.0

Source: [7, 9 and 10].

Furthermore, the share of developing countries grew substantially over the period of 1996-2006. In 2006, 40% of GM crops are produced in developing countries, mainly in Argentina, Brazil, India, China and Paraguay.

Main GM products are soybeans, maize, cotton and oilseed rape. In 2005, GM soybeans account for 62% of global GM crop area, followed by maize (22%), cotton (11%) and oilseed rape (5%) [10]. In terms of the share of global plantings to these four crops, GM traits account for 59% of soybean plantings in 2005. These shares are 13% for maize, 27% for cotton and 18% for oilseed rape [10]. Table 2 reports these shares for main GM producers.

[1] South Africa, Uruguay, Philippines, Australia, Romania, Mexico, Spain, Colombia, France, Iran, Honduras, Czech Republic, Portugal, Germany, and Slovakia.

Table 2: GM technology share of crop plantings in 2005 by country (% of total plantings)

	Soybeans	Maize	Cotton	Oilseed rape
World	*59*	*13*	*27*	*18*
USA	93	52	79	82
Argentina	99	62	50	n.a
Brazil	40	n.a	n.a	n.a
Canada	60	65	n.a	95
India	n.a	n.a	16	n.a
China	n.a	n.a	65	n.a
Paraguay	93	n.a	n.a	n.a

Source: [10]. Note: n.a= not applicable.

Regarding trade issues, in 2005, 90% of soybeans trade may have been GM [10]. Shares for maize, cotton and oilseed rape may have been respectively 80%, 57%, and 73%. Leading exporting countries of GMOs are the US, Argentina, Canada, Brazil, Australia and South Africa. On the import side, two groups of countries could be distinguished. First, countries, such as EU Member States, that have taken a restrictive stance on GM food and import few GM products. On the other hand, big importers of food, such as Japan, are less reluctant to import GM goods.

B. EU Legislation on GMOs

Trade of GM products is subject to WTO rules. But it is also regulated by the Cartagena Protocol on Biosafety (which has not been ratified by the US, Argentina and Canada). To date, harmonization efforts of national legislations have partly failed. International harmonization bodies have reached some success in handling safety approval; however, strong disagreement still exists on several specific rules, such as labeling regulation, consumer information and international agreements [11].

The EU legislation on GM products has been implemented since the beginning of the 90s and has two main objectives: the protection of human health and the environment and the free movement of safe GM products in the EU. This legislation has recently been updated and a new legal framework is now in place.[2] GM food and feed can be marketed only after a scientific evaluation, to be undertaken under the responsibility of the European Food Safety Authority, of any risks which they present for human and animal health and for the environment. This evaluation should be followed by a risk management decision by the Community, under a regulatory procedure ensuring close cooperation between the Commission and the Member States (Regulation (EC) 1829/2003). Besides, EU Member States can invoke the safeguard clause and ban the sale and use on their territories of GM products that have obtained a market authorization from the EU. To do so, they should justify that these products are risky for human health and the environment. Furthermore, the EU regulation also requires the traceability and labelling of all GM food and feed products derived from GMOs, regardless of the presence or absence of GM material in the final food or feed product. Two exemptions from the traceability and labelling requirements do however exist. First, conventional products contaminated by authorized GM products are not subject to these requirements if the GM content does not exceed the threshold of 0.9%. Second, products obtained from animals fed with GM feed or treated with GM medicinal products, such as meat, milk or eggs, are also exempt from the requirements.

Labelling obligation for GM products is not specific to the EU. In almost all countries, labelling is also mandatory. The threshold of GM content under which labelling is not required varies from one country to another (it is set at 5% or below). Labelling is voluntary only in few countries, such as the US, Argentina, Canada and South Africa.

C. Summary of the trade dispute to date

The dispute between the US, Canada and Argentina on the one hand, and the EU and its Member States on the other on the approval and marketing of biotech products by the EU covers a relatively long time period.[3] On May 13 and 14, 2003 the US, Canada and Argentina launched the WTO case against the EU by requesting consultations concerning the measures adopted by the EU. The consultations did not allow to solve the dispute and in August 2003, the complainants requested the establishment of a dispute settlement panel. The Director-General of the WTO composed the Panel on March 4, 2004. Over the course of the dispute, tons of documents were

[2] Details are available at http://ec.europa.eu/food/food/biotechnology/gmfood/index_en.htm. Note that other countries also updated their legislations on GMOs (for example, the US legislation on plant-made pharmaceutical production was updated in 2003).

[3] Panel report is available at: http://www.wto.org/english/tratop_e/dispu_e/dispu_e.htm

submitted by the disputing parties, as well as by the six independent scientific experts whose opinion was requested. The Panel report was postponed several times and finally delivered on September 29, 2006. Three types of measures were challenged by the complainants:[4]

- The alleged general moratorium on the approval of GMOs. The complainants argued that this moratorium was put in place in June 1999;
- Delays in the processing of product specific applications. EU failed to consider for final approval applications concerning certain specified biotech products for which the EU had commenced approval procedures. The complainants referred to 27 applications;
- Safeguard clauses adopted by certain Member States banning the marketing of certain GMO products.

The report concluded that the EU applied a general *de facto* moratorium on the approval of biotech products between June 1999 and August 2003 and consequently violated its obligations under Annex C(1)(a) first clause and Article 8 of the SPS Agreement [12]. This *de facto* moratorium led indeed to undue delays in the completion of EU approval procedures. The Panel asked the EU to bring the moratorium into conformity with its obligations "if, and to the extent that, the measure has not already ceased to exist". The panel however did not conclude that the moratorium was applied for achieving an appropriate level of SPS protection. Therefore, it cannot be considered an SPS measure within the meaning of Articles 5.1, 5.6 and 5.5 and, consequently, of Articles 2.2 and 2.3 of the SPS Agreement. The Panel also concluded that the EU moratorium was not an SPS regulation within the meaning of Annex B(1) and therefore rejected the claim raised under Annex B(1) and, consequently, Article 7 of the SPS Agreement. Furthermore, the Panel noted that the United States have not established that the EU acted inconsistently with its obligations under Annex C(1)(b) and, consequently, Article 8 of the SPS Agreement. Finally, it also concluded that Argentina failed to establish that the EU did not take account of Argentina's special needs as a developing country Member (Article 10.1 of the SPS Agreement). Given all these conclusions and the fact that Argentina did not claim the general moratorium was inconsistent with Annex C(1)(a), Argentina's complaint about this measure was not upheld by the Panel.

Regarding product-specific applications, the Panel concluded that the EU acted inconsistently with its obligations under Annex C(1)(a) first clause and Article 8 of the SPS Agreement in the approval procedures concerning 24 (out of 27) specific GM products. There were indeed undue delays in the completion of the approval procedures for each of these products. The Panel asked the EU to bring the product-specific measures into conformity with its obligations. Other claims under the SPS Agreement were rejected by the Panel. The Panel relied on similar arguments to the above mentioned ones to justify these rejections. For Canada and Argentine's alternative claims under the TBT Agreement, the Panel concluded that the product-specific measures were found to be SPS measures within the meaning of Annex A(1) of the SPS Agreement and therefore did not need to be addressed under the TBT Agreement further.

The Panel also found that the safeguard measures adopted by Austria, France, Germany, Greece, Italy and Luxembourg on certain products[5] were inconsistent with Articles 2.2 and 5.1 of the SPS Agreement because they were not based on a risk assessment satisfying the definition of the SPS Agreement. The Panel requested the EU to bring these measures into conformity with its obligations. Furthermore, as it already reached the conclusion that national bans were inconsistent with Article 5.1 of the SPS Agreement, the Panel saw no need to address the other claims raised under the SPS, the GATT 1994 and the TBT Agreements further. Until 2005 (last year included in our empirical analysis), none of these bans were removed. Member States have been asked several times by the European Commission to lift them. Following the implementation in 2003 of the new EU legislation on GMOs, the Commission asked countries to reconsider these bans "in view of the new regulatory framework and if necessary, to resubmit them".[6] However, in November 2004, no qualified majority was reached in the Council to ask Member States to lift their measures. Furthermore, in June

[4] A description of the challenged measures and the claims of inconsistency raised by each complainant country is available from the authors.

[5] As Belgium and Luxembourg are aggregated in our sample, we will not consider the Luxembourg's ban in our empirical application.

[6] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/05/793

2005, the Council voted against a proposal from the Commission, which required the remove of national safeguard measures.

Some critics were formulated in the literature against Panel's approach and conclusions. The applicability of the SPS Agreement to the EU regulations of GM products was questioned [13]. The Panel only had a "technical and textual approach of the SPS Agreement" and lacked to have a legal analysis of it. The interpretation of the precautionary principle by the Panel was also criticized [14]. This second analysis focuses on national bans adopted by certain EU Members. EU Members invoked Article 5.7 of the SPS Agreement (and its precautionary principle) to justify these bans. However, for the Panel, Article 5.7 can be invoked only if the relevant scientific information is insufficient, that is if this information does not allow to perform adequate risks assessments under article 5.1 and Annex A of the SPS Agreement. However, some documents provided by EU Members were found to be risks assessments in the meaning of Annex A and Article 5.1 by the Panel, who therefore rejected the invocation of Article 5.7. Conditions under which countries can invoke the precautionary principle within the SPS Agreement are therefore far from being clear.

The Panel report was adopted by the Dispute Settlement Body of the WTO on November 21, 2006. On December 2006, the EU announced its intention to conform to the recommendations. Due to the complexity of the issues involved, the EU would need a reasonable period of time to implement these recommendations and was ready to discuss the timeframe with the complainants. In June 2007, the complainant countries and the EU agreed that this period of time shall be twelve months from the date of adoption of the Panel report (i.e. from November 21, 2006). This deadline was postponed to January 11, 2008. To date, discussions continue between the parties.

III. Data and econometric specification

A. Data

Our study focuses on the main GM crops grown commercially and potentially affected by EU measures, namely maize, cotton and oilseed rape. We exclude soybeans from the sample of GM products affected by EU measures. RoundUp Ready is indeed the only GM soybean product commercially grown and was approved for import and use in food and feed by the EU before the 1999 moratorium [15]. However, we will consider this product when studying the impact of New Zealand, Switzerland and Norway's restrictions. Similarly, we do not include derived products (such as corn gluten or soya cake) in our sample. No authorization procedure existed for feed produced from GMOs until 2004 (date of application of regulation N°1829/2003). Consequently, these products were not affected by EU measures on GMOs.

We cover the period from 1994 to 2005. We start two years before the significant increase in the world production of GMOs and the adoption by EU (and other importers) of the first restrictions on these products. Thus, by observing trade flows both before and after the replacement of non-GM crops by GM ones and the implementation of European measures, we can investigate whether these measures had an impact on bilateral trade flows. Our trade data come from the BACI database (Base pour l'Analyse du Commerce International - World Database of International Trade) developed by the CEPII (Centre d'Etudes Prospectives et d'Informations Internationales - French Centre for International Economic Studies). This database uses original procedures to harmonise COMTRADE data (Commodity Trade Statistics Database).[7] We work at the 6-digit level of the Harmonized System of products classification (hereafter HS) and consider the following headings (in HS 2002):

- HS 100510: Maize (seeds);
- HS 100590: Maize (other);
- HS 120510: Rape or colza seeds, whether or not broken (low erucic acid rape or canola seeds);
- HS 120590: Rape or colza seeds, whether or not broken (other);[8]
- HS 120100: Soybeans, whether or not broken;
- HS 120720: Cotton seeds.

In the 1988 and 1996 versions of the HS classification on which the BACI database is based, both codes HS 120510 and HS 120590 are aggregated in one code (HS 120500). We therefore also aggregate them in our

[7] http://www.cepii.fr/francgraph/bdd/baci.htm

[8] Erucic acid is a monounsaturated omega-9 fatty acid. Low erucic acid rape or colza seeds have an erucic acid content of less than 2 % by weight and yield a solid component which contains less than 30 micromoles of glucosinolates per gram.

estimations.[9] In the world trade statistics, one cannot yet distinguish within the same HS code between trade flows of GM products and non-GM products. However, in the main GM producing countries, non-GM products have often been substituted to a large degree by GM ones (cf. Table 2). A fall in trade could therefore been interpreted at least partially as the result of the adoption of restrictions against GMOs by the importing countries. Of course, the decrease of trade can also result from other factors, such as changes in competitiveness or transaction costs. But, one of our objectives will be to disentangle the trade effects of the GM restrictions from the ones of other factors.

We restrict our sample to main exporting and importing countries of maize, oilseed rape and cotton. Our sample of exporters includes Argentina, Canada, the US, Brazil, Australia, China, Ukraine, Turkey, Romania, Bulgaria, Serbia-Montenegro, Poland, Czech Republic, Hungary, Lithuania, Chile and South Africa. For cotton, we also consider exports from Benin, Ivory Cost and Togo (the main exporters of cotton to the EU). The group of importing countries includes each EU Member State,[10] Norway, Switzerland, Turkey, Japan, New Zealand, Australia, China, Canada, the US, Argentina, Brazil, Mexico, South Korea, Indonesia and Thailand.

Other countries also adopted restrictions on GMOs. Since November 2005, Switzerland has a 5-year moratorium on the cultivation of GM crops and the import of genetically modified animals. The moratorium does not apply to research into GMOs nor does it stop the import of genetically modified food. Only imports of seeds are affected. Besides, US exports of maize seemed to have been affected by the time gap between the US and Swiss approvals. In 1996, New Zealand put in place a general moratorium, which expired in October, 2003. Officially, Norway has never adopted bans or moratoria on GM imports. However, few GM products can be imported in Norway. Imports of GM soybeans (HS 120100) and GM Maize (HS 100590) have not been approved. For comparison, we also investigate the impact of such restrictions in our analysis.

[9] This aggregation does not bias our study. Products belonging to both codes face exactly the same restrictions at the same time and by the same countries.

[10] We consider 14 EU Members (Belgium and Luxembourg are aggregated) until 2003. For 2004, we add the 10 new Members. EU Members are only considered as importing countries. Intra-EU trade flows are therefore not included in our sample.

B. Econometric specification

In this section, we tackle the trade impact of the measures adopted against GMOs. Our objective is accordingly to quantify the trade impact of EU measures on GMOs in the very perspective of the conclusions of the WTO panel. In addition to these measures, other factors, such as changes in competitiveness or transaction costs, may also lead to a redistribution of market shares among exporters. It is therefore interesting to further investigate if the decrease in US, Canadian and Argentine exports to the EU results from European GM restrictions or from other factors. Econometrics allows dealing with such issues and gravity equation offers an appropriate framework for this analysis, provided that the frequent misuses of this methodology are avoided. This equation can be seen as a reduced form of the theoretical trade flow prediction. Our theoretical foundation for trade patterns is the standard new trade monopolistic competition-CES demand-Iceberg costs model [16]. Producers operating under increasing returns in each country produce differentiated varieties that they ship, with a cost, to consumers in all countries. The value of exports from country *i* to country *j* in *t* can be written as follows [17]:

$$x_{ijt} = n_{it} p_{it}^{1-\sigma} (T_{ijt})^{1-\sigma} E_{jt} G_{jt}^{\sigma-1} \qquad (1)$$

with n_{it} and p_{it} the number of varieties and prices in country *i* in year *t*, E_{jt} and G_{jt} being the expenditure and price index of country *j* in *t*. T_{ijt} represents the iceberg transport costs in year *t*.

A theoretically consistent approach for estimating equation (1) consists in using fixed effects for each exporting and importing country. These fixed effects incorporate the size effects, but also the price and number of varieties of the exporting country and the size of demand and the price index of the importing country. This specification overcomes the “gold medal” mistake in gravity equations - the failure to consider relative prices [1]. However, that in the case of panel data, time-invariant country fixed effects are not sufficient to remove all the related bias: the cross-section bias will be removed but not the time-series bias. To remove the latter, we interact our country fixed effects with year dummies.[11] Furthermore, in the presence of heteroskedasticity, OLS method can yield

[11] This method is already applied to agricultural trade [18].

biased estimates [2]. One solution is to use the Poisson pseudo-maximum likelihood (PPML) method to estimate multiplicative equations like (1). In this specification, the dependent variable is measured in levels. However, this specification provides estimates that are comparable to elasticity estimates from the standard linear-in-logs specification. Furthermore, this specification adequately deals with zero-value observations.[12]

Transport costs are measured with the bilateral distance. These distances come from the CEPII database[13] and are defined as the sum of the bilateral distances between the biggest cities of countries, weighted by the population living in those cities. We also include a dummy variable "Common border" set to 1 for pairs of countries that share a border. Besides, we control for linguistic similarity by including a dummy, equal to one if both countries share an official language. Data are extracted from the above-mentioned CEPII database.

Our focus in this paper is on the trade impact of measures on GMOs. The presence of a measure potentially impacting exports of one of the three complainants, for a given product in a given year, is represented by dummy variables. We apply the following rules:

- We study the trade impact of GM measures in the perspective of the WTO complaint. We therefore consider that GM restrictions only affect exports of the three complainants;
- The US, Canada and Argentina do not necessarily produce GM maize, oilseed rape or cotton on a commercial basis (cf. Table 2). If they do not produce a GM product in a given year, dummy variables are set to 0 for these product, country and year;
- Our empirical application uses annual data. However, measures on GMOs can be put in place (or lifted) at any time of the year. Thus, the dummy variable is set to one in year *t* if the restriction is put in place before the middle of year *t* and set to zero if the restriction is put in place after. The middle of a year is June 30th. The following years and as long as the measure is in place, the dummy variable takes a value of 1. If the restriction is lifted, the dummy variable is set to zero in year *t* if the restriction is lifted before the middle of year *t* and set to one if the restriction is lifted after;
- EU refers to EU15 (with Belgium and Luxembourg aggregated) until 2003 and to EU25 in 2004 and 2005.

Using these rules, we define dummy variables as follows:

- EU moratorium and specific measures = 1 for products on which the EU imposes a moratorium and/or product-specific measures and during years of these moratorium and measure's implementation, if the exporter is Argentina, Canada or the US and the importer is one EU Member state; 0 otherwise.

Years of implementation of both moratorium and product-specific measures are often very similar. To avoid a collinearity problem, we decided to group both types of measures into a common variable.

Regarding national bans, dummies are defined as follows:

- Austria's safeguard measure = 1 for all products on which Austria adopted a safeguard measure and during years of measure's implementation, if the exporter is Argentina, Canada or the US and the importer is Austria; 0 otherwise.

Similarly, we define dummies for Germany, Italy, France and Greece's safeguard measures and for New Zealand's moratorium, Switzerland's moratorium and Norway's non-approval respectively.

After taking logs, our estimated equation takes the following form:

$$\begin{aligned} x_{ijt}^{k} = {} & \mu_{it}\,\mathrm{fe}_{it} + \lambda_{jt}\,\mathrm{fe}_{jt} + \delta_1 \ln d_{ij} + \delta_2\,\mathrm{cbord}_{ij} \\ & + \delta_3\,\mathrm{clang}_{ij} + \delta_4\,\mathrm{GMOs}_{ijt}^{k} + u_{ijt}^{k} \qquad (2) \end{aligned}$$

where x_{ijt}^{k} is the dollar value of country *j*'s imports from country *i* in year *t*, fe_{it} are the time-varying exporter fixed effects, fe_{jt} the time-varying importer fixed effects, d_{ij} the bilateral distance. cbord_{ij} and clang_{ij} are dummies to control for common border and common language. GMOs_{ijt}^{k} is the vector of

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[12] Other methods, such as standard OLS (with ln(1+flow) as the dependent variable) and Tobit, have been suggested in the literature to deal with zero trade flows. To properly discrimate between these methods, one can perform a heteroskedasticity-robust RESET test [19]. In our case, the test rejects models estimated using the OLS and Tobit regressions. Only the estimations using the PPML method pass the test.

[13] http://www.cepii.fr/anglaisgraph/bdd/distances.htm

dummies accounting for measures on GMOs. The vector δ_4 represents the estimated coefficients on these variables. u_{ijt}^{k} is the error term. We use cluster regressions to deal with the problem of clustering of errors. We do not control for bilateral tariffs, and this for two reasons. First, bilateral tariffs do not vary significantly over time. Second, while yearly data on bilateral tariffs are available in the TRAINS database, there are many missing values and these data do not include all specific duties, tariff quotas and anti-dumping duties applied by importing countries. In our estimations, the influence of bilateral applied protection is partly captured by country times year fixed effects.

IV. Estimation results

A. *Basic estimations*

We firstly estimate equation (2) in order to assess the accuracy of our modelling strategy and the possibility of identifying an effect of the measures under scrutiny. Columns (1) and (2) of Table 3 present an overview of the results. Column (1) includes importer, exporter, and time fixed effects. In column (2), importer fixed effects and exported fixed effects are interacted with time dummies. Results in both columns (1) and (2) are relatively similar. The second specification (countries fixed effects interacted with time dummies) is our preferred one.[14] We therefore focus on it.

First, regarding gravity covariates, the distance affects negatively and significantly bilateral imports. Common border and common language variables do not have the expected positive and significant effect. One explanation could be that our products are usually traded on organized exchanges or have a reference price. Therefore, cultural linkages between trade partners are less important for such goods than for differentiated products [20].

For all products, estimated coefficients on the variable "EU moratorium and product-specific measures" are negative and significant. These coefficients can be interpreted as a percentage change in the dependent variable when the dummy variable equals one. Thus, the value -2.61 for maize seeds means that the dependent variable is 92.6% (exp[-2.61]-1) lower when the dummy variable equals one than otherwise. In other words, this econometric specification tends to show that EU measures on GMOs reduce on average Argentina, Canada and US exports of maize seeds by 92.6%. One can note that the magnitude of the estimated coefficient on oilseed rape and cooton seeds is particularly high.

Regarding national bans put in place by certain EU Members, it appears that only the Austrian ones on maize (seeds and other) and the Italian one on maize seeds do not have a significant impact. All other national safeguard measures affect Argentina, Canada, and US exports. The impact of German and Greek measures is particularly high.

Interestingly, our results also show that estimated coefficients on New Zealand's moratorium on oilseed rape and soybeans and Norway's non-approval for maize other than seeds are also negative and significant. Thus, exports of maize other than seeds, oilseed rape and soybeans from Argentina, Canada and the US to New Zealand and Norway are also affected by the measures on GMOs put in place in these two importing countries. Surprisingly, the Swiss moratorium on soybeans seems to foster trade. However, the estimated coefficient is significant only at the 10% level.

So far, we have tentatively estimated the average trade impact of regulatory restrictions on GMOs on the three complainant's exports. One extension of our analysis consists in distinguishing the influence of the EU moratorium and product-specific measures on each exporting country and product. To do so, we divide the dummy "EU moratorium and specific measures" into three different dummies (one for Argentina, one for Canada and one for the US).[15] Column (3) of Table 3 describes the results. Argentine exports of maize seeds are not affected by any European product-specific measures. Furthermore,

[14] As we previously explained it, this specification allows to control for relative prices. Taking a different approach from our, a paper studies if non-GM soybean futures prices at the Chicago Board of Trade and at the Tokyo Grain Exchange respond to announcements of bans against GM crops by major food companies [21]. Interestingly, it concludes to the absence of response.

[15] Each dummy is set to one if the dummy "EU moratorium and specific measures" is equal to one and the exporting country is respectively Argentina, Canada and the US. Here, we focus only on "EU moratorium and specific measures". Highest export losses are indeed due to these measures. However, this divide could also be done for all other measures adopted by the importing countries against GM products but would be less relevant.

Argentina does not produce GM oilseed rape and Canada does not produce GM cotton (see Table 2). Therefore, no coefficients will be estimated for these country/product combinations. Estimated coefficients on all other country/product combinations, except the one on maize other than seeds for Argentina, are negative and significant at the 1% level. Strong variations in terms of magnitude are however observable for each product. For example, the estimated coefficient on Canadian exports of maize seeds is equal to -4.32, while the one on the US exports equals -2.52. The non-significance of the estimated coefficient on Argentine exports of maize seeds reflects the fact that, since the beginning of the introduction of GM goods in agriculture, Argentina has only authorized the production of GMOs already approved by its main trading partners, including the EU.

Our estimation results show the maximum trade effect that could be attributed to EU measures on GMOs. The variables "EU moratorium and specific measures" could capture the effect of concomitant phenomenons, in particular a rejection of GMOs by EU consumers. The year 1997 indeed corresponds to the arrival of the first loads of GMOs in Europe and to the application of the new regulation on "novel foods" that defines an authorization regime for foods derived from GMOs. In 1998, the Council of the European Union adopted a new regulation, which introduced additional specific labelling requirements for foods and food ingredients produced, in whole or in part, from genetically modified soybeans and maize. Similarly, in 2003, the EU adopted new rules on traceability and labelling.[16] However, one can argue that European measures against GM products were put in place following consumers' rejection of GMOs. In that case, it does not make much sense to disentangle both effects.

A second extension consists in testing if other GM producers, which did not challenge EU measures at the WTO, were also affected by these measures. Brazil constitutes the best example for such an investigation. Monsanto's 'Roundup Ready' soybean and Bollgard cotton were approved in Brazil in 2004 and 2005 respectively. As we already mentioned it, RR soybean was not affected by EU measures. We therefore focus on cotton and examine if Brazil's exports to the EU in 2005 were affected by EU measures. To do so, we add Brazil in the group of countries producing GM cotton and subject to EU moratorium and specific measures. Column (4) presents the results. The coefficient estimated on Brazil's exports is negative, significant at the 1% level, and higher to the ones on Argentina and US exports. Therefore, we can conclude that Brazilian cotton exports are also reduced by EU restrictions, although Brazil did not launch a WTO case against the EU.

[16] We defined for each product a new dummy variable "GM perception by consumers and labelling" set to one for EU imports from Argentina, Canada and the US from 1997 onwards. The inclusion of these dummies reduced significantly the estimated coefficients on the dummies "EU moratorium and specific measures". However, variables "GM perception" and "EU moratorium and specific measures" were highly colinear and one could have serious doubts about the robustness of the estimation.

Table 3: Influence of measures on GMOs

Dependent variable	Imports											
Model	(1)			(2)			(3)			(4)		
Ln distance	-1.49	(0.53)	***	-2.20	(0.36)	***	-2.19	(0.35)	***	-2.20	(0.35)	***
Common border	0.52	(0.70)		-0.12	(0.53)		-0.13	(0.52)		-0.14	(0.52)	
Common language	-0.04	(0.23)		-0.14	(0.24)		-0.17	(0.21)		-0.17	(0.21)	
EU morat. & spec. meas. on maize seeds	-2.66	(0.54)	***	-2.61	(0.58)	***						
on Argentina's exports												
on Canada's exports							-4.32	(0.69)	***	-4.34	(0.69)	***
on US exports							-2.52	(0.62)	***	-2.53	(0.62)	***
EU morat. & spec. meas. on maize (other)	-1.63	(0.66)	**	-1.61	(0.69)	**						
on Argentina's exports							0.50	(0.63)		0.49	(0.63)	
on Canada's exports							-5.08	(0.47)	***	-5.09	(0.47)	***
on US exports							-3.08	(0.44)	***	-3.08	(0.43)	***
EU morat. & spec. meas. on oilseed rape	-5.59	(0.66)	***	-5.55	(0.71)	***						
on Argentina's exports												
on Canada's exports							-3.69	(0.59)	***	-3.70	(0.59)	***
on US exports							-7.99	(0.35)	***	-8.00	(0.35)	***
EU morat. & spec. meas. on cotton seeds	-4.50	(0.75)	***	-4.49	(0.77)	***						
on Argentina's exports							-5.50	(0.89)	***	-5.51	(0.89)	***
on Canada's exports												
on US exports							-4.41	(0.83)	***	-4.41	(0.83)	***
on Brazil's exports										-5.76	(0.91)	***
Austria's ban on maize seeds	0.31	(0.75)		0.51	(0.87)		0.54	(0.86)		0.53	(0.86)	
Austria's ban on maize (other)	-1.22	(0.73)	*	-0.96	(0.74)		-1.13	(1.03)		-1.13	(1.03)	
Germany's ban on maize seeds	-3.76	(0.80)	***	-4.00	(0.78)	***	-3.97	(0.76)	***	-3.98	(0.77)	***
Germany's ban on maize (other)	-3.09	(0.65)	***	-3.17	(0.66)	***	-3.43	(1.11)	***	-3.43	(1.11)	***
Italy's ban on maize seeds	-1.14	(0.97)		-1.31	(1.02)		-1.24	(1.00)		-1.25	(1.01)	
Italy's ban on maize (other)	-2.10	(0.92)	**	-2.02	(0.93)	**	-2.44	(0.59)	***	-2.44	(0.59)	***
France's ban on oilseed rape	-1.92	(0.66)	***	-1.91	(0.71)	***	-1.57	(1.05)		-1.57	(1.05)	
Greece's ban on oilseed rape	-3.70	(1.52)	**	-3.60	(1.59)	**	-3.35	(0.64)	***	-3.36	(0.63)	***
New Zealand's morat. on maize seeds	-0.17	(0.56)		0.01	(0.89)		0.03	(0.88)		0.03	(0.88)	
New Zealand's morat. on maize (other)	0.51	(0.56)		0.70	(0.90)		0.72	(0.88)		0.72	(0.88)	
New Zealand's morat. on oilseed rape	-4.09	(0.60)	***	-3.72	(0.82)	***	-3.75	(0.82)	***	-3.75	(0.82)	***
New Zealand's morat. on soybeans	-2.03	(1.08)	*	-1.83	(1.08)	*	-1.81	(1.08)	*	-1.81	(1.08)	*
New Zealand's morat. on cotton seeds	-			-			-			-		
Switzerland's morat. on maize (other)	-0.54	(0.68)		-0.90	(0.83)		-0.90	(0.83)		-0.90	(0.83)	
Switzerland's morat. on soybeans	1.30	(0.44)	***	0.98	(0.56)	*	0.98	(0.56)	*	0.98	(0.56)	*
Norway's non-approv. on maize (other)	-2.04	(0.92)	**	-2.08	(1.00)	**	-2.09	(1.00)	**	-2.08	(1.00)	**
Norway's non-approv. on soybeans	-0.41	(0.75)		-0.45	(0.86)		-0.45	(0.86)		-0.45	(0.86)	
Observations	41520			41520			41520			41520		
FE importer, FE exporter, FE year	Yes			No			No			No		
FE importer x year and FE exporter x year	No			Yes			Yes			Yes		

Note: FE: Fixed Effects. Standard errors (importing country-exporting country clustered) in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels. Fixed effects are not reported.

B. Evaluation of export losses

Using Table 3, one can quantify in monetary terms the impact of EU measures on GMOs on Argentina, Canada and US exports. Export losses result from two different effects. First, a direct effect which consists in a reduction of trade flows of GM products subject to a moratorium or a safeguard measure. In addition to this direct effect, one can distinguish an indirect effect. The existence of measures against GM imports could also prevent the development and the production of new GM products. Both effects are however difficult to disentangle. The exports reduction can be calculated by product, country of export and measure at stake. Of course, we consider that exports are reduced only if the coefficient estimated on GM measures in Table 3 is significant. In addition, we make the following hypothesizes:

- We apply a reduction coefficient to each exporting country taken separately;
- We estimate a yearly reduction. As trade flows can fluctuate considerably from year to year, we use the average of the three last years (2003-2005) for actual exports.

The calculation is as follows:[17] actual yearly flows are divided by the exponent of the coefficient estimate on EU moratorium & specific measure from Table 3. This gives us the amount of trade that would happen in the absence of the measure on GMOs. To obtain the export losses due to GM measures, we subtract actual flows to this amount. Using this method, we assume that the trade impact of GM measures is constant over time and that trade losses due to GM regulations do not affect prices. Results (in thousand of USD) are reported in Table 4.

First, as expected given the size of this country, the US are the most affected by EU measures. Second, our results show that Argentina's losses on the EU market only come from the national safeguard measures adopted by certain EU Members. Finally, these estimations suggest that yearly US exports to the EU market between 2003 and 2005 were $2 billion lower than they would have been in the absence of the EU moratorium, product-specific measures and national bans. This number is equal to $306 million for Canada and to $77 million for Argentina.

In our study, we did not consider potential exports reorientation. A study has however shown that the Canada' oilseed rape and US corn sales to the EU were successfully shifted to other markets. Market losses have occured but only during a short period of time and globalization quickly offered new exports opportunities to GM producers [23].

[17] A similar approach is used to calculate the trade impact of US economic sanctions [22].

Table 4: Argentina, Canada and US exports lost due to EU measures on GMOs (thousand USD) by countries.

	Actual yearly exports average 2003-2005			Estimated yearly reduction in exports#		
	Argentina	Canada	United St.	Argentina	Canada	United St.
			HS 100510 - Maize (seeds)			
EU morat. & spec. meas.		1,343.7	62,176.9		99,687.3	710,594.7
Germany's safeg. meas.	74.1	68.2	855	3,852.1	3,545.3	44,446.8
			HS 100590 - Maize (other)			
EU morat. & spec. meas.		945.7	12,576.7		151,098.3	261,072.2
Germany's safeg. meas.	218.3	36.7	853.6	6,522.1	1,096.5	25,502.7
Italy's safeg. meas.	931.6	19.5	637.2	9,756.7	204.2	6,673.4
			HS 120500 - Oilseed rape (seeds and other)			
EU morat. & spec. meas.		1,290.7	135		50,395.2	398,290.1
Greece's safeg. meas.	0	4.4	0	0	121.0	0
			HS 120720 – Cotton seeds			
EU morat. & spec. meas.	234.5		6,905.9	57,145.8		561,238.8

Note: #: Calculated as [(actual yearly imports)/exp(coefficient on EU morat. & spec. meas. from Table 3)]- actual yearly imports.

V. Conclusion

The purpose of this paper is to study the trade impact of EU measures on GMOs in the perspective of the WTO complaint of Argentina, Canada and the US. Since the WTO panel condemned first a general *de facto* moratorium on the approval of GMOs, second undue delays in the processing of product specific applications, and third the inconsistency of the safeguard measures put in place by certain Member States, we take into account these three issues. Using the most recent advances in gravity equation estimation, we provide an estimation of losses in term of exports by product, exporting country and measure at stake. Our findings tend to ascertain the foundations of the dispute: trade losses have been faced by complainants and these losses can be attributed to European (or Member States) decisions transgressing WTO rules. EU measures on GMOs reduce on average Argentina, Canada and US exports of the affected products, with effects varying across products and complainants. In total, yearly US export losses between 2003 and 2005 were $2 billion as compared with a counterfactual without EU moratorium, product-specific measures and national bans. This number is equal to $306 million for Canada and to $77 million for Argentina.

We also investigate the impact of non-approvals of GM products adopted by other countries, such as New Zealand, Switzerland and Norway, as well as the trade impact of EU measures on a non-complaining exporting country, namely Brazil. The related results provide refreshing results on the case. We show that other importers than the EU have enforced trade-impeding measures on GMOs, while countries potentially negatively affected by European measures, such as Brazil for cotton, have not joined the WTO dispute. Such findings suggest that other determinants that export losses *stricto sensu* might have played a role in the decision of launching a case at the WTO. Ultimately, complaining countries must put in balance costs and benefits of launching a panel. Two different issues must be considered here. Firstly, market size matters: it is worth bearing the costs of a very complex and long panel when the market concerned is very large, because the losses are very large too. From this point of view, the EU is certainly an ideal target for complainants, as opposed to Norway or New Zealand. Secondly, launching a panel at the WTO also sheds light on the policies pursued by the complainant. In the case of GMOs, this may be a very sensitive issue. Brazil could have been part of the case launched by Canada, the US and Argentina. However, it would have been an official recognition of the fact that Brazil was actually permanently growing GMOs, despite the temporary nature of authorizations conceded.

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