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EU border rejections of unauthorized GM food and the trade deflection effects

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Abstract. We identify that consignments rejected by the European Union, due to the presence of unauthorized Genetically Modified food, have been diverted to third countries, creating trade deflections. We rely on a gravity model to examine the effects on food products. Our results show that the rejection of shipments by the EU has a side-effect on the global trade flows in the form of trade deflection, which can overcome losses related to A.A. The deflection occurs largely for products whose major importers have already approved most of the GM events rejected by the EU and with very concentrated export market. We also found that exporting countries with higher border rejections tend to increase their trade deflections, providing a deeper understanding of the effects of A.A on global trade flows.

Keywords: border rejections, GM food, trade deflection, European Union, third market.
JEL codes: Q17, Q18.

1. INTRODUCTION

There has been large regulatory heterogeneity across countries regarding regulatory approval processes for a Genetically Modified (GM) event that leads to Asynchronous Approval (AA), which means that the approval of a GM event does not occur simultaneously across countries (Stein, Rodríguez-Cerezo, 2010). Under this circumstance, a biotech crop might be cultivated and marketed for food and feed in one or more countries but remains unauthorized in a small group of countries. As GM crops cannot be consistently segregated, the probable outcome is that accidental presence of a small amount of GM events not approved in the importing country creates what is known as Low level Presence (LLP) (Kalaitzandonakes, 2011).

As science has been enhancing productivity and expanding international trade of GM crops, it has also been increasing the efficacy of detecting small amounts of GM events in shipments, resulting in detection of progressively smaller levels of co-mingling (Hobbs *et al.*, 2014) to impede trade. Although there has been some international guidance to address LLP issues (OECD

Task Force on the Safety of Novel Foods and Feeds; *Codex Alimentarius Commission* in the Codex Annex), countries have been establishing different thresholds for low level presence, and there is no expectation that an international harmonization will be achieved in the coming years. Thus, according to Roïz (2014), the probability of finding unauthorized events in supplies is going to increase, and this situation may cause trade disruptions with important exporting countries.

The FAO (2014) report showed that more than 20 out of 74 countries interviewed reported at least one LLP incident, and the number of incidents increased from 2001, reaching a peak in 2009, the year in which the greatest number of occurrences was reported. Although these incidents were reported by countries from all over the world, the European countries were the leaders in reporting the incidents, which is not a surprise since the EU has comprehensive and strict legislations on GM products which are reg.(EC) 1829/2003 and reg.(EC) 1830/2003 and the dir.(EC) 2001/2018. Furthermore, the EU has adopted the zero-tolerance policy regarding the presence of unauthorized GM events.

Considering the importance of the EU agri-food imports and taking into account that the EU has been considerably slow at approving new GMO events, the AA has become a sensitive issue for the continent. This can be observed in the extensive literature concerning the economic consequences of the AA in the EU agricultural and food sector (Backus *et al.*, 2008; Pérez-Domínguez, Jongeneel, 2011; Kalaitzandonakes *et al.*, 2014). However, a country's decision to enforce regulations banning the approval of some GM products has immediate implications for international trade and may cause welfare redistribution effects across countries (Lapan, Moschini, 2004). According to Baylis and Perloff (2010), bilateral trade barriers not only modify trade flows between the exporter and importer, but they can also divert trade to third countries.

There is a growing body of literature examining whether the imposition of strict trade policies by one importing country causes distortion in world trade flows. Bown and Crowley (2007) developed a pioneering Cournot model to show that discriminatory policies, such as an antidumping duty, applied by country A on imports from country B lead to four different effects on the pattern of world trade. A decline in the export of country B to country A, which is known as trade destruction; an increase in the export of country C to country A, which is the trade creation via import source diversion; an increase in the export of country B to country C, which is the trade deflection effect and the trade depression, which is a decrease in the export of country C to country B.

Most of the papers analysing these trade effects are related to antidumping measures (Prusa, 1997; Durling, Prusa, 2006; Malhotra, Kassan, 2006; Bown, Crowley, 2007; Bown, Crowley, 2010; Wang, Reed, 2015). Recently, the effects of other types of trade policies such as Voluntary Price Restraint (VPR) on Mexican tomato exports entering the United States and the end of the quota system for textile and clothing (Baylis, Perloff, 2010; Defever, Ornelas, 2013) have been analysed. As data on import rejections have become available, especially in the United States and the European Union, more authors have focused on the trade effects of food import refusals. Baylis *et al.* (2011) have observed significant trade deflection caused by the EU seafood refusals while Grant and Anders (2011) have also found trade deflection effects caused by the fishery and seafood refusals by the FDA in the United States. Their results suggest that import refusals are more correlated to exports to third markets.

The annual reports of the Rapid Alert System for Food and Feed (RASFF) have presented a steady increase in the number of border rejections due to GM events not authorized in the EU over the period of 2008-2014[1]. There were 191 notifications reported about the «hazard category Genetically Modified Food and Feed and Novel Food» mostly involving the product categories of food preparation; papaya, maize flour, cereals, nuts and other seeds and fructose. The AA constitutes a source of uncertainty for exporting countries related to border rejections because shipments may not pass to inspections. As it is expected that more and more new GM products will be developed and will be traded at different rates across countries, border rejections due to AA are likely to increase even more.

Some authors have addressed the market disruption created by the combination of AA and zero-tolerance policy[2] for LLP. In the context of specific incidents of unapproved GM crops, such as the discoveries of the Star Link corn, Liberty Link rice and Triffid Flax, negative impacts on prices and sales have been found on the exporting countries (Carter, Smith, 2007; Li *et al.*, 2010; Ryan, Smith, 2012). By considering a large set of importers and exporters, Faria and Wieck (2015) have shown that asynchronous approval negatively impact trade flows of cotton, maize and soybeans. To our knowledge the trade destruction effect of AA between an exporting country and an importing country is well documented in the literature. However, the potential trade deflection

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[1] We have not found notifications of border rejections due to unauthorized GM events before 2008.

[2] It states that any imported food or feed material cannot contain even trace amounts of GM substances that have not been approved in the country.

effect of AA still needs to be investigated. We provide the first attempt to estimate the trade deflection effect of asynchronous approval between the EU and its main exporters by addressing the following question: when the EU rejects a shipment due to the presence of an unauthorized GM event, does it lead to substantial trade deflections to third countries? We examine the trade deflection impact of AA keeping focus on border rejections after inspections which represent cases where regulations are enforced and present a *de facto* trade obstacle.

By considering a sample comprised of 184 importing countries and 134 exporting countries over the period of 2008-2014, we found empirical evidence to corroborate the hypothesis that the rejection of consignments due to unauthorized GM events at the ports of entry in the European Union has a side-effect on the global trade flows, i.e. there is a trade deflection effect of AA which might minimise the losses that the industry in the exporting country would bear with the ban in the EU market. The results are of economic relevance mainly for big producers and exporters of GM crops.

The paper is organized as follows. Section 2 presents the theoretical framework and the empirical model applied in the estimation of trade deflection effects. In Section 3, we discuss our empirical results and in Section 4, we draw the conclusions.

2. THEORETICAL FRAMEWORK AND EMPIRICAL MODEL

The changes in trade policies of a group of countries produce an indirect effect in the trade flows among other countries. This is known as trade deflection and the magnitude of these effects depends upon the type of the product and the ability of the exporters to adjust to trade policy changes. The trade deflection can compensate possible losses of the exporting country by selling the goods to a third market. Hence, this theme gained prominence in the international trade literature and became the subject of debate stimulating empirical studies that examined the effects of trade distortion due to the imposition of trade policies, showing evidence of a trade deflection in the different economic sectors (Bown, Crowley, 2007; Brook *et al.*, 2009; Baylis *et al.*, 2010; Grant, Anders, 2011; Defeverand, Ornelas, 2013).

In this context, the AA is a crucial issue due to its potential to create trade disruption in GMO products as shipment containing LLP may be rejected especially in countries operating atzero-tolerance policy. This is the case of the EU whose zero-tolerance policy bans any food imports contaminated by a GMO event that has not been approved in the EU. The combination of AA and the zero-tolerance policy results inthe economic risk of rejections of shipments at the EU border.

Tab. 1. Regulatory Approvals for the Event Code CUH-CP551-8 Rainbow, SunUp GM papaya.

Country	Food Use	Feed Use	Cultivation
Canada	2003		
Japan	2011		2011
United States	1997	1996	1996

Source: GM approval database, ISAAA (2019).

Table 1 shows a detailed example of an asynchronous regulatory approval for the Rainbow, SunUp GM papaya (GM event CUH-CP551-8). We observe considerable time lag between the first approval in the United States and the approval in Japan. The Rainbow, SunUp papaya has been marketed in the US since 1998, but it is still not authorised to be commercialised in the EU.

The asynchronicity as presented in Table 1 becomes a difficult problem for commodities traded globally because perfect segregation of approved from unapproved GM crop is difficult in the global agricultural commodity system. Under the AA condition trade disruption is likely to occur and it can significantly deteriorate into effective border rejections (Magnier *et al.*, 2009).

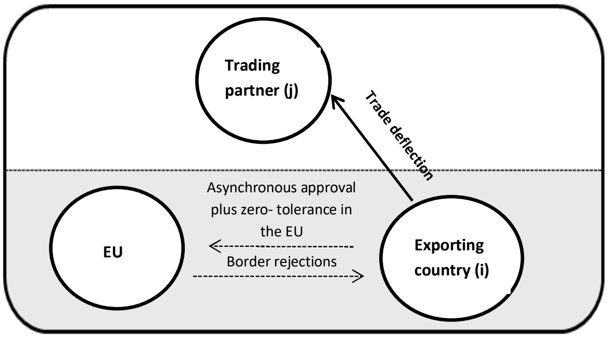
We hypothesise that the shipments rejected in the EU can be sent to other trading partners where the GMO event has already beenauthorised. Taking the Rainbow, SunUp GM papaya as an example, one might assume that Canada and Japan would be potential buyers for papayas rejected by the EU.

Figure 1 illustrates potential trade deflection effects under the circumstance of border rejections of shipments with unauthorized GM events in the EU ports of entry.

Figure 1 shows that an exporter (i) trades both with the EU and other trading partners (j). The grey part of the Figure represents the trade flows subject to AA between the EU and a specific exporting country (i). Whenever non-GM products and different GM products use the same logistics, storage and loading facilities, some cross-contamination is likely to occur,and commercial shipments might contain atrace of a GM event not yet approved in the EU. Considering the zero-tolerance policy on unauthorized GM material in the EU, the shipmentswill almost certainly be refused at the port of entry leading to trade destruction.

However, the exporter can send the rejected consignment toa trading partner that has already approved the GM event rejected by the EU, or to a trading partner

Fig. 1. Trade deflection due to border rejections of unauthorized GM events.



Source: our elaborations.

that allows for the import of GMO products for commercial use and does not enforce any specified threshold for unapproved GMO events. This trade deflection effect shown by the solid arrow connecting the exporting country (*i*) to third markets (*j*) is what we are interested in this paper. The magnitudes of trade deflection are expected to be correlated with the status of approval of GM events in the exporting country and its trading partners. Thus, if the GM events rejected by the EU are already approved by other trading partners, the rejected consignments could be easily sent to third markets.

To evaluate the trade deflection effects we rely on the structural theory-based gravity model as that developed by Anderson and van Wincoop (2003, 2004) with a focus on the demand side of the market. Their model includes multilateral resistance terms which provide theoretical support for the analysis of trade deflection. In their model, a rise in trade barriers with all trading partners will raise the multilateral resistance. In the context of our paper, the border rejections in the EU can be considered as a component of the outward multilateral resistance terms faced by the exporting country*(i)*. Therefore, higher border rejections in the EU faced by an exporter will lower the demand for its goods and consequently its supply price. Considering the bilateral barrier between the exporting county *(i)* and the trading partner *(j)* unchanged, this raises the level of trade between them what we call trade deflection.

In the empirical version of our gravity model, the imports of a trading partner *j* originating from exporting country *i* of product *k* in year *t* are estimated in its multiplicative form in accordance with Equation 1[3]:

[3] The countries' income is not included in the empirical model, because the dummy variables to control fixed effects also capture the effect of variables that are specific to exporting and importing country such as income.

$$E(M_{jik,t}) = exp[\beta_0 + \gamma I_{it} + \lambda + \beta_1 \ln(Dist_{ji}) + \beta_2 \ln(1 + \pi_{jik,t}) + \beta_3 cont_{ji} + \beta_4 lang_{ji} + \beta_5 col_{ji} + \beta_6 EUrej_{ik,t}] \quad (1)$$

We estimate Equation 1 for each product k (food preparation, fresh papayas, cereal flour, maize, cereal, nuts and other seeds, fructose and fructose syrup). To address the problem of zero trade flows, we used a Poisson Pseudo-Maximum-Likelihood (PPML) approach developed by Santos Silva and Tenreyro (2006), which provides unbiased estimates in the presence of heteroskedasticity and performs well even if the proportion of zeroes is very high (Santos Silva, Tenreyro, 2011). The definition of each variable is presented in Table 2, where γ_s, λ_s and β_s are the parameters to be estimated.

We are particularly interested in the coefficient β_6 which is expected to capture the trade deflection effect of GM event-related border rejection in the EU. We expect a positive value for this coefficient, suggesting that the exporting country increases its sale to third countries when the product is rejected by the EU.

3. DATA

The main source of information for our research is the Rapid Alert System for Food and Feed – RASFF portal database which provides information on the number of notifications classified asborder rejections. We

Tab. 2. Definition of Variables.

Variable name	Definition
$M_{jik,t}$	Country *j's* import value ($ million) of product *k* originating from country *i* in year *t*
I_{it} and I_{jt}	Exporter-time and importer-time dummies to control for multilateral resistance
$Dist_{ji}$	Simple distance between the most important cities in importing country *j* and exporting country *i*
$\pi_{jik,t}$	The bilateral ad valorem applied tariff by importing country *j* over the product *k* originating from country *i* in year *t*
$cont_{ji}$	Dummy variable denoting whether the importing and exporting countries have a common border
$lang_{ji}$	Dummy variable denoting whether the importing and exporting countries have a common language
col_{ji}	Dummy variable denoting whether the importing country or exporting country was a colony of the other at some point in time
$EUrej_{ik,t}$	Number of border rejections of product *k*,per year *t*, for exporter *i* caused by the presence of unauthorized GM events at the port of entry in the EU.

Source: Own compilation.

considered only the border rejections belonging to the hazard category «unauthorized genetically modified/ Novel food» [4]. We gathered a total of 191 notifications of border rejections in which 38 were deleted as the action taken by the notifying country was «destruction». Table 1.A. Appendix shows the available information pertained to the database of border rejections. The RASSF database provides, among other information, the origin of the rejected shipment and a description of the product category. We matched the product category description with HS codes at a 6-digit level of disaggregation. Firstly, we found the 4-digit level based on specific characteristics of the products and country of origin. Secondly, we used more specific information such as colour, package size, among others to match the products to a 6-digit level code.

The products frequently subject to border rejections are «food preparation[5]» (HS: 210390, 210610, 210690), «fresh papayas» (HS: 080720), «cereal flour,of maize (corn)» (HS: 110220), «cereal[6]» (HS: 100590, 100620, 100630), «nuts and other seeds» (HS: 200819) and «other fructose and fructose syrup» (HS: 170260) which account for 49.6% of all notifications. Therefore, our sample comprises 76 notifications of border rejections over the period of 2008-2014.

We collected data on bilateral annual imports at the 6-digit level of the 2002 Harmonized System (HS 2002) for the products mentioned above and matched them with theEU border rejection data. Our sample consists of 184 importing countries and 134 exporting countries which were selected according to their share in the total international trade of these products. They accounted for at least 60% of global trade for each product in 2014. Trade data are obtained from the UN Commodity Trade Statistics Database (COMTRADE).

Bilateral ad valorem applied tariffs, including preferential rates, are derived from Trade Analysis and Information System (TRAINS) provided by World Integrated Trade Solution (WITS), distances, contiguity, common language and colony are collected from the *Centre d'Estudes Prospectives et d'Informations Internacionales* (CEPII).

[4] Since 2017, GMO / Novel food category has been disaggregated into two categories.

[5] 210390: Sauces & preps. therefore, mixed condiments and mixed seasonings, 210610: Protein; concentrates and textured protein substances; 210690: Food preparations; n.e.c. in item no. 2106.10

[6] 100590: Cereals; maize (corn), other than seed; 100620: Cereals; husked (brown) rice; 100630: Cereals; rice, semi-milled or wholly milled, whether or not polished or glazed.

4. RESULTS

4.1. Border rejections due to unauthorized GM/Novel foodin the EU

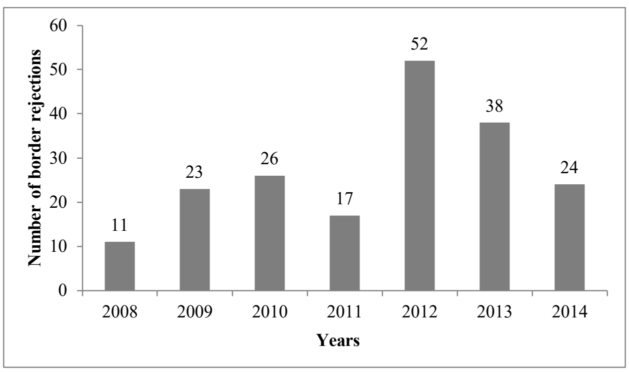
An analysis starting in 2008 indicates that, since 2009, the number of rejections has been between 20 and 26 annually, with a significant increase in 2012 and 2013 (Fig. 2). Faria and Wieck (2015) observed a rather dynamic development in the number of new GM events approved between 2009 and 2012 which seems to explain this high number of border rejections in 2012. Table 4 shows that China is the country most affected by RASFF rejections, and it is responsible for 37 out of 52 rejections in 2012. As China is a big importer of GM crops worldwide, their content in food products exported by China can be high.

An analysis of the products in Table 3 indicates that food preparation has often been barred at EU markets. These products accounted for 32.6% of all EU border rejections due to unauthorized GM/Novel food over the periodof 2008-2014.

The main origins of these products are the United States, China and India. Papaya, which is mostly exported by Thailand and the United States, presents the second highest number of border rejections accounting for 7.1%. Together, food preparation, papaya and maize flour are responsible for 43.1% of all EU border rejections meaning that they are concentrated in a small group of products.

Table 4 shows that although 18 countries faced at least one rejection over the period, China and the United States are by far the countries more subject to refusals at the entry of the EU. China presented 13 consignments rejected annually, including especially cereals, maize flour and food preparation. The US had an annual aver-

Fig. 2. Number of border rejections of unauthorized GM/Novel food 2008-2014.



Source: Own calculation based on RASFF annual reports.

Tab. 3. Number of border rejections of unauthorized GM/Novel food by product.

Product category	2008-2014	% 2008-2014
Food preparation	50	*32.68*
Papaya	11	*7.19*
Maize flour	5	*3.26*
Cereal	4	*2.61*
Nuts and seeds	4	*2.61*
Fructose	2	*1.30*
Others	77	*50.32*
Total	153	*100*

Source: Own calculation based on RASFF annual reports.

age of seven consignments rejected mainly of food preparation, cereals, maize flour, and nuts and seeds.

4.2. Trade deflection of border rejections due to unauthorized GM/Novel food in the EU

The results of the econometric estimation of the gravity Equation (1) for each category of products are shown in Table 5. Considering the potential simultaneity bias between trade flows and the number of border rejections, we follow Beestermöller *et al.* (2018) by including in our regressions one-year lagged border rejections variable to account for this source of endogeneity. The rationale behind this approach is that it is hardly likely that the border rejections of the current year would be affected by trade flows of the next year.

Looking at the trade deflection effects, we observe positive and statistically significant coefficients of the EU border rejections for all products, as expected, suggesting that a higher frequency of border rejections of unauthorized GM/Novel food in the EU leads to an increase in the export to third markets. The highest coefficients of border rejections are found for papaya followed by fructose and cereals.

The negative and statistically significant coefficients for distance are consistent with the standard gravity model for all product equations. As expected, the coefficients of tariffs are negative for all products except for fructose, and statistically significant for food preparation, cereals, and nuts and seeds.

The effects of common language, common border and colony relationships do not follow the same pattern, as they are either negative or positive depending on the product. However, these findings are not surprising since we are dealing with disaggregated gravity equation. Controversial signs for these variables have also been found in the literature regarding sectoral gravity estimation as in Faria and Wieck (2015) and Xiong and Beghin (2011).

Tab. 4. Number of border rejections of unauthorized GM/Novel food by country of origin and year.

Country of origin	2008	2009	2010	2011	2012	2013	2014	2008-2014	Annual Mean	% 2008-2014
China	2	3	15	8	37	20	3	88	13	*46*
The United States	5	11	4	2	1	7	16	46	7	*24*
Hong Kong	0	1	0	5	7	1	0	18	3	*9*
Thailand	0	0	0	0	2	7	3	12	2	*6*
Colombia	0	4	0	0	0	0	0	4	1	*2*
India	0	0	1	2	0	0	1	4	1	*2*
Israel	0	1	2	0	0	0	0	3	0	*2*
Brazil	0	0	0	0	0	1	1	2	0	*1*
Canada	0	0	2	0	0	0	0	2	0	*1*
Pakistan	0	0	0	0	0	2	0	2	0	*1*
Japan	0	1	1	0	0	0	0	2	0	*1*
Taiwan	0	1	0	0	1	0	0	2	0	*1*
Argentina	0	0	1	0	0	0	0	1	0	*1*
South Korea	0	0	0	0	1	0	0	1	0	*1*
Nigeria	0	0	0	0	1	0	0	1	0	*1*
Senegal	0	0	0	0	1	0	0	1	0	*1*
Bangladesh	0	0	0	0	1	0	0	1	0	*1*
Total	7	22	26	17	52	38	24	191	27	*100*

Source: Own calculation based on RASFF annual reports.

Tab. 5. Estimation results by product category.

Variable	Food preparation	Papaya	Maize flour	Cereals	Nuts and seeds	Fructose
$\ln(Dist_{ji})$	-0.669***	-1.175***	-3.343***	-0.563***	-1.434***	-1.942***
	(0.052)	(0.149)	(0.335)	(0.102)	(0.143)	(0.184)
$\ln(1 + \pi_{jik,t})$	-0.100***	-0.337	-0.047	-0.528***	-0.790***	0.199
	(0.023)	(0.271))	(0.116)	(0.080)	(0.084)	(0.123)
$cont_{ji}$	0.794***	0.307*	2.242***	-1.200***	-0.667***	0.427
	(0.095)	(0.168)	(0.364)	(0.258)	(0.250)	(0.299)
$lang_{ji}$	-0.085	-0.628*	0.806***	-0.653***	0.339	-1.139*
	(0.108)	(0.360)	(0.258)	(0.200)	(0.218)	(0.606)
col_{ji}	0.328***	-1.395**	-1.132**	0.449	0.771***	-0.116
	(0.089)	(0.695)	(0.507)	(0.283)	(0.275)	(0.715)
$EUref_{ik,t}$	2.063***	14.404***	2.260**	10.308***	1.907***	12.806***
	(0.185)	(1.038)	(1.081)	(1.569)	(0.234)	(1.253)
FE importer-time and exporter-time	Yes[1]	Yes	Yes	Yes[1]	Yes	Yes
Obs.	7,734	557	1,666	10,029	1,868	639
Pseudo-R^2	0.77	0.99	0.98	0.74	0.84	0.99
N. parameters	977	241	335	1309	250	184
BIC	9,158	1,438	2,707	12,500	2,081	1,202

Source: Own calculation.
Notes: ***, **, *indicate level of significance at 1%, 5% and 10%, respectively. Robust Standard errorsare between parentheses.[1]We have used importer-product-time and exporter-product-time dummies for food preparation and cereals as they are an aggregate of other products.We changed the scale of the variable by dividing it by 10. Therefore, the coefficient values are multiplied by 10.

The magnitudes of the trade deflection effects (Tab. 6) indicate that for each border rejection of unauthorized GM/Novel food in the EU, exportsto other trading partners increase by 3.2%, 2.6% and 1.8% for papaya, fructose and cereals, respectively. For the other products, the magnitudes are relatively small but still considerable and statistically significant.

Plausible explanations for the differencesin the magnitudes of trade deflections across product categories lie in the status of GM approval between exporting countries and their major trading partners, in the market concentration of exporting countries, and in the frequency of border rejections. We briefly discuss these three reasons.

In our sample, 60% of all papaya rejectionswere from American shipments and 30% from China. According to ISAAA (2019), there are only four GM events in the world, and the United States has approved three of them. The Rainbow and SunUp papaya varieties are widely marketed in the United States. As Canada and Japan are major importers of papaya from the United States,and they have also approved Rainbow and SunUp papaya for food use and cultivation, the United States can easily send the rejected shipments to these important markets.

Regarding cereals, we observe for maize that there are 146 GM events worldwide, but the major importers have already approved many of them. This is the case of Japan that has approved 88 GM events for maize, Mexico (85 GM events), South Korea (83 GM events), and Taiwan (84 GM events). Thus, the possibility of deflecting trade to these major destinations would be higher. For rice, it can be observed that there are only seven events approved worldwide, but we found that 12 countries have approved at least one event for rice. Furthermore, China which is the main importing country of this product has approved two GM eventsand the United

Tab. 6. Magnitudes of trade deflection effects.

Product	Coefficient*	Semi-elasticity**	P-value	[95% Conf. Interval]	
Foodpreparation	0,206	0,229	0,000	*0,185*	*0,274*
Papaya	1,440	3,223	0,000	*2,363*	*4,082*
Maizeflour	0,226	0,254	0,061	*-0,012*	*0,519*
Cereals	1,030	1,803	0,000	*0,941*	*2,666*
Nutsandseeds	0,190	0,210	0,000	*0,155*	*0,266*
Fructose	1,280	2,599	0,000	*1,715*	*3,483*

Source: Own calculation.
Notes: *the coefficient values were divided by 10 so that the variable number of border rejections can be interpreted in its original scale. **Semi-elasticities are calculated through (.

Tab. 7. Share of world exports by the top-5 exporting countries and trade deflection.

Product	Shareof world exports (%)	Semi-elasticity
Papaya	*74*	3.222
Cereals	*44*	1.803
Maize flour	*57*	0.253
Fructose	*82*	2.598
Nuts and seeds	*62*	0.210
Food preparation	*39*	0.229

Source: Own calculation.

States has approved five events. This pattern suggests ample opportunity for deflecting trade. Finally, as fructose syrup is mainly processed from maize, it can contain GM maize events and the trade deflection would be determined by the same conditions as maize.

Turning to the discussion of market concentration, one might expect that the higher the market power of the exporting country, the easier it would be to deflect the shipments rejected by the EU, as the major importers would not have many options to buy from other countries. Table 7 shows the share of world exports by the top-5 exporting countries and the magnitudes of trade deflection by products.

We observe a clear correlation between the market concentration and trade deflection magnitudes. The top-5 exporting countries account for 74% and 82% of world exports of papaya and fructose, respectively. These are the most concentrated export markets in our sample, and they are also the product categories with the highest semi-elasticities. On the other hand, maize flour and food preparation which present less concentrated export markets also have lower magnitudes of trade deflections.

Exporting countries facing higher rejections in their destination markets tend to learn and improve their trade strategies for deflecting trade. This learning process may be related to the frequency of the border rejections. We address this issue considering in our estimation the variable one-year lagged cumulative number of past rejections by the EU (ac$EUref_{ik,t-1}$) as a proxy for potential learning process effects (Tab. 8).

Apart from nuts and seeds, the positive and statistically significant coefficients of the cumulative number of past rejections indicate that exporting countries may acquire knowledge when facing higher border rejections by the EU, therefore increasing their trade deflections to third countries.

Tab. 8. Estimation results of cumulative number of past rejections.

Variable	Food preparation	Papaya	Maize flour	Cereals	Nuts and seeds	Fructose
$\ln(Dist_{ji})$	-0.6691***	-1.1754***	-3.3437***	-0.5634***	-1.4346***	-1.9420***
	(0.052)	(0.149)	(0.335)	(0.102)	(0.143)	(0.184)
$\ln(1 + \pi_{jik,t})$	-0.1005***	-0,3375	-0,0473	-0.5284***	-0.7908***	0,1992
	(0.023)	(0.271)	(0.116)	(0.800)	(0.084)	(0.123)
$cont_{ji}$	0.7949***	0.3072*	2.2426***	-1.2002***	-0.6673***	0,4278
	(0.095)	(0.168)	(0.364)	(0.258)	(0.250)	(0.299)
$lang_{ji}$	-0,0854	-0.6286*	0.8069***	-0.6539***	0,3399	-1.1398*
	(0.108)	(0.360)	(0.258)	(0.200)	(0.218)	(0.606)
col_{ji}	0.3287***	-1.3950**	-1.1328**	0,449	0.7714***	-0,1166
	(0.089)	(0.695)	(0.507)	(0.283)	(0.275)	(0.715)
ac$EUref_{ik,t-1}$	188.1624***	336.1086***	52.7357**	240.5316***	-54,3985	298.8233***
	(10.308)	(24.237)	(25.229)	(36.621)	(40.586)	(29.239)
FE importer-time and exporter-time	Yes[1]	Yes	Yes	Yes[1]	Yes	Yes
Obs.	7734	557	1666	10029	1868	639
Pseudo-R2	0,775	0,995	0,989	0,783	0,844	0,999
N. Parameters	978	241	335	1308	251	184
BIC	9158	1432	2708	12600	2082	1203

Source: Own calculation.

Note: ***, **, * indicate level of significance at 1%,5%, and 10%, respectively. Standard errors in parentheses.[1]We have used importer-product-time and exporter-product-time dummies for food preparation and cereals as they are an aggregated of other products.We have changed the scale of the variable by dividing it by 1000. Therefore, the coefficients values are multiplied by 1000.

5. DISCUSSION OF THE RESULTS

The empirical literature has indicated that changes in trade policy between two countries commonly affect relative prices and therefore the relation that those countries have with their other trade partners. In fact, Anderson and van Wincoop (2003,2004) greatest contribution for the gravity model has been to include the multilateral resistance terms that capture these broader effects as a result of changes in bilateral trade caused by trade policy. Considering the expansion of regional and other agreements between countries, trade deflection has been common as a result of trade policies such as antidumping measures, voluntary price restraint, food safety regulations and the end of the quota system (Prusa, 1997; Durling, Prusa, 2006; Malhotra, Kassan, 2006; Bown, Crowley, 2007; Bown, Crowley, 2010; Wang, Reed, 2015; Baylis, Perloff, 2010; Defever, Ornelas, 2013).

A major contribution of this paper is that it illustrates the importance assumed by deflection in the asynchronous regulatory approval context for trade with GM crops. The AA is a particular circumstance in which identity-preservation (IP) systems must be established to prevent an unapproved variety from entering the importing market. It can greatly affect commodity prices and industry profits. However, despite of the best intentions of those participating in IP systems, commodity trade does not function internationally at levels of one hundred percent purity (Phillipson, Smith, 2016), and rejections due to the presence of unauthorized Genetically Modified food can result in great losses for exporters.

These facts have possibly increased the importance of flexibility by exporters and their strategy to change destination once their products are rejected. As shown by the paper, this adaptation process has been evolving fast particularly for countries that have EU among their trade partners. Ryan and Smith (2012) have analysed the economic losses that the Canadian flax industry incurred in late 2009 when Triffid flax was detected in the EU food products. The authors argued that the fact that China bought up most of the flax in early 2010 helped the Canadian industry to offset the economic losses. The results of this paper are in line with this previous research, as it confirms that trade deflection to third countries is becoming an important way to offset economics losses. Furthermore, they are also in line with the magnitudes of the trade deflection found in the literature which should be useful to drive policy strategies.

We have identified trade deflection effects for all the researched product categories, but there are sizable differences in the response, expressed by the estimated values of trade semi-elasticity across product categories, which ranged from 0.21% for nuts and seeds to 3.22% for papaya. Yet these trade deflection magnitudes are consistent with other results presented in the literature such as Bown and Crowley (2007) who have found a 5-7% average increase in Japanese export deflection to other trading partners followed by an US antidumping duty. The results obtained are also close to those estimated by Baylys *et al.* (2011) that captured trade deflection effects for EU refusal of seafood products around 3%. Also focusing on seafood products, but considering US import refusals, Grant and Anders (2011) estimated partial elasticity from 1% to 2% depending on the model specification.

It is also important to emphasize that our estimates suggest that trade deflections are higher for product categories for which more GMO events have already been approved in major importers that will be competing for the product with the EU, indicating that harmonization in the regulatory approval is important not only for countries that are willing to expand their market share in the short run, but also for the EU when competitiveness for food increases in the world. It has also been indicated that deflection is higher for products that present very concentrated export markets, since their share facilitates the identification of alternative destinations. Finally, we found that exporting countries faced with higher border rejections of unauthorized GM/Novel food in the EU visualize trade deflections to third countries as an important opportunity if not to expand their markets, at least to reduce their losses.

6. CONCLUSIONS

In this paper, we evaluated whether the asynchronous approval between the EU and its trading partners has been causing trade deflection in food products, as well as providing a measure of its significance. Using data about EU border rejections of unauthorized GM/Novel food and bilateral trade for six food product categories from 2008 to 2014, we identified that trade deflections caused by the EU border rejections are relevant for food products. Each border rejection of unauthorized GM/Novel food in the EU increases the exports to other trading partners by 3.2%, 2.6% and 1.8% for papaya, fructose and cereals, respectively. For the other products, the magnitudes are relatively small but still considerable and statistically significant.

Thus, the effects of AA of GM events between the EU and exporting countries seem to be affecting the global trade flows. The extension to third countries is significant and it has direct implications for global welfare. On the one hand this trade deflection can be a way to reduce the negative effects of asynchronous approval and mitigate the economic losses of the exporting countries that re-export the refused commodities to third markets. On the other hand, the third countries may not have yet an established GM regulatory framework which would make those countries more vulnerable to situations in which contamination of GM crops and non-GM crops could limit economic value in their trade markets.

A limitation of our paper is that we do not provide insight as to where the products rejected by the EU go, since they are no longer commercialized in the EU market. Future work should address this important issue by identifying and characterizing the third markets that are willing to accept the rejected commodities. It is important to know and characterize which are the countries receiving the redirected shipments, to identify if these are countries that have not yet defined their biosecurity regulations for GM, or the gap between GM regulations are very large among them. This would allow an even broader understanding of the trade deflection process due to the presence of unauthorized GM events.

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APPENDIX

Tab. 1.A. Selected border rejections in the database.

Product category	Subject	HS code	Action take
cereals and bakery products	unauthorised GM (LLRice62) long grain parboiled brown rice from the United States	100620	official detention
cereals and bakery products	unauthorised GM (MON 88017) corn flour from the United States	110220	official detention
cereals and bakery products	unauthorised GM (MON 88017: 0.07 %) tortilla chips from the United States	190590	re-dispatch
cocoa and cocoa preparations, coffee and tea	unauthorised novel food ingredient SiraitiaGrosvenorii and unauthorised substance anthraquinone (0.087 mg/kg - ppm) in herbal tea from the United States	090240	official detention
cocoa and cocoa preparations, coffee and tea	unauthorised novel food ingredient Hoodia gordonii and novel food ingredient Tuckahoe (Peltrandavirgilica) in slimming coffee from Thailand	210690	official detention
confectionery	unauthorised GM rice (LLRICE601) in confectionery for decoration from the United States	170490	re-dispatch
dietetic foods, food supplements, fortified foods	unauthorised novel food ingredient noni in energy drink from the United States	220210	official detention
dietetic foods, food supplements, fortified foods	unauthorised GM (FP 967) linseed used in food supplement from Israel	210690	official detention
dietetic foods, food supplements, fortified foods	unauthorised GM (FP967) linseed used in food supplement from Israel	210690	official detention
fruits and vegetables	Presence of unidentified GM organisms (P35S and TNOS) in kidney beans and sesame seeds paste balls from China	120740	official detention
fruits and vegetables	unauthorised GM premium Hawaii papaya from the United States	080720	re-dispatch or destruction
fruits and vegetables	unauthorised GM (positive on GMO papaya) green papaya from Thailand	080720	import not authorised
fruits and vegetables	unauthorised GM (Detection of 35S promoter) dehydrated papaya from Thailand	200600	re-dispatch
fruits and vegetables	unauthorised GM fresh green papaya from Thailand	080720	import not authorised
nuts, nut products and seeds	unauthorised GM maize Yieldgard VT in toasted almond crunch from the United States	200819	re-dispatch or destruction
other food product / mixed	unauthorised GM (CrylAb/CrylAc detected /g) rice noodles from China	190219	official detention
other food product / mixed	unauthorised novel food comfrei (Symphytum officinalis) from Brazil	130219	import not authorised
soups, broths, sauces and condiments	unauthorised GM soya and wheat in eel sauce from Japan	210390	re-dispatch

Source: Own compilation based on RASFF annual reports.