Quantifying the Trade and Welfare Effects of EU Aflatoxin Regulations on the Dried Fruit Industry

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Abstract

Increased concerns on food contaminants draw special attention to food safety regulations. These regulations may have direct impact on food trade. The aim of the paper is to assess the impact of regulations concerning aflatoxin maximum residue limits (MRL) on dried fruits trade. The empirical method we adopt combines both gravity and welfare methodologies in a partial equilibrium context. Findings reveal that the EU regulations act as barriers to trade. Results indicate that the tighter the aflatoxin MRL regulations adopted by the export destinations (importing country), the poorer becomes the export performance of the exporting country. In addition, the results of welfare analysis show that tighter standards impose a burden on foreign producers. While producers of EU enjoy larger producer profits, both domestic and international welfare increase as a result of tighter MRL standards. The findings provide further evidence on the fact that the welfare effect of MRLs is positive and significant, although the effect on trade may be negative. In addition, wider regulatory heterogeneity is found to decrease the value of trade among trading nations.

Key Words

export performance; food safety; maximum residue limits

1 Introduction

During the last several decades, increased concerns on food contaminants urged policy makers to take precautionary measures in order to protect domestic markets from imported foods with unwanted residues and additives, and ensure food safety. Consequently, the importance of national food safety standards has increased. Amongst the various food safety issues, mycotoxins received high attention with their significant adverse health effects in humans. Mycotoxins are toxic compounds of mould infestations affecting nearly one-quarter of global food and feed crops (DOHLMAN, 2003). Aflatoxins have been considered as the most toxic form of mycotoxins due to their carcinogenic and mutagenic potency.

European Union (EU) countries have the most stringent regulations for aflatoxins, and they adopted a unified MRL (Maximum Residue Limits) policy on aflatoxin contaminants (EUROPEAN COMMISSION (2001). EU enlargement waves of 2004 and 2007 further extended the tight standards adopted by new members. From the producers' point of view, complying with higher standards often impose higher costs of production. Thus, extension of tighter standards to a larger economic geography in Europe is expected to negatively affect the exports of food, that are exposed to high risk of aflatoxins, from developing countries to Europe. In the Czech Republic, for instance, MRL on aflatoxins went down to 2 parts per billion (ppb) from 5 ppb when it became a member to the EU. A simulation study by OTSUKI et al. (2001) on trade effect of the MRL harmonisation reveals that the cost of reducing health risk by approximately 1.4 deaths per billion a year in Europe decreases African exports of cereals, dried fruits and nuts by 64% or US$670 million. More recently, MUNASIB and ROY (2013) found out that a 10% increase in the gap between standards of exporters and importers is associated with as much as a 4.4% decline in maize exports from low-income countries. In contradiction to these findings, however, XIONG AND BEGHIN (2017) concluded that tighter EU regulations on MRL on aflatoxins did not have significant effects on African ground nut exports. Empirical evidence on the effect of food safety standards on international trade remains far from conclusive. Meeting quality and safety standards in food industry imposes some compliance and certification costs. These costs are burdensome for small producers. Several authors suggest that tight regulations on food safety impose considerable barriers to trade (WILSON and OTSUKI, 2003; CHEN et al., 2008; DISDIER et al. 2008; WEI et al., 2012; WINCHESTER et al., 2012; FERRO et al., 2015; KEIICHIRO et al., 2015; LI and BEGHIN, 2017). LI and BEGHIN (2014) used aggregation indices of non-tariff measures to quantify the impact of MRL regulations on agricultural and food trade. Their calculations reveal protectionism based on both country and product levels. On the contrary, some other research suggests that the compliance and certification costs are only a small fraction (less than 5%) of total production costs (ALOUI and KENNY, 2005; CATO et al, 2005; MAERTENS and SWINNEN, 2007). Furthermore, some empirical evidence shows that the standards can act as catalysts for trade (HENSON and JAFFE, 2008; MAERTENS and SWINNEN, 2009; MINTEN et al., 2009). LIU and YUE (2012), employing similarity indexes for MRL, analysed the impact of MRL regulations on international trade. They found that stricter MRL standards increase exports of developing countries to developed countries. Conflicting results leave the impact of standards on trade as uncertain. Nevertheless, standards remain potentially important barriers to international trade.

The aim of the research is to provide further evidence for the trade effects of regulatory standards by using aflatoxin maximum residue limits (MRL) regulations on dried fruit industry as an example. There are at least two reasons to focus on dried fruits. First, dried fruits industry has been growing very fast since dried fruits are getting increasingly popular for being considered as one of the healthiest appetites. The industry accounts for a supply value of nearly 7000 million dollars in 2015, which is 47% higher compared to that of 2006 (INC, 2016a). More than 80% of world dried fruit exports come from developing market economies (WORLD TRADE MAP, 2016), indicating industry's importance for developing countries.

Second, dried fruits (excluding figs) are among those that have been subject to strictest MRLs. MRLs established by EU for dried fruits and nuts intended for direct human intake are 4 ppb for total aflatoxin and 2 ppb for aflatoxin B1 (EUROPEAN COMMISSION, 2006). There is no equivalent Codex standard, and the acceptable tolerances for aflatoxins in food intake identified by various national standards range from 1 to 50 ppb. The EU is the largest importer of the edible nuts and dried fruit industry in the world (CBI, 2015).

World's major dried fruit suppliers are the low and middle - income countries of Africa and Middle East (INC, 2016a). Thus, the major exporters of dried fruit industry are developing countries. Dried fruit industry exclusively relies on domestic inputs, thus provide opportunities for value added and employment to the developing countries. However, dried fruits have been a particular focus of aflatoxin regulations worldwide since the drying and preserving process promotes the growth of a fungus, which contains aflatoxins. On the other hand, many of the Sub-Saharan, African, Middle Eastern and Asian countries are also known to be exposed to high humidity, warm temperatures, and drought which are also associated with high levels of aflatoxins (MITCHELL et al., 2016). Clearly, given their poor capacity to ensure food safety, low-income countries lag behind evolving standards (higher safety norms) imposed by industrialised countries. Ultimately, increasing demand for higher standards by industrial countries impose higher compliance costs to the producers of the low-income countries, in a way acting as barriers to trade (HENSON and JAFFE, 2008).

The significance of losses imposes important economic drawbacks on developing countries, which rely heavily on agricultural exports of these commodities. Given their potential importance to impede international trade, it is much debated whether the standards are imposed on health protection grounds or may be abused to serve as non-tariff trade barriers (MASKUS and WILSON, 2001; ALEMANNO, 2007). In line with on-going debates on academic and political grounds, quantifying the welfare effects of national food safety standards started to attract interests of the academics (HENSON et al., 2000; KEIICHIRO et al., 2015; SCHUSTER and MAERTENS, 2015). However, existing literature seems to be far from conclusion with limited empirical evidence, and in need for further research focusing on the economic effects of food safety standards (OTSUKI et al., 2001; WILSON, 2003; ROBERTS, 2009; XIONG and BEGHIN, 2014, AGYEKUM and JOLLY, 2017). Understanding the impact of food safety standards on food trade is of importance for exporters, and policymakers to assume the benefits of international harmonisation. This research attempts to make a contribution to the existing literature with further evidence on the impact of MRL regulations on dried fruit industry.

Finally, some limitations of this research need to be mentioned. First, the empirical investigation undertaken in this research is implemented at the very specific product level with a sole focus on dried fruit industry. Dried fruits, being one of the major export items of low-income countries, are highly exposed to risks of aflatoxins. Lack of regulatory uniformity on worldwide implementation of MRLs on aflatoxins, however, increases the importance of investigation on economic impact of trade on dried fruits. Second, the analysis is limited to a restricted sample of countries. The data consists of bilateral trade values of dried fruits between and 45 exporter countries, over the period 2002 – 2016. Yet, the coverage of data is one of the largest in related literature, and accounts for more than 85% of the world's dried fruit trade. Finally, simulation study is based on the estimation of a single supply curve identifying foreign exports, instead of different supply curves for each exporter country. This allows a rough estimation of the results from the changes in EU aflatoxin MRL regulations for major exporters of dried fruit (Turkey, USA, China, and Chile). Even though estimation of country specific individual supply curves would increase the accuracy of impact measurement, unavailability of historical domestic supply quantity and price data does not permit estimation of individual supply curves.

The rest of the paper is organised as follows. Section 2 elaborates worldwide aflatoxin standards, and the dried fruit exports. Section 3 describes the data, and methodology. Section 4 provides results of the empirical analysis. Section 5 makes the concluding remarks.

2 International MRL Standards and Dried Fruit Industry

Aflatoxins are type of mycotoxins, defined as toxic secondary metabolites produced by three moulds of Aspergillus species: Aspergillus Parasiticus, Aspergillus Flavus and Aspergillus Nomius (WHO, 1998) and are associated with important health risks. Acute exposure to aflatoxin can result in adverse toxicological effects on humans called aflatoxicosis. There are varied effects of aflatoxin exposure leading to acute and chronic outcomes, including rapid death, and hepatocellular carcinoma (KENSLER et al., 2011). One of the most severe aflatoxicosis cases occurred in Kenya in 2004. 317 cases were reported, and 125 people died (IFPRI, 2010). A recent aflatoxin contamination was experienced in Europe in 2013 (BOTANA and SAINZ, 2015).

Humans are exposed to aflatoxins through dietary intake of contaminated food. During the outbreak of aflatoxicosis-induced death of people in Kenya, individual daily B1 exposure was estimated to be 50mg/day. Research provides that the level of aflatoxin concentration in a grain product may vary from 1µg/kg to greater than 12,000 µg/kg (KENSLER et al., 2011). Even though sufficient information is not available to specify a certain amount of tolerable dietary intake of aflatoxins, FAO/WHO Joint Expert Committee on Food Additives urge for "As Low as Reasonably Achievable" amount of intake.

Wide range of agricultural products are affected by aflatoxins, including cereals, oilseeds, spices, tree nuts, milk, meat, dried fruits, groundnuts, and maize. Foodstuffs and grains may get contaminated at any stage of production from pre-harvest to storage. Aflatoxin exposure is especially high in areas with high temperature, and humidity. Genotype of the planted crop, and soil type are also considered to be influential on aflatoxin contamination. Africa and Asia are denoted as being high-risk areas of aflatoxin exposure due to their climatic conditions. Widespread concern on potent health effects of aflatoxins however, led to regulatory actions by governments. Food monitoring policies, and the implementation of optimal drying and storage practices decreased the level of exposure to aflatoxins in most developed countries to a great extent. Developing countries on the other hand, hardly implement food security and safety policies, due to insufficient resources, infrastructure, and technology.

Lack of uniformity in worldwide regulations concerning aflatoxins, imposes significant barriers to international trade of food produces particularly between developed, and developing countries. Harmonisation of national standards would ensure that they are imposed on unarbitrary, scientific grounds. Joint FAO/WHO Codex Alimentarius Commission (CODEX) in this respect is an attempt for international harmonisation, and proposes harmonised international food standards, guidelines, and codes of practice. However, government regulations concerning MRLs remain far from international harmonisation. In 2003, the EU aligned its food standards on MRLs on a tighter than ever basis. Stringent approach of European Union towards food safety issue uses precautionary principle. The principle suggests taking regulatory actions against any risk, even though scientific evidence of risk is incomplete. Therefore, use of import bans, and high regulatory barriers towards imports from developing countries by European Union members are often justified on food safety grounds.

Table 1 shows the discrepancies between various countries in terms of their allowable maximum total aflatoxin, and B1 level regulations. These countries are the major exporters and importers of dried fruit. In April 2002 the European Union harmonised its MRL policy on aflatoxin contaminants, since then EU regulations on MRL are considered to be the most stringent standards. EU requires maximum levels for not only total aflatoxin, but also for Aflatoxin B1, which is most commonly detected component of aflatoxin. Imports of nuts, groundnuts, dried fruits, cereals, maize, and milk are those products subject to EU maximum aflatoxin level requirement regulations. International Codex Alimentarius, on the other hand, imposes maximum level of aflatoxin for only raw peanuts. Similarly, dried fruits are exempted from maximum level requirements for aflatoxin in Canada and Japan. Turkish regulations concerning aflatoxin maximum limits tend to be lower than Codex and most of other developed countries such as USA, Japan, Canada, but higher than EU.

Table 1. MRLs for aflatoxin for various countries

Country	Aflatoxin Total	Aflatoxin B1
Canada	-	-
Chile	5	-
China	-	-
EU	4	2
Japan	-	10
Russian Fed.	-	-
Turkey	10	5
USA	20	-

Source: FAO (2003)

EU appears to be the world's largest market of dry fruit exports and imports. EU, Turkey, USA, Chile, Thailand, and China account for 75% of world dried fruit exports in 2015 (WORLD TRADE MAP, 2015). EU alone stands to be a major destination for dried fruits with a market share of more than 50% (see Table 2). Turkey traditionally has been one of the world's largest producers and exporters of dried fruits, figs, raisins, and apricots in particular, and supplies nearly 30% of European dried fruit imports.

Table 2. World's top dried fruit* exporting and importing countries (2015)

Exporting Countries			Importing Countries		
Country	**Export Value** (in thousand US$)	**Market Share** (in %)	**Country**	**Import Value** (in thousand US$)	**Market Share** (in %)
World	4,008,614	100.00	World	3,970,218	100.00
EU-28	845,097	21.08	EU-28	2,012,987	50.70
Turkey	756,505	18.87	USA	271,906	6.85
USA	658,458	16.43	Japan	149,527	3.77
Chile	371,522	9.27	Canada	135,520	3.41
China	176,986	4.42	Russian Fed.	78,059	1.97

*Dried fruits that are categorised under HS0813+HS080620
Source: WORLD TRADE MAP (2015)

Statistics indicate that a large portion of world dried fruit exports comes from developing countries to the markets of developed countries. EU members represent a significant market share in dried fruit imports. Hence, strictness of EU standards on maximum aflatoxin levels often expected to impose preventive effects on trade with developing countries.

3 Data and Methods

FUGAZZA (2013) summarises main methodological approaches to measure the impact of non-tariff barriers on trade standards. The methods are based on the analysis of foregone trade via gravity estimation (OTSUKI et al., 2001; WILSON and OTSUKI, 2004, FONTAGNE et al., 2005; DISDIER et al., 2008). Such frameworks focused on trade cost effects of standards and ignored welfare effects. Recent theoretical contributions, however, propose that imposition of standards may also result in increased domestic and international welfare (BEGHIN and BUREAU, 2001; CHEN et al., 2008; MAERTENS and SWINNEN, 2009; BEGHIN et al., 2012; AGYEKUM and JOLLY, 2017). This type of analysis involves and indirect measure of standards by substituting tariff rate equivalents for technical barriers.

In this paper, we adopt the empirical framework used by DISDIER and MARETTE (2010). The framework combines both gravity and welfare methodologies in a partial equilibrium context. The coefficient measuring the foregone trade linked to given change in MRL standard is estimated via the gravity model, and taken into account to determine the relative variations in price and quantity. Welfare effects are, then, evaluated based on these changes in price and quantity. The following subsections specify the gravity model, elaborate on the measurement of welfare effects, and define the data employed (see appendix for further details on equations and calculations).

3.1 Empirical Estimation Method

The econometric analysis of trade flows follows the gravity model developed by TINBERGEN (1962). Analogous to Newton's Gravity Law, bilateral trade between the two countries is proportional to the product of each country's "economic mass", often measured by GDP, and indirectly proportional to the distance between the countries' "respective economic centres of gravity", often capital cities. This model is referred to as baseline (standard) gravity model, and formulated as:

$$V_{xmt} = \frac{GDPPC_{mt}^{b_1} GDPPC_{xt}^{b_2}}{DIST_{mx}^{b_3}} \qquad (1)$$

Here subscripts m and x refer to importing and exporting countries respectively. V denotes the value of trade flows, GDPPC is Gross Domestic Product per capita, and DIST represents the distance variable. TINBERGEN (1962) gravity models are widely used to assess the trade flow effects of various types of trade costs, including technical barriers to trade, between the trading partners (MASKUS et al., 2001). Other variables that impact on trade could be relative prices, policy tools, subsidies, technical barriers to trade, and other type of trade costs.

There are a number of studies that employ gravity model in their empirical analysis (see, e.g. OTSUKI, et al., 2001; WILSON and OTSUKI, 2003; SUN et al., 2005; CHEN et al., 2008, WEI et al., 2012). Estimation of the standard gravity model yields results that are restricted to the examination of bilateral costs among trading partners assuming a structure isolated from the rest of the world. However, trade between the two partners increases as bilateral trade cost *relative* to the average trade cost between each of the trading partner and the rest of the world decreases. Not only the bilateral trade resistance between country pairs, but multilateral trade resistance that the trading country faces with all its trading partners should be addressed in estimating the gravity model of international trade. Hence, standard form of the gravity equation lacks an underpinning of economic theory that is, the fact that value of trade from x to m would be influenced by comparative economic density and trade costs between x and m relative to those of the rest of the world. This lack of theoretical foundation of empirical model results in two important implications. First, omitted variables render biased estimations. Second, it is impossible to correctly calculate comparative statistics exercises of international trade flows (ANDERSON and VAN WINCOOP, 2003).

In order to circumvent the problem, ANDERSON and VAN WINCOOP (2003) developed an augmented version of the traditional gravity model by controlling for "multilateral trade resistance" term. Multilateral trade resistance term referring to the trade barriers that each trading partner faces in trade with all its trade partners, the theory – consistent gravity model is based on constant elasticity of substitution preferences of consumers in a general equilibrium structure. The theory consistent gravity model includes inward and outward multilateral resistance terms. Multilateral resistance terms define the dependence of the exports (x) and imports (m) of the country multilateral trade costs across all trade regions of rest of the World, which is nearly unobservable.

A widely used procedure to estimate the theoretical gravity equation with unobservable multilateral resistance terms is to replace inward and outward multilateral resistance indices with inward and outward region specific dummies. This approach earlier adopted by ANDERSON and VAN WINCOOP (2003), EATON and KORTUM (2002), ROSE and VAN WINCOOP (2001), yields unbiased estimates for the gravity equation. Allowing for importer and exporter fixed effect dummies across the sample, we apply two step Heckman estimation model as given in equations (2a) and (2b):

$$\begin{aligned} V^*_{xmt} = {} & b^*_0 + b^*_1 \ln(GDPPC_{xt}) + \\ & b^*_2(GDPPC_{mt}) + b^*_3 \ln(DIST_{xm}) + \\ & b^*_4 MRL_{xm} + b^*_5 language_{xm} + \\ & b^*_6 colony_{xm} + b^*_7 border_{xm} + \tau H_{xmt} + \\ & fe^*_x + fe^*_m + \upsilon_{xmt} \end{aligned} \tag{2a}$$

$$\begin{aligned} ln(V_{xmt}|(V_{xmt} > 0) = {} & b_0 + b_1 ln(GDPPC_{xt}) + \\ & b_2 ln(GDPPC_{mt}) + b_3 \ln(DIST_{xm}) + \\ & b_4 MRL_{xm} + b_5 language_{xm} + \\ & b_6 colony_{xm} + b_7 border_{xm} + \mu_{xmt} + \\ & fe_x + fe_m + \varepsilon_{xmt} \end{aligned} \tag{2b}$$

Where, selection equation 2(a) is a probit model in which V^*_{xmt} is a binary variable that equals 1 if dried fruit exports from country x to country m at time t is non-zero, and equals zero otherwise. Equation (2b) is the outcome equation that explains the value of trade conditional on trade taking place.

Here, V_{xmt} represents the value of exports in dried fruits (HS0813 + HS080620) from exporting country (x) to importing country (m) in time (t). Parameter bs are estimated coefficients. fe addresses specific effects for importing and exporting countries. Multilateral resistance terms are, therefore proxied, and captured by using dummies for exporter country and importer country. The coefficient measures the common element of the origin country's (exporter) trade with destination (importer) respectively, which is also called as multilateral resistance term. H is the exclusion variable that does not enter the outcome equation. Following MUNASIB and ROY (2013), we calculated the historical frequency of non-zero trade by taking proportion of years that trade has taken place in the five – year moving window. $GDPPC$ is the real per capita GDP. $DIST_{xm}$ is the geographical distance between exporting and the importing countries. $language$, $border$, and $colony$ are dummy variables identifying common language, common border, and colonial ties between importing and exporting countries respectively. μ_{xmt} is the inverse Mill ratio calculated from the selection equation, entering outcome equation. MRL_{xm} represents an independent measure on maximum allowable limits imposed on imported dried fruit. We employ two different measures for MRL interchangeably. These are MRL regulations adopted by export destinations (MRL_m) and a heterogeneity index (I). Further explanation of heterogeneity index (I) is provided under section 3.3.

Under the theoretical and empirical framework suggested above we test the following hypotheses are to be tested:

H1: Tighter aflatoxin MRL regulations adopted by the export destinations (importing country) are likely to have a negative influence on the export performance of the exporting country.

MRL with lower values ppb in importing country are hypothesised to increase export performance of the exporting country. A direct measure of maximum allowable aflatoxin B1 level imposed by the importing country ($MRLm$) is employed in the model, in order to assess the effect of MRL regulations adopted by the export destinations. Coefficient of $MRLm$ variable is tested empirically to investigate the so-called effect. Existence of a statistically significant positive coefficient is expected to support the hypothesis.

H2: Wider regulatory heterogeneity is likely to decrease the value of trade among the trading nations.

This hypothesis is tested by employing a heterogeneity index (I). Regulatory heterogeneity for which a larger positive value indicates that the importing country has relatively more stringent MRL standard. Increase in stringency of MRL standard in importing country relative to exporting country is assumed to impose barriers to trade for the exporting country. A corollary is that exporting country with more stringent MRL regulations should have easier access to importing destinations with less stringent MRL regulations. When testing this hypothesis, the variable we employ is $max\{I,0\}$. Thus, we test for dissimilarity in MRL regulations for the case only when regulatory heterogeneity is positive. Statistically significant negative coefficient, then, is expected to verify the hypothesis, indicating a negative relationship between regulatory heterogeneity and value of trade among the trading partners.

3.2 Measuring Welfare Effects

Theoretically assessing the economic impact of standards requires consideration of price and quantity changes, as a result of supply and demand shifting effects. GANSLANDT and MARKUSEN (2001) provide a theoretical demonstration on how standards and technical regulations may have both trade impeding and demand enhancing effects. A typical framework for this kind of analysis is to apply a tariff-equivalent method to quantify the welfare effects associated with the implementation of standards.

Our conceptual and theoretical setup follows DISDIER and MARETTE (2010). Using a similar partial equilibrium framework we accounted for costs and benefits affecting domestic consumers, domestic and foreign producers. The market we analyse is assumed to be homogenous, except for a specific attribute that is potentially unsafe to consume. Following BEGHIN et al. (2012), we assume that the implementation of MRL regulations assure elimination of the undesired characteristic, and full protection of the consumers.

To derive the demand, we assume the following utility function for a representative consumer, as suggested by POLINSKY and ROGERSON (1983):

$$U(q,w) = aq - \frac{bq^2}{2} - Kq_f prob.\lambda + w \tag{3}$$

where q represents quantity of the good, under the assumption that the consumer does not distinguish between foreign and domestic goods considering them as perfect substitutes to each other. So that, $q = q_f + q_d$. The term $aq - \frac{bq^2}{2}$ captures the immediate satisfaction of a representative consumer from consuming foreign and domestic products, and w is the numéraire good. The term $-Kq_f p\lambda$ is the expected damage associated with the consumption of foreign product. Parameter λ represents the value of damage linked to per unit consumption, and $prob.$ is the probability of having contamination from foreign consumption. The consumer's knowledge regarding the damage brought by consumption of the foreign good is parameterised by K. If K =1, consumer is aware of the specific characteristic brought by the foreign product, and internalise the externality by reducing foreign consumption. Conversely, if consumer is unaware of the specific characteristic, then $K = 0$.

The value of damage, λ, linked to per unit consumption of the commodity in question with a probability of having contamination is determined by using results from SCKOKAI et al. (2014). They found that consumers are willing to pay a 0.29 average price premium for 'reduced mycotoxins'. Per unit damage is calculated by using domestic price, P_e. Per unit damage is equal to $\lambda = 0.29 \times P_e$. Since the cost of ignorance arises because consumers are unaware of the possible damage and keep consuming the product, the cost of ignorance for unaware consumers becomes λQ_f. When stricter MRL standards are imposed on the product, it is assumed that the probability of contamination is eliminated and a possible damage is prevented. Hence, cost of ignorance decreases.

Demand is derived from maximisation of the utility function (3) under a budget constraint. Under the assumption of uninternalised damage ($I = 0$), inverse aggregate demand function becomes:

$$P(Q_d) = a - bQ_d \tag{4}$$

On the supply side, there are N_d domestic firms, and N_f foreign firms. Assuming a perfectly competitive industry for both domestic and foreign producers, a representative foreign producer produces q units of output to maximise profits:

$$\pi_f = p\gamma q_f - c_f q_f - 1/2 g_f q_f^2 \tag{5}$$

where, c and g are variable cost parameters.[1] Parameter γ represents the proportion of foreign products entering domestic market. Recall that only foreign producers are impacted by the adoption of the safety standards, and domestic producers are assumed to already comply with the standards. So that, γq_f refers to the foreign supply of products entering domestic market after the inspection. The parameter, $0 \leq \gamma \leq 1$, depends on the stringency of inspection policy.

Similarly, representative domestic producer maximised profit when,

$$\pi_d = pq_d - c_d q_d - 1/2 g_d q_d^2 \tag{6}$$

Profit maximisation of (5) and (6) yields individual supply functions for foreign and domestic producers. We derive aggregate supply function by adding up all individual firm supply functions, and the inverse supply ($S = S_D + S_F$) becomes:

$$P(Q_s) = \frac{c_d c_f Q + c_d g_f \gamma + c_f g_d}{c_d c_f \gamma^2} \tag{7}$$

With $\hat{c} = \frac{c_d c_f}{c_d c_f \gamma^2}$ and $\hat{g} = \frac{c_d g_f \gamma + c_f g_d}{c_d c_f \gamma^2}$, inverse aggregate supply function becomes:

$$P(Q_s) = \hat{c}Q + \hat{g} \tag{8}$$

Figure 1 shows domestic demand (D), foreign supply (S_F), and total supply $(S = S_D + S_F)$. Price (P) is located on the vertical axis, and the quantity (Q) is given on the horizontal axis. The initial situation, preceding reinforcement of stricter safety standard, leads to an equilibrium E (Figure 1). Initial equilibrium, E, is determined by equating aggregate supply (8) and aggregate demand (4), with a given γ proportion of foreign goods entering domestic market after the inspection. For this initial situation, parameters are calibrated in so as to replicate prices, and quantities over the period 2002-2016.[2] Based on price and quantity observations, we estimated the demand, and supply functions.

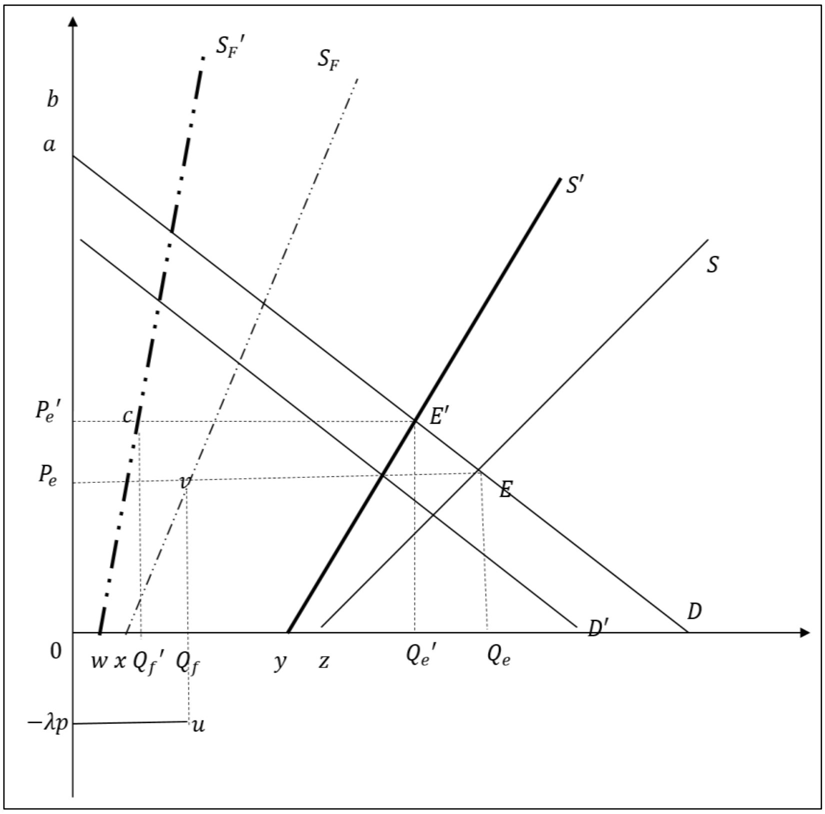
Enforcement of MRL standards imposes welfare changes by shifting foreign supply and influencing both the equilibrium price, and the cost of ignorance. If the MRL enforcement has significant impact on value of trade, then equation (9) can be integrated into a calibrated model provides welfare effects of the MRL enforcement by importing country. Thus, by using statistically significant coefficient of b_4 from the gravity equation, the price and quantity effects linked to any changes in MRL standards can be measured. The marginal change in value of exports with respect to a unit change in MRL can be expressed as $\Delta V_{xmt} = b_4 \Delta MRL_m$. Since $V_{xmt} = P_e x q_f$, relative variation in value of exports with respect to a change in MRL can be rewritten as follows:

$$\frac{P_e' - P_e}{P_e} + \frac{q_f' - q_f}{q_f} = b_4 \Delta MRL_m \tag{9}$$

[1] Even though bilateral tariffs are available in WTO Tariff Analysis Online database, due to large amount of missing values we did not control for tariffs. Thus, we assumed zero import tariff and no sunk costs in order to keep the analysis simple.

[2] We used PRODCOM annual data to account for domestic production, and COMTRADE import data to account for foreign supply. Domestic prices were estimated by dividing the value of imports by the quantity of imports.

Figure 1. Welfare effects of reinforced safety standard



Source: Figure is adopted from FUGAZZA (2013)

Assuming that domestic firms already implemented stricter standards, compliance costs fall only on foreign firms. These additional costs of compliance then, shift foreign supply curve, influencing the proportion of foreign products entering domestic market (γ). Thus, change in MRL influences the share of foreign products entering domestic market with a change of parameter γ to $\hat{\gamma}$. For a given value of γ linked to initial equilibrium, E, the value of $\hat{\gamma}$ is calculated by solving the equation (9), as a result of welfare shifts. Shift of the supply curve from S to S' yields a new equilibrium price, P_e', and quantity, Q_e'.

Based on econometric estimations of supply (both foreign and domestic) and demand, welfare effects of a reinforced regulation are calculated. Given the calculated parameters, change in domestic welfare as a result of imposed regulation is given by the difference between initial domestic welfare ($xvEz + aeP_e - \lambda ptQ_e^F 0$) and new domestic welfare ($wcE'y + aE'P_e'$). Change in foreign producers' surplus is given by the difference between initial foreign exporters' surplus ($xvEz$) and the new foreign exporters' surplus ($vcE'y$). Finally, change in domestic welfare and change in foreign exporters' surplus together gives the change in international welfare as a result of imposed standard policy.

3.3 Data Sources

Our trade data on dried fruit are extracted from International Trade Centre, World Trade Map. It consists of the US $ value of bilateral trade in HS0813 (fruit, dried, other than that of heading no.0801 to 0806; mixtures of nuts or dried fruits of this chapter) and HS080620 (fruit, edible; grapes, dried). The EU is the largest importer of dried fruits, accounting more than 50% of total world trade in dried fruits. EU imports around 60% of dried fruits from international markets. Thus, dried fruit exporters are assumed to be highly influenced by and concerned with the EU MRL policy on aflatoxins. This is the reason why we focus on the bilateral trade between EU and the exporters of dried fruit. The data consists of bilateral trade values of dried fruits between EU-28 and the exporter countries. Due to availability of data, we take 45 exporter countries into consideration.[3] These countries' exports account for more than 85% of the world's dried fruit trade.

Data for aflatoxin MRL of exporting and importing countries are obtained from FAO survey of worldwide regulations for mycotoxins in food and feed conducted in 2003 (FAO, 2004). Use of time – invariant FAO survey data for the years 2003 in a regression with observations from other years implies the assumption that aflatoxin regulations have not changed over the period of analysis. Even though it might be the case for some countries that the regulations have changed over time, data for maximum allowable aflatoxin levels are only available for some specific years. However, as long as the relative severity of standards among trading partners have not changed, the magnitude, and the effect of any change in maximum allowable levels should be of minor

[3] Exporter countries considered in the study are EU28, Turkey, USA, Chile, China, South Africa, Iran, Australia, Uzbekistan, India, Argentina, Afghanistan, Pakistan, Canada, UAE, Norway, Russian Federation, Thailand, Azerbaijan, Gabon, Switzerland, Egypt, Peru, Ecuador, Tunisia, Costa Rica, Vietnam, Philippines, Panama, Bosnia, Brazil, Saudi Arabia, Serbia, New Zealand, Morocco, Indonesia, Lebanon, Colombia, Ghana, Singapore, Sri Lanka, Mexico, Malaysia, Japan, Ukraine.

importance. Two measures (MRL_m and I) are used interchangeably, running two different estimations for gravity equation. Table 4 present the variables in the model and their descriptive statistics.

In estimation of gravity models, an independent measure of maximum residue limits is integrated into the model to quantify the effect of changes in residue limits on bilateral trade. In this research, we consider two different variables to specify the effect of aflatoxin standards imposed on dried fruit. First, following OTSUKI et al. (2001), a direct measure of maximum allowable aflatoxin B1 residue limit imposed on dried fruit imports by the importer m, denoted by $MRLm$ is employed in gravity. OTSUKI et al. (2001) used data on maximum allowable aflatoxin levels specified for each product, which allows for a consistent measurement of standards across countries. Thus, in order to be able to detect the impact of MRL regulations on dried fruit industry exports we followed OTSUKI et al. (2001). However, a standard imposed by importing country could be discouraging for exporting countries that have the least similar standards, while encouraging for the exporting countries with similar standards. Therefore, employing a direct measure of MRL standard enforced by the importing country may not completely capture the trade effects. Thus, we designed a second variable (heterogeneity index) that represents the similarity/dissimilarity between the exporting and importing countries. Following ACHTERBOSCH et al. (2009), we employed an index constructed to measure regulatory heterogeneity. The index reveals relative differences in MRL regulatory terms between exporting and importing countries. Index is calculated as follows:

$$I = \frac{MRL_x - MRL_m}{MRL_x + MRL_m} \qquad \text{for } max\{I, 0\} \tag{10}$$

Calculated index gives standardized difference in MRLs for aflatoxin, and lies in the interval [-1,1]. Extreme values of -1 and 1 represent the restrictive case of trade in which one of the trading partners bans aflatoxin. Index values near to 0 represent regulatory similarity. Since we are mainly concerned with the impact of regulatory MRL imposed by importing countries, we focus on positive regulatory heterogeneity. We test for dissimilarity in MRL regulations for the case only when regulatory heterogeneity is positive. Note that variable I is not in logarithmic terms since the value of zero for I reflects the case of regulatory harmonisation (homogeneity) among the trading partners.

Table 4. Data source and summary statistics for the variables that are used in empirical analysis

Variable	Source and Definition	Mean	Std. Dev.	Min.	Max.
V_{xmt}	Value of Bilateral Trade from Exporting Country x to Importing Country m in millions of current US$ in year t (International Trade Centre, World Trade Map)	9.66	9.56	1	55.3
$GDPPC_{xt}$	Real per capita GDP of Exporter Country x in year t in US$ (World Bank's WDI)	16073	15010	4078	38711
$GDPPC_{mt}$	Real per capita GDP of Importer Country m in year t in US$ (World Bank's WDI)	20171	10756	1888	40837
$DIST_{xm}$	Direct line distance from the capital of Exporting Country x to the Capital of Importing Country m, measured in kilometres (Mayer, T., and Zignago, S., 2011)	7998	4201	834	17228
$language_{xm}$	Dummy variable identifying use of common language between the exporter and the importer (Melitz, J., and Toubal, F., 2012).				
$colony_{xm}$	Dummy variable identifying existence of any colonial ties between the exporter and the importer (Hensel, P.R., 2014).				
$border_{xm}$	Dummy variable identifying existence of a common border between the exporter and the importer (Mayer, T., and Zignago, S., 2011).				
H	Exclusion variable, calculated on the basis of historical trade frequency.	9	5.5	5	14
MRL_m	Importing Country Regulations on Maximum Residue Limits for Aflatoxin B1(FAO Survey of Worldwide Mycotoxin Regulations)	4.97	7.14	2	30
MRL_x	Exporting Country Regulations on Maximum Residue Limits for Aflatoxin B1(FAO Survey of Worldwide Mycotoxin Regulations)	5.83	3.12	2.5	10
I	Regulatory heterogeneity index constructed to reveal relative differences in MRL regulatory terms among exporting and importing countries.				

Source: authors´ own compilation

4 Empirical Findings

We follow a two-step procedure to analyse the economic impact of MRL regulations on dried fruit trade. The first step investigates the results from gravity estimation. Gravity estimation is the one most widely used to relate bilateral trade flows to various factors that affect barriers to trade. Our estimation strategy is Heckman Sample Selection model. Applying Heckman Sample Selection in estimation of gravity equation accounts for zero trade flows between countries. In addition, the model allows us to decompose extensive and intensive margins to trade.

Second step explores the simulation results of two alternative scenarios on MRL enforcement by EU aflatoxin regulations based on trade and welfare effects. First scenario takes harmonisation on tighter standards into consideration with the assumption of a decrease in EU aflatoxin regulations on MRLs to 2 ppb. Due to increasing health concerns, it is an option that EU may further tighten regulations. Second scenario, on the other hand focuses on the trade effects of a less stringent regulation on aflatoxin MRLs (6 ppb). Second scenario seems to be more reasonable given the trade partners' pressure on EU to relax her MRL standards. The effects of a possible increase in MRLs on public health have already been an issue of debate for European Food Safety Authority (EFSA)[4].

4.1 Gravity Estimation Results

We conduct panel unit root tests for the variables to ascertain that all variables are stationary before the actual estimation can be carried out. Results of the panel unit root tests in Table 5 report that all variables are stationary.

Table 5. Panel unit root test results

Variables	$lnGDPPC_{xt}$	$lnGDPPC_{mt}$	lnV_{xmt}
Levin-Lin-Chu statistic	-18.003	-13.748	-16.168
p-value	0.0000	0.0000	0.0000
ADF Fisher chi-square	220.24	249.33	242.97
p-value	0.0002	0.0000	0.0000
PP-Fisher chi-square	133.74	178.45	291.18
p-value	0.0561	0.0012	0.0000

Source: authors´ own estimation

Since panel data are used to estimate trade effect of aflatoxin regulations, the poolability of the data would need to be tested using the F test to choose the appropriate model. Thus, an F test is conducted to check whether the countries in the sample are homogenous or heterogeneous. The test contrasts the fixed effects model with the pooled OLS model. As the computed F value (8.47) is above the critical value (2.23) at 0.05 significance level, null hypothesis of the F test is rejected. Thus, the countries within the sample are considered to expose some heterogeneity due to the existence of individual fixed effects, and fixed effects model is chosen to undertake the analysis of panel data.

Tables 6 and 7 present the results of two models on testing two different hypotheses (H1 and H2). Table 6 provides the results from simple OLS estimation, and Table 7 gives the results from Heckman selection procedure. Both models control for multilateral resistance by including importer and exporter fixed effects.

Estimation results presented in Table 6 show that the results are consistent with theoretical expectations. All of the estimated coefficients of the control variables have signs that are intuitive and are as expected which are also highly statistically significant. Since it is one of our variables of principal interest, the most important findings of this research is that the estimated coefficient on importer country's MRL variable is positive. Since smaller MRL of importing country indi-

Table 6. OLS Regression results

	Regression 1	Regression 2
Dependent Variable: log (value of bilateral trade flow)	Coefficient	Coefficient
Log (importing country's MRLs)	1.356*** (0.182)	-
I (Regulatory heterogeneity index)	-	-2.957*** (0.436)
Log (importing country's GDP pc)	2.209*** (0.179)	2.136*** (0.179)
Log (exporting country's GDP pc)	5.291*** (1.731)	5.294*** (1.743)
Log (DIST)	-0.826*** (0.285)	-0.854*** (0.288)
Language	0.104*** (0.292)	0.110** (0.323)
Colony	0.361** (0.192)	0.428** (0.220)
Border	0.214** (0.232)	0.271** (0.322)
Adjusted R^2	0.24	0.23

***imply significance at 0.01 level
Source: authors´ own estimation

[4] EFSA held a panel on 'Effect on public health of a possible increase of the maximum level for 'aflatoxin total' from 4 to 10 ppb in peanuts and processed products thereof, intended for direct human consumption or use as an ingredient in foodstuffs' on the request of European Commission in 23.01.2018.

Table 7. Two step Heckman estimation (maximum likelihood) results

	Regression 1		Regression 2	
	Selection Eqn.	**Outcome Eqn.**	**Selection Eqn.**	**Outcome Eqn.**
Log (importing country's MRLs)	0.918*** (0.141)	1.128*** (0.201)	-	-
I (Regulatory Heterogeneity)	-	-	-1.016** (0.221)	-1.734*** (0.289)
Log (importing country's GDP pc)	1.983*** (0.433)	2.101*** (0.450)	1.822*** (0.389)	1.921*** (0.395)
Log (exporting country's GDP pc)	2.344*** (0.245)	2.912*** (0.278)	2.432*** (0.303)	3.213*** (0.341)
Log (distance)	-1.352*** (0.176)	-2.001*** (0.145)	-1.945*** (0.152)	-2.389*** (0.234)
Language	0.231** (0.098)	0.281** (0.114)	0.287** (0.121)	0.434*** (0.147)
Colony	0.198* (0.183)	0.249** (0.188)	0.224** (0.174)	0.365** (0.191)
Border	0.201** (0.082)	0.267** (0.110)	0.313* (0.134)	0.487* (0.129)
H (Exclusion Variable)	0.545***		0.567***	
Estimated Correlation (rho)	0.817***		0.992***	
Estimated Selection (lambda)	1.311***		1.278***	
Adjusted R^2	0.57		0.54	

Source: authors´ own estimations

cates tighter standards, the positive sign implies that the tighter standards impose negative effects on exports. Thus, positive sign of the MRL standards imposed by the importing country supports hypothesis 1 which states that the stringency of the importer standards may have trade diverting effects. Estimations show that for 1% increase in the MRL of aflatoxin in importing countries, dried fruit exports increase by 1.36%.

The coefficient of regulatory heterogeneity index (I), on the other hand, is negative and statistically significant. Findings reveal that regulatory heterogeneity imposes a considerable negative impact on the value of trade among the trading nations. The result implies that as the standards across trading partners diverge, the trade value decreases. The finding supports hypothesis 2.

The coefficient estimates for the importer and exporter GDP per capita are both positive and statistically significant. Positive coefficient estimate of importing countries show the wealth effect of buyers. According to the estimations, as income increases 1%, the estimated demand for dried fruits increase by more than 2%, implying that the dried fruits can be categorised under the luxury items. The effect of exporter's per capita GDP on exports appears also to be positive and statistically significant. Increased GDP per capita that may be thought of increased supply (production) of agriculture, as well as dried fruits, naturally increases the value of exports. Even though the coefficient on distance is negative, as expected, it seems that the distance is of minor importance with a relatively smaller coefficient. The inelasticity of dried fruit exports with respect to distance may be explained with the relatively longer expiry dates of dried fruits. However, these results potentially may suffer from selection biasedness, since they are based only on positive trade flows.

Heckman selection procedure accounts for zero trade flows. As shown in the Table 7, our exclusion variable, H, is statistically significant, and has a strong positive association with the existence of positive trade flows. Estimated correlation and estimated selection coefficients, both, appear to be statistically significant, confirming that biased results have been generated unless controlled for zero trade flows.

Higher MRL of aflatoxin implemented by importing country increases both the probability and value of trade. As also expected, regulatory heterogeneity across trading partners has strong negative effect on both the probability and the amount of trade. These findings, complying with each other, suggest that MRL standards act as barriers to trade for exporting countries. Economic masses of both exporting and importing countries appear to have strong positive effect on both probability and propensity to trade. As the geographical distance increases among trading partners, on the other hand, both the probability and propensity to trade decrease significantly. Finally, both the probability and value of trade appear to be positively affected by the colonial ties, common language, and border.

Heckman sample selection model also allows us to explore both the intensive and extensive margins to trade. The extensive margin to trade describes the changes in probability to trade as its determinants change. The intensive margin to trade, on the other hand, refers to the change in value of trade with respect to changes in independent variables. In the Heckman selection model, the former refers to the marginal effect of underlying determinants in the selection equation, and the latter is given by the coefficient in outcome regression. Due to non-linearity of the Heckman Maximum Likelihood estimation, we cannot interpret the coefficients of the selection equation directly as marginal changes. Extensive margin to trade, thus, deviates from the raw coefficients of the selection equation by a factor of fitted probabilities of trade. Extensive margins to trade are computed by STATA software as the difference between unconditional and conditional marginal effects.

Table 8 presents the extensive and intensive margins of MRL and regulatory heterogeneity (I). Effect of both MRL and I on probability to trade (extensive margin), and intensity (intensive margin) are statistically significant. Positive impact of MRL and negative impact of I, both appear to be stronger on the intensity of trade than probability of trade. This reveals two important conclusions. First, as the maximum allowable limits on aflatoxins increase, exporters find the export performances increased. Second, the regulatory differences among trading partners, in terms of their maximum allowable aflatoxin limits, reduce the export performance of exporter countries.

Table 8. Marginal effects of MRLs

	Intensive Margin	Extensive Margin
MRL	1.128*** (0.201)	0.956*** (0.322)
I	-1.734*** (0.289)	-0.989** (0.274)

Source: authors´ own estimations

4.2 Simulation Results

Last stage of the empirical analysis presents simulation results of two different scenarios on MRL enforcement by EU aflatoxin regulations. Policy changes concerning European aflatoxin MRL are expected to impose high impact on the major exporters of dried fruits. Therefore, we conduct a simulation analysis to evaluate the implications of changes in EU aflatoxin MRL regulations for major exporters of dried fruit (Turkey, USA, China, and Chile). The first scenario takes EU legislation with tighter standards into consideration, assuming a decrease in EU aflatoxin MRL by 2 units change to 2 ppb. The second scenario, on the other hand, focuses on a more realistic case of relaxing aflatoxin MRL by 2 units change to 6 ppb. Resulting welfare changes with respect to the calibrated scenarios are calculated on the basis of previously estimated marginal effects of MRL (Table 8).

Table 9. Values of parameters for calibration

Variable	EU-28
Domestic production sold on the domestic market (tons) in 2015*	125,812
Imports sold on the domestic market (tons) in 2015**	116,096
Total consumption in 2015 (tons)	241,908
Price per kg in $US***	4.79
Own price elasticity of demand****	-1.92
Own price elasticity of domestic supply****	0.47

*Domestic production data for EU come from EUROSTAT PRODCOM database.
**Import quantities and prices come from UN COMTRADE database.
***Price is estimated by dividing the value of imports by the quantity of imports.
****Own price elasticities of supply and demand are estimated based on historical supply, demand, and quantity data.
Source: authors´ own calculations

Table 9 provides the details of the parameters used for calibrating the scenario, under the assumption that consumers are unaware of the aflatoxin threat. With the initial situation preceding aflatoxin legislation change, parameters of the model are calibrated in such a way as to replicate market prices and quantities for the year 2015 in EU-28. Observed quantity sold (Q_e), imported (Q_f), and average price (P_e) over the period 2002-2016 allowed us to estimate supply and demand functions. We first calculated price elasticity of demand ($E_d = p.\frac{\partial Q_d}{Q_d.\partial p}$) and supply ($E_s = p.\frac{\partial Q_s}{Q_s.\partial p}$). By using obtained value for price elasticity of demand, the calibration leads to estimated coefficients of the demand function (eqn. 4) equal to $1/\bar{b} = -\bar{E}_d.Q_e/P_e$, and $\bar{a} = \bar{b}Q_e + P_e$. Similarly, the estimated coefficients of the foreign supply function (Q_f), are calculated by using the same method. It is assumed that the proportion of foreign supply entering the domestic market (EU), γ=0.8, before the policy change[5].

Any policy change in MRL enforcement will have an impact on welfare since it would lead to foreign supply shift. By using statistically significant coefficient of $b_4$from gravity equation, we measured the price and quantity effects linked to any changes in MRL standards. With the change in MRL standards, exporters to EU are expected to get directly affected. Share of foreign supply of dried fruits entering the domestic market (γ) changes to $\hat{\gamma}$ as a result of the change in MRL regulations. The new share of foreign supply $\hat{\gamma}$, and the foreign supply shifts are calculated by solving the equation (9) for a given initial $\gamma = 0.79.$[6] For stricter MRL standard $\hat{\gamma}$ becomes smaller than the initial γ, and becomes larger than γ when MRL standard is relaxed.

Shift of foreign supply from $S_F \; to \; S_F'$, as a result of stricter MRL policy, is expected to influence both the equilibrium price, and quantity (see Appendix, Figure 1). Relaxing MRL for aflatoxins, on the other hand, would yield a rightward shift in supply curve of foreign dried fruits, resulting in lower equilibrium price. Case for relaxed MRL is not shown on Figure, in order to keep the figure uncomplicated. Per unit damage, $\lambda = 0.29 \times P_e,$ is computed based on new equilibrium price, P_e', and used in calculation of cost of ignorance for unaware consumers (λQ_f).

Table 9 presents the calculated quantitative effects of the assumed changes in enforcement of MRL policy by the EU. The results of the welfare analysis show that, the enforcement of stricter MRL standards decrease foreign producers' surplus in EU market of dried fruits. Even though domestic consumers of the EU suffer from negative effect of higher prices, they benefit from better standards eliminating the risk of aflatoxins. Thus, the net change in consumers' surplus becomes positive when consumers are unaware of the damage, and the cost of ignorance is eliminated by the safety standard imposed. Domestic producers also benefit from the standard, enjoying higher prices without suffering from any compliance costs. Results confirm that the enforcement of increased MRL may be a socially preferable and beneficial policy option since its net effect on both domestic and international welfare is positive[7].

Table 9 shows large welfare losses for consumers for increased MRL. Relaxed MRL standards shift the foreign supply curve by increasing the proportion of foreign goods' entry into the domestic market, resulting in lower prices. Relaxed standards, however, increase the probability of contamination with the entrance of foreign goods that can carry potentially dangerous characteristic (aflatoxin) into domestic market. Yet, consumers cannot internalise the damage if they are not aware of the danger, which raises the cost of ignorance. Thus, even though surplus of domestic consumers increase as a result of lower prices, consumers suffer from the negative effect due to the prominent rise in cost of ignorance. First and second rows of the Table 10 seem to be in line with these explanations. Domestic producers' profits, on the other hand, decrease due to both decreasing prices and lost market power. Resulting effect of relaxed MRL on domestic welfare turns out to be negative. Profit variation for foreign producers is positive due to increased market entrance, despite lower prices. Finally, positive change in international welfare indicates that relaxing MRL standards benefit foreign consumers

Table 10. Welfare effects induced by stricter MRL standards

EU-28	$\Delta MRL = -2$	$\Delta MRL = +2$
Change in Domestic Consumers' Surplus, without Cost of Ignorance (US$)	-255,013,000	+338,282,000
Change in Cost of Ignorance (US$)[8]	336,034,000	- 398,125,000
Change in Domestic Producers' Surplus (US$)	204,349,000	- 276,910,000
Change in Domestic Welfare (US$)	285,370,000	- 336,753,000
Change in Foreign Exporters' Surplus (US$)	-73,768,000	+ 121,820,000
Change in International Welfare (US$)	211,601,000	-214,933,000

Source: authors´ own calculations

5 International Nut and Dried Fruit Council reports that 63% of dried fruits were rejected at the border, of which 34% of rejections were due to presence of aflatoxins (INC, 2016b).

6 Wolfram Language is employed for these calculations.

7 Domestic welfare is calculated as the sum of consumer surplus with cost of ignorance and producer surplus. International welfare, on the other hand, is given by the sum of domestic welfare and foreign producers' welfare.

8 The value stands positive for tighter standards and negative for increased MRL, since the cost of ignorance disappears with tighter standards, and increases when standards are relaxed. When cost of ignorance disappears it is to the benefit of consumers, and shown with a positive value. However, increased cost of ignorance leads to a loss for consumers, and represented with a negative value.

more than the economic cost imposed on domestic welfare. This confirms that the MRL standards are costly from the side of foreign producers, and act as barriers to trade.

Final step of the simulation focuses on changes in value of trade associated with two scenarios. Following OTSUKI ET AL. (2001), we used the following formula to estimate the changes in value of exports by major exporters (Turkey, USA, China, Chile) as a consequence of simulated changes in MRL policy of EU:

$$\partial V_{xm} = \bar{b}_4 \frac{V_{xm}}{MRL_m} (MRL_m^* - MRL_m) \quad (11)$$

here, V_{xm} is the value of dried fruit exports in year 2016 from the exporter country x to European Union (m), ∂V_{xm} indicates the predicted change in V_{xm}, $\bar{b}_4$ is the estimated coefficient of gravity equation 2 (b). MRL_m is the existing MRL implemented by EU, and MRL_m^* is the MRL associated with a given regulatory scenario.

Estimated values of trade flows under the regulatory scenarios are presented in Table 11. The total value of predicted change in trade flow of dried fruits from major exporters to EU is +/-4.6 million US$, when MRL regulations for aflatoxins are relaxed/ tightened by 2 ppb compared to status quo. This absolute value refers to more than 55 % change on average.

Table 11. Change in trade flows

Exporters	Predicted Change in the Value of Exports – under the assumption of +/-2 *ppb* change in aflatoxin MRL	
	mio US$	Percentage
Turkey	+/-2.8	+/- 56%
USA	+/-0.8	+/- 57%
China	+/-0.2	+/- 57%
Chile	+/-0.8	+/- 53%

Source: authors´ own calculations

5 Concluding Remarks

Significance of potential externalities associated with unsafe food led to an expansion of standards in markets for food products. Standards refer to the specification of product and process characteristics, intended to harmonise the treatment of intermediates in the production process and/or the attributes of final goods (MOENIUS, 2004). National systems of food safety differ according to their capacities to undertake food safety controls. Institutional structures and procedures, physical infrastructures, human capital, and capacity for sustainability are the key elements to identify capacities for food safety controls in different countries (HENSON, 2003). While high-income countries are characterised with higher capacities to enforce and comply with standards, standards may impose important barriers for low-income countries with lower capacities for food safety regulations. Thus, even though aimed at increasing social welfare, standards may inhibit trade and result in ‘regulatory protection’ (BALDWIN, 2000). Debates on the effects of food additives, and food safety standards attract much academic interest on the quantification of the trade effects of food standards. This paper intends to highlight the trade effects of MRL standards on aflatoxins on dried fruit industry.

We analysed the effect of EU aflatoxin regulations on dried fruit industry. The reason why we focus on EU as the importer country is first EU has been the largest importer of the world dried fruit industry (Table 2). Second, EU has historically implemented the tightest standards on aflatoxin, and further extended enforcement of these tight standards to a larger geography with the recent enlargement waves. Thus, EU is considered as the biggest actor in dried fruit trade.

In this research, we adopted the empirical framework used by DISDIER and MARETTE (2010). The framework combines both gravity and welfare methodologies in a partial equilibrium context. The coefficient measuring the foregone trade linked to stricter standard is estimated via gravity model, and taken into account to determine the relative variations in price and quantity. Welfare effects are, then, evaluated based on these changes in price and quantity. Quantitative analyses are based on bilateral trade between EU-28 and 45 trade partners over the period 2002 - 2016.

The findings indicate that the higher MRL of aflatoxin implemented by importing country increases both the probability and value of trade. As also expected, regulatory heterogeneity across trading partners has strong negative effect on both the probability and the amount of trade. The results of welfare analysis show that tighter standards impose a burden on foreign producers. Cost of compliance for the foreign producers raise the production costs for foreign producers and decrease their surplus in their trade with EU. This raises the equilibrium price of dried fruit in EU market, and imposes another burden on EU consumers by decreasing their surplus. However, loss in consumer surplus is offset by the eliminated cost of ignorance. While producers of EU enjoy larger producer profits, both domestic and international welfare increase as a result of tighter MRL standards.

This research, however, is restricted with some limitations. Numerical results of the estimations are crucially dependent on underlying assumptions, functional forms, and quality of data. If we have changed our assumption of unaware consumers this would affect the impact of policy change on consumers, domestic producers, and foreign producers welfare. BEGHIN et al. (2012) found that the difference between unaware and aware consumers in terms of net welfare effect is 5%.

As increased standards are associated with improved dietary safety and health protection, standard setting policies in food industry need to be considered in broader context than a shallow economic cost benefit analysis. The negative economic impact of tighter standards should be viewed with caution since the positive aspects of reduced health risks are ignored. Hence, compensation of huge economic costs to the exporters of developing countries in dried fruit industry would necessarily be required with a global consensus on science based standards, and efforts to facilitate technical assistance to increase the productivity in organic agriculture in developing countries.

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Appendix

Table 3. Explanations of the symbols used in the equations

Equation 1: Gravity Equation

$$V_{xmt} = \frac{GDPPC_{mt}^{b_1} GDPPC_{xt}^{b_2}}{DIST_{mx}^{b_3}}$$

b_1, b_2, b_3	Exponential coefficients identify the relationship between the dependent variable V_{xmt} (value of exports from exporter country x to importer country m in time period t) and the independent variables $GDPPC_{mt}, GDPPC_{xt}, DIST_{mx}$.

Equation 2a: Heckman Selection Equation

$$V_{xmt}^* = b_0^* + b_1^* \ln(GDPPC_{xt}) + b_2^*(GDPPC_{mt}) + b_3^* \ln(DIST_{xm}) + b_4^* MRL_{xm} + b_5^* language_{xm} + b_6^* colony_{xm} + b_7^* border_{xm} + \tau H_{xmt} + fe_x^* + fe_m^* + \upsilon_{xmt}$$

V_{xmt}^*	Binary variable that equals 1 if dried fruit exports from country x to country m at time t is non-zero, and equals zero otherwise. $*$ indicates that the dependent variable in the model is identifying the probability of trade.
b_0^*	Constant term.
b_1^*, b_2^*, b_3^*, b_4^*, b_5^*, b_6^*, b_7^*	Coefficients measuring the relationship between the independent variables ($lnGDPPC_{xt}, lnGDPPC_{mt}, lnDIST_{xm}, MRL_{xm}, language_{xm}, colony_{xm}, border_{xm}$) and the probability of trade between exporter country x and the importer country m in time period t (V_{xmt}^*).
MRL_{xm}	denotes two variables (MRL_m and I) that are used interchangeably as the independent measure on maximum allowable limits imposed by the importer country m on imported dried fruit exported by country x.
τH_{xmt}	Coefficient τ denotes the relationship between the exclusion variable (H) and the probability of trade. H is the historical frequency of non-zero trade, and calculated by taking proportion of years of non-zero trade in the five – year moving window.
fe	Importer and exporter fixed effects on the probability of trade.
υ_{xmt}	Error term

Equation 2b: Heckman Outcome Equation

$$ln(V_{xmt} | (V_{xmt} > 0) = b_0 + b_1 ln(GDPPC_{xt}) + b_2 ln(GDPPC_{mt}) + b_3 \ln(DIST_{xm}) + b_4 MRL_{xm} + b_5 language_{xm} + b_6 colony_{xm} + b_7 border_{xm} + \mu_{xmt} + fe_x + fe_m + \varepsilon_{xmt}$$

$ln(V_{xmt} \| (V_{xmt} > 0)$	Dependent variable defined as the value of trade conditional on trade taking place.
b_0	Constant term
$b_1, b_2, b_3, b_4, b_5, b_6, b_7$	Coefficients measuring the relationship between the independent variables ($lnGDPPC_{xt}, lnGDPPC_{mt}, lnDIST_{xm}, MRL_{xm}, language_{xm}, colony_{xm}, border_{xm}$) and the dependent variable $ln(V_{xmt} \| (V_{xmt} > 0)$
μ_{xmt}	Inverse Mill ratio calculated from the selection equation.
fe	Importer and exporter fixed effects on the value of trade conditional on trade taking place.
ε_{xmt}	Error term

Equation 3: Consumption Utility Function

$$U(q, w) = aq - \frac{bq^2}{2} - Kq_f p\lambda + w$$

$U(q, w)$	Utility function of a representative consumer, consuming q units of dried fruits (including foreign and domestic production), and the numeraire good w.
K	Consumer's knowledge regarding the damage of aflatoxins brought by consumption of the imported dried fruit.
λ	Value of damage linked to per unit consumption of the commodity in question with a probability of having contamination.

Equation 4: Demand Function

$$P(Q_d) = a - bQ_d$$

$P(Q_d)$	Price as a function of quantity demanded.
a	Constant term of the demand function.
b	Slope of the demand function.

Equation 5: Foreign Producer Profit Function $\pi_f = p\gamma q_f - c_f q_f - 1/2 g_f q_f^2$	
π_f	A representative foreign producer profit.
p	Price of the product.
γ	The proportion of foreign products entering domestic market.
q_f	Quantity of foreign supply to the domestic market (imports).
c_f, g_f	Variable cost parameters. Subscripts f denote foreign.
Equation 6: Domestic Producer Profit Function $\pi_d = pq_d - c_d q_d - 1/2 g_d q_d^2$	
π_d	A representative domestic producer profit.
q_d	Quantity of domestic supply to the domestic market.
c_d, g_d	Variable cost parameters. Subscripts d denote domestic.
Equation 7: Supply Function $P(Q_s) = \frac{c_d c_f Q_s + c_d g_f \gamma + c_f g_d}{c_d c_f \gamma^2}$	
$P(Q_s)$	Price as a function of quantity supplied. Q_s denotes the sum of foreign (q_f) and domestic supply (q_d) to the domestic market.
Equation 8: Reduced Form Supply Function $P(Q_s) = \hat{c}Q_s + \hat{g}$	
$\hat{c}$	$\hat{c} = \frac{c_d c_f}{c_d c_f \gamma^2}$, ^ denotes that the cost parameter belongs to the aggregate supply function.
$\hat{g}$	$\hat{g} = \frac{c_d g_f \gamma + c_f g_d}{c_d c_f \gamma^2}$, ^ denotes that the cost parameter belongs to the aggregate supply function.
Equation 9: Relative Variation in Value of Exports with Respect to a Change in MRL $\frac{P'_e - P_e}{P_e} + \frac{Q'_f - Q_f}{Q_f} = b_4 \Delta MRL_m$	
P_e	Equilibrium price established in the domestic market. ' indicates new equilibrium price after shifts in the foreign supply curve as a result of the changes in MRL.
Equation 10: Regulatory Heterogeneity Index $I = \frac{MRL_x - MRL_m}{MRL_x + MRL_m}$ for $max\{I, 0\}$	
I	Heterogeneity index computed and ranges between 1 and 0. Negative values represent the case of smaller MRL for exporter country, which makes it easier for the exporter to export. So that we treat the case as regulatory homogeneity, where I=0.
Equation 11: Simulation Analysis $\partial V_{xm} = \bar{b}_4 \frac{V_{xm}}{MRL_m}(MRL_m^* - MRL_m)$	
V_{xm}	Value of dried fruit exports in year 2016 from the exporter country x to European Union (m).
∂V_{xm}	Predicted change in V_{xm}.
$\bar{b}_4$	Estimated coefficient of gravity equation 2 (b).
MRL_m^*	MRL associated with a given regulatory scenario.