

Preliminary

Mycotoxin Regulations and Trade

Abdul Munasib*

Assistant Professor of Economics
Department of Economics and Legal Studies in Business
Oklahoma State University
343 Business Building
Stillwater, OK 74078-4011
Phone (405) 744-8763
Fax (405) 744-5180
e-mail munasib@okstate.edu

Devesh Roy

Research Fellow
Markets, Trade, and Institutions Division
International Food Policy Research Institute (IFPRI)
2033 K. St., N.W.
Washington, DC, 20006-1002 U.S.A.
Phones (202) 862-5691
Fax (202) 467-4439
e-mail d.roy@cgiar.org

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* Contact author.

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Abstract

This research assesses the effects of mycotoxins regulations on international trade flows. Mycotoxins regulations reflected in the mandatory maximum permissible limits impose costs on the producers that could take the form of both variable and fixed costs. Our methodological framework is based on Melitz (2003), Melitz, Helpman and Rubinstein (2008), and Djankov et al (forthcoming), all of which consider the fixed costs of exporting. In our case we capture the effect of aflatoxin regulations as being reflected in costs of exporting which could vary across markets. Our results indicate that in specifications that allow for sample selection, exporter and importer heterogeneity and zero trade, there is robust evidence for these regulations not having any significant effect on trade flows contrary to the earlier findings. We also assess the effects in difference in difference specification to assess the variation in effects by size and in difference specification to look at market relocation effect. We introduce the concept of bridge to cross in the context of a non-tariff barrier to capture variation of the implications of standard across exporters. We find some evidence of effects on trade of low to middle income producers but not in case of Africa per se on which the existing results are based. The composition of trade in maize (with a large part of trade being in maize as feed as well as significant productivity differences per se across countries with trade dominated by highly productive countries) could account for such a result. We suggest the way forward in the context of SPS research of the types similar to mycotoxins regulation.

“A World Bank study has calculated that the European Union regulation on aflatoxins costs Africa \$750 million each year in exports of cereals, dried fruit and nuts. And what does it achieve? It may possibly save the life of one citizen of the European Union every two years . . . Surely a more reasonable balance can be found”. Kofi Anan (2001) – UN conference on Least Developed Economies, 2001

1. Introduction

This paper assesses the effects of mycotoxins regulations (specifically aflatoxins standards) on international trade flows of maize and groundnuts. Mycotoxins regulations reflected in the mandatory maximum residue limits impose costs on the producers that could take the form of both variable and fixed costs. The regulations by imposing costs of exporting can have three types of effects: (1) *Volume of trade effect* – countries already trading with one another could trade less (the intensive margin), (2) *Missing trade or lost trade effect* – As regulations are tightened producers/countries could be screened off the export market (alternatively producers/countries could find it unprofitable to export) (the extensive margin). The ones to be screened off the export markets would be the ones comparatively less productive (3) *Market reallocation effect* – Following points (1) and (2), exporters could reallocate their supplies across markets including reallocation towards domestic markets. Note that missing trade effect is not independent of market reallocation effect as lost trade in a particular market can surface as new trade in some other market.

Wu (2008) points out that the issue of mycotoxins has been historically observed for a long time but the real recognition came from the 1960 discovery of aflatoxins in UK that resulted in deaths of 100,000 Turkey. Wu(2008) further points out that now several dozen mycotoxins have been identified. This paper focuses on only one of them i.e. aflatoxins which has drawn the maximum attention with regard to food safety as yet.

According to Dohlman (2004), the risk of contamination by mycotoxins is an important food safety concern for grains and other field crops. Mycotoxins are postulated to affect as much as one-quarter of global food and feed crop output. Food contaminated with mycotoxins, particularly

with aflatoxins can cause sometimes-fatal acute illness, and are associated with increased cancer risk. Faced with these risks many countries have imposed regulatory standards that limit the level of mycotoxins in food and also in feed. Dohlman (2004) states that diverging perceptions of tolerable health risks—associated largely with the level of economic development and the susceptibility of a nation’s crops to contamination—have led to widely varying standards among different national or multilateral agencies. Considering a set of 48 countries with established limits for total aflatoxins in food, Dohlman (2004) states that standards had a wide variation ranging from 0 to 50 parts per billion.

How do these standards affect international trade in products that are subject to these standards? Summary evidence exists on the market losses following greater stringency of mycotoxins regulations. Thailand for example was once among the world’s leading corn exporters, regularly ranking among the top five exporters during the 1970s and 1980s. But partly due to aflatoxin problems, Thai corn regularly sold at a discount on international markets, costing Thailand about \$50 million per year in lost export value (Tangthirasunan, 1998). According to FAO, the direct costs of mycotoxin contamination of corn and peanuts in Southeast Asia (Thailand, Indonesia, and the Philippines) amounted to several hundred million dollars annually (Bhat and Vasanthi, 1999). Total peanut meal imports by the EU member countries fell from over 1 million tons in the mid-1970s to just 200,000-400,000 tons annually after 1982 i.e. when the mycotoxins regulations were tightened in EU.

Little rigorous empirical research exists on the effect of food safety regulations on international trade flows. The same holds true for the assessment of the effect of aflatoxins regulations on trade flows. In case of aflatoxins standards, Otsuki et al (2001a) in an earlier paper explored the trade effect of the European Commission (EC) proposal to harmonize aflatoxin

standards announced in 1998 that would tighten the average level of aflatoxins standards in the EU. It was later implemented in 2002.

The paper predicted the trade effect of setting aflatoxin standards under three regulatory scenarios: standards set at pre-EU harmonized levels (status quo), the harmonized EU standard adopted across Europe, and a standard set by the Codex.¹ Their findings suggested that the trade of nine African countries would potentially decline by \$400 million under the proposed, stringent new EU standards whereas this trade would have increased by \$670 million had the EU based its new harmonized standards based on Codex guidelines. A second study, focusing only on edible groundnut exports from Africa by the same authors, estimated that the new EU standard for aflatoxin would result in an 11 percent decline in EU imports from Africa, and a trade flow some 63 percent lower than it would have been had the Codex standards been adopted (Otsuki et al. 2001b).

These numbers coming from this first study on the issue were indeed sensational. Recently Diaz Rios and Jaffee (2008) criticize the findings in Otsuki et al (2001a and 2001b) arguing that they over estimate the effects of aflatoxins standards and underestimate the effects of Codex standards for Africa.

Using data from interceptions in Europe they argue that those unable to meet European standards would not meet the Codex standards either. Further, the marginalization of Africa in world groundnut markets had started much earlier than the change in standards regime and decline in exports could not necessarily be associated with tightened standards. Among other reasons was the increased substitution of groundnut oils with vegetable oils, with many countries in Africa having a comparative advantage in the former.²

¹ In addition, the authors examined the trade-off between human health and trade flows for each of these three regulatory scenarios based on risk assessment studies.

²

These criticisms are in addition to the choice of model that we want to highlight in case of Otsuki et al (2001a) and Otsuki et al (2001b) which was overly simplified and in its specification highly prone to errors. Otsuki et al (2001a, 2001b) used the Gravity Model, an empirical model of international trade flows that has been used for a long period of time.

Since the publication of the paper two main developments have occurred in the evolution of the gravity model of trade both of which have important bearing on the assessment of the effects of mycotoxins regulations on trade. The first development relates to the measurement of trade costs where it was shown by Anderson and van Wincoop (2003) that bilateral trade costs (usually bilateral distance) as used in Otsuki et al (2001a and 2001b) and several other papers of that vintage – was not the measure of trade costs that followed theoretical derivation of the gravity model. Anderson and van Wincoop (2003) showed that trade costs had to be measured as a ‘multilateral resistance’ term as opposed to a bilateral cost. This term was reflected in exporter and importer price indices (in fact an ideal price index of composite goods) as shown by Anderson and van Wincoop (2003).

The second major development in the context of gravity models was regarding the issue of zero trade in empirical analysis. Note that both at the product level and at the aggregate level some countries do not trade with each other on a sustained basis. Following Melitz (2003) and Helpman et al. (2008) gravity models of international trade have been derived which can accommodate the presence of zero trade flows between countries. The theoretical framework in which zero trade flows emerge is the one in which firms differ in productivity and there are fixed costs to exporting which are partner specific. Hence, only firms that have a level of productivity beyond a certain threshold find it profitable to export. Thus, if no firm/farm has productivity levels high enough to benefit from exporting, zero trade at the product, and even at the aggregate level, is possible between two countries.

We believe such a framework that incorporates zero trade is a clear improvement in empirical analysis of trade flows. Hence, the empirical model that we use for estimation is based on Melitz [2003], Helpman, Melitz and Rubinstein [2008], and Djankov et al (forthcoming) all of which consider the fixed costs of exporting. In our case we assume that the level of these costs of exporting vis-à-vis aflatoxins regulations is a function of the level of the regulation. As aflatoxins standards vary across markets, it follows that the costs of exporting based on aflatoxins regulations could vary across markets as well.

Using a framework in which zero trade is accounted for we do not find evidence that there is significant effect of mycotoxins regulation on trade of maize and groundnuts. The effects that are obtained in OLS (log linear) specifications as in Wilson et al (2001) mostly disappear when accounting for multilateral resistance (exporter and importer heterogeneity), sample selection and zero trade. Our difference in difference specification where we modify to have regulatory gap as the variable to capture regulation preserves the results. We do find some correlation between relative levels of aflatoxins regulations and relative volume of trade flows in case of groundnuts. We do not find such evidence in case of maize exports. In both cases however we find that accounting for zero trade is important and there can be significant selection bias without taking into account zero trade.

It is important also to discuss some other alternative methods assessing the effect of mycotoxins regulation on trade. An alternative approach is the one adopted by Wu (2008) and is also implicit in the analysis of Diaz Rios and Jaffee (2008) i.e. to associate export loss with consignment rejections.³ Based on existing data Wu(2008) projects probability of rejections and through that

³ Using interception data Diaz Rios and Jaffee (2008) argue that for China, about half of its intercepted consignments over the 2000–2006 period would have been compliant with the Codex standard. For Egypt, Nicaragua, India, and South Africa—only about one-third of intercepted consignments would have been compliant with the Codex standard. Sub-Saharan Africa fares the worst in this analysis. Some 83% of the region’s intercepted consignments over the 2000–2006 period would have been noncompliant with the Codex standard. None of the intercepted consignments from Malawi, Uganda, or Zimbabwe would have met the Codex standard, and the majority of intercepted Ghanaian consignments had aflatoxin levels above 50 ppb.

expected loss assuming probability of rejections to be an monotonic and increasing function of the level of tightness of standards. Using this method Wu (2008) estimates global loss of 22% in peanut exports at $20\mu g/kg$ and loss of 92% at a standard of $4\mu g/kg$ (both standards uniformly adopted).⁴

The paper is organized as follows. Section 2 presents the theoretical model underlying the one of the empirical analysis. Section 3 presents information about data sources and some descriptive statistics based on dataset used. Section 4 discusses the results of the empirical analysis. Section 5 concludes.

2. Model for trade flows

2.1. Aggregate Trade

The starting point of the derivation of the estimable equation that takes into account the points raised above (fixed costs of exporting and the possibility of zero trade) is the Melitz (2003) model. Following Melitz (2003), we model the world economy with J countries, indexed $j = 1, 2, \dots, J$, each consuming and producing a continuum of products. Utility of a representative consumer in country j is given as:

$$(1) u_j = \left[\int_{z \in S_j} x_j(z)^\rho dz \right]^{\frac{1}{\rho}}, \quad \rho \in (0, 1),$$

where $x_j(z)$ is consumption of product z and S_j is the set of products available for consumption. Elasticity of substitution $\sigma = 1/(1 - \rho)$ is assumed to be the same for all countries. Since σ is also the constant demand elasticity of each product, country j 's demand for product z is,

⁴ The global loss related to loss of exports for the US, China, Argentina and Africa.

$$(2) x_j(a, z) = \frac{p_j(a, z)^{-\sigma} Y_j}{P_j^{1-\sigma}},$$

where $p_j(a, z)$ is the price of product z in country j , a is a productivity parameter (more on this later), Y_j is the income of country j , and the ideal price index is given as:

$$(3) P_j = \left[\int_{z \in S_j} p_j^{1-\sigma} dz \right]^{\frac{1}{1-\sigma}}.$$

There are $\sum_{j=1}^J N_j$ products in the world where country j has a measure N_j of firms and each firm produces a distinct product.

Monopolistic competition in the final product implies,

$$(4) p_j(a, z) = \tau_{ij} \frac{c_j a}{\rho} = p_j(a),$$

where a measures the number of bundles of the country's inputs used by the firm per unit of output and c_j measures the cost of this bundle. Also, τ_{ij} is the iceberg transport cost between countries i and j where it is assumed that $\tau_{ij} = 1$ and $\tau_{ij} > 1 \forall i \neq j$. As in Melitz [2003], $(1/a)$ is the firm's productivity level. The cumulative distribution function $G(a)$ with support $[a_L, a_H]$ describes the distribution of a across firms where $a_H > a_L > 0$. Function $G(a)$ is assumed to be the same for all countries.

We assume that there are fixed costs of exporting resulting from imposition of standards.

Note, from (2) and ((4) we can write $x_j(a, z)$ simply as $x_j(a)$.

Define $\pi_{ij}(a)$ as the operating profits from sales of a country j product to country i . Then a_{ij} is the cutoff productivity level such that $\pi_{ij}(a_{ij}) = 0$. Then, only a fraction $G(a_{ij})$ of N_j firms export to country i . If $a_{ij} \leq a_L$ then no firms from j exports to i and if $a_{ij} \geq a_H$ then all firms from j exports to i , the latter being a rather unlikely event.

Next, to characterize bilateral trade volumes, we follow Melitz, Helpman and Rubinstein [2008]. Define,

(5)

$$V_{ij} = \begin{cases} \int_{a_L}^{a_{ij}} a^{1-\sigma} dG(a) & \text{for } a_{ij} \geq a_L \\ 0 & \text{otherwise} \end{cases}.$$

This identifies “productivity zone” such that if a firm in country j falls within this zone it will export to country i . Then, the value of country i ’s imports from country j is,⁵

$$(6) M_{ij} = \left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} Y_i N_j V_{ij},$$

and the relative value of imports from two similar countries j and k to country i is,

$$(7) \frac{M_{ij}}{M_{ik}} = \frac{\left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} Y_i N_j V_{ij}}{\left[\frac{\tau_{ik} c_k}{\rho P_i} \right]^{1-\sigma} Y_i N_k V_{ik}} = \left[\frac{\tau_{ij} c_j}{\tau_{ik} c_k} \right]^{1-\sigma} \frac{N_j V_{ij}}{N_k V_{ik}}.$$

Taking log on both sides of equation (7) gives,

$$(8) \ln \frac{M_{ij}}{M_{ik}} = (1-\sigma) \ln \frac{\tau_{ij}}{\tau_{ik}} + (1-\sigma) \ln \frac{c_j}{c_k} + \ln \frac{N_j}{N_k} + \ln \frac{V_{ij}}{V_{ik}}.$$

Since the volume of exports from j to i , $E_{ji} = M_{ij}$, equation (8) implies,

$$(9) \ln \frac{E_{ji}}{E_{ki}} = f \left(\ln \frac{\tau_{ij}}{\tau_{ik}}, \ln \frac{c_j}{c_k}, \ln \frac{N_j}{N_k}, \ln \frac{V_{ij}}{V_{ik}} \right).$$

Equation (9) is specified at an aggregate level. In this paper we are interested in product level trade flows viz. that of groundnuts and maize. Note that the analysis in Otsuki et al (2001a, 2001b) look at the effect on trade of different products likely to be affected by aflatoxins regulation i.e. it is a product level analysis as well. Further, they look at trade only between Africa and Europe. In

⁵ See appendix for derivation.

contrast incorporation of trade with different trading partners is very important for us as we exploit the variation in trade across countries with different stringency of regulation to identify the effects of aflatoxins regulations.

Below, we will thus move to product level by specifying the estimable equation for maize and groundnuts. To summarize, equation (9) establishes the determinants of the relative value of aggregate exports from two countries j and k to country i as a linear function of the following.

(a) $\left(\ln \frac{\tau_{ij}}{\tau_{ik}} \right)$: relative iceberg transport costs.

(b) $\left(\ln \frac{c_j}{c_k} \right)$: relative input usage.

(c) $\left(\ln \frac{N_j}{N_k} \right)$: relative number of firms.

(d) $\left(\ln \frac{V_{ij}}{V_{ik}} \right)$: relative productivity zones.

Equation (9), therefore, facilitates a gravity equation where $\left(\ln \frac{E_{ji}}{E_{ki}} \right)$, the left hand side of (9) is regressed on the logs of above mentioned proxies. Our variable of interest is aflatoxin standards. We want to exploit the variation in exports of a single country to different countries. This is because export to different countries are subject to different aflatoxin standards. Using equation (6) we get,

$$(10) \quad \frac{M_{ij}}{M_{kj}} = \frac{\left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} Y_i N_j V_{ij}}{\left[\frac{\tau_{kj} c_j}{\rho P_k} \right]^{1-\sigma} Y_k N_j V_{kj}} = \left[\frac{\tau_{ij} P_k}{\tau_{kj} P_i} \right]^{1-\sigma} \frac{Y_i V_{ij}}{Y_k V_{kj}},$$

from which follows,

$$(11) \ln \frac{M_{ij}}{M_{kj}} = (1 - \sigma) \ln \frac{\tau_{ij}}{\tau_{kj}} + (\sigma - 1) \ln \frac{P_i}{P_k} + \ln \frac{Y_i}{Y_k} + \ln \frac{V_{ij}}{V_{kj}},$$

and thereby,

$$(12) \ln \frac{E_{ji}}{E_{jk}} = f \left(\ln \frac{\tau_{ij}}{\tau_{kj}}, \ln \frac{P_i}{P_k}, \ln \frac{Y_i}{Y_k}, \ln \frac{V_{ij}}{V_{kj}} \right),$$

where the left hand side is the (log of) the ratio of exports of country j to countries i and k . The ratio V_{ij}/V_{kj} is the ratio of productivity zones pertaining to exports to i relative to k . To focus on the effect of varying Aflatoxin standards, (12) might be more applicable than (9).

2.2. Moving to product level analysis

Equations (9) and (12) are at the aggregate levels involving total exports. Following Djankov et al. (2008), we assume that similar relationships hold at the industry level. In that case we can stretch the same idea for specific industries that are subject to Aflatoxin standards. Let there be R industries indexed by $r = 1, 2, \dots, R$. Going back to operating profits,

$$(13) \pi_{ij}(a) = (1 - \rho) \left(\frac{\tau_{ij} c_j a}{\rho P_i} \right)^{1-\sigma} Y_i - c_j f_{ij},$$

where f_{ij} is the coefficient of fixed cost of exports. The zero profit condition $\pi_{ij}(a_{ij}) = 0$ implies,

$$(14) (1 - \rho) \left(\frac{\tau_{ij} c_j a_{ij}}{\rho P_i} \right)^{1-\sigma} Y_i = c_j f_{ij}.$$

Now, consider an individual industry r with the export fixed cost coefficient f_{ij}^r . Then,

$$(15) (1 - \rho) \left(\frac{\tau_{ij} c_j a_{ij}^r}{\rho P_i} \right)^{1-\sigma} Y_i = c_j f_{ij}^r.$$

For instance, suppose that industry r has an additional fixed cost of meeting certain standard whereas industry q does not. In that case an industry r firm needs to be more productive than

industry q and $a_{ij}^r < a_{ij}^q$, everything else being the same. To calculate the bilateral trade volumes for industry r then we have the following equations,⁶

$$(16) V_{ij}^r = \begin{cases} \int_{a_L^r}^{a_{ij}^r} a^{1-\sigma} dG(a) & \text{for } a_{ij}^r \geq a_L^r \\ 0 & \text{otherwise} \end{cases}$$

$$(17) M_{ij}^r = \left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} Y_i N_j^r V_{ij}^r,$$

$$(18) \ln \frac{E_{ji}^r}{E_{ki}^r} = f \left(\ln \frac{\tau_{ij}}{\tau_{ik}}, \ln \frac{c_j}{c_k}, \ln \frac{N_j^r}{N_k^r}, \ln \frac{V_{ij}^r}{V_{ik}^r} \right),$$

$$(19) \ln \frac{E_{ji}^r}{E_{jk}^r} = f \left(\ln \frac{\tau_{ij}}{\tau_{kj}}, \ln \frac{P_i}{P_k}, \ln \frac{Y_i}{Y_k}, \ln \frac{V_{ij}^r}{V_{kj}^r} \right),$$

where, an r superscript indicates that the variable pertains to industry r (e.g., N_j^r is the number of operating firms in industry r in country j).

As before, equation (19) will be better suited for our purpose. The key variable, the variable of interest, is $\left(V_{ij}^r / V_{kj}^r \right)$. This compares the productivity zone for industry r exports by comparing the zones for the countries i and k .

In equation (19), if we focus on maize and groundnuts, we would be comparing the exports from same country to two different destinations which could vary in terms of their aflatoxins regulations. Our conjecture is that the productivity zone in which exports can occur is a function of the level of aflatoxins regulations (among other things) with higher productivity level cutoffs required if the aflatoxins regulations are more stringent.

⁶ See appendix for detailed derivation.

3. Difference in difference specification for varying effects by size.

Drawing from equation (17) we specify the gravity model in difference in difference form. If we hypothesize that the effect of mycotoxins/aflatoxins regulation is embodied in the fixed costs of meeting the standard then the effect of the regulation could vary across exporters by size. The basic difference in difference specification is given as:

$$\ln x_{ij} = \alpha_i + \beta_j + C_{ij} + \ln \text{bridge}_{ij} * \text{size measure } j + \eta_{ij} + \varepsilon_{ij} \quad (19a)$$

We define the regulatory variable as a bridge. Being a regulatory gap between importing and exporting country standard it is a pair specific variable. A bridge between *i and j* is the gap between the regulation of the importing and the exporting country or the gap between contamination in the exporting country and the regulation in the importing country. Defined this way we are able to control for exporter and importer fixed effects in specification in (19a). We believe that this variation across exporters for the same regulation is novel and we would argue is meaningful in the context of non-tariff barriers (ntbs). This is because based on their regulation or the level of contamination, different level of activities and costs have to be performed or incurred. Apart from its intuitive appeal, this measure of regulation enables controlling for multilateral resistance through inclusion of exporter and importer fixed effects.

The basis for the specification in (19a) is that with fixed costs of meeting the regulation, a bigger bridge to cross is likely to have a greater effect on smaller producers vis-à-vis larger producers. From the point of view of data two main issues arise in equation (19). First relates to measure of bridge, the second relates to measures of size. These are discussed below in the section on data and descriptive statistics.

In the difference in difference estimation we include the inverse mills ratio from a probit model of trading in maize or groundnut. A significant coefficient on the inverse mills ratio would

indicate a problem of sample selection in the regressions involving level of trade flows. Recall that in a two stage heckman estimation, implementing such a method requires that in the first stage estimation we should have an exclusion variable that affects the probability whether or not the country exports but does not affect the value of trade in the second stage. Our exclusion variable is the historical frequency of non-zero trade i.e. a proportion of years in a moving window that the two countries traded with each other. Thus for 1995, historical frequency of positive trade for any trading pairs will be given by the proportion of years in the five year window beginning 1988 that non-zero trade occurred. Subsequently, for 1996, the window would start from 1989. C_{ij} refers to a vector of pair varying control variables.

3. Data and Descriptive Statistics

This paper uses data from several secondary sources. Data on maize and groundnut trade flows is obtained from United Nations Comtrade database. Agricultural trade is often subject to seasonal fluctuations. We therefore average the data over five time periods to control for abnormal trade flows.

The level of mycotoxins regulations is obtained from two publications from Food and Agriculture Organization (FAO) titled Worldwide regulations for mycotoxins in food and feed in 1995 (Food and Nutrition paper number 64) and 2003 (FAO 2003). Note that some countries in the dataset at some points followed the Codex standard.⁷ In case of those countries the Codex standard relevant for that period was assigned to the countries. Also, a good number of low income countries do not have any official mycotoxins regulation. Another set of countries includes those who did not

⁷ Codex standard is specified only for aggregate level of mycotoxins and not specifically aflatoxins. Assuming 60% share of aflatoxins in total mycotoxins, the level employed is $\frac{6\mu g}{kg}$.

respond to the query sent by FAO/WHO. The data on regulation for these countries is missing and hence we do not include them in our sample.

We define our regulatory variable as follows. Suppose the permissible limit in country i be defined as μ_i . We define the regulation in country i to equal $1/\mu_i$. It is clear that as permissible limits become smaller, regulation takes a higher value. We then assign a value equal to 0 for countries that have reported to FAO/WHO inquiry but do not have any restriction on permissible limits. Defined in this way our regulation variable takes a value between 0 and 1 (with the 1 being the lowest permissible limit (parts per billion) in the data. There is significant variation in the data on regulation, see example of a few countries below (Table 1).

Table 1: Aflatoxins standards (2003) in select countries

Country/Region	aflatoxins limit in human food $\mu g/kg$	Standard/regulation
Australia	5	0.2
China	20	0.05
European Union	4*	0.25
Guatemala	20	0.05
India	30	0.03
USA	20	0.05

Source: Wu (2009)

*-applies to cereals & cereal products, nuts not subject to further processing, & dried fruit

Apart from regulation in the importing country, our modified regulation variable captures a bridge to cross (btc) in terms of the regulatory gap. The regulatory gap is the difference between the aflatoxins standard in the importing country and the exporting country. The rationale for (btc) is that since costs have to be incurred in meeting domestic standards, the extra costs to be incurred in meeting the standards in exports is taken to be a function of the gap that needs to be bridged in order to meet the cutoff. In construction of the btc variable we follow the following scheme as given in Table 2.

Table 2: Scheme for construction of bridge to cross (btc) based on regulatory gap

Regulation in exporting country	Regulation in importing country	Bridge equals

√	x	0
x	√	Import country standard
√	√	Import country standard- export country standard if >0 =0 if difference <=0
x	x	0

The bridge as defined in Table 2 above has the following feature. It equals zero if the countries have the same standard. It also equals zero if exporting country and importing country both have no regulation. If importing country has regulation while exporting country has no regulation we define importing country standard to be the bridge. In other cases it is the difference between importing country and exporting country standard with the provision that bridge is zero if importing country has a laxer standard vis-à-vis the exporter.

An important point to note particularly in case of maize trade is the distinction between maize as food and maize as feed. A large portion of global trade in maize is for feed purposes. The regulations between maize as food and maize as feed are significantly different. Within maize as feed category regulations vary as well. For example feed for baby animals is often subject to a tighter regulation than feed for matured animals. We choose the weakest regulation among feed for the importing country where available.

The Comtrade data does not make a distinction between maize intended for food and maize intended for feed. We draw from FAOSTAT the agricultural and food database of the Food and Agricultural Organization which gives the share of maize production for food and for feed for most countries. Since we have no way of dividing the trade into food and feed components and subject them to different standards, in case of maize we modify the permissible limits and get a new weighted measure (of food and feed regulation) where weights are the shares of feed and food in maize production in the exporting country.

In our empirical analysis we are interested in effects across three kinds of sample viz. the global sample, the sample of low income exporters (in the context of the paper defined as countries with incomes below median per capita gdp) and of African countries. Note that given the two stage specification, the sample in second stage regression is much smaller since it only includes non-zero exports. Table 3 and Table 4 present the summary statistics for the maize and groundnut regressions.

A large number of bilateral pairs do not involve trade in either maize or in groundnut. Globally 23% of trading pairs have maize trade while the numbers are 15% and 10% in case of poor countries and African exporters respectively. In case of groundnut the value of trade is much lower and much fewer countries export. In terms of the trading pairs, globally only 7% of such relationships have any groundnut trade. Importantly, nearly the same percentage of trading pairs with poor country as exporter have trade in groundnuts. The corresponding figure for African exporters is 5%.

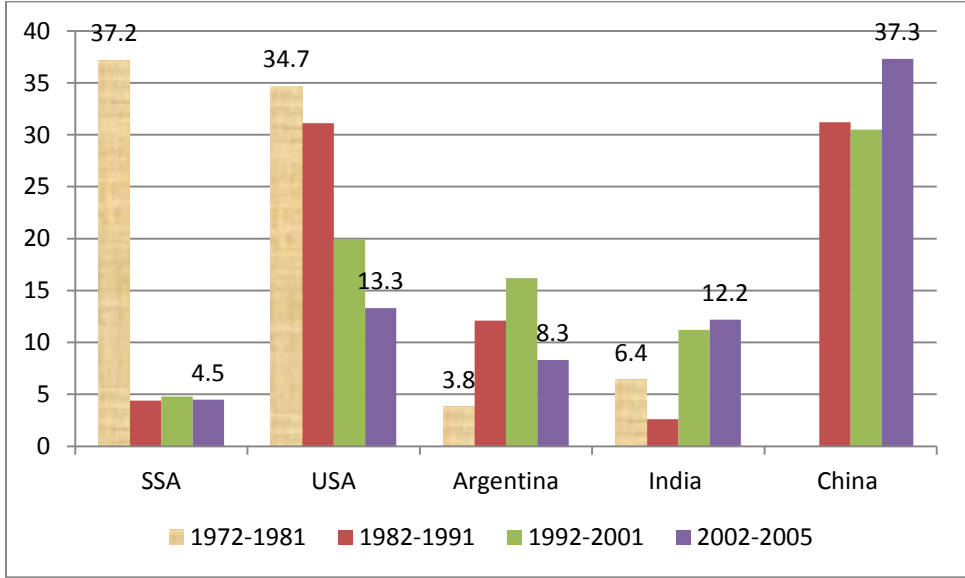
According to FAO (2006), the structure of the world maize market can be characterized as one with a high level of concentration in terms of exports but very low concentration on the import side. The main reason for this development is the fact that those countries which usually have significant maize surpluses for exports are relatively few in number, while those relying on international markets to meet their needs for domestic animal feeding purposes by importing maize (as a primary feed ingredient) are many (FAO (2006)). The United States is the world's largest maize exporter which accounts for roughly 60 percent of the global share, down from over 70 percent a decade ago, followed by Argentina and China. Brazil, the Republic of South Africa and Ukraine are among a few other countries which often have surpluses for exports.

In case of groundnuts also, China, experienced an impressive expansion of production, as a result of market reforms in 1978 and the use of higher-yielding varieties and agricultural inputs

(Diop et al. 2004). Since 1992, China has consistently ranked as the largest groundnut-producing country, accounting for 39 percent of world production in 2005. During the period 1990 to 2005, China’s production increased from 6 to 14 million tons with average yields improving from 2.1 tons/ha to 3.1 tons/ha (Diaz Rios and Jaffee (2008)). Diaz Rios and Jaffee (2008) also point out that less than 10 percent of Chinese production is exported, enabling exporters to select only the highest-quality product to meet overseas requirements. They also point out that in Argentina, Brazil, Nicaragua, and Egypt, production has grown steadily, as a result of increased growing areas as well as significant increases in yields.

Figure 1 below shows the share (in percent) of different countries/regions in global groundnut exports based on comtrade data and Diaz Rios and Jaffee(2008). The decline of Africa and rise of China and India/Argentina as exporters is quite distinct. The last two time periods are included in our sample.

Figure 1: Share of countries/regions in world groundnut trade



Source: Diaz Rios and Jaffee (2008) and Comtrade

In contrast, in Africa traditionally larger producers—including Senegal, Sudan, and South Africa have experienced stagnant or declining production over much of the past decade. With the

exception of South Africa, average yields per hectare have consistently been below 1 ton/ha in SSA countries, rising above this level only during years of exceptional weather conditions (Diaz Rios and Jaffee (2008)).

On the side of non-tariff measures, regulation and regulatory gap (btc) are our main variables. The regulation regarding permissible limits is on average weakest in Africa followed by other poor countries relative to the world as a whole. In terms of the bridge to cross in order to meet the regulation of the trading partner, poor countries and Africa have a larger bridge to cross vis-à-vis the rest of the world. Note that both in case of maize as well as groundnuts, African countries have on average equal bridges to cross as other poor country exporters.

Table 3: Summary statistics for maize sample

All countries				
Full sample (N=17169)			Non-zero trade (N=4055)	
	Mean	Standard deviation	Mean	Standard deviation
Bilateral maize trade (in 1000 US deflated dollars)	1182.751	25614.180	5008.408	52528.540
Historical frequency of non-zero maize trade	1.311	3.154	5.129	4.625
Regulation	0.127	0.140	0.135	0.120
Log of regulation	0.134	0.165	0.140	0.151
Pair wise bridge to cross (log)	-4.819	2.368	-4.976	2.294
Pair wise bridge to cross (actual)	0.071	0.148	0.060	0.129
Low income exporters				
Full sample (N=6190)			Non-zero trade (N=967)	
	Mean	Standard deviation	Mean	Standard deviation
Bilateral maize trade (in 1000 US deflated dollars)	314.752	6819.520	2015.910	17161.630
Historical frequency of non-zero maize trade	0.608	2.031	3.624	3.877
Regulation	0.102	0.181	0.091	0.163
Log of regulation	0.135	0.164	0.133	0.131
Pair wise bridge to cross (log)	-4.260	2.386	-4.096	2.312
Pair wise bridge to cross (actual)	0.089	0.155	0.085	0.124
African exporters				
Full sample (N=3037)			Non-zero trade (N=300)	
	Mean	Standard deviation	Mean	Standard deviation
Bilateral maize trade (in 1000 US deflated dollars)	23.221	399.730	235.011	1253.934
Historical frequency of non-zero maize trade	0.302	1.229	2.580	2.923

Regulation	0.098	0.109	0.088	0.076
Log of regulation	0.135	0.165	0.137	0.114
Pair wise bridge to cross (log)	-4.506	2.417	-4.275	2.406
Pair wise bridge to cross (actual)	0.083	0.154	0.082	0.108

Table 4: Summary statistics for groundnut sample (groundnuts in shell)

All countries				
Full sample (N=17890)			Non-zero trade (N=1259)	
	Mean	Standard deviation	Mean	Standard deviation
Bilateral groundnut trade (in 1000 US deflated dollars)	12.955	224.208	184.085	826.627
Historical frequency of non-zero groundnut trade	0.654	2.351	6.293	5.189
Regulation	0.203	0.232	0.218	0.207
Log of regulation	0.199	0.231	0.284	0.240
Pair wise bridge to cross (log)	-4.755	2.602	-4.473	2.691
Pair wise bridge to cross (actual)	0.109	0.201	0.130	0.210
Low income exporters				
Full sample (N=6257)			Non-zero trade (N=467)	
	Mean	Standard deviation	Mean	Standard deviation
Bilateral groundnut trade (in 1000 US deflated dollars)	18.890	280.724	253.099	999.277
Historical frequency of non-zero groundnut trade	0.588	2.137	5.769	4.593
Regulation	0.169	0.280	0.093	0.125
Log of regulation	0.199	0.231	0.249	0.250
Pair wise bridge to cross (log)	-4.183	2.621	-3.393	2.539
Pair wise bridge to cross (actual)	0.133	0.213	0.185	0.239
African exporters				
Full sample (N=2981)			Non-zero trade (N=148)	
	Mean	Standard deviation	Mean	Standard deviation
Bilateral groundnut trade (in 1000 US deflated dollars)	3.365	49.453	67.692	212.588
Historical frequency of non-zero groundnut trade	0.287	1.252	3.753	3.406
Regulation	0.149	0.248	0.132	0.133
Log of regulation	0.199	0.231	0.306	0.275
Pair wise bridge to cross (log)	-4.164	2.642	-3.509	2.812
Pair wise bridge to cross (actual)	0.136	0.215	0.214	0.259

In addition to the variables related to maize and groundnut sector, several trade and other economic variables were used in the analysis. Several of those variables were obtained from World Development Indicators (WDI) publication of the World Bank. The distance between the trading partners and whether or not countries share a common border have also been obtained from the CEPII dataset. Similar pair wise variables were obtained such as shared ethnicity, colonial link or

heritage, whether the pair contains both landlocked countries, both coastal countries, both have same legal origin, are members in a currency union and finally whether they are involved in a conflict at a particular time.

The distance measure here is the bilateral distances between the biggest cities of the two trading partners weighted by the share of the city in the country's population.⁸ The tariff data for maize and groundnuts imports in different countries is obtained from UNCTAD's TRAINS database.⁹

Based on world development indicators on an average groundnut exporting countries are poorer. Groundnut exporters are also marginally farther from the economic centers of the world.

4. Estimation, Results and Conclusion

4.1 Estimating equation (difference specification)

Since we want to exploit the variation in exports of a particular product of a country to different trading partners, our estimation equation comes from equation (19)), which we rewrite as,

$$(20) e_{ik}^r = f(\delta_{ik}, \mu_{ik}, y_{ik}, v_{ik}^r),$$

where, $e_{ik}^r = \ln \frac{E_{ji}^r}{E_{jk}^r}$, $\delta_{ik} = \ln \frac{\tau_{ij}}{\tau_{kj}}$, $\mu_{ik} = \ln \frac{P_i}{P_k}$, $y_{ik} = \ln \frac{Y_i}{Y_k}$, $v_{ik}^r = \ln \frac{V_{ij}^r}{V_{kj}^r}$. The dependent variable

is the ratio of export volumes of industry r (of country j) to countries i and k . The measures and proxy variables from the RHS variables are the following:

(a) δ_{ik} = ratio of trade costs (ratio of bilateral distance).

⁸ In specifications where we include trading pair fixed effects, bilateral distance is not included as it is subsumed in pair fixed effects.

⁹ Tariff barriers for groundnuts are not an obstacle in major high-income importing countries: the two largest groundnut importers in this category, the European Union and Canada, have a zero tariff for unprocessed groundnuts and low-processed groundnuts for the Generalized System of Preferences and for least-developed countries. In contrast to the European Union and Canada, Japan and especially Korea have a higher tariff regime for groundnuts (**Beghin et al 2008**).

- (b) μ_{ik} = ratio of (ideal) price indices of the importing countries.
- (c) y_{ik} = GDP ratios of the importing countries i and k .
- (d) v_{ik}^r = ratio of ‘productivity zones’ of industry r corresponding to the importing countries i and k (aflatoxin regulation standards).

In estimating this equation, two main econometric issues arise. The first one is the issue of the price indices. The standard practice is to use country fixed effects to proxy for the ideal price indices (Feenstra 2004). Fixed effects have been introduced into the gravity equation by a number of authors such as Harrigan (1996), Hummels (1999), Redding and Venables (2000) and Rose and van Wincoop (2001). We follow the literature and introduce exporter and importer fixed effects to take into account the ideal price indices in the importing and exporting countries. Given that our variables of interest are ratios (for the same exporter across different importers), we introduce trading pair fixed effects to account for relative ideal price indices across trading partners.

The second econometric issue is related to zero trade. One practice in the literature to capture the bias arising from zero trade is to do a Heckman correction where a Probit model is run the first stage to capture existence of trade between a trading pair [Melitz et al. 2008]. We therefore adopt a two step heckman procedure where we in the first step the regressand is whether or not there is non-zero trade between the partners and in the second stage, our dependent variable is the volume of trade.

Hence, in the first stage of the estimation procedure the dependent variable is binary based on whether or not the relative trade flows from country j to country i over country k is zero or not. If positive trade flows (the ratio) are observed then the dependent variable takes the value 1, else zero otherwise. Note that this indicator variable (for both maize and groundnuts) is regressed on an

extensive set of regressors, at least some of which do not appear in the value of trade equation to satisfy the exclusion condition in the Heckman estimation procedure.

The first stage in the estimation is thus specified as:

$$I_{ji}^r = h(X_j, X_i, K_{ij}) \quad (21)$$

In equation (21), the regressand is the binary variable that equals 1 if country j exports to i and equals 0 otherwise. The regressors are variables that determine whether or not the countries i and j are likely to have non-zero trade in maize and groundnut respectively. Among the variables included in the regressors, some are exporter or importer specific and some vary across the trading pair. Also, the variables included in the first stage are not identical to the regressors included in the second stage.

Notable among the regressors in the first stage are some of the proxies for fixed costs of exporting i.e. number of documents to be cleared for export, time taken to reach and clear ports and administrative and other costs associated with the act of exporting. Most importantly we include the aflatoxins regulation in the importing country as one of the explanatory variables affecting whether or not groundnut or maize exports occur. We treat this as another proxy for fixed costs of exporting to the particular market.

4.2 Results

Our estimation results show that there is a significant relationship between ratio of aflatoxin regulations and trade flow ratios in case of groundnuts. We do not obtain evidence for significant relationship in case of maize trade. The results are presented in table 5 below.

In table 5 only selected coefficients of the regression have been presented. These are relative GDP ratios, relative bilateral distance, relative aflatoxins regulations and the inverse mills ratio that

by its significance implies whether or not selection bias from not accounting for zero trade is likely to be important. Results from both groundnut and maize regressions show that selection bias is likely to be significant if correction is not made for zero trade.

Table 5: Relative regulation and relative trade flows- Regression results

	Groundnut Heckman- j/k FE	Maize Heckman- j/k FE
Relative GDP ratios	0.071	-0.310
	-0.143	(0.148)**
Relative weighted bilateral distance	-1.816	-2.042
	(0.036)***	(0.041)***
Relative levels of aflatoxins regulation	0.034	0.009
	(0.006)***	0.007
Non-selection hazard	0.150	0.147
	(0.044)***	(0.056)***
Constant	-0.454	-0.377
	(0.082)***	(0.100)***
Observations	21,099	19,717
R-squared	0.47	0.43

In the Table 5, the fact that non-selection hazard (the inverse Mills ratio) is significant indicates that accounting for zero trade is needed.

$$\frac{V_{ij}^r}{V_{kj}^r} = \frac{\text{allowable mycotoxin in country } j}{\text{allowable mycotoxin in country } k},$$

a positive coefficient indicates that raising aflatoxin standards lowers relative trade values.

Given that we observe significant effect of relative aflatoxins regulations on relative exports, what can be told about the value of exports affected. To reiterate the existing studies focus on absolute value of trade loss while we emphasize the relative value of exports to include the market reallocation effect (in language of Wu (2008), the market shifting effect).

Below we conduct a basic calculation of the effect on relative exports under different scenarios. These are exclusive movement of standards in a particular country from a level of

$\frac{9\mu g}{kg}$ to $\frac{4\mu g}{kg}$, $\frac{9\mu g}{kg}$ to $\frac{2\mu g}{kg}$, $\frac{15\mu g}{kg}$ to $\frac{4\mu g}{kg}$, $\frac{15\mu g}{kg}$ to $\frac{2\mu g}{kg}$ and $\frac{20\mu g}{kg}$ to $\frac{4\mu g}{kg}$ respectively.

$\frac{9\mu g}{kg}$ is the derived aflatoxins standards for Codex. $\frac{20\mu g}{kg}$ is the US standard and $\frac{2\mu g}{kg}$ is the

harmonized EU aflatoxins standards. Table 6 below shows the result of hypothetical changes where starting from same standard one country moves to a tighter standard. For the biggest percentage change in relative regulation in moving from a limit of 15 to 2, the exports of groundnuts to low standard market will go up by 22.5 percent. Moving from Codex standard to the harmonized EU standard will raise the exports to low standard market by 13.5 percent.

Table 6: Effect on relative exports from hypothetical changes in aflatoxins standards

Change in aflatoxins regulation ratio	% change in regulation ratio	% change in export ratio
9 to 4	225	6.75
9 to 2	450	13.5
15 to 4	375	11.25
15 to 2	750	22.5
20 to 4	500	15

5. Results from difference in difference specification

Table 7 below presents the results of OLS regressions and difference in difference specification for maize trade flows. Few points are noticeable. Most importantly, there is no significant effect of the regulatory gap or the bridge to cross in case of maize for most cases. The results however show that there is a negative and significant effect on the trade of poor countries.

Results also show the importance of controlling for exporter and importer fixed effects in regressions. Controlling for exporter fixed effects makes significant difference in the results.

Consider the case of maize trade from Africa. In the naïve OLS specification there is a negative and significant effect of the bridge to cross on the trade flow of maize. Accounting for exporter and importer fixed effects, the effect vanishes. This is particularly important in the light of the results in

Otsuki et al where using a simple log linear version of gravity model they showed highly significant and negative effects on African trade. The results point out that their models were most likely misspecified. The exporter characteristics such as productivity could be accounting for low trade by Africa. The effect on exports of poor country is important since according to us the model is well specified.

Also, recall our variable of interest. It is not the regulation in the importing country but the bridge between domestic and foreign regulation. Where this is significant it implies that trade could increase if regulatory gap is closed if there is any to begin with. Results also show that across all specifications selection issue is significant (the significance of inverse mills ratio) in the regressions.

Similar effects are obtained in case of groundnut trade with the exception that the interaction of the size variable with the *btc* term is weakly significant at 10% implying that there is a negative significant effect of the bridge to cross for African groundnut producers.

Table 7: Aftatoxins regulation and maize trade

VARIABLES	Full sample			Poor country			Africa		
	OLS without fixed effects	OLS with fixed effects	did_x3	ols1-poor	ols2-poor	did_x3-poor	ols1-africa	ols2-africa	did_x3-africa
Bridge to cross in the trading pair	0.0891*** (0.0267)	0.00817 (0.0331)		0.048 (0.05)	0.051 (0.07)		- 0.16** (0.07)	-0.13 (0.15)	
Size measure interacted with bridge			-0.04 (0.03)			-0.16** (0.074)			-0.116 (0.108)
IMR1		-1.722*** (0.107)	- 1.7** * (0.13)						
IMR2					- 1.8** * (0.24)	- 1.760** * (0.248)			
IMR3							- 1.43** * (0.50)		-1.38*** (0.499)
Pair contiguity	2.435*** (0.244)	1.267*** (0.221)	1.271 *** (0.21)	1.520 *** (0.44)	0.54 (0.53)	0.56 (0.51)	1.56** (0.64)	0.303 (1.00)	0.265 (0.916)
Pair same ethnolinguisticity	0.543*** (0.156)	0.325** (0.150)	0.328 ** (0.14)	-0.296 (0.29)	0.230 (0.38)	0.324 (0.329)	0.094 (0.36)	0.935 (0.62)	0.880 (0.607)

Pair with colonial relationship	-0.449 (0.308)	-0.215 (0.270)	- 0.204 (0.18)	1.066 * (0.60)	-0.188 (0.64)	-0.223 (0.583)	1.45** (0.62)	-0.20 (1.61)	-0.0168 (1.859)
Both countries in trading pair landlocked	0.978* (0.520)	4.451 (3.217)	4.058 (3.18)	0.653 (0.85)	0.170 (5.93)	-0.408 (5.557)	0.139 (0.74)	-12.64 (8.91)	-14.73* (8.53)
Both countries in the trading pair coastal	0.805*** (0.164)	-3.528 (3.207)	- 3.125 (3.16)	-0.217 (0.30)	0.569 (5.87)	1.125 (5.39)	0.048 (0.39)	12.31 (8.95)	14.35* (8.65)
Pair same legal origin	0.378*** (0.134)	0.152* (0.0906)	0.156 * (0.09)	0.060 6 (0.27)	0.332 (0.25)	0.359 (0.250)	0.585 (0.37)	0.600 (0.48)	0.627 (0.489)
Pair in a currency union	2.760*** (0.384)	2.059*** (0.313)	2.035 *** (0.30)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pair in conflict	-0.337 (0.516)	-0.137 (0.367)	- 0.155 (0.31)	-2.108 (1.57)	-0.797 (1.83)	-0.780 (1.48)	0 (0)	0 (0)	0 (0)
Both countries in GATT	-0.0662 (0.184)	1.428*** (0.384)	1.453 *** (0.35)	- 1.002 *** (0.32)	2.065 *** (0.52)	2.18*** (0.602)	0.130 (0.55)	0.183 (1.77)	0.176 (2.104)
Bilateral distance	-0.222*** (0.0689)	-1.168*** (0.0699)	- 1.167 *** (0.09)	- 0.960 *** (0.15)	- 1.132 *** (0.26)	- 1.19*** (0.257)	- 1.4*** (0.27)	- 1.321* (0.73)	-1.327** (0.67)
Importer log gdp	0.284*** (0.0447)			0.291 (0.19)			- 0.71** (0.31)		
Exporter log gdp	-0.191*** (0.0429)			- 0.433 *** (0.08)			-0.067 (0.12)		
Timecluster FE		yes	yes		yes	yes		yes	yes
Exporting country FE		yes	yes		yes	yes		yes	yes
Importing country FE		yes	yes		yes	yes		yes	yes
Observations	4055	4055	4055	967	967	967	300	300	300
R-squared	0.426	0.746	0.746	0.397	0.698	0.700	0.490	0.700	0.700

Table 8: Aflatoxins regulation and groundnut trade

VARIABLES	Full Sample			Poor Exporters			African Exporters			
	ols1	ols2	did_x1	ols1-poor	ols2-poor	did_x1-poor	ols1-africa	ols2-africa	did_x1-africa	did_x3-africa
ij_btc	0.13 ***	0.108 ***		0.082 7	0.083 7		- 0.0263	- 0.0997		

	(0.03)	(0.03 68)			(0.062 2)	(0.091 5)			(0.093 5)	(0.121)		
ijx1			0.066 6 (0.04 58)				0.0628 (0.112)				-0.213* (0.122)	
ijx3				0.021 2 (0.04 57)				0.0408 (0.0961)				-0.189 (0.137)
eta		- 1.305 *** (0.19 1)	- 1.306 *** (0.19 2)	- 1.280 *** (0.18 1)								
eta1						- 1.113 *** (0.332)	- 1.102** * (0.391)	- 1.098** * (0.389)				
eta2										-1.643 (1.036)	-1.688 (1.101)	-1.731 (1.058)
ij_contig	0.827 *** (0.28 4)	0.644 ** (0.25 8)	0.657 ** (0.28 0)	0.649 ** (0.26 2)	- 0.093 9 (0.549)	0.371 (0.726)	0.426 (0.854)	0.402 (0.755)	-1.536 (0.999)	3.662 (3.310)	3.650 (2.994)	3.677 (3.301)
ij_ethylang	0.405 * (0.21 1)	0.003 00 (0.24 5)	0.012 5 (0.24 5)	0.001 67 (0.23 0)	0.795 ** (0.367)	-0.436 (0.454)	-0.433 (0.485)	-0.441 (0.485)	1.297* * (0.534)	3.745* * (1.627)	3.749** * (1.430)	3.685** * (1.368)
ij_colony	- 0.134 (0.37 9)	0.701 ** (0.34 3)	0.727 ** (0.32 5)	0.711 * (0.38 1)	- 0.099 1 (0.776)	0.000 720 (0.879)	0.0266 (0.916)	- 0.00473 (0.892)	0.351 (0.819)	2.023 (1.964)	1.883 (1.663)	1.885 (1.696)
ij_landlock	- 0.590 (0.63 6)	- 1.294 (3.72 0)	- 0.504 (4.22 3)	- 1.173 (4.00 7)	- 2.136 * (1.112)	-4.955 (5.584)	-8.874 (5.448)	-6.753 (6.425)	2.232* * (1.126)	-12.55 (12.37)	-12.35 (11.91)	-14.96 (10.59)
ij_coastal	0.590 ** (0.23 2)	- 1.754 (3.78 3)	- 0.015 4 (4.15 3)	- 1.650 (3.86 5)	1.030 *** (0.391)	5.079 (5.788)	8.885* (5.358)	6.807 (6.489)	-0.864 (0.667)	7.717 (11.36)	7.582 (11.21)	10.24 (10.02)
ij_legal	- 0.207 (0.18 9)	- 0.225 (0.17 7)	- 0.226 (0.16 4)	- 0.252 (0.16 6)	- 0.127 (0.329)	0.431 (0.319)	0.423 (0.328)	0.430 (0.285)	1.045* * (0.516)	-0.289 (1.249)	-0.319 (1.292)	-0.281 (1.085)
ij_currency	1.062 *** (0.40 6)	0.743 * (0.39 0)	0.888 ** (0.38 1)	0.941 ** (0.40 6)	- 2.337 (3.109)	7.650 ** (3.756)	-7.984* (4.420)	7.625** (3.792)	-2.618 (2.808)	0 (4.723)	12.76** * (4.928)	-13.53** (6.886)
ij_conflict	- 0.677 (0.66 2)	- 1.311 (0.58 8)	- 1.323 (0.55 1)	- 1.324 (0.64 8)	- -1.207 (1.533)	- -1.844 (1.319)	- -1.892 (1.350)	- -1.862 (1.194)	0.253 (1.916)	-2.087 (4.616)	-2.251 (4.379)	-2.184 (2.933)
ij_gatt	- 0.696	- 0.343	- 0.342	- 0.328	- 0.821	- -0.187	- -0.223	- -0.211	- 2.234*	- -3.090	- -2.406	- -2.439

	**				**			**				
	(0.28	(0.50	(0.46	(0.47	(0.406	(0.527		(0.673	(5.990		(7.309)	(6.107)
	4)	1)	4)	5)))	(0.508)	(0.549)))		
	0.315	-	-	-		0.766		-				
ij_tau	***	0.212	0.185	0.198	0.103	*	-0.742*	-0.757	1.315*	**	0.134	0.0555
	(0.09	(0.16	(0.16	(0.16	(0.199	(0.397	(0.410)	(0.469)	(0.423	(1.773)	(1.568)
	95)	5)	5)	2)))))		(1.686)
i_lngdp	0.074											
	0				-0.283				0.648			
	(0.06				(0.266				(0.517			
	42)))			
j_lngdp	0.068											
	8				-0.106				0.0343			
	(0.07				(0.122				(0.228			
	43)))			
Timeclust FE		yes	yes	yes		yes	yes	yes		yes	yes	yes
Exporting country FE		yes	yes	yes		yes	yes	yes		yes	yes	yes
Importing country FE		yes	yes	yes		yes	yes	yes		yes	yes	yes
Observations	1250	1259	1259	1256	462	467	467	467	145	148	148	148
R-squared	0.269	0.683	0.682	0.681	0.362	0.789	0.789	0.788	0.418	0.888	0.893	0.892

6. Conclusions and policy implications

Using global data on trade flows we find that there no significant effect of aflatoxins standards in exports of maize and groundnuts. The effects of mycotoxins regulations on trade are found to be significant only in a naïve specification of the empirical model. Employing contemporary methods and improved data we find robust evidence that the regulation does not have a significant effect on trade flows though some effects are found in specific samples (for example maize trade of poor exporters) and groundnuts exports of African countries.

In estimating the effect we introduce the concept of bridge to cross as a variable that captures regulation pertinent for trade. The measure is intuitive but more importantly it allowed us to control for multilateral resistance in the context of gravity models and other unobserved exporter and importer heterogeneity. While importing country regulation can be a rigid policy measure for exporting country, regulatory gap is an actionable variable for the exporting country.

There can be several conjectures made for absence of effects of mycotoxins regulation on trade in general. First, consider maize. Substantial share of trade in maize is as feed or other derived products.¹⁰ These products are subject to lower standards. In our empirical analysis we have not yet differentiated between maize as food and as feed. The regulation variable uses the standard for food and feed in maize weighted by the production shares in exporting country. Clearly this is not perfect and could affect the result one way or the other. Since, these standards do not bind for maize as feed, the effect of the regulation would tend to diminish.

Secondly, the North South productivity differences in the products considered here quite wide now (think of GM maize) possibly because use of biotech in several countries). With the vast difference in productivity, the markets are highly concentrated especially with overwhelming dominance of the United States. Similar is the situation in groundnuts with China controlling nearly 40% of the market. Many potential exporters are not even at threshold of exporting with or without high aflatoxins standards. The effect of standards in turn could turn out to be insignificant as observed. From the point of view of developing countries, it is important to note that a vast majority of them are net importers of maize. With only few exceptions, for example most countries in Africa import maize. In terms of size, Egypt is Africa's top importer in spite of being also the third largest producer after the Republic of South Africa and Nigeria (FAO 2006).

One suggested improvement that will apply to both groundnut and maize trade (and is work in progress) is to refine the measure of mycotoxins regulations in the analysis. Currently, the aflatoxins regulation measure that we use varies across exporters owing to the regulatory gap. The same standard however can have different implications across the exporting countries based on their

¹⁰ Globally, around 460 million tons, or 65 percent, of total world maize production is used for feed purposes while around 15 percent is used for food and the remaining mainly destined for various types of industrial uses. The leading users of maize for animal feeding are the United States, China, EU and Brazil; together they account for almost 70 percent of the global use of maize for animal feed.

existing levels of contamination as well. A “bridge to cross” measure that is being developed will result in an extra variation and will be technically more meaningful. The estimates using such a measure of regulation should improve the estimates.

Finally we do find some evidence of effect of bridge to cross in case of groundnut exports from Africa though the effect is weak. We also find evidence of market reallocation in terms of relative trade flows. Groundnuts is definitely important in some poor countries particularly in Africa. According to Beghin et al (2008), in Senegal, for instance, an estimated one million people (one-tenth of the population) are involved in groundnut production and processing. Groundnuts account for about 2 percent of gross domestic product (GDP) and 9 percent of exports in Senegal (Akobundu 1998). In Gambia, about three-quarters of the farmers grow groundnuts on about 53 percent of the arable land. Yet even though exports get affected in terms of reallocation across markets including domestic markets, it is hard to quantify the net revenue loss.

Also, there are costs of exporting beyond the aflatoxins regulation and some producers would be screened off the markets independent of the regulation, a situation which we think is highly pertinent in case of maize. In effect there is self selection in exporting with more productive firms/farms being exporters. The only difference that emerges with aflatoxins standards is that the range of productivity that relates to exporting firms/farms turns out to be higher.

Finally, our idea of bridge to cross has radically different policy implication than studies that focus on importing country regulation the effect of which we have argued cannot be correctly identified. As a bridge to cross idea even though importing country standards may not be altered but altering the size of the bridge could bring in clear benefits. We have proposed the idea in terms of the regulatory gap but when looked at as a gap between contamination and regulation, the mechanism could be quite clear. The benefits could be clearly marked in terms of reduced

contamination since many countries given their contamination levels have a very large bridge to cross, be it European standards or the one from Codex.

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Appendix

Aggregate volume of imports,

$$\begin{aligned}
 M_{ij} &= \int_{a_L}^{a_{ij}} [x_j(a) p_j(a) N_j] dG(a) \\
 &= \int_{a_L}^{a_{ij}} \frac{p_j(a)^{-\sigma} Y_i}{P_i^{1-\sigma}} p_j(a) N_j dG(a) \quad [\text{using (2)}] \\
 &= Y_i N_j \int_{a_L}^{a_{ij}} \left[\frac{p_j(a)}{P_i} \right]^{1-\sigma} dG(a) \\
 &= Y_i N_j \int_{a_L}^{a_{ij}} \left[\frac{\tau_{ij} c_j a}{\rho P_i} \right]^{1-\sigma} dG(a) \quad [\text{since these are the traded quantities, } \tau_{ij} > 1] \\
 &= Y_i N_j \left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} \int_{a_L}^{a_{ij}} a^{1-\sigma} dG(a) \quad [\text{using (4)}] \\
 &= \left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} Y_i N_j V_{ij} \quad [\text{using (5)}]
 \end{aligned}$$

Volume of imports from industry r ,

$$\begin{aligned}
 M_{ij}^r &= \int_{a_L}^{a_{ij}^r} [x_j(a) p_j(a) N_j^r] dG(a) \\
 &= Y_i N_j^r \left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} \int_{a_L}^{a_{ij}^r} a^{1-\sigma} dG(a) \\
 &= \left[\frac{\tau_{ij} c_j}{\rho P_i} \right]^{1-\sigma} Y_i N_j^r V_{ij}^r. \quad [\text{using (15)}]
 \end{aligned}$$

Table 9: First stage of maize regression

VARIABLES	Full Sample			Poor Exporters			African Exporters		
	ij_lngn1tr d	ij_nztrd	mills	ij_lngn1tr d	ij_nztrd	mills	ij_lngn1tr d	ij_nztrd	mills

ij_btc	0.108*** (0.0400)	-0.0181 (0.0166)		0.0837 (0.0752)	-0.0369 (0.0351)		-0.0997 (0.107)	0.0161 (0.0645)	
ij_contig	0.644*** (0.242)	0.412*** (0.118)		0.371 (0.490)	0.0619 (0.227)		3.662*** (1.125)	-0.858 (0.536)	
ij_ethlang	-0.00300 (0.216)	0.276*** (0.0877)		-0.436 (0.320)	0.295* (0.151)		-3.745*** (0.609)	0.0855 (0.259)	
ij_colony	0.701** (0.334)	0.365** (0.147)		0.000720 (0.627)	0.0155 (0.315)		2.023** (0.873)	-0.301 (0.526)	
ij_landlock	-0.381 (2.541)	-0.753 (0.693)		-9.462*** (3.539)	-1.175 (0.913)		-2.092 (5.564)	-4.660 (1844)	
ij_coastal	-0.0801 (2.522)	0.869 (0.662)		9.586*** (3.393)	1.371 (0.856)		-2.737 (5.521)	4.691 (1844)	
ij_legal	0.225 (0.158)	0.236*** (0.0598)		0.431* (0.243)	0.194* (0.109)		-0.289 (0.540)	0.149 (0.202)	
ij_currency	-0.743** (0.377)	-0.343 (0.211)		-7.650*** (2.553)	-0.285 (0.816)			5.304 (4239)	
ij_conflict	-1.311** (0.511)	-0.371 (0.242)		-1.844* (1.062)	0.707 (0.527)		-2.087 (1.871)	11.46 (0)	
ij_gatt	-0.343 (0.416)	0.152 (0.167)		-0.187 (0.469)	0.313 (0.246)		-3.090* (1.648)	0.307 (0.573)	
ij_tau	-0.212 (0.146)	0.596*** (0.0459)		-0.766*** (0.273)	0.843*** (0.100)		0.134 (0.742)	1.192*** (0.288)	
ij_trdfrq		0.224*** (0.0106)			0.291*** (0.0246)			0.410*** (0.0602)	
Timeclust FE	yes	yes		yes	yes		yes	yes	
Exporting country FE	yes	yes		yes	yes		yes	yes	
Importing country FE	yes	yes		yes	yes		yes	yes	
lambda			- 1.305*** (0.168)			- 1.113*** (0.278)			- 1.643*** (0.453)
Constant		4.262*** (0.986)			-1.875 (0)			-4.991 (0)	
Observations	17890	17890	17890	6257	6257	6257	2597	2597	2597
N	17890	17890	17890	6257	6257	6257	2597	2597	2597
N-censored	16631	16631	16631	5790	5790	5790	2449	2449	2449
chisq	2425	2425	2425	1575	1575	1575	756.0	756.0	756.0
p-value	0	0	0	0	0	0	0	0	0

Table 10: First stage of groundnut regression

VARIABLES	Full Sample			Poor Exporters			African Exporters		
	ij_lngn1tr d	ij_nztrd	mills	ij_lngn1tr d	ij_nztrd	mills	ij_lngn1tr d	ij_nztrd	mills
ij_btc	0.108*** (0.0400)	-0.0181 (0.0166)		0.0837 (0.0752)	-0.0369 (0.0351)		-0.0997 (0.107)	0.0161 (0.0645)	
ij_contig	0.644***	0.412***		0.371	0.0619		3.662***	-0.858	

	(0.242)	(0.118)	(0.490)	(0.227)	(1.125)	(0.536)			
ij_ethlang	-0.00300	0.276***	-0.436	0.295*	-3.745***	0.0855			
	(0.216)	(0.0877)	(0.320)	(0.151)	(0.609)	(0.259)			
ij_colony	0.701**	0.365**	0.000720	0.0155	2.023**	-0.301			
	(0.334)	(0.147)	(0.627)	(0.315)	(0.873)	(0.526)			
ij_landlock	-0.381	-0.753	-9.462***	-1.175	-2.092	-4.660			
	(2.541)	(0.693)	(3.539)	(0.913)	(5.564)	(1844)			
ij_coastal	-0.0801	0.869	9.586***	1.371	-2.737	4.691			
	(2.522)	(0.662)	(3.393)	(0.856)	(5.521)	(1844)			
ij_legal	0.225	0.236***	0.431*	0.194*	-0.289	0.149			
	(0.158)	(0.0598)	(0.243)	(0.109)	(0.540)	(0.202)			
ij_currency	-0.743**	-0.343	-7.650***	-0.285		5.304			
	(0.377)	(0.211)	(2.553)	(0.816)		(4239)			
ij_conflict	-1.311**	-0.371	-1.844*	0.707	-2.087	11.46			
	(0.511)	(0.242)	(1.062)	(0.527)	(1.871)	(0)			
ij_gatt	-0.343	0.152	-0.187	0.313	-3.090*	0.307			
	(0.416)	(0.167)	(0.469)	(0.246)	(1.648)	(0.573)			
		-		-		-			
ij_tau	-0.212	0.596***	-0.766***	0.843***	0.134	1.192***			
	(0.146)	(0.0459)	(0.273)	(0.100)	(0.742)	(0.288)			
ij_trdfreq		0.224***		0.291***		0.410***			
		(0.0106)		(0.0246)		(0.0602)			
Timeclust FE	yes	yes	yes	yes	yes	yes			
Exporting country FE	yes	yes	yes	yes	yes	yes			
Importing country FE	yes	yes	yes	yes	yes	yes			
		-		-		-			
lambda		1.305***		1.113***		1.643***			
		(0.168)		(0.278)		(0.453)			
		-		-		-			
Constant		4.262***		-1.875		-4.991			
		(0.986)		(0)		(0)			
Observations	17890	17890	17890	6257	6257	6257	2597	2597	2597
N	17890	17890	17890	6257	6257	6257	2597	2597	2597
N-censored	16631	16631	16631	5790	5790	5790	2449	2449	2449
chisq	2425	2425	2425	1575	1575	1575	756.0	756.0	756.0
p-value	0	0	0	0	0	0	0	0	0