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Saving two in a billion: quantifying the trade effect of European food safety standards on African exports ☆

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Abstract

A growing concern over health risks associated with food products has prompted close examination of sanitary and phytosanitary standards in industrialized countries. This paper quantifies the impact of a new harmonized aflatoxin standard set by the EU on food exports from Africa. We employ a gravity model to estimate the impact of changes in differing levels of protection based on the EU standard, in contrast to those suggested by international standards. The analysis is based on trade and regulatory survey data for 15 European countries and nine African countries between 1989 and 1998. Our results suggest that the implementation of the new aflatoxin standard in the EU will have a negative impact on African exports of cereals, dried fruits and nuts to Europe. The new EU standard, which would reduce health risk by approximately 1.4 deaths per billion a year, will decrease these African exports by 64% or US$ 670 million, in contrast to regulation set through an international standard.

Keywords: Agricultural trade; Sanitary and phytosanitary measures; Food safety; Aflatoxins; Health risks

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☆ The views and interpretations expressed in this paper are those of the authors and do not necessarily represent the views and policies of the World Bank.

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Introduction

While traditional trade barriers in agriculture such as tariffs continue to decline, technical and regulatory barriers are increasingly subject to debate. This includes discussion over the appropriate levels of sanitary and phytosanitary standards (SPS) (Wilson, 2000) and related food safety concerns. Public discourse and concern about the health risks of food and appropriate sanitary standards is particularly evident in industrialized countries (Pinstrup-Andersen, 2000). Debate over food safety has been especially prominent in Europe (Nielsen and Anderson, 2001). In particular, the use of import bans and regulatory intervention by the European Commission is increasingly justified, in part, under the precautionary principle. This principle suggests that regulatory action against risk be taken, even when science has not established direct cause and effect relationships. The Commission's approach has been challenged in trade policy talks on the basis that import restrictions have been imposed without sufficient support in international science. The ban in Europe of hormone-treated beef is one recent high-profile example.

The World Trade Organization (WTO) Agreement on Sanitary and Phytosanitary Standards encourages their member countries to harmonize national standards with international standards, and recommendations developed by other WTO member governments in international organizations, such as the joint FAO/WHO Codex Alimentarius Commission (Codex) for food safety. The Agreement does permit importing countries to impose more stringent measures than the international standards. It also provides for 'emergency' measures to be taken to limit or ban imports. These actions should be taken on an interim basis, however, until final decisions are made based on risk assessments and scientific analysis. The text of the Agreement requires scientific justification, if differing standards create an unnecessary obstacle to trade. In this respect, international standards may be considered a baseline for WTO members to follow. Trade disputes are likely to arise when the difference in the standards generate a significant cost on exporting countries.

The cost of regulatory intervention in food safety cases, one assumes from anecdotal and case study references, can be significant (World Bank, 2000). This is especially true for developing countries attempting to penetrate developed country agricultural markets. For example, consider that in low and middle- income countries, the share of food exports in total trade remained high at approximately 13% in the 1990s (World Bank calculation based on GTAP database). If increasingly restrictive sanitary and phytosanitary measures limit market access, these countries could incur significant export loss. A more detailed picture, therefore, of the trade-off between appropriate levels of risk to human health, and the costs of differing levels of food safety standards on trade, is increasingly important in a public policy context.

Measuring the trade effect of sanitary and phytosanitary standards, however, is particularly complex. This fact is well documented in Orden and Roberts (1997). Notwithstanding these complexities, real world experience indicates that the costs of regulatory intervention may be high. Consider that during the period between June 1996 and June 1997, the US rejection level of imports due to food additives averaged 3% of the total food imports from developing countries (Henson et al., 2000).[1] The loss arising from rejection is not limited to the value of the product. It also includes transportation and other export costs, which are incurred by the exporter. Costs may also be borne by importing agents, shipping companies, and brokers. Even when exporters are able to meet new standards, compliance often involves significant capital expenditures for product re-design, building administrative systems, and maintaining new quality control, testing, and certification procedures, for example (Henson et al., 2000; Maskus and Wilson (2001a,b)

How regulatory costs for exporters compare with possible gains in higher sanitary and phytosanitary levels in importing countries is a key part of today's trade policy debate. Information on how standards affect trade flows when an international standard is in place and shared bilaterally, as opposed to conditions in which differing national standards are imposed on exporters, is at the center of our questions in this paper. As recently reviewed in Maskus and Wilson (2001a,b) the empirical evidence and information on the trade impact of standards is extremely limited. This fact motivates the importance of providing economic estimates based on empirical analysis of how standards impact trade flows and of predicting changing trade patterns under alternative food safety standards.

In this paper, we explore the trade effect of a European Commission (EC) proposal to harmonize aflatoxin standards announced in 1998. It was scheduled for enforcement and implementation in April 2002. The EC proposal has raised a number of disputes between the Commission and trade partners in the WTO. The case serves as a good example of the trade-off between acceptable levels of risk, how harmonized standards affect trade, and contrasting perspectives of developed and developing countries in international trade disputes. Our objective is to predict the trade effect of setting aflatoxin standards at differing levels. We examine bilateral trade flows between Africa and Europe under three regulatory scenarios: standards set at pre-EU harmonized levels (status quo), the new harmonized EU standard adopted across Europe, and a standard set by the Codex. In addition, we examine the trade-off between human health and trade flows for each of these three regulatory scenarios. We draw information on the human health implications of aflatoxin contamination from risk assessments conducted by the joint FAO/WHO Expert Committee on Food Additives (JECFA).

Based on the Food and Agriculture Organization's (FAO) cross country survey on food safety standards, we then develop a gravity model to measure the trade flow effect of aflatoxin standards under each scenario outlined above. The results are then used to calculate potential export revenue gains and losses at each different standard we examine. We explore trade in cereals, dried fruits, nuts and vegetables between 15 member states of the European Union and nine African countries in the 10 years prior to 1998.

The advantage of empirical analysis based on a gravity model includes the ability to examine the relationship between policy variables and bilateral trade flows where

[1] Based on Table 5 in Henson et al. (2000), the average rate of food product rejection because of food additives was computed for Africa, Latin America and Asia.

cross-sectional or panel data is available. In contrast, a gravity model is not suitable for obtaining separate estimates of the effect of standards on compliance costs of firms in meeting a particular standard or on consumers' demand schedules. A gravity model cannot be used to identify the demand and supply effect of standards.

Aflatoxin contamination and international standards

Aflatoxins are a group of structurally related toxic compounds which contaminate certain foods and result in the production of acute liver carcinogens. They are substances that can produce liver cancer in the human body. Aflatoxins are particularly prevalent in stored agricultural crops, such as peanuts, (*Aspergillus flavus*). The health risk associated with aflatoxins was identified in 1960, following the deaths of 100,000 turkeys in the United Kingdom, and high incidences of liver disease found in ducklings from Kenya and in hatchery trout from the United States (US Food and Drug Administration (USFDA), 2000).

According to the joint research by the United Nations Development Program (UNDP) and FAO in 2000, the major aflatoxins of health concern are designated B1, B2, G1, and G2. These toxins are usually found together in foods. Joint research completed by the FAO and the World Health Organization (WHO) in 1997 indicates that aflatoxin B1 is usually predominant and the most toxic of the four categories. It has been identified in corn and corn products, groundnuts and groundnut products, cottonseed, milk, and tree nuts such as Brazil nuts, pecans, pistachio nuts, and walnuts.

Severe aflatoxicosis, a pathological condition caused by aflatoxin intake, is produced when moderate to high levels of aflatoxins are consumed. Acute episodes of disease ensue, and may include hemorrhage, acute liver damage, edema, alteration in digestion, absorption and/or metabolism of nutrients, and possibly death (USFDA). Chronic aflatoxicosis can result from ingestion of low to moderate levels of aflatoxins. Some of the common symptoms of this condition are impaired food conversion and slower rates of growth (USFDA).

An important case of aflatoxin contamination occurred in 150 villages in Northwest India in the fall of 1974. Contaminated corn was found to be the major cause of the outbreak. 397 people suffered from severe aflatoxicosis, and 108 individuals died. A second outbreak was reported in Kenya in 1982, where aflatoxin intake was estimated at 38 μg/kg body weight. In developed countries, aflatoxin contamination rarely occurs at levels that cause notable aflatoxicosis in humans. Studies on human toxicity from ingestion of aflatoxins, therefore, have focused only on their carcinogenic effect (USFDA).

A number of studies have revealed an association between liver cancer incidence and the aflatoxin content of the diet. It should be noted, however, that these studies have not established a direct cause and effect relationship. A 1997 report by JECFA concluded that, "aflatoxins should be treated as carcinogenic food contaminants, the intake of which should be reduced to levels as low as reasonably achievable" (FAO/WHO, 1997). The difficult public policy question, at least in part, centers on consensus definitions of 'reasonably achieveable.'

The EU regulation of aflatoxins

Member countries of the European Union have implemented different standards for aflatoxins in food products. As Fig. 1 indicates, the stringency of the standards varied across countries. Austria, for example, set the standard for Aflatoxin B1 at one ppb, while Portugal set its standard at 20 ppb. Some countries have set tighter standards on particular product categories. For example, France had a very stringent Aflatoxin B1 standard on groundnuts, but a much less restrictive standard on other foods. In general, a tighter standard on Aflatoxin B1 is applied to food products intended for direct human consumption, rather than those subject to further processing.

Country	Commodity	Aflatoxin B1	Aflatoxin Total
Austria	all foods	1	-
	milling and shelled products and derived food	2	-
Belgium	groundnuts	5	-
Denmark	groundnuts	2	4
	Brazil nuts	2	4
	dried figs	2	4
Finland	all foods	-	5
France	all foods	10	-
	groundnuts	1	-
	wheat meal	3	-
	wheat bran	10	-
	vegetable oils, cereals, wheat meal	5	-
Germany	all foods	2	4
	enzyme	-	0.05
Greece	nuts and edible seeds	5	10
	dried fruits	5	10
Ireland	all foods	5	30
Italy	all foods	5	10
	dried figs	5	10
	spices	20	40
Luxembourg	groundnuts	5	-
The Netherlands	all foods	5	-
Portugal	all foods	20	-
	groundnuts	25	-
Spain	all foods	5	10
Sweden	all foods	-	5
United Kingdom	nuts, dried figs	-	4
	groundnuts, copra, palm-kernel, cotton seed	20	-
Norway (EEA)	all foods	-	5
	Brazil nuts	-	5
	mixed foodstuffs depending on animal	50	-
Africa (average)	groundnuts	14	44
Codex		-	15

Source: FAO (1995)

Note: Notation "-" signifies "did not have one."

Fig. 1. Maximum allowable aflatoxin levels in Europe and Africa (ppb).

In 1997 the European Commission proposed a uniform standard for total aflatoxins, setting the acceptable level of the contaminant in food products (European Commission, 1997). For example, it set a standard of 4 ppb in cereals, edible nuts, dried and preserved fruits, and groundnuts intended for direct human consumption, and 10 ppb in groundnuts subject to further processing. It also established a level for Aflatoxin M1, which is usually present in milk at 0.05 ppb.

The harmonized standard for the European Union is tighter than those which have been applied in most member countries (Fig. 1). For eight EU members (Belgium, Greece, Ireland, Italy, Luxembourg, The Netherlands, Spain, and Sweden) the new regulation results in a reduction in the acceptable aflatoxin levels in food imports by more than 50 percent. Exporters to Europe, including Bolivia, Brazil, Peru, India, Argentina, Canada, Mexico, Uruguay, Australia, and Pakistan requested that the Commission provide the risk assessments on which it had based its proposed standard (WTO, G/SPS/R/12, 1998). In comments submitted to the WTO a representative of the Gambia maintained that the proposed standard would, "effectively restrict entry of the Gambia's groundnuts and essentially the groundnuts from producer countries in the developing world to the European Union" (WTO, G/SPS/GEN/50, 1998).

Peru suggested that the measure constituted an unjustifiable trade barrier, and a violation of the WTO Agreement on Sanitary and Phytosanitary Standards (WTO, G/SPS/R/14, 1999). India also raised concerns about the implications of the new regulation. In its submission to the WTO, India stated that, "in the case of milk, it is understood that the calculation for aflatoxin composition for all contaminants/pesticides are based on the maximum consumption figures of 1500 g per person per day, which is 7–8 times higher than the world's per capita consumption of milk. Such an evaluation, based on exaggerated assumptions, would naturally result in unrealistic and impractical standards leading to creation of non-tariff trade barriers" (WTO, G/SPS/GEN/55, 1998).

Several Asian countries also expressed concern about the impact of the regulation on exports of cereals. Thailand had previously suffered from considerable losses in corn exports as a result of high levels of aflatoxins, and requested EU assistance to developing countries that export products subject to the new regulation (WTO, G/SPS/GEN/57, 1998).

In part as a result of the objections raised by European trading partners, the Commission relaxed the aflatoxin standard for cereals, dried fruits and nuts (see Fig. 2). A July 1998 Commission regulation (European Commission, 1998), established the total aflatoxin standard in groundnuts subject to further processing at 15 ppb (8 ppb for Aflatoxin B1), in other nuts and dried fruit subject to further processing at 10 ppb (5 ppb for Aflatoxin B1). A more stringent standard on cereals and dried fruits, and nuts intended for direct human consumption was set at 4 ppb (2 ppb for Aflatoxin B1). According to the revised regulation in March 2001 (European Commission, 2001), EU members were to implement the necessary laws to comply with the new standards no later than April 2002.

The Codex standard on total aflatoxin contamination in processed and unprocessed food is set at 15 ppb (Fig. 1). In contrast, the harmonized European standard for total aflatoxin contamination in food products is more restrictive. The Commission

		Aflatoxins: maximum admissible levels(1) (ug/kg)		
	Products	B1	B1 + B2 + G1 + G2	M1
2.1.1	Groundnuts, nuts and dried fruit			
2.1.1.1.	Groundnuts, nuts and dried fruit and Processed products thereof, intended for Direct human consumption or as an Ingredient in foodstuffs.	2	4	–
2.1.1.2.	Groundnuts to be subjected to sorting, or other physical treatment, before human Consumption or use as an ingredient in foodstuffs.	8	15	–
2.1.1.3.	Nuts and dried fruit to be subjected to Sorting, or other physical treatment, Before human consumption or use as An ingredient in foodstuffs.	5	10	–
2.1.2.	Cereals (including buckwheat, *Fagopyrum sp.)*			
2.1.2.1.	Cereals (including buckwheat, *Fagopyrum sp.*) and processed products Thereof intended for direct human Consumption or as an ingredient in Foodstuffs.	2	4	–
2.1.2.2	Cereals (including buckwheat, *Fagopyrum sp.* To be subjected to sorting, or Other physical treatment, before human Consumption or use as an ingredient in Foodstuffs.	–	–	–
2.1.3	Milk (raw milk, milk for the manufacture of milk-based products and heat-treated Milk as defined by Council Directive 92/46/EEC of 16 June 1992 laying down The health rules for the production and Placing on the market of raw milk, heat-treated Milk and milk-based products.	–	–	0.05

Source: Commission Regulation No. 1525/98

Fig. 2. The European Commissions proposal of maximum allowable aflatoxins levels.

established a 4 ppb level for total aflatoxins in cereals, dried fruits, and nuts intended for direct human consumption. Furthermore, the Commission set the standard for Aflatoxin B1 at 2 ppb for food products intended for direct human consumption, at 5 ppb for Aflatoxin B1 in other nuts and dried fruit subject to further processing, and at 8 ppb for Aflatoxin B1 in groundnuts subject to further processing (Fig. 2). In contrast, Codex has not recommended any standard specific to Aflatoxin B1 contamination (Fig. 1 regulatory approach to Aflatoxin).

For example, suppose that regulation based on the Codex's standard for total aflatoxin contamination led to regulation on the same basis as the Commission's regulation on Aflatoxin B1. It is generally known that 50–70% of the total aflatoxin level of 15 ppb is accounted for by Aflatoxin B1 contamination.[2] If regulation based on the Codex standard on total aflatoxin has an regulatory effect equivalent to Aflatoxin B1 contamination in this range, then Aflatoxin B1 contamination should be within 7.5 –10.5 ppb. This level is significantly higher than the European harmonized standard for groundnuts, other nuts, dried and preserved fruits and cereals for direct consumption.

Human health risks under the EU harmonized standard and Codex international standards

Scientific research on relationships between chronic aflatoxicosis in humans, and the amount of aflatoxin intake is inconclusive. To date, a risk assessment completed by joint FAO/WHO Expert Committee on Food Additives (JECFA) provides the most comprehensive information on aflatoxin risk to human health. JECFA analyzed potential health effect of aflatoxin for two hypothetical levels (10 parts per billion (ppb) and 20 ppb). JECFA estimated that implementing a 10 ppb total aflatoxin standard leads to a risk of 39 cancer deaths per year per billion people, with an uncertainty range between 7 and 164 people.[3] In comparison, a 20 ppb standard yields a risk of 41 cancers per year per billion people with an uncertainty range between 8 and 173 cancer deaths. It therefore estimated that reducing the standard from 20 to 10 ppb in countries where percentage of carriers of hepatitis B1 is around 1% (e.g. members of the European community) would result in a drop in the population risk of approximately two cancer deaths a year per billion people.

This result can be used to estimate the cancer death risks associated with different regulatory scenarios we examine – the pre EU harmonized standard (status quo), the new harmonized EU standard, and a Codex standard (referred to as Scenarios I, II and III, respectively). Approximately 0.2 cancer deaths will be saved each year by tightening total aflatoxin standards by one ppb, if a linear relationship is assumed between cancer death risk and aflatoxin intake. If we assume that 60% of all aflatoxins are in fact Aflatoxin B1, by adopting the average of the lower (50 ppb) and upper (70 ppb) bounds of share of Aflatoxin B1 in total aflatoxin (50 and 70%), 0.33 (=0.2/0.6) cancer deaths can be saved by tightening the Aflatoxin B1 standard. If the same assumption is used to establish a baseline estimate for a Codex standard, it would be set at 9 ppb. For groundnuts, other nuts, dried and preserved fruits and cereals for direct consumption, the difference between this baseline estimate and the new EU standard is 7 ppb. Provided that these foods fully account for the aflatoxin intake in the JECFA's scenario, this implies that the EU standard will result in 2.3 less cancer deaths per year than when the baseline level is taken. Similar calculations

[2] Based on interviews with sources at the US Department of Agriculture (August 22, 2000), and sources within the US peanut industry (August 25, 2000).

[3] The estimates assume a population with 1% carriers of hepatitis (i.e. European population) and used potency values equal to 0.3 cancer deaths per year per 100,000 people among carriers of Hepatitis B and 0.01 cancer deaths per year per 100,000 population among noncarriers (FAO/WHO, 1997).

cannot be completed for food products for further processing. Aflatoxin contamination in these products in its final form is unknown.

Market access of African food exports

Western Europe and other high-income countries are the major export destinations for developing countries. Fig. 3 illustrates the dependency of developing country food exporters on developed country's markets. Western Europe is the major destination for exports from the Middle East and Africa. High-income Asian countries, Australia, New Zealand and North America are the major destinations of middle and low-income countries in Asia. Latin America has diversified its export markets more than the other developing regions. Africa and the Middle East are likely, therefore, to be significantly affected by regulation set in European import markets due to their high dependency on these markets.

As noted in Henson et al. (2000), the draft European regulation on aflatoxins raised serious concerns among exporters of food products subject to the proposed EU new standard, particularly in developing countries. Firm-level data on compliance costs of regulation in aflatoxins cases are lacking. It is clear, however, that the least developed countries are relatively more vulnerable to regulatory changes than industrialized nations, due to a relative scarcity of public resources to finance compliance with sanitary and phytosanitary standards. Moreover, as Fig. 1 indicates, standards applied by African countries are less stringent than those applied in Europe. One would expect, therefore, that domestic producers in Europe would be more capable of meeting higher standards.

Exporters \ Importers	West Europe	Rest of high Income countries	Middle East/ Africa	Asia	Latin America	Rest of the world	Total
West Europe	152,348 **(0.74)**[1]	16,609 **(0.08)**	13,545 **(0.07)**	4,944 **(0.02)**	3,832 **(0.02)**	13,781 **(0.07)**	205,059 **(1.00)**
Rest of high income Countries	13,432 **(0.13)**	48,868 **(0.47)**	8,647 **(0.08)**	19,318 **(0.19)**	9,602 **(0.09)**	3,077 **(0.03)**	102,943 **(1.00)**
Middle East/Africa	14,855 **(0.57)**	3,123 **(0.12)**	4,031 **(0.16)**	1,985 **(0.08)**	298 **(0.01)**	1,576 **(0.06)**	25,868 **(1.00)**
Asia[2]	9,030 **(0.15)**	26,218 **(0.44)**	5,312 **(0.09)**	15,039 **(0.25)**	982 **(0.02)**	3,341 **(0.06)**	59,922 **(1.00)**
Latin America	17,969 **(0.33)**	17,421 **(0.32)**	3,955 **(0.07)**	3,830 **(0.07)**	9,073 **(0.17)**	1,844 **(0.03)**	54,082 **(1.00)**
Rest of the world	7,919 **(0.41)**	2,935 **(0.15)**	1,263 **(0.07)**	2,232 **(0.11)**	256 **(0.01)**	4,817 **(0.25)**	19,422 **(1.00)**

Source: World Bank calculations, based on GTAP

Notes:

1. Inside parentheses are shares in parentage in total value of exports from a given region. The regions in the first column are origins of export of food products, and the regions in the first row are destinations for these products

2. Excluding Hong Kong, Japan, South Korea and Taiwan, which are included in the rest of high income countries.

Fig. 3. Food exports by destination regions in 1995 (1995 US$ million).

The least developed countries, such as those in Africa, are still largely dependent upon on raw food exports (Ng and Yeats, mimeo), such as groundnuts and other commodities we examine. As Finger and Schuler (2000) note, the cost of compliance with WTO obligations related to the SPS Agreement in the least developed countries can exceed total government development budgets for all expenditures. For example Sub-Saharan Africa (SSA) is the least developed region in the world. Gross Domestic Product (GDP) Per Capita (mean) in 1990 was $510. Thirty-eight out of 50 SSA countries fell into the lowest income group of the World Bank's classification in 1999. Fast technological changes have enhanced inspection capacities in developed countries, and allowed them to adopt progressively more restrictive sanitary and phytosanitary standards. Securing sales in these major markets is expected to become more challenging and costly over time.

The empirical analysis of the effect of aflatoxin standards

In this section, we conduct an empirical analysis to evaluate the implications of aflatoxin standards in the EU countries in prior to 1998 for nine African food exporters. Bilateral trade flows are then compared under three regulatory scenarios: Scenarios I, II and III.

There are a limited number of studies that have used empirical data to estimate the trade effect of standards in economics literature. Quantifying the trade and economic impact of standards involves significant complexity. Standards affect market demand and supply in complex and interrelated ways. Unlike tariffs, change in the equilibrium price cannot be predicted, unless it is known how import demand and export supply shifts. These changes are induced by many factors, such as compliance costs and change in consumer preferences associated with improved product information and quality (Hooker and Caswell, 1999; Maskus and Wilson, 2001a,b). Partial equilibrium analysis has been used to analyze demand, supply, and welfare effect of standards (Paarlberg and Lee, 1998; Calvin and Krissoff, 1998). Studies using this approach, however, assume a hypothetical relationship between food safety, demand, and supply. Compliance costs and preference changes are not directly measured in these studies.

Econometric approaches have also been used to estimate the effect of standards on trade flow (Moenius, 1999; Otsuki, Wilson and Sewadeh, mimeo). Otsuki, Wilson and Sewadeh employ a direct measure of the impact of food safety standards expressed in maximum allowable contamination in their econometric analysis. The effect of differing levels of regulatory stringency on trade was demonstrated, therefore, across countries.

In the first stage of this analysis, we use an econometric approach to determine the effect of European aflatoxin standards on African exports. The framework in our empirical study follows the gravity model that developed in Otsuki, Wilson and Sewadeh. A gravity model is a widely used method to explain trade patterns between countries using each country's measures of 'mass' and geographical distance between countries to assess changes in trade flows. In most countries, aflatoxin standards on foods, for example, are specified for both Aflatoxin B1 alone, and total level of Aflatoxins B1, B2, G1 and G2 (See Fig. 1). In practice, meeting the B1 standard is more difficult than meeting the standard set for total aflatoxin contamination. The B1 standard is the one most likely to affect bilateral trade flows.

Our specification of gravity model is as follows:

$$\ln(V_{ij}^k) = b_0^k + b_1^k\ln(\mathrm{PCGNP}^j) + b_2^k\ln(\mathrm{PCGNP}iy) + b_3^k\ln(\mathrm{DIST}^{ij}) + b_4^k\mathrm{YEAR} + b_5^k\mathrm{COL}^{ij} + b_6^k\ln(STi^k) + \varepsilon_{ij}^k \quad (1)$$

where V_{ij}^k denotes value of trade in product k from African country j to EU country member i. It is obtained from trade data of the United Nations Statistical Office. Trade data include bilateral trade value across time. We use data for the time period between 1989 and 1998. Parameter b's are coefficient. PCGNP is real per capita GNP in 1995 US dollars. DIST is geographical distance between country i and j, and YEAR is a year. COL is colonial tie dummy. It equals one if a colonial tie between country i and j, exists, and is zero otherwise.

ST_i^k is maximum level of Aflatoxin B1 imposed on import of food product k by EU country i. It is obtained from FAO survey of mycotoxin standards on food and feed stuffs in 1995 (FAO, 1995). A greater value of this variable implies a more lax regulation of Aflatoxin B1 contamination, and vise versa. If this standard is applied at the border, products with Aflatoxin B1 contamination equal to or below *ST* successfully enter the importing country. Products with Aflatoxin B1 contamination above *ST* are retained in the exporting country or rejected at the importing country's border. The coefficient for this variable in our gravity model generally implies changes in exports associated with an incremental change (relaxation or tightening) in *ST*. If this standard does limits trade, this coefficient is expected to be positive.

Data on the maximum allowable level of aflatoxins, expressed as contamination in parts per billion, is available for all European countries in this study. Using 1995 regulatory data for a regression with observations from other years implies that aflatoxin regulations in Europe have not changed throughout the period covered by our analysis. Dummy variables for exporting countries are included in the model in order to control unobserved factors such as environment and product quality, which may vary across these countries. The term ε_{ij}^k is the error term and is assumed to be normally distributed with mean zero.

We selected product categories for examination where data are available. We first conduct the analysis at an aggregate level that is defined by the two digit level under the STIC Revision 2 classification. The value of trade of 'cereals and cereal preparations' and 'fruits, nuts and vegetables' are regressed on the variables presented above.

United Nations trade data for 15 European countries and 9 African countries are used in the analysis. The European countries included in the data are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden and United Kingdom. These countries were members of the European Union as of 2000, and are importers of African food exports. The African countries in our analysis include Chad, Egypt, the Gambia, Mali, Nigeria, Senegal, South Africa, Sudan, and Zimbabwe. These countries have been among the leading exporters of food products to Europe. A fixed-effect model for importing countries as cross-sectional groups is used, as the error term is considered to reflect common characteristics within a group of observations associated with each country.

We focus on the case of at-the-border inspection and regulation. How decisions made by exporters change with differing standards is an interesting and important question for examination. This question can be better analyzed, however, using survey data from exporting firms. In our analysis, we focus on changes in exports at differing standards, based on COMPTRADE data. This data set contains bilateral trade data which tracks trade between countries. Information on how specific firms may or may not be able to meet regulatory requirements is beyond the scope of this data set and our analysis. Firm-level data on specific compliance costs of individual companies in meeting the new aflatoxin standards are lacking. Moreover, our model is based on exporters' short-run behavior. It cannot take into consideration changes in the ability of specific firms, over time, to meet stricter standards.

The result of the gravity-model estimation is reported in Fig. 4. The results for cereal products and fruits, nuts, and vegetables indicate that the gravity model is generally well-behaved. The coefficient estimate for GNP per capital in Europe is positive, reflecting the wealth effect of buyers. The coefficient for geographical distance is negative, as a greater distance tends to increase costs of trade.

Since the smaller value of *ST* implies the tighter standard, the positive coefficient here implies that tighter standards for Aflatoxin B1 have significant negative effects on trade flows of both cereals and fruits, nuts and vegetables. Since a double-log specification is used, the coefficient of a variable can be interpreted as elasticity.

Fig. 4 also suggests that colonial ties have significant positive implications for trade. The effect is greater for fruits and vegetables. This may be due to the fact that these products were specifically produced for export (tropical fruits and nuts) under colonial rule. The result is consistent with the result found in the case of the

Products	Cereals and cereal preparations		Fruits, nuts, and vegetable	
	Coefficient	t-value	Coefficient	t-value
Constant	63.4272	0.706	38.3051	0.817
GNP per capita in Europe	1.4254**	2.665	3.0476**	11.618
GNP per capita in Africa	-0.9890	-1.028	0.9378*	1.769
Geographical distance	-4.8551**	-4.201	-3.6408**	-7.323
Aflatoxin B1 Standards	1.0517**	4.144	0.4327**	4.008
Year	-0.0132	-0.285	-0.0184	-0.779
Dummy for colonization ties	2.1195**	4.866	3.2571**	14.316
Number of observations	346		865	
Adjusted R-squared	0.2566		0.6636	

Note: 1. Fixed-effect models for importing countries are estimated.

2. '*' and '**' imply significance at the 10 and 5 percent levels under a two-tail test, respectively.

Fig. 4. Regression results on the value of products under the SITC-2 digit level (the double log specification).

Africa–Europe groundnuts trade in Otsuki, Wilson and Sewadeh. For example, Egypt, the Gambia, South Africa, Sudan, and Nigeria have a tendency to export to the United Kingdom. In contrast, Mali, Senegal and Chad have tendency to export to France. Language and cultural assimilation, as well as historical trade relationships may have created a strong export dependency on in countries that had colonial ties (Otsuki, Wilson and Sewadeh). These factors may continue to affect trade patterns, and separating their effect from that of standards is necessary. In sum, we find that colonial ties appear to have important implications for trade in the cases we examine.

In order to evaluate the effect of the new EU aflatoxin regulations (Scenario II), we now limit scope of analysis to the categories of food products that are specifically subject to the new regulation. The overall category of ‘cereals and cereal preparations’ is covered by the new harmonized standard. The ‘fruits, nuts and vegetables’ category has specific products, such as dried and preserved fruits, nuts and vegetables which are subject to the standard. These products have been a particular focus of aflatoxin regulations worldwide, since the drying and preserving process promotes the growth of fungi which contains aflatoxins. Consequently, we repeated our analysis with a higher level of disaggregation of these product categories. We focus on dried and preserved fruits, groundnuts and other nuts.

Fig. 5 shows the elasticity of Aflatoxin B1 standards on trade flows in cereals and cereal preparations, and in the sub-categories of fruits, nuts and vegetables. The table suggests that the standards’ effect is significant on all the products in this group. Thus, these products are expected to be significantly affected by the new harmonized standard. The magnitude of the effect will be greater on “groundnuts and other edible nuts” than on “coconuts, Brazil nuts and cashew nuts,” reflecting the fact that groundnuts are products for which aflatoxin contamination typically is of public concern (Otsuki et al., 2001). The magnitude of the effect will be moderate on “dried or preserved fruits.” Cereal products are highly sensitive to the aflatoxin standard, implying that trade in these products will be affected by the new harmonized standard in significant manner.

	Elasticity of standards
Cereals and cereal preparations	1.0517**
Fruits, nuts and vegetables	
Coconuts, Brazil and cashew nuts	0.7419*
Groundnuts and other edible nuts	1.2950**
Dried or preserved fruits	0.7705**

Note: ‘*’ and ‘**’ imply significance at the 10 and 5 percent levels under a two-tail test, respectively.

Fig. 5. Elasticity of Aflatoxin B1 standards on trade flow.

Simulations

This section provides results from the second stage of our empirical analysis, how trade flows between Africa and Europe would differ under conditions in which: (1) the pre-EU harmonized standard is maintained on African exports, (2) the new EU harmonized standard is imposed, and (3) a standard developed using Codex guidelines were imposed. The predicted trade flows in value under these scenarios is computed for each European and African country for products analyzed in the previous section. An upper and a lower bound for change in trade flows are imposed in order for the result to reflect non-negative exports and capacity constraints on exports; i.e., trade flow will not increase or decrease by more than 100 percent. The upper bound is imposed to avoid a change in trade volume beyond the productive capacity of a country. The upper bound limits an increase in volume by more than 100% of the volume traded in 1998.

In order to establish a baseline estimate for the CODEX international standard, we again assume the 9 ppb for the studied products based on the standard on the level of total aflatoxins contamination (15 ppb). Given this assumption, Aflatoxin B1 contamination should be below 9 ppb in order to sustain total aflatoxins below a 15 ppb level.

The following formula is used to predict changes in volume associated with changes in standards:

$$dV_{ij}^{k} = \tilde{b}_{6}\frac{V_{ij}^{k}}{ST_{i}^{k}}(ST_{i}^{k*}-ST_{i}^{k}) \qquad 2$$

where V_{ij} is the value of trade flow in 1998 from African country j to European country i for product k, dV_{ij} is predicted change in V_{ij}, $\tilde{b}_6$ is the estimated coefficient for country i's maximum aflatoxin B1 level in 1998 ($ST^{k}i$ in Eq. (1)), and $ST^{k*}i$ is the maximum aflatoxin levels associated with a given regulatory scenario. The value of V_{ij} can be used to represent the level of trade flows under the pre-EU harmonized standard. Thus we are able to obtain an estimated value of trade flows under all three regulatory scenarios.

Cereals exhibit a significant difference under each scenario. As shown in Fig. 6, the predicted loss of cereals trade under the new European standard is US$ 177 million, [4]or 59% lower than the value of EU–Africa cereal trade under the pre-EU harmonized standard. The difference in trade flows is even wider between the new standard and the Codex standard, as the Codex standard is much less stringent than even the pre-EU harmonized standard. The predicted total trade flow under the new European harmonized standard is US$ 120 millions, or 76% lower than it would be if a Codex standard were adopted (US$ 500 million). Among the EU countries, Austria alone is estimated to have an increase in imports, since it had a lower Afla-

[4] This number is an estimation based on the United Nations trade statistics.

	The Value of imports in 1998	Predicted change in the value of imports		Predicted value of imports		Reduction in value of imports in using the EU harmonized standard rather than the Codex standard (%)
		EU harmonized standard	Codex standard (assumed level)	EU harmonized standard	Codex standard (assumed level)	
	(US$ million)	(US$ million)	(US$ million)	(US$ million)	(US$ million)	
Austria	5	+5	+5	10	10	0
Belgium -Luxembourg	16	-10	+13	6	29	80
Denmark	5	+0	+5	5	11	50
Finland	3	-1	+3	2	5	61
France	146	-92	+123	54	270	80
Germany	10	0	+10	10	20	50
Ireland	5	-3	+4	2	9	80
Italy	35	-22	+29	13	65	80
Netherlands	13	-8	+11	5	24	80
Norway	na	na	na	na	na	na
Portugal	37	-35	-22	2	16	87
Spain	16	-10	+13	6	29	80
Sweden	3	-1	+3	2	6	61
U.K.	3	0	+3	3	7	50
EU	298	-177(-59%)	+202(+68%)	120	500	76

Fig. 6. Comparison of predicted trade flow under alternative scenarios:cereals and cereal preparations from Africa (US$ 1000).

toxin B1 standard prior to 1998. France is estimated to decrease cereals imports by the largest magnitude of US$ 92 million under the new harmonized standard.[5]

As shown in Fig. 7, the predicted change in the value of trade flows of dried and preserved fruits and edible nuts under the new standard is US$ 220 million,[6] or 47% lower than the trade in these products in 1998. The estimated trade flow under the new standard is US$252 million, which is 53% lower than that under a Codex standard–US$ 539 million.

Finally, the predicted value of African exports along with human health risks under the EU standard are compared to those under alternative regulatory scenarios. Compared to the status quo (an average standard of 4.8 ppb for Aflatoxin B1 for the 15 EU members) the new standard will result in 0.9 less cancer deaths per year, for the cost of $ 340 million (see Fig. 8). It is assumed that cereal products, nuts, and dried fruits account for the entire aflatoxin intake on which the JECFA risk assessment is based. As discussed earlier, the EU harmonized standard (2 ppb in Aflatoxin B1) is estimated to achieve 2.3 less cancer deaths per year associated with aflatoxin intake, relative to the Codex international standard, which is more relaxed

[5] It should be noted, however, that it had standards on other micotoxins that may be much stricter than the aflatoxins on cereals. These micotoxins include searalenone and ochratoxin (FAO, 1995). Standards on these chemicals may remain after the EU standards harmonization. If so, the estimated decrease may be smaller in magnitude.

[6] This number is under estimation based on the United Nations Trade Statistics.

	The Value of imports in 1998	Predicted change in the value of imports		Predicted value of imports		Reduction in value of imports in using the EU harmonized standard rather than the Codex standard (%)
		EU harmonized standard	Codex standard (assumed level)	EU harmonized standard	Codex standard (assumed level)	
	(US$ million)	(US$ million)	(US$ million)	(US$ million)	(US$ million)	
Austria	6.3	+4.9	+6.3	11.2	12.6	11
Belgium -Luxembourg	13.4	-7.1	+9.3	6.4	22.7	72
Denmark	7.4	0.0	+7.4	7.4	14.9	50
Finland	2.9	-0.6	+2.9	2.4	5.8	60
France	361.5	-177.0	+8.2	184.5	369.7	50
Germany	10.9	0.0	+10.9	10.9	21.8	50
Ireland	3.7	-2.3	+3.0	1.4	6.7	80
Italy	17.4	-8.6	+11.4	8.8	28.8	70
Netherlands	10.8	-5.9	+7.7	5.0	18.6	73
Norway	18.5	-17.5	-14.2	1.0	4.3	76
Portugal	6.7	-4.3	+1.7	2.4	8.4	71
Spain	4.5	-1.8	+3.3	2.7	7.8	65
Sweden	4.1	-0.3	+4.1	3.8	8.1	53
U.K.	4.1	0.0	+4.1	4.1	8.3	50
EU	472	-220(-47%)	+66(+14%)	252	539	53

Fig. 7. Comparison of predicted trade flow under alternative scenarios:Edible nuts from Africa (US$ 1000).

	Relative to Codex	Relative to the pre-EU harmonization (1998 trade)
Loss in the value of African food exports	$ 670 million	$ 340 million
Number of cancer deaths saved	2.3 persons	0.9 persons

Fig. 8. The value of African food exports and human health risk under the new EU harmonized standard relative to those under the alternative regulatory scenario.

(9 ppb). This will occur at a cost of $670 million. If the average of Aflatoxin B1 standard in the 15 EU countries (4.8 ppb) is used to compare with cancer deaths saved under the EU harmonized standard, then one would assume 0.9 less cancer deaths under the EU harmonized standard.

Trade losses in this analysis are estimated only for selected European and African countries. Our simulation exercise does not predict these countries'response, which might include diverting trade to other partners. European countries in particular, are likely to shift their food imports from Africa to other countries, even as they may have to pay higher prices than they did for African imports. African countries may not be able to find alternative markets outside Europe due to their high dependency on the European market. This simulation also does not consider African countries' potential benefits from compliance. If African countries are able to comply with the European standards, liver cancer deaths of African population would decrease, as well. These benefits will clearly offset the export losses. While these issues are of significant interest, they are beyond the scope of this simulation analysis.

Implications

This paper examines impact of sanitary and phytosanitary standards on food trade between Africa and Europe. Using regression analysis, we estimated the elasticity of the pre-EU harmonized aflatoxin standards on the value of trade flows from nine African countries to 15 European countries. Our results suggest that cereals, dried fruits and edible nuts trade are affected by aflatoxin standards in Europe. A one percent lower maximum allowable level of contamination will reduce trade flow by 1.1% for cereals, 0.43% for fruits, nuts and vegetables. Among fruits, nuts, and vegetables, groundnuts are found to be highly sensitive to the aflatoxin standards, a 1.3% reduction for a 1% change in the standard.

The simulation is then performed under three regulatory scenarios (1) pre-EU harmonized standard (status-quo), (2) an international standard indicated by guidelines set by Codex, and (3) the EU new harmonized standard, which is scheduled to be implemented in April 2002. We find that the EU harmonized standard will impose a considerable loss of export revenue from cereals, edible nuts, and dried and preserved fruits in African countries. In particular, the EU harmonized standard will impose far greater trade impediments when compared with trade under CODEX standard. When the EU harmonized standard is implemented, African export revenue from Europe is estimated to decrease by 59% for cereals, and 47% for dried and preserved fruits and edible nuts, compared to export revenue under the pre-EU harmonized standard. The difference is estimated to be approximately US$ 400 million for cereals, dried and preserved fruits, and nuts under the harmonized standard. Trade flow of these products is found to increase by US$ 670 million if the standards are imposed based upon those suggested by Codex guidelines instead of the EU harmonized standard.

Our results suggest several areas for consideration in a public policy context. There are significant trade costs associated with setting a food safety standard at levels lower than an international standard would suggest. The EU decided to regulate Aflatoxin B1 contamination at extremely low levels of risk. In the case of cereals, dried and preserved fruits, and edible nuts, 2.3 deaths per billion risk reduction per year will be achieved under the EU harmonized standard (2 ppb), as opposed to the level that follows the Codex guideline (9 ppb). This estimated reduction of liver cancer is small compared to the total number of deaths of liver cancer in the European Union. WHO estimates approximately 33,000 people die from liver cancer every year in EU which has population of half billion.

The economic analysis in our work relates to on-going debate over the possible revisions to the WTO SPS Agreement. The Agreement recognizes the rights of member countries to determine the 'appropriate levels of protection' of human health. As noted above, the SPS Agreement also provides for 'precaution' by members when an importing nation believes that the science and risk factors in any given case are such that restrictive measures must be taken. This should be a temporary measure, however, until scientific analysis and risk factors have become clearer. Moreover, the fundamental basis of the Agreement is founded in such principles. The European standard for alfatoxin at the new harmonized level is not intended to be temporary and is being promulgated in a context of a substantial amount of internationally accepted scientific evidence on the risks associated with aflatoxin.

The level set by Europe and our findings on the magnitude of the trade effect in this case, therefore, raise important questions for consideration. Are the costs of a proliferation of national standards, set in absence of progress by Codex in setting an internationally agreed level for Aflatoxin B1 directly, acceptable? If the WTO disciplines are to be strengthened, progress needs to be made on harmonized international standards set by CODEX. A concerted effort to identify key standards affecting food safety that have not been harmonized by Codex, and action to accelerate this process through international consensus, would help avert trade friction caused by divergent national standards.

Our results also suggest that it is possible to use economic modeling and empirical analysis to inform WTO discussions on 'appropriate protection' and 'least trade distorting' in SPS cases. Economic analysis of the trade effect of food safety standards, such as ours, can also be useful in the continued debate over the 'precautionary principle' and the SPS Agreement. Is the risk of harm to human health associated with aflatoxin B1 such that precaution should be taken by regulators in setting a very stringent standard, even with a high cost to world trade? Our results would suggest that there can be a very high cost to exporters in setting standards to address relatively small risks to human health. Finally, if there are areas of global consensus on standards, efforts to facilitate transfer of technology and technical assistance to the least developed countries in meeting food safety standards would serve to both increase safety and expand access to important agricultural markets for these countries.

Our results also suggest several areas for further empirical research and extension of the analysis in this paper. A gravity model is unable to disentangle demand and supply effect of standards. The application of a system of equations with unit prices would make welfare analysis feasible. The utility gain of consumers in the importing countries can thus be estimated and compared with welfare losses from the exporting countries. A dynamic of consumers and exporters' decisions could also be considered in the model framework used in this paper. Consumers' response also can better be modeled by incorporating their dynamic behavior, since their current purchase decisions are typically influenced on their perception of product quality and safety, that is characterized through repeated purchases.

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