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# Global Trade and Food Safety

## Winners and Losers in a Fragmented System

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How food safety is addressed in the world trade system is critical for developing countries that continue to rely on agricultural exports. An analysis shows that adopting a worldwide standard for a toxin affecting nuts and grains could increase trade in these commodities by $38 billion compared with levels under today's widely divergent national standards.

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## Summary findings

Food safety standards and the tradeoff between these standards and agricultural export growth are at the forefront of the trade policy debate. How food safety is addressed in the world trade system is critical for developing countries that continue to rely on agricultural exports. In a fragmented system of conflicting national food safety standards and no globally accepted standards, export prospects for the least developed countries can be severely limited.

Wilson and Otsuki examine the impact that adopting international food safety standards and harmonizing standards would have on global food trade patterns. They estimate the effect of aflatoxin standards in 15 importing countries (including 4 developing countries) on exports from 31 countries (21 of them developing). Aflatoxin is a natural substance that can contaminate certain nuts and grains when storage and drying facilities are inadequate.

The analysis shows that adopting a worldwide standard for aflatoxin B1 (potentially the most toxic of aflatoxins) based on current international guidelines would increase nut and cereal trade among the countries studied by $6.1 billion compared with 1998 levels. This harmonization of standards would increase world exports by $38.8 billion.


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# Global Trade and Food Safety:

## Winners and Losers in a Fragmented System

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## I. Introduction

The need to understand more precisely how food safety regulations affect trade is being driven, to a great extent, as a function of challenges in meeting the Agreement on the Application of Sanitary and Phytosanitary Standards (the "SPS Agreement") of the World Trade Organization (WTO). The SPS Agreement sets general guidelines under which trade in agricultural products is conducted to ensure standards are based on sound science, and does not arbitrarily discriminate or restrict trade. The WTO rules do allow members to set domestic standards at any level they deem appropriate, however, governments are encouraged to use international standards–where they exist. The WTO disciplines suggest, therefore, that harmonization and equivalence are the preferred methods of ensuring non-discrimination. A fragmented system of unilateral action on food safety standards is counter to both general WTO principles, and economically inefficient due to high transaction costs for exporters and global consumers. Although there is only limited empirical data in this field, it is assumed that developing countries are most directly affected by a fragmented system in which firms must meet differing standards for multiple export markets.

In the food trade, the Codex Alimentarius Commission (Codex) plays a central role in setting internationally acceptable standards. While governments through Codex have made progress in crafting harmonized standards in some areas, through the Commission consensus on key international food safety standards is lacking while national standards proliferate. Since regulatory requirements and product standards are substantially different across countries, typically between developed and developing countries (World Bank, 2001), trade disputes in a non-harmonized system are inevitable.[1] The rising number of notifications to the WTO from developed and developing countries about national sanitary and phytosanitary standards (a 26 percent increase from 1995 to 1998) reflects this fact. Understanding the trade impact of these differing standards, therefore, is of significant importance and an area of key public policy concern as options to expand trade in agricultural products are examined.

This paper analyzes how global trade patterns in selected food products will change when differing levels of aflatoxin B1 standard are assumed. Aflatoxins are a group of toxic substances that can contaminate certain foods. There is evidence that aflatoxin B1 contamination is linked to liver cancer . The analysis here extends Otsuki et al. (2001b) by broadening the country coverage from Africa to a global scope, and by explicitly examining how imports and exports differ under various regulatory scenarios. The paper examines trade among 15 importing (4 developing) countries and 31 (21 developing) exporting countries in the world. All of these countries are WTO members except for Russia, Kazakhstan, and Vietnam. These three countries are, however, observers.

The paper is organized as follows. Section II reviews the concepts and debates over food safety regulations in general in the world food trade. Section III reviews issues related to aflatoxin regulations and world food trade. Section IV develops the empirical methodology to estimate the effect of aflatoxin regulations on bilateral trade flows.

[1] One example of the widely different approach to standards and food safety among trading partners is the new European Union (EU) maximum allowable level of aflatoxins in cereals, dried and preserved fruits and nut imports. This regulation, set for implementation in April 2002, has generated concern among exporting countries, many of them developing countries. Among the countries expressing concerns over the new EU standards were Argentina, Australia, Brazil, Canada, Colombia, India, Indonesia, Malaysia, Mexico, the Philippines, Senegal, South Africa, Thailand, Turkey, Uruguay and the US (1998, CRC Press LLC).

Section V then reports the results, and Section VI concludes and discusses the policy implications.

## II. World Food Safety Regulations and Trade

Food safety regulations are mandatory controls over the quality attributes of a final product, based on the potential effects on human health from food handling, preparation, or consumption (Hooker 1999). The growing prominence of food safety controls in the public policy debate is based on both scientific and economic grounds (Henson and Caswell 1999). The role of science in forming food safety regulations includes the assessment of risk of food related hazards, the management of risk at a socially acceptable level, and the release of information about risk to the public. The economic basis for food safety regulation emerges out of the concept of a "socially optimum" level of risk at which the marginal costs of food safety regulations equal their marginal benefits to the society.

What about trade rules and food safety? The WTO Sanitary and Phytosanitary (SPS) Agreement disciplines play an important role in promoting harmonization of food safety standards. The Agreement was entered into force as part of the Uruguay Round Agreements in January, 1995. The overall goal of the Agreement is to ensure transparency and non-discrimination in how governments can apply food safety, animal, and plant health regulations. SPS measures also address issues relating to market failures involved with imperfect information on food safety that can arise when consumers cannot pay for desired levels of safety and/or producers fail to supply improved food safety (IATRC 2001).

Disputes related to SPS measures are often based on questions of (1) whether a food safety standard is based on sound scientific principles, (2) whether there is discrimination between treatment of domestic and foreign producers, and (3) whether the regulation in place is appropriate to mitigate against risk to public health and least trade distorting. The International Agricultural Trade Research Consortium (IATRC)( 2001) outlines three disputes that have challenged the use of science as a ground for food safety measures. The first case is where the U.S. and Canada challenged the scientific basis for the European Union(EU) ban on growth hormones in beef production. The second dispute challenged by the U.S. was regarding Japanese testing requirements regarding treatment effectiveness for new varieties of selected horticultural products. In the third case, Canada challenged Australia's ban on salmon imports to prevent the spread of fish diseases.

Food safety measures may have different implications in terms of the welfare effects in different countries depending on the differences in risk perceptions, available market information, the incidence of risk in production, and traditional methods of food processing and preparation as noted by IATRC (2001). The benefits of food safety regulation are reductions in risks of morbidity and mortality associated with the consumption of contaminated food (Antle, 1999). The costs of food safety regulation include the cost of production, the compliance cost, the administrative cost borne by the taxpayers, and the deadweight loss associated with taxation (Antle).

Petrey and Johnson (1993), Ndayisenga and Kinsey (1994), and Thilmany and Barrett (1997) illustrate the case where food safety regulations impede trade. DeRemer (1997) and Thornsbury et al.(1997) estimated the total impact of technical barriers on

U.S. exports of agricultural products, and it was $4,907 million in 1996, or 90 percent of which was due to sanitary and phytosanitary measures. The impact of food safety measures was estimated to be around $2,288 million.

According to Henson and Caswell (1999), several international standards organizations, such as Codex, the International Plant Protection Convention (IPPC), and the International Office of Epizotics (OIE) have attempted to harmonize food safety regulations. Codex has designed a food code, particularly to serve as a global food treaty that can promote and protect SPS standards. The WTO is a proponent of using this food code to resolve scientific disputes. According to Henson and Caswell (1999), there are two approaches through which national food safety regulations can be justified. First, is the adoption of international standards that are assumed to comply with the provision of SPS agreement. Second, is the assessment of the risks to human health, plants and animal life, as per food safety regulations.

**III. The Regulation of Aflatoxins**

The regulation of aflatoxins in food products has gained considerable attention in recent years. Aflatoxins are a group of structurally related toxic compounds that contaminate certain foods and have been associated with acute liver carcinogens in humans. The different types of poisonous aflatoxins found in food are B1, B2, G1 and G2 (UNDP-FAO, 2000). Aflatoxin B1 is the most toxic and common aflatoxin. It is generally present in corn and corn products, groundnuts and groundnut products, cottonseed milk, and tree nuts, e.g. Brazil nuts, pecans, pistachio nuts, and walnuts (FAO-WHO,1997). In 1997, a Joint FAO/WHO Expert Committee on Food Additives

(JECFA) estimated that reducing the aflatoxin standard from 20 ppb (part per billion) to 10 ppb will decrease 2 cancer deaths a year per billion people.

In 1997, the European Commission (EC) proposed a harmonization of maximum acceptable level of aflatoxins in certain foodstuffs. The standard ranged from 4ppb in cereals, edible nuts, and dried fruit, to 10ppb for nuts that are subject to further processing. Henson et al. (2000) noted that the EC proposal had led to concern among food exporters about the new and more restrictive standards' effect on trade patterns. Several exporting countries feared losses in their exports as a result of the more restrictive standard. Countries such as Bolivia, Brazil, Peru, India, Argentina, Canada, Mexico, Uruguay, Australia, and Pakistan requested detailed risk assessments from the European Union used in designing the new standard. As a consequence of consultations with their trading partners about these concerns, the European Commission relaxed the proposed aflatoxin standard in cereals, dried fruits, and nuts.

The revised aflatoxin standard in groundnuts subject to further processing was set at 15 ppb (8 ppb for B1) and 10 ppb (5 ppb for B1) for other nuts and dried fruits subject to further processing. For cereals, dried fruits, and nuts intended for direct human consumption, the standard was much more stringent and was set at 4 ppb (2 ppb for B1).[2] The aflatoxin standards suggested by Codex is significantly more relaxed than the EU standards. While Codex does set a standard specifically for B1 group of aflatoxin, it assumes that 50-70 percent or around 7.5-10.5 ppb of the total aflatoxin level of 15 ppb is caused by aflatoxin B1. The overall Codex standard, therefore, is approximately 9ppb.

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[2]Otsuki, Wilson and Sewadeh (2001a) provide a more detailed discussion of aflatoxin standards.

Otsuki et al. (2001b) find that the implementation of the new aflatoxin standard by the European Commission will have an adverse effect on African exports of cereals, dried fruits, and edible nuts to Europe. The results for 9 African and 15 European countries show that as the maximum allowable level of aflatoxin B1 is lowered by 1 percent, exports of cereals from Africa to Europe decreases by 1.1 percent and the drop is 0.43 percent for fruits, nuts and vegetables. Groundnuts are most significantly affected by aflatoxin standards with a 1.3 percent decrease in exports. Results suggest that the aflatoxin standards proposed by the European Commission are far more stringent than the guidelines set by Codex when considering reduced exports. The total loss of export revenue for the 9 African countries in the study is estimated to be US $400 under EU standards, compared to a gain of US $670 million if standards were adopted according to Codex guidelines.

## IV. An Econometric Model to Examine Trade and Food Safety Standards

When a measure of stringency of standards is available, an econometric approach has an advantage in measuring the statistical relationship between standards and trade flow, without prior imposition of the sign of the effect. It is also useful for examining policy implications once the relationship is estimated. Swann *et al.* (1996), Blind and Jungmittag (1999), Moenius (2000), Otsuki et al. (2001a), and Otsuki et al. (2001b), employed an econometric model where trade flows were regressed on a proxy for standards along with other factors that promote or divert trade. Swann *et al.* and Blind and Jungmittag regressed import and export on the stock of standards. Using a gravity model, Moenius regressed bilateral trade flow on the stock of standards along with Gross

National Product (GNP) and population, and geographical distance between variables countries.

A gravity model is used to explain bilateral trade flows using key economic variables that represent the size of a country's economy, such as Gross National Product (GNP) and population, and geographical distance between variable countries. When combined with data on food safety standards in importing countries, bilateral trade flow data allows analysis of how differing standards promote or limit trade between pairs of importing and exporting countries.

Our specification of gravity model is as follows:

$$\ln V_{ij} = b_0 + b_1 \ln GNPPC_i + b_2 \ln GNPPC_j + b_3 \ln DIST_{ij} + b_4 \ln ST_i$$
$$+ b_5 Dcol + b_6 D_{EU} + b_7 D_{ASEAN} + b_8 D_{NAFTA} + b_9 D_{MERCOSUR} + \varepsilon_{ij}$$

$V_{ij}$ denotes the value of trade from country $j$ to country $i$. It is obtained from the trade data of the United Nations Statistical Office. Products that are included in this analysis include wheat (SITC041), rice (SITC042), maize (SITC044), dried and preserved fruits (SITC052), and nuts (SITC05171 and 05172). We use data for the time period between 1995 and 1998. Parameter $b$'s are coefficients, and $\varepsilon_{ij}^{k}$ is the error term that is assumed to be normally distributed with mean zero. $GNPPCi$ and $GNPPCj$ are real per-capita GNP of importing country $i$ and exporting country $j$ in 1995 U.S. dollars, respectively. $DIST$ is the geographical distance between country $i$ and $j$.

$ST_i$ is the maximum level of Aflatoxin B1 imposed on imports by the importing country, $i$. It is expressed as Aflatoxin B1 contamination in parts per billion, and is obtained from FAO survey of mycotoxin standards on food and feedstuffs in 1995 (FAO, 1995). Table 1 depicts the Aflatoxin B1 standards for the importing countries in our sample. A greater value of this variable implies a more lax regulation of Aflatoxin B1 contamination, and vice versa. If this standard is applied at the border, products with Aflatoxin B1 contamination equal to or below *ST* would 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. In this respect, a country that exports food products to more than one country faces different aflatoxin standards. Positive trade flows in COMTRADE data recorded from country to country with different standards imply that countries export food products with differing levels of aflatoxin contamination. Under the fragmented system of standard setting, aflatoxin standards for food safety tend to be heterogeneous within a given exporting country (e.g. there are production and distribution channels that satisfy different aflatoxin standards). The standards of exporting countries, therefore, do not necessarily measure minimum level of aflatoxin contamination in their exports.

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 limit trade, then this coefficient is expected to be positive.

A dummy variable for colonial ties is included in order to control the omitted variable effect of colonial ties on trade flow as used in Otsuki et al. (2001a, 2001b). It takes the value of one if a colonial tie exists between a given set of importing and exporting countries, and zero, otherwise. Dummy variables for the free trade area (FTA) are included for a similar reason, as preferential treatment of exporting countries in a

FTA member is likely to have a trade-promoting effect (Soloaga and Winters, 1999). The terms $D_{EU}$, $D_{ASEAN}$, $D_{NAFTA}$ and $D_{MERCOSUR}$ denote the dummies for European Union, ASEAN, NAFTA and MERCOSUR, respectively. Dummy variables for the year also are included in the model, in order to control for systematic differences across time.

**V. Results**

Separate regressions are run for three product groups, cereals, nut products and dried and preserved fruits using an fixed-effects model. Following the models developed by Otsuki et al. (2001a, 2001b), a panel is formed, with respect to exporting countries whose unobserved characteristics that are country-specific, may cause systematic variation.

Results are reported in Table 2.[3] The results generally supports the conclusion that the gravity model is well suited to examine all product groups in the analysis. The coefficients for distance are negative and are significant for all of the product groups. The coefficients for per-capita GNP in importing countries are positive and significant for all of the product groups. The results for per-capita GNP are not predictable in prior due to two counteractive effects, domestic absorption and the scale effect on production.

We find that aflatoxin B1 standards in importing countries have a negative effect on trade flows in the cereals and nuts regression. The impact of the standard is insignificant in the dried and preserved fruits regression. The first two results are consistent with the findings in Otsuki et al. (2001b). When global trade is examined in

[3] The results were examined for robustness of variances using WLS. The fixed-effects model result is found to be robust against heteroscedasticity of the standard error.

cereals and nuts, we find that a more stringent standard tends to limit trade. The results for dried and preserved fruits indicates, however, that the negative effect of the aflatoxin standard cannot be generalized globally.

The EU dummy is found to be positive and significant for all of the product groups. The Mercosur dummy is found to be positive and significant for cereals and dried and preserved fruits, but is insignificant for cereals. The results for the other FTA dummies do not show a strong support for the trade-promoting effect of a FTA.

*Simulation Exercises Under Various Scenarios*

In this section, we predict how trade patterns change, as aflatoxin B1 standards are harmonized at varying levels. We make the following assumptions prior to conducting the simulation analysis. The first relates to the effect of an exporting country's standard on its exports. We do not have data on exporting country standards in all of the cases. Importing and exporting countries are treated independently, therefore, such that an assumed level of aflatoxin B1 standard of a country as an importer does not imply the level of maximum aflatoxin B1 contamination of its exports of the same product.

The fixed-effects model coefficient estimates on the standard variable are used to predict changes in trade flows associated with different levels of aflatoxin B1 standards.[4] Figure 1 presents the simulated relationship between aflatoxin standards and total trade flows between the 31 exporting countries and 15 importing countries.

[4] See Otsuki et al (2001a) for a detailed description of the methodology.

One important observation is the total trade flow under different levels of harmonization. Table 3 highlights the gains and losses for the trade flow of cereals and nuts at, (1) the Codex Standard, (2) EU harmonizing at 2 ppb and (3), the harmonized level of 2 ppb for all nations compared to the break even point where the sums of losses and gains from a harmonized standard are equal. This break-even point provides a zero-sum condition on the changes in the value of exports across the exporting countries. The Codex standard at 9 ppb being more lax than the standard at break even point (5.1 ppb for cereals and 4.1 ppb for nuts), increases the total trade flow of cereals and nuts by $6140 million. On the other hand, the stringency of EU standard at 2 ppb reduces the trade flow by $6050 million. The loss in trade flow is significantly less ($995 million) when only EU harmonizes at 2ppb while the rest of the countries maintain their status quo level i.e. standards remain unchanged from the 1998 level.

The other interesting issue would be to do a country level analysis that compares trade flow for all the exporters under a different level of standard. This paper presents five different scenarios to highlight this issue.

*Scenario One:* The first scenario compares (1) the value of exports when Europe adopts it new standard of 2 ppb in 2002 with all other countries' standards unchanged from their 1998 levels, and (2) all importing countries standards remain unchanged from their 1998 levels. This comparison shows how trade will change after Europe implements its new standard in 2002 for 31 exporting countries.

The results are reported in Table 4. They suggest that the value of exports under case (1) is US $ 995 million (8.3 percent) less compared to the case (2). Hungary, Israel and Brazil are found to be gainers from the EU harmonized standard. Their largest trading partner of cereals and nuts is Austria, which had a 1 ppb standard prior to the harmonization. The other importing countries in the exercise are all expected to decrease exports .

*Scenario Two:* In this case, the comparison is between (1) all importing countries adopting a standard of 2ppb and (2) Europe implements its 2ppb standard and all other countries stay at 1998 levels of regulatory stringency. As shown in Table 5 the value of exports under case (1) is US$ 5.1 billion (46 percent) lower when compared to case (2). This implies that trade becomes much more restricted when all importers adopt the EU harmonized standard.

While there is not an obvious pattern of distribution of gainers and losers in scenario 1, scenario 2 shows a clear contrast in the difference between developed and developing countries. The global harmonization at 2 ppb generates more loss for non-OECD countries than OECD countries. This is because the change in standards in non-OECD importing countries is more drastic than that in OECD countries given standards are less stringent in non-OECD today. Non-OECD countries that export primarily to other non-OECD countries tend to lose from a world wide harmonization of standards at 2ppb.

*Scenario Three:* The third scenario compares (1) a harmonization under a break-even condition where the sums of loss and gains from a harmonized standard are equal and (2) all importing countries standards remain unchanged from their 1998 levels. As Table 6 indicates, the majority of non-OECD exporting countries are losers whereas OECD countries are primarily gainers in this scenario. The OECD member countries are estimated to gain by US$ 536 million or 7.7 percent of the total exports from the OECD member countries in the sample. In contrast, the non-OECD countries are estimated to lose by US$ 502 million or 10 percent of the total exports from the non OECD countries in the sample.

*Scenario Four:* In this case, we examine trade flow when (1) all countries adopt an international standard of 9ppb in contrast to (2) all importing countries remaining at 1998 standards. Harmonization at the Codex level is estimated to increase the value of cereal and nut exports by US$ 6.1 billion or 51 percent of the status-quo level of 1998.

The results reported in Table 7 indicates that the value of exports under the case (1) generates US$ 6 billion more than the case (2). In this scenario the EU countries e.g. France, Denmark and the Netherlands gain as a result of Codex standard. This is because these countries trade with other EU countries such as Germany and U.K which have relatively stringent standard currently. When the standards are relaxed to the Codex standard at 9 ppb, these countries experience an increase in trade flows. In contrast, developing countries such as Pakistan, Vietnam and Thailand exhibit a trade loss as a consequence of adopting the Codex standard.

*Scenario Five*: In this exercise we compare the case where (1) all the importing countries adopting a standard of 2ppb and (2) harmonization of standards by all countries at 9ppb. The results in Table 7 suggest that harmonization at the 2 ppb level across all the importing countries will result in US$ 12.2 billion or 67 percent decrease in cereal and nut exports. Some of the losing exporters under case (1) i.e. at 2ppb are Thailand, Uruguay and Paraguay.. As we expect when the standards reach the stringency level of 2 ppb from the Codex standard, all the countries experience a loss in trade flows. Results are depicted in table 8.

Combined with the result in Table 5, the case (2) will result in $US 7.1 billion (64 percent) more exports than the case where only EU harmonizes standard at 2 ppb leaving other importing countries unchanged their standards.

In sum, the country-level analysis indicates that the value of exports from EU countries are relatively unaffected by the EU harmonized standard whereas developing countries are mostly losers from the harmonization.

In the final simulation, changes in value of trade flow are computed for each importing and exporting country. The trading partner within the sample countries which account for the largest gain and loss of trade flow is then identified. Table 9 and 10 contain all the results.

Table 9 presents the result for importing countries. The highest gain is experienced by U.K. with an estimated increase of 718.7 thousand, accounting for 45 percent of the total positive change in trade flow. Countries that increase imports from the harmonization at the break-even point level are UK, Germany, Austria, Brazil, France, Australia, Spain, Italy and Israel. However, among them three EU countries UK, Germany and Austria constitute for more than 90 percent of the gains. This reinstates the fact that EU countries have had the most stringent standard in the world and thus they are better off when standards are relaxed to 5.1 for cereals and 4.7 for nuts at the break even point. France is the major exporting partner to most of the EU importing countries. The harmonization thus will tend to increase intra-regional trade in EU or industrialized countries in general. India suffers the biggest loss in imports, with Thailand as its trading partner whose trade flow will decrease the most. This result confirms that India has the most lax standards (30 ppb) of all the importing countries in the sample.

Table 10 shows the result of the same exercise for the exporting countries. The result indicates that France increases exports accounting for 71.6 percent of the total positive gain. The six EU countries (France, Italy, Netherlands, Germany, Spain and Hungary) account for more than 95 percent of gains in exports. Their trading partners gaining from the harmonization are also EU countries, Germany, UK and Austria. This also confirms that the harmonization at the break-even point will greatly increase intra-EU trade. It should be noted that the trading partners(i.e. the importers) of the gainers are the countries with very stringent aflatoxin standard. Hence it is obvious that harmonization at the break even point benefits the six EU countries, the gains coming from countries moving to relatively lax standard from very stringent standard. On the other hand, most developing countries lose exports as a result of harmonization. Countries like Canada, Mexico, Australia and Pakistan who feared losses due to the stringent standards set by EU (2 ppb), suffer a loss in exports even from harmonization at the break-even point. With stringent standard level at EU harmonization, some countries in table 10 (e.g. Israel, Egypt) with very small gains are likely to lose . It is interesting to note that developing countries like India and Nigeria gain as exporters as a result of harmonization even though as importers they lose. This is due to the separation assumption on the base model for simulation. The change in the value of exports and imports of these countries are computed as though they were different countries. Hence, it is possible that India and Nigeria have the EU countries as their trading partners and hence, gain as exporters as a result of relaxation of standard in the EU due to harmonization. USA and Canada will also decrease their exports due to the contraction of mutual trade since their standards are more lax than the break-even level.

Simulation results in table 10 shows that U.S. and Canada lose in exports as a consequence of harmonization at the break-even point. Authors' calculation based on the UN COMTRADE data records report that U.S. and Canada experienced a 5.6% decline in exports in the global market between 1995-1998 .[5] Hence, it is reasonable to assume that harmonization of aflatoxin standard in general (may be different from the break even point level) will adversely affect U.S. and Canada as exporters. However, the effect of harmonization on European Union countries is imprecise. These countries experience a positive change in exports at the break-even point whereas UN COMTRADE data records show that there is a downward trend of 3.2% in exports for these countries between 1995-1998. Hence, the net effect of harmonization is hard to predict. On the other hand, the Asian, African and Latin American countries are found to have a positive trend in exports for the period 1995-1998. This positive growth is as high as 27% for the Asian countries. Consider Vietnam, Thailand, Sri Lanka and Pakistan as representative of the Asian sector. These countries who are actually suffering a loss in exports at the break even point might turn out to be gainers due to harmonization if this loss is offset by the positive trend in exports. The African and Latin American countries in our sample exhibit both positive and negative change in trade flow at the break even point. Hence, the net effect of harmonized aflatoxin standards on these countries is unclear at this point.

## VI. Conclusions

This study examines the impact of adopting international food safety standards and harmonization of standards on global food trade patterns. The paper develops

[5] Factors other than aflatoxin standard also affect this change in exports

econometric models and a simulation method to estimate the effect of aflatoxin standards in 15 importing (4 developing) countries on exports from 31 (21 developing ) countries.

The analysis extends Otsuki et al. (2001b) by broadening the country coverage from Africa to a global scope and by explicitly examining how imports and exports differ under various regulatory scenarios. Our analysis uses the first stage estimates of the elasticity of bilateral trade flows in certain foods with respect to the Aflatoxin B1 standard.

The findings support those in Otsuki et al. (2001b) which show that the value of trade in cereals and nuts is negatively affected by aflatoxin B1 standard and that this negative relationship is not apparent in the case of dried and preserved fruits trade.

The results in this analysis are combined to predict how the direction of trade is altered by food safety regulations under alternative scenarios. We find that adopting an international standard for aflatoxin B1 based on current Codex guidelines will increase cereal and nut trade among countries in the exercise by $US 6.1 billion, or 51 percent from the 1998 levels. It is $US 12.2 billion or 67 percent more than the value of exports under the case where all 15 importing countries harmonize their standards at the 2 ppb level. Moreover, we estimate that world exports would rise by $38.8 billion if an international standard (Codex) were adopted, compared to the current divergent national standards in place. Exports are estimated to decrease by $3.1 billion if the world adopted the EU standard (i.e. 2 ppb) compared to current national standards.

Harmonization of this food safety standard at a level more stringent than one suggested by international standards indicates that food safety standards can severely limit developing country exports. This analysis reveals, moreover, the trade impact of a fragmented food safety system in which national regulations differ across trading partners. An initiative to encourage international standards, along with mechanisms to directly assist developing countries in raising standards to international levels merits serious consideration. In this specific case of aflatoxin standards, one might consider programs to provide vaccination against hepatitis B to lower risk of liver cancer (along with other serious health risks), encouraging the development of an international standard to be adopted worldwide, and aid to the least developed producers of agricultural commodities most affected by aflatoxin contaminations.[6]

[6] For details on conclusions by JECFA regarding aflatoxin standards and risk see; John L. Herrman, World Health Organization, World Trade Organization, Presentation at the Risk Assessment Workshop, June 19-20, 2000, http://www.wto.org/english/tratop_e/sps_e/risk00_e/risk00_e.htm#programme.

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**Figure 1. Estimated Relationship between Aflatoxin B1 Standards and Trade Flow**

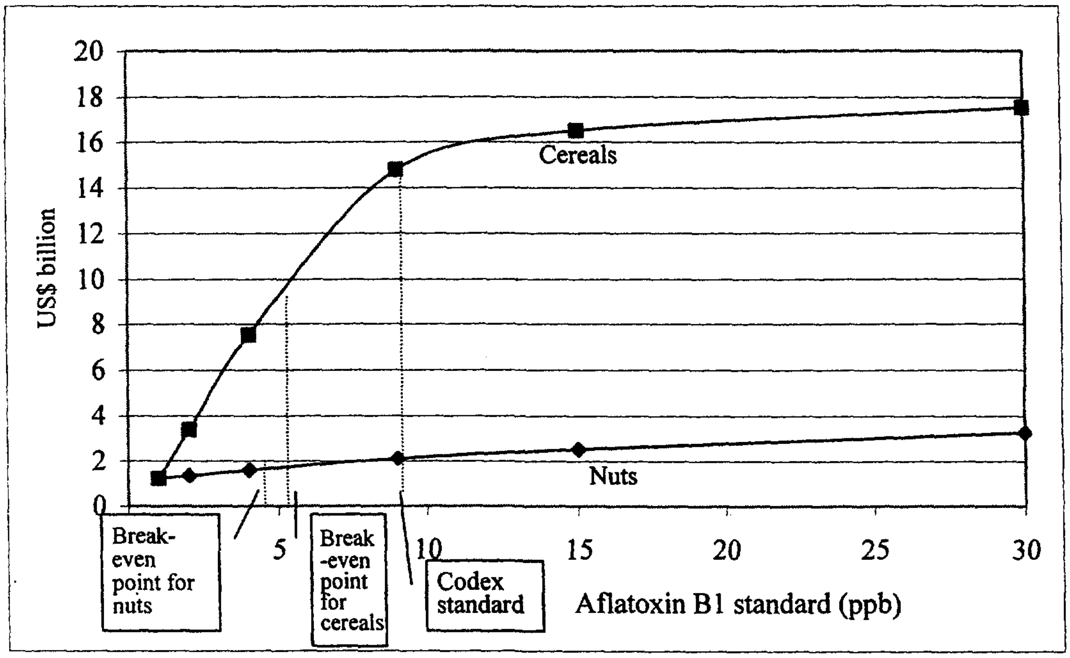

**Table 1. Aflatoxin B1 Standards followed by the Importing Countries**

| Importer | Standards for cereals and dried fruits (ppb) | Standards for nuts (ppb) |
|---|---|---|
| Australia | 2.5 | 7.5 |
| Austria | 1 | 1 |
| Brazil | 5 | 5 |
| Canada | 7.5 | 7.5 |
| France | 5 | 1 |
| Germany | 2 | 2 |
| India | 30 | 30 |
| Israel | 5 | 5 |
| Italy | 5 | 5 |
| Japan | 10 | 10 |
| Malaysia | 17.5 | 17.5 |
| Nigeria | 20 | 20 |
| Spain | 5 | 5 |
| UK | 2 | 2 |
| USA | 10 | 10 |

Source: FAO (1995)

**Table 2. Fixed-Effects Model Regression Results (Dependent Variable = Value of Trade Flow)**

| | Cereals | Nuts | Dried/preserved Fruits |
|---|---|---|---|
| Log of importer's GNP per capita | 0.25***<br>(0.09) | 0.27***<br>(0.09) | 0.77***<br>(0.1) |
| Log of exporter's GNP per capita | 0.99**<br>(0.48) | 0.55<br>(0.5) | 2.90***<br>(0.48) |
| Log of distance | -1.66***<br>(0.15) | -1.08***<br>(0.14) | -1.10***<br>(0.12) |
| Log of standard | 1.12***<br>(0.13) | 0.34***<br>(0.11) | 0.09<br>(0.11) |
| Colonial tie dummy | 2.44***<br>(0.92) | 1.84***<br>(0.61) | 1.8***<br>(0.51) |
| Dummy for European Union Member | 2.75***<br>(0.4) | 2.12***<br>(0.38) | 1.04***<br>(0.33) |
| Dummy for Mercosur Member | 3.76***<br>(0.85) | -0.96<br>(1.09) | 3.9***<br>(0.97) |
| Dummy for Asean Member | -1.93<br>(1.34) | -0.35<br>(1.17) | 2.23**<br>(1.06) |
| Dummy for NAFTA Member | -2.60***<br>(0.78) | 0.70<br>(0.7) | 1.03*<br>(0.61) |
| Time dummy for year 96 | 0.01<br>(0.23) | 0.02<br>(0.21) | 0.25<br>(0.19) |
| Time dummy for year 97 | 0.09<br>(0.23) | 0.20<br>(0.2) | -0.25<br>(0.19) |
| Time dummy for year 98 | 0.19<br>(0.23) | 0.03<br>(0.21) | -0.38*<br>(0.19) |
| Adjusted R-squared | 0.555 | 0.517 | 0.546 |
| Number of observations | 970 | 912 | 844 |

1. *, ** and *** imply significance at the 10 percent, 5 percent and 1 percent levels under a two-tailed test respectively.
2. Inside parentheses are standard errors.

**Table 3. Predicted Value of Trade Flow under Alternative Regulatory Scenarios (US$ million)**

| | Cereals | | | Nuts | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Flow | Change (B) | B/A % | Flow | Change (D) | D/C % | Flow | Change (F) | F/E % |
| Benchmark (No change) | (A) 9117 | 0 | 0.0 | (C) 2840 | 0 | 0.0 | (E) 11957 | 0 | 0.0 |
| Break-even Point | 9117 | 0 | 0.0 | 2840 | 0 | 0.0 | 11957 | 0 | 0.0 |
| Codex 9 ppb | 14783 | +5666 | +62.1 | 3313 | +473 | +16.7 | 18096 | +6140 | +51.3 |
| EU harmoniz-ation 2 ppb | 8108 | -1009 | -11.1 | 2854 | +14 | +0.5 | 10962 | -995 | -8.3 |
| All 2 ppb | 3382 | -5735 | -62.9 | 2524 | -315 | -11.1 | 5906 | -6050 | -50.6 |

**Table 4: Scenario 1**

| Exporter | EU 2ppb with the rest of the importers status-quo (US $1,000) | Status Quo (US$1,000) | Change from Status Quo (US $1,000) | % difference with status quo |
|---|---|---|---|---|
| Hungary | 51825 | 46737 | 5088 | 10.89 |
| Israel | 7260 | 7176 | 84 | 1.17 |
| Brazil | 26270 | 26228 | 42 | 0.16 |
| Paraguay | 37269 | 37366 | -97 | -0.26 |
| Uruguay | 46849 | 47068 | -219 | -0.47 |
| Sri Lanka | 20067 | 20162 | -95 | -0.47 |
| Argentina | 3840299 | 3858778 | -18479 | -0.48 |
| Tanzania | 5837 | 5871 | -34 | -0.58 |
| Vietnam | 35028 | 35420 | -392 | -1.11 |
| Pakistan | 94809 | 96083 | -1274 | -1.33 |
| India | 184913 | 188000 | -3087 | -1.64 |
| Egypt | 2593 | 2645 | -52 | -1.97 |
| Australia | 138015 | 142713 | -4698 | -3.29 |
| Thailand | 623751 | 646472 | -22721 | -3.51 |
| South Africa | 22410 | 23250 | -840 | -3.61 |
| Mexico | 4635 | 4888 | -253 | -5.18 |
| USA | 3673428 | 3901735 | -228307 | -5.85 |
| Zimbabwe | 2598 | 2805 | -207 | -7.38 |
| Nigeria | 1531 | 1724 | -193 | -11.19 |
| Canada | 362278 | 415762 | -53484 | -12.86 |
| Kazakhstan | 13464 | 15722 | -2258 | -14.36 |
| Russia | 2449 | 2958 | -509 | -17.21 |
| France | 1020665 | 1261822 | -241157 | -19.11 |
| Romania | 6642 | 8216 | -1574 | -19.16 |
| Spain | 99084 | 128920 | -29836 | -23.14 |
| Netherlands | 121900 | 165978 | -44078 | -26.56 |
| Italy | 290317 | 439438 | -149121 | -33.93 |
| Senegal | 4739 | 7258 | -2519 | -34.71 |
| Denmark | 13133 | 21342 | -8209 | -38.46 |
| Germany | 192118 | 363257 | -171139 | -47.11 |
| Austria | 15869 | 30843 | -14974 | -48.55 |
| Total | 21924092 | 23913276 | -1989184 | -8.32 |

## Table 5: Scenario 2

| Exporter | All importers 2ppb | EU 2ppb with the rest of the importers status-quo | Change from EU 2 ppb with the rest of the importers status quo | % difference with EU 2 ppb and the rest of the importers status-quo |
|---|---|---|---|---|
| | (US $1,000) | (US$1,000) | (US $1,000) | |
| Netherlands | 121376 | 121900 | -524 | -0.43 |
| France | 1012015 | 1020665 | -8650 | -0.85 |
| Germany | 190229 | 192118 | -1889 | -0.98 |
| Spain | 97327 | 99084 | -1757 | -1.77 |
| Denmark | 12853 | 13133 | -280 | -2.13 |
| Austria | 15522 | 15869 | -347 | -2.19 |
| Italy | 282161 | 290317 | -8156 | -2.81 |
| Israel | 6897 | 7260 | -363 | -5.00 |
| Hungary | 46576 | 51825 | -5249 | -10.13 |
| Brazil | 23535 | 26270 | -2735 | -10.41 |
| Tanzania | 4971 | 5837 | -866 | -14.84 |
| India | 142176 | 184913 | -42737 | -23.11 |
| Nigeria | 1114 | 1531 | -417 | -27.24 |
| Egypt | 1841 | 2593 | -752 | -29.00 |
| Romania | 4543 | 6642 | -2099 | -31.60 |
| Mexico | 3094 | 4635 | -1541 | -33.25 |
| Sri Lanka | 13246 | 20067 | -6821 | -33.99 |
| South Africa | 14762 | 22410 | -7648 | -34.13 |
| USA | 2394095 | 3673428 | -1279333 | -34.83 |
| Kazakhstan | 7920 | 13464 | -5544 | -41.18 |
| Senegal | 2703 | 4739 | -2036 | -42.96 |
| Russia | 1254 | 2449 | -1195 | -48.80 |
| Zimbabwe | 1060 | 2598 | -1538 | -59.20 |
| Vietnam | 12544 | 35028 | -22484 | -64.19 |
| Paraguay | 12177 | 37269 | -25092 | -67.33 |
| Argentina | 1253267 | 3840299 | -2587032 | -67.37 |
| Uruguay | 15287 | 46849 | -31562 | -67.37 |
| Australia | 41214 | 138015 | -96801 | -70.14 |
| Canada | 97333 | 362278 | -264945 | -73.13 |
| Thailand | 63760 | 623751 | -559991 | -89.78 |
| Pakistan | 9573 | 94809 | -85236 | -89.90 |
| Total | 5906424 | 10962047 | -5055623 | -46.12 |

**Table 6: Scenario 3**

| Exporter | Break –Even point | Status Quo | Change from Status Quo | % difference with status quo |
|---|---|---|---|---|
| | (US $1,000) | (US$1,000) | (US $1,000) | |
| France | 2124519 | 1261822 | 862697 | 68.37 |
| Netherlands | 250961 | 165978 | 84983 | 51.20 |
| Hungary | 66231 | 46737 | 19494 | 41.71 |
| Denmark | 29763 | 21342 | 8421 | 39.46 |
| Italy | 566311 | 439438 | 126873 | 28.87 |
| Spain | 164350 | 128920 | 35430 | 27.48 |
| Austria | 38430 | 30843 | 7587 | 24.60 |
| Germany | 434150 | 363257 | 70893 | 19.52 |
| Israel | 8551 | 7176 | 1375 | 19.16 |
| Nigeria | 1977 | 1724 | 253 | 14.68 |
| Romania | 8828 | 8216 | 612 | 7.45 |
| Brazil | 28169 | 26228 | 1941 | 7.40 |
| Egypt | 2833 | 2645 | 188 | 7.11 |
| Tanzania | 6234 | 5871 | 363 | 6.18 |
| India | 193889 | 188000 | 5889 | 3.13 |
| Paraguay | 37742 | 37366 | 376 | 1.01 |
| Uruguay | 47169 | 47068 | 101 | 0.21 |
| Argentina | 3864668 | 3858778 | 5890 | 0.15 |
| Kazakhstan | 15162 | 15722 | -560 | -3.56 |
| South Africa | 22029 | 23250 | -1221 | -5.25 |
| Russia | 2726 | 2958 | -232 | -7.84 |
| Senegal | 6405 | 7258 | -853 | -11.75 |
| USA | 3419356 | 3901735 | -482379 | -12.36 |
| Mexico | 4259 | 4888 | -629 | -12.87 |
| Sri Lanka | 16509 | 20162 | -3653 | -18.12 |
| Zimbabwe | 2255 | 2805 | -550 | -19.61 |
| Canada | 281076 | 415762 | -134686 | -32.39 |
| Australia | 79534 | 142713 | -63179 | -44.27 |
| Vietnam | 19278 | 35420 | -16142 | -45.57 |
| Thailand | 226445 | 646472 | -420027 | -64.97 |
| Pakistan | 21361 | 96083 | -74722 | -77.77 |
| Total | 11991170 | 11956637 | 34533 | 0.29 |

**Table 7: Scenario 4**

| Exporter | Codex Standard | Status Quo | Change from Status Quo | % difference with status quo |
|---|---|---|---|---|
| | (US $1,000) | (US$1,000) | (US $1,000) | |
| France | 2458854 | 1261822 | 1197032 | 94.87 |
| Denmark | 40883 | 21342 | 19541 | 91.56 |
| Netherlands | 317510 | 165978 | 151532 | 91.30 |
| Austria | 58441 | 30843 | 27598 | 89.48 |
| Paraguay | 70092 | 37366 | 32726 | 87.58 |
| Germany | 678527 | 363257 | 315270 | 86.79 |
| Uruguay | 87431 | 47068 | 40363 | 85.75 |
| Argentina | 7161983 | 3858778 | 3303205 | 85.60 |
| Italy | 806800 | 439438 | 367362 | 83.60 |
| Hungary | 85001 | 46737 | 38264 | 81.87 |
| Spain | 226340 | 128920 | 97420 | 75.57 |
| Romania | 13284 | 8216 | 5068 | 61.68 |
| Nigeria | 2608 | 1724 | 884 | 51.28 |
| Egypt | 3942 | 2645 | 1297 | 49.04 |
| Senegal | 10795 | 7258 | 3537 | 48.73 |
| Kazakhstan | 22322 | 15722 | 6600 | 41.98 |
| Russia | 4185 | 2958 | 1227 | 41.48 |
| Israel | 10122 | 7176 | 2946 | 41.05 |
| India | 241664 | 188000 | 53664 | 28.54 |
| Tanzania | 7534 | 5871 | 1663 | 28.33 |
| Brazil | 33164 | 26228 | 6936 | 26.45 |
| South Africa | 28413 | 23250 | 5163 | 22.21 |
| USA | 4602486 | 3901735 | 700751 | 17.96 |
| Canada | 481298 | 415762 | 65536 | 15.76 |
| Zimbabwe | 3199 | 2805 | 394 | 14.05 |
| Mexico | 5560 | 4888 | 672 | 13.75 |
| Sri Lanka | 20275 | 20162 | 113 | 0.56 |
| Australia | 125813 | 142713 | -16900 | -11.84 |
| Vietnam | 27389 | 35420 | -8031 | -22.67 |
| Thailand | 420877 | 646472 | -225595 | -34.90 |
| Pakistan | 39472 | 96083 | -56611 | -58.92 |
| Total | 18096264 | 11956637 | 6139627 | 51.35 |

**Table 8: Scenario 5**

| Exporter | All importers 2ppb | Codex Standard | Change from Codex Standard | % difference with Codex Standard |
|---|---|---|---|---|
| | (US $1,000) | (US$1,000) | (US $1,000) | |
| Brazil | 23535 | 33164 | -9629 | -29.03 |
| Israel | 6897 | 10122 | -3225 | -31.86 |
| Tanzania | 4971 | 7534 | -2563 | -34.02 |
| Sri Lanka | 13246 | 20275 | -7029 | -34.67 |
| India | 142176 | 241664 | -99488 | -41.17 |
| Mexico | 3094 | 5560 | -2466 | -44.35 |
| Hungary | 46576 | 85001 | -38425 | -45.21 |
| South Africa | 14762 | 28413 | -13651 | -48.04 |
| USA | 2394095 | 4602486 | -2208391 | -47.98 |
| Egypt | 1841 | 3942 | -2101 | -53.30 |
| Vietnam | 12544 | 27389 | -14845 | -54.20 |
| Nigeria | 1114 | 2608 | -1494 | -57.29 |
| Spain | 97327 | 226340 | -129013 | -57.00 |
| France | 1012015 | 2458854 | -1446839 | -58.84 |
| Netherlands | 121376 | 317510 | -196134 | -61.77 |
| Italy | 282161 | 806800 | -524639 | -65.03 |
| Kazakhstan | 7920 | 22322 | -14402 | -64.52 |
| Romania | 4543 | 13284 | -8741 | -65.80 |
| Australia | 41214 | 125813 | -84599 | -67.24 |
| Zimbabwe | 1060 | 3199 | -2139 | -66.86 |
| Denmark | 12853 | 40883 | -28030 | -68.56 |
| Russia | 1254 | 4185 | -2931 | -70.04 |
| Germany | 190229 | 678527 | -488298 | -71.96 |
| Austria | 15522 | 58441 | -42919 | -73.44 |
| Senegal | 2703 | 10795 | -8092 | -74.96 |
| Pakistan | 9573 | 39472 | -29899 | -75.75 |
| Canada | 97333 | 481298 | -383965 | -79.78 |
| Argentina | 1253267 | 7161983 | -5908716 | -82.50 |
| Paraguay | 12177 | 70092 | -57915 | -82.63 |
| Uruguay | 15287 | 87431 | -72144 | -82.52 |
| Thailand | 63760 | 420877 | -357117 | -84.85 |
| Total | 5906425 | 18096264 | -12189839 | -67.36 |

## Table 9. Predicted Change in Imports at the Break-Even Point

| Importer | Change (US$ 1,000) | Share in total positive (negative) change in percent | Change (%) in country's export | Partner whose trade flow will increase most | Change (US$ 1,000) | Partner whose trade flow will decrease most | Change (US$ 1,000) |
|---|---|---|---|---|---|---|---|
| UK | +718725 | +45 | +91 | France | 462788 | | |
| Germany | +642428 | +40.2 | +93 | France | 394212 | | |
| Austria | +93678 | +5.9 | +100 | USA | 40773 | | |
| Brazil | +74081 | +4.6 | +2 | Argentina | 71104 | India | 38 |
| France | +33577 | +2.1 | +4 | USA | 9111 | | |
| Australia | +18859 | +1.2 | +33 | Thailand | 8608 | India | 1851 |
| Spain | +7943 | +0.5 | +1 | France | 3489 | India | 99 |
| Italy | +6874 | +0.4 | +1 | France | 3403 | India | 125 |
| Israel | +1554 | +0.1 | +1 | USA | 770 | India | 159 |
| USA | -132257 | -8.3 | -52 | | | Canada | 91800 |
| Nigeria | -170477 | -10.7 | -78 | | | USA | 98833 |
| Japan | -190853 | -11.9 | -49 | | | USA | 80737 |
| Malaysia | -283674 | -17.8 | -73 | | | Thailand | 125267 |
| Canada | -325236 | -20.4 | -22 | | | USA | 307920 |
| India | -495190 | -31 | -91 | | | Thailand | 231528 |

**Table 10. Predicted Change in Exports at the Break-even Point**

| Exporter | Change (US$ 1,000) | Share in total positive (negative) change in percent | Change (%) in country's export | Partner whose trade flow will increase most | Change (US$ 1,000) | Partner whose trade flow will decrease most | Change (US$ 1,000) |
|---|---|---|---|---|---|---|---|
| France | +861288 | +71.6 | +69 | UK | 463235 | India | 1562 |
| Italy | +120195 | +10.0 | +28 | Germany | 71352 | India | 1482 |
| The Netherlands | +84559 | +7.0 | +52 | Germany | 57252 | India | 98 |
| Germany | +56169 | +4.7 | +17 | UK | 49075 | India | 343 |
| Spain | +27681 | +2.3 | +24 | UK | 13166 | Nigeria | 326 |
| Hungary | +19984 | +1.7 | +42 | Austria | 17829 | India | 1155 |
| India | +8828 | +0.7 | +4 | UK | 30390 | Malaysia | 16447 |
| Denmark | +8332 | +0.7 | +40 | Germany | 5492 | India | 61 |
| Austria | +7490 | +0.6 | +25 | Germany | 5279 | India | 74 |
| Argentina | +5542 | +0.5 | 0 | Brazil | 82251 | Nigeria | 20996 |
| Tanzania | +2118 | +0.2 | +10 | UK | 3010 | India | 419 |
| Romania | +543 | +0.05 | +7 | Austria | 746 | India | 455 |
| Paraguay | +367 | +0.03 | +1 | Brazil | 818 | USA | 137 |
| Nigeria | +314 | +0.03 | +16 | UK | 458 | India | 97 |
| Uruguay | +95 | +0.01 | 0 | Brazil | 1005 | Nigeria | 255 |
| Egypt | +51 | +0.01 | +4 | UK | 102 | India | 40 |
| Israel | +34 | +0.01 | +8 | Austria | 42 | India | 17 |
| Brazil | -189 | -0.02 | -1 | Austria | 1185 | USA | 735 |
| Russia | -239 | -0.02 | -8 | Germany | 204 | India | 368 |
| Zimbabwe | -478 | -0.04 | -14 | UK | 533 | Nigeria | 404 |
| Senegal | -643 | -0.05 | -6 | France | 397 | Nigeria | 867 |
| Mexico | -729 | -0.06 | -16 | Germany | 101 | USA | 259 |
| Kazakhstan | -837 | -0.07 | -6 | Germany | 1023 | India | 1694 |
| South Africa | -2188 | -0.2 | -17 | UK | 2045 | Nigeria | 1764 |
| Sri Lanka | -5163 | -0.4 | -25 | Austria | 625 | India | 2706 |
| Vietnam | -17471 | -1.5 | -49 | Austria | 468 | Malaysia | 10742 |
| Australia | -64675 | -5.4 | -55 | Germany | 1309 | Malaysia | 28509 |
| Pakistan | -75124 | -6.2 | -83 | Germany | 385 | India | 71428 |
| Canada | -134549 | -11.2 | -33 | UK | 12308 | USA | 91532 |
| Thailand | -419924 | -34.9 | -65 | Australia | 8614 | India | 231402 |
| USA | -481349 | -40 | -17 | UK | 67538 | Canada | 291574 |

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