

To Spray or Not to Spray?

Pesticides, Banana Exports, and Food Safety

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Abstract

How governments regulate food safety and environmental protection, including pesticide residue levels, has important implications for trade. The World Trade Organization (WTO) Ministerial held in Doha, Qatar in November 2001 included statements on standards and their impact on market access for developing countries. These issues will continue to be important in trade policy dialogues. It is assumed—and evidence from recent analysis confirms—that food safety standards can affect the ability of agricultural producers to meet regulatory standards set by importing countries. Wilson and Otsuki explore a fundamental question in food safety and environmental standards: Do regulations on pesticide have an effect on trade?

The authors examine regulatory data from 11 OECD importing countries and trade data from 19 exporting

countries. The results suggest that a 10 percent increase in regulatory stringency—tighter restrictions on the pesticide chlorpyrifos—leads to a decrease in banana imports by 14.8 percent. This represents a significant impact on trade and affect prospects of developing countries who continue to rely on exports of agricultural commodities, such as bananas. The findings also suggest that the lack of consensus on international standards and divergent national regulations on pesticides is costly. For example, the authors estimate that if the world were to adopt a standard at a level of regulatory stringency suggested by Codex (the body charged with setting global standards in this area), in contrast with one set at the level in place in the European Union, there would be a US\$5.3 billion loss in world exports.

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To Spray or Not to Spray: Pesticides, Banana Exports, and Food Safety

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1. Introduction

How governments regulate food safety and environmental protection, including pesticide residue levels, has important implications for international trade. Within this context, the growing use of pesticides accounts for a significant portion of the increase in food productivity over the past several decades. Pesticides clearly have assisted in controlling pests and maintaining the availability of low cost and high quality food. For example, Owens (1986) reports that crop and livestock production in the United States would drop by 25 to 30 percent, and prices of agricultural products would increase by 50 to 75 percent, if pesticides were completely withdrawn from use. Pesticides also allow for improved storage and distribution of crops, fruits, and grains.

There are also health risks, however, associated with pesticides. These risks include on-farm ingestion by workers, discharge of toxic chemicals into the air and water, and consumption of foods that contain pesticide residues by consumers.

Setting a balance between risk and methods to increase agricultural productivity is particularly important for developing countries. Many developing countries depend on food exports for exchange earning, particularly in cash crops. Bananas provide governments of exporting countries in Latin America, for example, exchange earnings with which to undertake important development plans and programs. They are the world's fourth most important export commodity and food crop (World Bank 1999). Developing countries constituted 20 percent of the total world demand for pesticides in

1995. The World Bank estimates that demand will grow to 40 percent over the period 1995 to 2000 (Poapongsakorn et al., 1999). Moreover, the most hazardous pesticides are still used in developing countries. Many of these are now banned or heavily regulated in developed countries. For example, Thailand imports large quantities of World Health Organization (WHO) I and II (most hazardous) pesticides (Poapongsakorn et al., 1999).¹

The way in which pesticides are regulated and standards set for minimum residue levels are also of importance relative to developing country exports. The costs of compliance with tighter food safety standards by exporters can be high. Otsuki et al. (2001a, 2001b) suggests that a change in food safety standards of one importing country affects a broad range of exporting countries. Forgone exports due to additional compliance costs with more restrictive standards can be significant.

The increasingly contentious debate over the balance between risk, precaution, and multilateral trade obligations increases the utility of empirical analysis on the effect of standards on trade. This paper attempts to broaden understanding of how standards on pesticide residues affect bananas exports. We conducted an empirical analysis of the relationship between pesticide residue standards in 11 Organization for Economic Cooperation and Development (OECD) countries and banana exports from 19 developing countries. A gravity model is used to examine the hypothesis that pesticide residue standards can be trade limiting. Chlorpyrifos standards are investigated, as it is one of the most commonly used pesticides in worldwide banana production.

¹ The World Health Organization (WHO) has classified pesticides into four categories (I, II, III, and IV) with the lower numbers indicating higher level of toxicity.

The organization of this paper is as follows. Section 2 reviews toxic pesticides that are or have been commonly used in the world along with their health implications. Section 3 reviews the European Union (EU) and international policies regarding banana trade and pesticide residues in food imports. Section 4 provides an overview of global banana trade. Section 5 develops an empirical framework to analyze the relationship between pesticide residue standards and bilateral trade flows. Section 6 reports the results and predicts trade flows under alternative levels of harmonized standards. Section 7 provides policy implications of the analysis.

2. Health hazards of pesticides

2.1 General issues

Pesticides are diverse and omnipresent. Approximately 1400 pesticides are being used worldwide. Commonly used pesticides include herbicides (destroys unwanted weeds and plants), insecticides (kills insects and other arthropods), rodenticide (controls mice and other rodents), and fungicides (kills fungi). All pesticides are toxic by their nature, and hence, they cause human and animal health hazards through exposure or dietary intake.

Prior Informed Consent (PIC) held in September 1998 identified 22 harmful pesticides and five industrial chemicals that have been banned or severely restricted in a number of countries and required that these pesticides cannot be exported unless agreed

by the importing country. The PIC list included the following 22 hazardous pesticides.² Pesticides such as DDT, Chlordane, Lindane and Aldrin have been completely banned or severely restricted in North America and Europe because of their acute toxicity.

Pesticide residues to the local environment (air, soil and surface water) affect the lives of birds, wildlife, domestic animals, fish, livestock and human beings. Human health hazards vary with the type of the pesticides and also with the extent of exposure. Moderate human health hazards from pesticides include mild headaches, flu, skin rashes, blurred vision and other neurological disorders while rare, but severe human health hazards include paralysis, blindness, and even death. (GAO,1994). A study by Repetto and Baliga (1996) shows that pesticides can damage the human immune system by reducing the number of white blood cells and disease fighting lymphocytes. Long run health impacts include cancer, infertility, miscarriage, male sterility, birth defects, and effects on the nervous system.

Farm workers are at much greater risk of toxicity due to exposure to pesticides. According to the United States Environmental Protection Agency (EPA) approximately 4 million U.S. farm workers are at high risk of pesticide exposure and about 10,000 to 20,000 pesticide-poisoned farm workers are treated every year. Risk of birth defects is reported with certain pesticides, particularly, the herbicide 2,4-D used in farmland (Garry et al., 1996). Pingali et al. (1994) found a greater probability of eye and skin problems

² They are 2,4,5-T, Aldrin, Captafol, Chlordane, Chlordimeform, Chlorobenzilate, DDT, Dieldrin, Dinoseb, 1,2-dibromoethane (EDB), Fluoroacetamide, HCH, Heptachlor, Hexachlorobenzene, Lindane, Mercury compounds, certain formulations of Monocrotophos, Methamidophos, Phosphamidon, Methyl-parathion and Parathion. The industrial chemicals are: Crocidolite, Polybrominated Biphenyls (PBB), Polychlorinated Biphenyls (PCB), Polychlorinated Terphenyls (PCT), Tris (2,3 dibromopropyl) phosphate.

associated with on-site use of pesticides among rice producers in the Philippines.³ Crissman et al. (1994) found a link between pesticide use and incidence of chronic dermatitis among Ecuadorian potato producers.⁴ Also, the EPA (1992) reports that a significant population of Nebraska farm workers had reduced levels of blood cholinesterase, a common symptom of organophosphate exposure.

People residing close to farmland can also experience pesticide related problems due to dumping of pesticide wastes, wind drafts from aerial spraying, or from the use of empty pesticide containers for drinking water storage. Repetto and Baliga (1996) found that in Nicaragua, people living near cotton fields sprayed with insecticides had depressed cholinesterase levels that may occur due to exposure to common insecticides like organophosphates. The EPA estimated that between less than 1 percent of the community water systems and rural domestic wells had concentration of pesticide residues higher than maximum allowable level.

Risk of dietary exposure to pesticide residues are of much concern. The probability of estimated aggregated cancer risk⁵ turned out to be 0.006 assuming consumption of food with residues at the level of maximum residue limit (National

³ According to Pingali et al.'s (1994) case study over the period 1989-1991, the probability of eye abnormalities among the sample households was 17 percent higher when three doses of insecticide were applied instead of one recommended amount. They also indicate that the probability of having skin problems was 20 percent higher when two applications of herbicide were applied instead of one application as recommended. Insecticides include organophosphates such as methylparathion and chlorpyrifos, carbamates such as BPMC, carbaryl, and carbofuran and pyrethroids such as cypermethrin and deltamethrin. Butachlor was the primary herbicide used. These insecticides are WHO Class I and II, and these herbicides are Class IV chemicals.

⁴ According to Crissman et al.'s (1994) study in 1991-1992, 93 percent of the farm workers exposed to pesticides have skin problems compared to 81 percent in the sample group of nonexposed farm workers. Chronic dermatitis was 28 percent compared to 14 percent in the sample group.

⁵ Excess cancer risk estimates the probability that a person will die from cancer due to exposure of pesticides based on the current number of survivors to such exposures.

Research Council, 1987). Some pesticides, e.g. dieldrin, DDT and heptachlor, whose registration has been cancelled, have higher cancer risks than the normally used pesticides. In an EPA report of 1987, pesticides in food were considered to be most hazardous to human health. The EPA identified 55 pesticides that could leave carcinogenic residues in food (National Academy of Sciences, 1987). However, no evidence was found that the presence of pesticide residues in food contribute significantly to cancer risk in the U.S. (National Academy of Sciences, 1989). Most fresh produce in California in 1990 contained negligible amounts of residues that are above the maximum residue limits (American Council on Science and Health, 1998).⁶

2.2 Chlorpyrifos pesticides and health implications

In this paper we focus on a particular insecticide known as chlorpyrifos. It is one of the more widely used organophosphates⁷ and is categorized as a Class II pesticide by the WHO, indicating a moderately high level of toxicity. According to the EPA, chlorpyrifos is mainly used on agricultural farms, and in non-agricultural settings such as homes, office buildings, schools and warehouses. It is used as a perimeter treatment that is sprayed to kill ants, mites, cockroaches, crickets, grasshoppers, millipedes, etc. (USEPA 2000). Pinese and Elder (1994), points out that chlorpyrifos is commonly used to repel rust thrips in banana production. For example, Chiquita Brands International Inc, one of the world's largest banana companies, uses a method to impregnate chlorpyrifos

⁶ Only 0.17 percent contained residues above the allowable limits, and 0.62 percent had residues of pesticides that are not legalized for that commodity.

⁷ Organophosphates account for about 50% of the insecticides used in the U.S. (<http://www.epa.gov/pesticides/op/chlorpyrifos/consumerqs.htm> #2)

on the bags that cover ripening bananas, in order to protect them from rust thrips.(Gallagher, McWhirter and Wells 1998).

This pesticide can over-stimulate the nervous system causing nausea, lung congestion, chest pain, and dizziness. At high exposure levels, it can cause respiratory paralysis and death. It is highly toxic to fish, crab, shrimp, birds and other wildlife. Risk mitigation acts by the EPA currently include the gradual elimination in the use of chlorpyrifos by homeowners and limited use in agriculture and in other professions.

3. Pesticide residue standards and food trade

The Acceptable Daily Intake (ADI) of the pesticide residue which is established “on the basis of a complete review of the available information, including data on the biochemical, metabolic, pharmacological, and toxicological properties of the pesticide is derived from studies of experimental animals and observations in humans” (GEMS/Food, 1997). The total dietary intake of a particular pesticide residue in a food product is calculated by summing over consumption of all the food containing the residue, weighted by the maximum residue level (MRL) of a particular pesticide in each food.⁸

MRLs on food imports were generally set individually by each country, and they have been referred to as regulatory standards at the border. While regional trade arrangements were formed, some effort to harmonize MRLs have been made in the 1990’s.

The European Union has been implementing a program to harmonize MRLs of pesticides in food sold since 1993 (Chan and King, 2000). Between 1993 and July 2000,

⁸ The MRL is an index that represents the maximum concentration of a pesticide residue (expressed as mg/kg) legally permitted in food commodities and animal feeds.

the EU established MRLs for specific crop and pesticide combinations for 102 active pesticide ingredients. For several crop and pesticide combinations, however, acceptable data to establish MRLs were not available. In July 2000, the position for 102 pesticides or active ingredients were closed off. Data were not available for some crop/active ingredient combinations, and the MRL was set at the analytical Limit of Determination (LOD) i.e., analytical zero for that combination. All of the EU MRL positions established in July 2000 were approved and implemented as national legislation by all of the EU member countries in July 2001 (Chan and King, 2000). Another set of MRLs for 585 pesticides were closed off in December 2000 with the legislation intended to be implemented in December 2001. The EC legislation also required member and nonmember countries to monitor pesticide residues in food. Failure to do so by March 2000 led to suspension of imports from 43 countries (WTO G/SPS/R/20, January 16, 2001).

In the U.S., only pesticides that have been licensed can be used or sold based on the standards set by the Food Quality Protection Act of 1996. The EPA reviews all pesticides to ensure that they meet the requirements of the act. The first group of pesticides to be reviewed by the EPA were organophosphates (including chlorpyrifos). According to Young, Rao and Cort (1996), a typical pesticide has to go through 100 tests before it gets approved for use in the U.S., and the entire process can take more than three years. Once approved, labeling instructions must be developed for proper use, handling, storage and disposal. The OECD countries also have environmental programs to regulate pesticide residue standards and manage risk from pesticides. The Working

Group of Pesticides of the OECD conducts risk assessments of pesticides that have been on the market for a long time, and on newly developed pesticides (US EPA 2001).

In Japan, the Ministry of Agriculture, Forestry and Fisheries implemented the first pesticide residue standard set on apples in 1956 (Sapporo City Institute of Public Health of Japan, 1997⁹). By 1978, pesticide residue standards were extended to 53 food items and 28 pesticides. Standards were planned to be set on all food items and 200 pesticides by the year 2000.

On the other hand, around 30 percent of the pesticides marketed in the developing countries do not meet the international standards (WHO 2001). The poor quality pesticides are mostly prevalent in sub-Saharan Africa, where regulations are very weak. Lack of administrative regulatory capacity and agricultural development programs partially cause the unsafe use of pesticides in the developing countries (Paarlberg 1992).

Efforts have been made to develop guidelines for global food trade by international standard development bodies. The Codex Committee on Pesticide Residues (CCPR) a subsidiary body of the Codex Alimentarius Commission (Codex) develops MRL based on food consumption data in order to ensure that it stays within the limits of ADI. The Global Environment Monitoring System–Food Contamination Monitoring and Assessment Program (GEMS/Food), in collaboration with CCPR (FAO/WHO) prepared the guidelines for predicting dietary intake of pesticide residue in 1989. These guidelines assist in the formulation of international dietary exposure assessments for most pesticides. Certain pesticides require more accurate and detailed guidelines for dietary exposure

⁹ Pesticide residue standards in food. 1997, Public Health no.16 December. Sapporo City Institute of Public Health. <http://www.city.sapporo.jp/eiken/various/pesticid/agri.htm>

assessment. The guidelines were revised in 1995 that provided the basis for exposure assessment of long term hazards posed by pesticide residues at the national and international levels. These guidelines are detailed enough in order to provide reasonable assurance that the Codex MRLs will not result in a dietary intake of a pesticide that will exceed its ADI, and hence convince national authorities to adopt Codex standards.

4. Banana markets and policies

In the world banana trade, the developing countries' share is 68 percent (UN Comtrade Records, 1998).¹⁰ The developing countries' share of bananas to the total developing countries' fruits and vegetables exports is 14 percent. As shown in Table 1, the United States, Japan and EU countries are major importers of bananas. Central and South American countries and several EU countries are major exporters of bananas.

Banana production involves various stages of processing and marketing, which promotes vertical integration. This has made the industry oligopolistic, being dominated by multinational enterprises such as Chiquita Brands, Inc., Dole Food Company, and Del Monte Foods Company (Carlos, 1981). These enterprises are particularly dominant in Latin America.

The banana market underwent a drastic change in the early to mid 1990s when the Common Market Organization (CMO) for bananas introduced in July 1993 was extended to the Single European Market (SEM). Under the Single European Market, the various national schemes throughout the EU were harmonized and replaced by a common market regulation for bananas. Before harmonization occurred, Germany had no tariffs on imports and Denmark, Belgium, Luxembourg and Ireland had 20 percent tariff rates. In

¹⁰ The data are total value of bananas and plantains. But bananas have a dominant share at 99 percent.

countries such as France, Greece, Italy, Portugal and Spain, market access was determined by national quotas. Hence, the banana market in Europe was highly segmented before 1993.

The harmonization policy was opposed by member countries such as Germany (applying zero tariffs on imports from third countries) and also Denmark, Belgium, Luxembourg and Ireland (applying 20 percent tariffs on imports from non-member countries), which had low banana prices and expected large price increases with harmonization. Banana exporting Latin and Central American countries also opposed the EU policy. Under the new regime, the ACP (African Caribbean and Pacific Countries), suppliers were allowed up to 857.7 thousand tons of duty free exports. However the third countries (non ACP suppliers) including the dollar exporters¹¹ had to face tariffs of 100 ECUs per ton for a 2 million ton quota. The ACP suppliers had country specific quota and countries like Cameroon and Cote d'Ivoire met their quota levels. These countries were categorized as non-traditional ACP banana suppliers and they faced the same tariff-quota regime as the non-ACP countries (Thagesen and Mathews ,1997 and Verissimo, 2001)

A General Agreement on Tariffs and Trade (GATT) panel led by Colombia, Costa Rica, Guatemala, Nicaragua and Venezuela argued that the preferential trading agreement between EU and the ACP countries were inconsistent with the provisions of GATT. This led to a change in the CMO regime, and the four Latin American countries except Guatemala reached an agreement with the EU in December 22, 1994 known as the Banana Framework Agreement (Thagesen and Mathews, 1997). The quota was increased

¹¹ Dollar exporting countries include Colombia, Costa Rica, Guatemala, Honduras, Panamá, Ecuador and Brazil.

to 2.2 million tons, and the specific tariff was reduced to 75 ECUs per ton for the third countries. The four Banana Framework Agreement (BFA) countries, Costa Rica, Colombia, Nicaragua and Venezuela had 49.4% share of 2.2 million tons. A further 90,000 tone quota was allocated to the non-traditional ACP suppliers that include Cote d'Ivoire, Cameroon, Belize and Dominican Republic. The remaining 50.6% minus 90,000 tones went to the third countries i.e. the non BFA countries and was mainly shared by Ecuador, Panama, Honduras and Guatemala.(refer to Table 2).

With a ruling from the WTO Dispute Settlement Panel in late 1999, the third country quota was further increased to 2.55 million tons, with a specific tariff of 75 Euros per ton (McCorriston, 2000). These quotas were further assigned to each of the non-ACP exporting countries. Among those, Columbia, Costa Rica, Ecuador, and Panama accounted for 95 percent of the total quota share assigned to the third countries. Each allocation is 23.03, 25.61, 26.17 and 15.76 percent, respectively.

Whether these EU quotas were binding, actual banana exports from the ACP and non-ACP countries were examined by the WTO in April 1999. The WTO reports that the total exports from the ACP countries were below the total quota of 857.7 thousand tons, but that the quotas on the non-ACP countries were actually binding in 1998 (WT/DS27/ARB, WTO, 1999).

Considering the fact that in the late 1980's, about 75 percent of the world's bananas were exported by the Latin American countries, it is not surprising that Kersten (1995) finds that, under the new regime, the Latin American banana exporting countries lost market share. The cost to EU consumers has risen to US\$ 2 billion a year from US\$ 400 million a year, a huge portion of the cost being redistributed from the French

and the British to the Germans, who had no tariff before the Common Market Organization took place (Borrell, 1997). The U.S. has three big banana distributors, namely Chiquita, Dole and Del Monte, who lost market share to the EU competing firms due to harmonization.

5. The econometric model and data

The eleven importing countries studied include, 6 EU countries (Belgium, Luxembourg, France, Germany, the Netherlands, and the United Kingdom), Canada, Japan, New Zealand, Switzerland, and the United States. The nineteen exporting countries studied include 10 Central and South American Countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Panama), 4 African countries (Cameroon, Cote d'Ivoire, Morocco and South Africa), 5 Asian countries (China, India, Indonesia, Philippines and Taiwan). These exporting countries are the major exporters of bananas in each region. The six EU countries are aggregated and treated as one country.

A gravity model is used to analyze the effects of pesticide residue standards on bilateral trade flows, using the key economic variables that represent the size of a country's economy such as Gross National Product (GNP) and population, and also the geographical distance between the variable countries is used. A Logarithm of bilateral trade flows in real value is regressed on logarithms of GNP of the exporters and the importers, geographical distance between each pair of importers and exporters, pesticide residue standards for chlorpyrifos in the importing country, rainfall levels in the exporting countries, and dummies for a free trade agreement (FTA), colonial ties, years, and regional dummies.

The specification of the gravity model is as follows:

$$\begin{aligned} \ln(V_{ij}^t) = & b_0 + b_1 \ln(GNP_i^t) + b_2 \ln(GNP_j^t) + b_3 \ln(POP_i^t) + b_4 \ln(POP_j^t) + b_5 \ln(DIST_{ij}) \\ & + b_6 \ln(PST_i^t) + b_7 \ln(RAIN_j^t) + b_8 D_{BFA} + b_9 D_{NBFA} + b_{10} D_{NTACP} + b_{11} D_{APEC} + b_{12} D_{NAFTA} \\ & + b_{13} D_{EUCOLij} + b_{14} D_{USACOLij} + b_{15} D_{1997} + b_{16} D_{1998} + \varepsilon_{ij}^t \end{aligned}$$

where i and j stand for the importer and exporter respectively, and t denotes time.

Parameter b 's are coefficients, and ε_{ij} is the error term that is assumed to be normally distributed with mean zero. The data used here is for the time period 1997 to 1999. V_{ij} denotes the value of trade from country j to country i . It is obtained from the trade database of the United Nations Statistical Office. Banana and plantains (SITC Revision 1 code of 0513) are the products included here for the analysis. GNP_i , POP_i , GNP_j , and POP_j are the real Gross National Products (expressed in 1995 U.S. dollars) and populations for the importing and exporting countries, respectively, were obtained from the World Development Indicators of the World Bank for the period of 1997-1999. The total GNP and population is used for the EU. $DIST_{ij}$ is the geographical distance between country i and j . The rainfall data ($RAIN_j$) is included, since it affects the level of production in the exporting countries. The data source is the surface data inventories of the U.S. National Climatic Data Center. The average rainfall and distance among the 6 EU countries is used for the EU.

PST_i is the maximum residue limit of the pesticide chlorpyrifos, imposed on imports by the importing country i . The maximum residue limit (MRL) is expressed in parts per million (ppm), and was obtained from the Ministry of Agriculture and Forestry, New Zealand. A higher (lower) value of the standard implies more lax (stringent)

regulation of the pesticide residue limit. Assuming that the regulation on pesticide residue limits are strictly imposed by importing countries, chlorpyrifos residues contents in the imported bananas are less than the MRLs of the individual importing countries. The 0.05 ppm standard is used for the EU because all but the Netherlands had this standard. The validity of this assumption is tested in the post-regression analysis by omitting the Netherland from the EU. The coefficient for the pesticide residue standard implies that the change in the value of trade for an incremental change in the residue standard. The coefficient is expected to be positive if this standard limits trade.

The tariff-quota system that the EU have exercised on banana imports may have had distinct effects on their trade flows. It is not precisely known in many cases whether quota was binding or not, and what tariff rate are applied to each exporting countries in a given year. It is therefore difficult to specify in the model how the EU tariff-quota policies might affect trade flow. Dummy variables for EU tariff-quota arrangements are used to control for the effect of the tariff-quota system while the inclusion of these dummy variables necessarily imposes the assumption that the value of banana imports from all exporting countries within a given EU tariff-quota regime to the EU increases or decreases in a same proportion by the regime. As Table 2 indicates, there are four mutually exclusive groups of countries that export bananas to the EU, (1) BFA, (2) non-BFA and non-ACP, (3) non-BFA and traditional ACP, and (4) non-BFA and non-traditional ACP. For example, the dummy for BFA supplier equals one if EU countries import from a BFA supplier, and zero otherwise. Likewise the dummy variables for the other groups. A dummy variable for the second group is not included in the analysis since there is no ACP country in our sample. Assuming that there is no other systematic

tariff-quota arrangement between the rest of the OECD countries and our exporting countries, the EU tariff-quota arrangement dummies can be used to compared with no-arrangement cases. Thus, we can test (1) whether the EU tariff-quota arrangement actually encouraged or discouraged banana trade, and (2) how the effect of the EU's differential treatment of exporting countries differ from each other.

Colonial tie dummies are included to control the omitted variable effect of colonial ties on trade flows (Otsuki et al., 2001a, 2001b, Wilson and Otsuki, 2001). The NAFTA and APEC dummies (D_{APEC} and D_{NAFTA} , respectively), are included to capture the trade promoting effects due to free trade agreement. Year dummies, D_{1997} and D_{1998} , are included in the model to control for systematic differences across time.

A Fixed-Effect model is estimated and reported in Table 3 assuming that country-specific effects vary systematically among the exporting countries. The results for alternative specifications are also presented in the table. The model in the second column omits the population variables of both importing and exporting countries. This is done to examine whether the result of the full model (Model I) is robust against multicollinearity between the GNP and population variables. The model in the third column, instead, omits the EU tariff-quota arrangement dummies in order to examine the robustness of the result when this arrangement is not accounted for.

In Models I, II and III, an importing country's GNP is significant while an importing country's population is insignificant. Geographic distance is negative and significant as expected. The comparison between Model I and II indicates that the magnitude of the coefficient estimates greatly change with or without the population variables, suggesting high multicollinearity between the GNP and population variables.

However, the coefficient estimates for the other explanatory variables are close enough to support that the specification with respect to the GNP and population variables do not matter much.

The chlorpyrifos standard is positive and significant in the all three models. The difference in the coefficient estimates between Model I and II indicates a slight sign of multicollinearity between the standards and population variables, but it is acceptably small. The positive sign indicates that banana imports are greater for a country that has less stringent standards on pesticide residues. The results support the hypothesis that this pesticide standard can have a trade diversion effect. The evidence indicates that decisions on banana export destinations are made considering these pesticide residue standards when the other major determinants of the trade such as GNP, population, trade policies and the other country specific effects are controlled.

The magnitude of the coefficient (1.48) in the Model I, which can be described as the elasticity of chlorpyrifos standard for bilateral trade flow, shows a high responsiveness of banana exports. This elasticity is greater than the case of the Aflatoxin B1 standard for cereals and nuts (from 0.34 to 1.12) that are found in Wilson and Otsuki's (mimeo) cross country study on aflatoxin standards. The validity of the assumption that all the six EU countries follow a single standard is examined by omitting the Netherlands when aggregating the variables for the EU. The magnitude and statistical significance of this coefficient estimate are found to be unchanged under the alternative data construction, and those of the other explanatory variables found not to differ between the two cases. This implies that the single standard assumption is acceptable.

The rainfall variable is insignificant. Most of the exporting countries in this study are located close to the tropics where the rainfall is heavy. The result perhaps indicates that having a higher level of rainfall among these countries does not necessarily imply higher productivity of banana production.

The results with respect to the EU tariff-quota arrangement generally indicate a higher trade flow under the arrangement. Non-BFA signatories among non-traditional ACP countries exported more due to the arrangement with other things being fixed. The effect of the arrangement is insignificant on the BFA signatories, however. The comparison between Model I and III indicates that the coefficient estimates for the key explanatory variables are not affected by the omission of these dummies. The coefficient for the standards variable is particularly almost unchanged.

The colonial tie dummies are insignificant. This is presumably because the EU's tariff-quota arrangement in large part reflected preferential arrangement for their former colonies. The APEC dummy is positive and significant, suggesting that the FTA works favorably on the member countries. On the other hand, the NAFTA dummy is insignificant, suggesting that it is not the case.

6. Simulation

Table 4 presents the changes in the values of the banana exports from the 19 exporting countries under four alternative regulatory scenarios from those under the pre-harmonization status. These alternative scenarios include (1) when all importers follow the standard of 0.05 ppm (the standard for EU countries except for the Netherlands); (2) when a standard of 0.1 ppm followed by all importers (the standard for the U.S., Canada

and Switzerland); (3) when a harmonized standard of 0.5 ppm is followed (the standard for Japan and the Netherlands); and (4) when the standard is 2 ppm (New Zealand). The 2.0 ppm standard is also recommended by the Codex as an international standard. We assume that the predicted increase or decrease in the value of export will exceed 100 percent of the pre-harmonization level for each importing exporting country pair in order to avoid unrealistic cases; i.e., negative exports or more than double export.

Under the first scenario, all countries lose due to the standard of 0.05 ppm. China, Taiwan and South-East Asia are predicted to lose more in percentage, as their major trading partner is Japan, which had relatively less stringent standard under the pre-harmonization status. The Philippines loss is the greatest in terms of level as it is the largest banana exporter in Asia. On the contrary, the loss experienced by the African countries is less as they have mainly exported to the EU in the pre-harmonization, which had the most stringent standard. The percentage losses of Latin American countries will be between those extremes since their banana exports have been diversified between the EU and the U.S. Among these countries, Costa Rica, Guatemala, Columbia and Ecuador account for the significant part of these losses in terms of level as expected. The India's percentage loss is greater than those of Latin America because its major export partner is the U.S.

When the standard is relaxed to 0.1 ppm, 15 of the exporting countries are predicted to increase in export while China, Indonesia and Philippines and Taiwan will still lose. This is because the Japan's pre-harmonization standard is still less stringent than this standard. Among the countries that increase export, African countries will increase most due to the EU's stringent pre-harmonization standard.

At the standard of 2.0 ppm, which is also recommended by the Codex, all the exporting countries will increase their exports by 96.7 to 100 percent. The total values of banana exports under the most stringent standard is US\$ 1.8 billion or 49.1 percent less than that under the pre-harmonization status. The least stringent (Codex) standard will lead to a US\$ 3.5 billion increase in banana exports. The total values of banana exports under the most stringent standards differ by US\$ 5.3 billion or 75 lower than that under the least stringent (Codex) standard scenario. This implies that the both pre-harmonization and the EU standards will lead to a trade flow significantly smaller than that under the internationally recommended standard.

7. Conclusion

Understanding the trade-offs between public health, food productivity and economic development is essential for crafting efficient regulatory and trade policies. The purpose of this paper is to shed light on implication of pesticide residue standards. This paper employs a gravity model to examine the relationship between chlorpyrifos pesticide standards and banana exports from 19 major exporting countries in the developing regions to major importing countries in the OECD group.

The results indicate a negative effect of chlorpyrifos standard imposed by the OECD countries on banana exports from the studied exporting countries. A ten percent increase in regulatory stringency - tighter restrictions on the pesticide chlorpyrifos - leads to a decrease of banana imports by 1.48 percent. Our simulation analysis based on the gravity model parameter estimates indicate a significant difference in trade flow under alternative regulatory scenarios. It is estimated that US\$ 5.3 billion in lost exports occur

per year if an international standard were set at EU levels of regulatory stringency in contract to a world standard set by Codex at the internationally-recommended level.

A comparable estimate of the effect of a tighter pesticide residue standard on health of consumers who benefit from decreased level of pesticide use in imported food is not available. Our result suggests, however, that the costs of higher food safety standards imposed by importing countries can be considerable. Scientific findings on pesticide hazards do indicate that greater risks are borne by farm workers and those exposed to pesticide residues in the air, soil and drinking water. Health hazards are predominant in developing countries simply because of relatively more unsafe techniques involved with pesticide use, poor health condition among the population, and use of more toxic pesticides. A reduced health risk associated with a tighter pesticide residue standard may offset the direct losses and losses in potential productivity losses from reduced pesticide applications.

Balancing risk, health, and trade is further complicated when considering alternatives to pesticide use, such as introduction of genetically modified organisms to control pests, or investment in organic foods. The growing market for organic foods in the United States and Europe may provide alternative opportunities for food exporting countries. For example, organic products exported from the Dominican Republic now amount to around 20 percent of fruit and vegetable exports (Holderness et al., 1999). In the Dominican Republic, organic banana production now involves some 2,500 smallholder farmers (Holderness et al.).

Table 1. Major World Importers and Exporters of Bananas and Plantains

Top 10 Importer	Value (\$US million)	% of the World Total	Top 10 Exporter	Value (\$US million)	% of the World Total
United States of America	1,389	20%	Ecuador	954	20%
Germany	689	17%	Belgium-Luxembourg	800	17%
Belgium-Luxembourg	556	12%	Costa Rica	564	12%
Japan	548	12%	Colombia	560	12%
United Kingdom	534	5%	Philippines	241	5%
Italy	346	4%	Panama	184	4%
France	201	3%	Italy	165	3%
Sweden	152	3%	United States of America	161	3%
Russian Federation	151	3%	France	151	3%
Canada	149	3%	Guatemala	147	3%

Source: Food and Agricultural Organization (1998).

Table 2. The Banana Trade Regime effective December 22, 1994 (Banana Framework Agreement)

Traditional ACP banana suppliers (quota=857, 700 tone)	Countries not categorized as traditional ACP banana suppliers (quota=2.2 million tone)		
	BFA countries (quota=1.1 million tone)	Non-traditional ACP banana suppliers (quota=90,000 tone)	Non BFA countries (quota=1.0 million tone)
African Caribbean and Pacific Countries except Cote d'Ivoire, Cameroon, and Dominican Republic	*Costa Rica, *Colombia, Nicaragua, Venezuela	*Cote d'Ivoire, *Cameroon, Belize, Dominican Republic	The rest of the countries

Countries with "*" are in the sample for our analysis.

Table 3. Regression Results

	Model I		Model II		Model III	
Dependent variable: Log(Value of trade flow)						
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Constant	-28.38*	15.20	-5.75	14.28	-46.35***	13.81
Log (Importing country's GNP)	3.30***	0.68	0.88***	0.17	3.29***	0.70
Log (Exporting country's GNP)	1.57	1.91	0.53	0.52	1.58	1.99
Log (Importing country's Population)	-2.68***	0.73			-2.59***	0.74
Log (Exporting country's Population)	-0.26	2.03			0.51	2.05
Log (Geographic distance)	-2.18***	0.47	-2.06***	0.48	-1.76***	0.48
Log (Chlorpyrifos Standard)	1.48***	0.29	1.34***	0.29	1.45***	0.30
Log (Rainfall)	-0.12	1.22	0.06	1.24	-0.24	1.27
Dummies for BFA	0.89	1.48	1.29	1.49		
Dummies for non-BFA	3.35***	1.15	3.91***	1.14		
Dummies for non-ACP	6.18***	1.74	5.19***	1.76		
Dummies for Colonial ties to the EU	-0.40	1.28	-0.07	1.27	0.14	0.99
Dummies for Colonial ties to USA	0.27	1.76	0.28	1.81	-0.24	1.83
Dummies for NAFTA member	1.87	1.46	1.67	1.50	2.11	1.52
Dummies for APEC member	1.68*	0.93	0.66	0.89	2.62***	0.89
Dummies for year 1998	-0.02	0.48	0.23	0.45	0.02	0.50
Dummies for year 1999	0.14	0.42	0.23	0.43	0.20	0.44
Adjusted R-squared	0.534		0.503		0.484	
Number of observation used	240		240		240	

Note: A fixed-effects model is used with exporting countries as cross-section.

The notations "*", "**", and "***" imply the 10, 5 and 1 percent significance, respectively.

Table 4. Change in Trade Flows under Different Harmonization Scenarios Compared with Pre-Harmonization Status by Exporting Countries (without the EU quota in place)

Harmonized level	0.05 ppm		0.1 ppm		0.5 ppm		2.0 ppm	
Pre-Harmonization level of	France, Germany, UK, Belgium, Luxembourg		USA, Canada, Switzerland		Japan, the Netherlands		New Zealand Codex	
	(US\$ 1,000)	% change	(US\$ 1,000)	% change	(US\$ 1,000)	% change	(US\$ 1,000)	% change
Exporters								
Cote d'Ivoire	-445	-0.4	117,942	99.5	118,547	100	118,547	100
Cameroon	-127	-0.1	109,084	99.8	109,256	100	109,256	100
Morocco	-3	-6.1	45	91.8	49	100	49	100
South Africa	-9	-3.5	245	95	256	99.2	258	100
China	-5,655	-99.7	-5,632	-99.3	25	0.4	5,673	100
Indonesia	-363	-98.9	-356	-97	7	1.9	367	100
India	-140	-64.8	26	12	216	100	216	100
Philippines	-335,744	-99.8	-334,465	-99.5	-1,645	-0.5	332,987	99
Taiwan, China	-46,799	-100	-46,780	-99.9	21	0	46,814	100
Costa Rica	-360,202	-46.8	277,916	36.1	766,138	99.6	768,981	100
Guatemala	-143,935	-65.5	24,384	11.1	219,883	100	219,883	100
Honduras	-90,508	-55.7	39,701	24.4	162,632	100	162,632	100
Mexico	-54,062	-71.3	1,199	1.6	73,848	97.4	75,727	99.9
Panama	-41,919	-17.9	177,278	75.6	233,385	99.5	233,995	99.7
Argentina	-3	-1.5	197	98	201	100	201	100
Brazil	-811	-28.6	1,732	61.1	2,833	100	2,833	100
Chile	-73	-48.3	52	34.4	151	100	151	100
Colombia	-206,862	-34.9	312,205	52.6	593,173	100	593,173	100
Ecuador	-461,353	-52.1	177,907	20.1	730,463	82.5	856,589	96.7
Total	-1,749,013	-49.1	852,680	23.9	3,009,439	84.5	3,528,332	99.1

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