A Preliminary Empirical Assessment of the Effect of Phytosanitary Regulations on US Fresh Fruit and Vegetable Imports

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Introduction

United States (US) imports of fresh fruits and vegetables have grown substantially in recent decades and account for a steadily increasing share of domestic consumption. Since 1989, the value of US fresh vegetables imports has increased from $811.5 million to $4.28 billion in 2007, or an annual growth rate of 10.5 percent. During the same period, the value of US fresh fruit imports increased from $1.5 billion to $5.47 billion, or an annual growth rate of 7.6 percent. The rate of growth in imports of fresh vegetables has exceeded the rate of growth in total agricultural imports, with the fresh vegetable share of total US agricultural imports increasing from 3.6 percent in 1989 to 5.95 percent in 2007. The rate of growth in imports of fresh fruits has been almost identical to rate of growth in total agricultural imports at nearly 7 percent, with the import share of fresh fruits in total agricultural imports holding near 7.5 percent (USDA, FASonline, 2008).

Several factors have been posited to explain the growth in US fresh fruit and vegetable imports, including increasing consumer incomes, dietary needs, consumer demand for year-round access to fresh fruits and vegetables, and the implementation of free trade agreements such as the North American Free Trade Agreement (NAFTA) (Huang and Huang, 2007).

With the growth in US imports of fresh fruits and vegetables comes increased concern for the introduction of pests and diseases into the US via shipments of these products from abroad. Introductions can occur naturally, through migration, or passively via water or wind dispersion. However, most foreign pests and diseases are introduced via human-mediated pathways, either accidentally or intentionally through smuggling or introduction of biological controls. While the lack of data precludes ranking the relative importance of these pathways, trade and travel are believed to be important vectors (National Research Council 2002). Because of this concern, US fresh fruits and vegetables imports are highly regulated by the Animal and Plant Health Inspection Service of the US Department of Agriculture (USDA/APHIS).

The most restrictive regulations prohibit the importation of specific fresh fruits or vegetables from countries that have identified pest risks and have not developed approved mitigation practices. For example, the US permits the importation of fresh apples and oranges from only a subset of countries that export these commodities, with approved countries only accounting for 39 and 68 percent of global exports of apples and oranges (USDA, Economic Research Service, 2009).

Alternatively, exporters may have access to the US market subject to a set of regulations that often require the use of a specific treatment. For example, fumigation with methyl bromide, which is a common pest-risk mitigation strategy, is often a condition for product entry. Phytosanitary measures are not required for all shipments of fresh fruits or vegetables into the US, but vary by the country of origin and the fresh fruit or vegetable being shipped.

Regional trade agreements (RTAs), such as NAFTA, in addition to the Uruguay Round Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures, have provided countries opportunities to discuss and potentially challenge existing and proposed SPS regulations (Roberts and Orden, 1997). Both Agreements require measures to be based on scientific evidence and be minimally trade distorting, and have borne results in both high-profile and obscure cases (Josling, Roberts, and Orden, 2004). The World Trade Organization (WTO) reports that just under one half of the 53 complaints related to phytosanitary measures applied to fruits and vegetables have been resolved between trading partners, most before reaching formal dispute settlement (WTO, 2009).

Since the implementation of NAFTA and the Uruguay Round agreement, APHIS has granted a number of countries new access to ship fresh fruit and vegetables into the US. For example, in 2007 a new regulation was implemented that permitted the importation of fresh mangoes from India if a set of pest-risk mitigation practices, including the irradiation of all mangoes prior to export and the use of fungicides or orchard inspections, were implemented. Changes to phytosanitary rules that permit new market access have in some instances led to significant increases in trade, such as sharp increase in the value of US avocado imports which in 2007 totaled more than $550 million, up from only $28.1 million since the elimination of the US ban on Mexican avocados in 1997. However, from an exporter's perspective, building capacity and meeting pest-risk mitigation and inspection procedures mandated by APHIS may take time. It is likely that the increase in imports of fresh fruits and vegetables as a result of new market access occurs over time as exporters invest in production capacity to ensure conformity with APHIS requirements and build proper marketing channels in the US.

The objective of this paper is to investigate how existing SPS regulations and new market access impact the importation of fresh fruits and vegetables into the US. Specifically, this study will address two questions:

1. How and to what extent do differing single mitigation treatments, such as fumigation, irradiation, or cold treatment, affect the level and composition of US imports of fresh fruits and vegetables?
2. What portion of the observed increase in US imports of fresh fruits and vegetables can be attributed to new market access, particularly for developing countries?

In order to achieve these objectives, we construct a unique and comprehensive database on US SPS measures pertaining to the importation of fresh fruits and vegetables which has been developed using current and archived versions of the APHIS Fresh Fruits and Vegetables Import Manual, the Code of Federal Regulations, Federal Register notices, and APHIS reports. We are able to track country eligibility, treatment requirements by type, origin and destination restrictions, systems approaches, and new market access provisions by exporter-and-commodity over the period 1996-2007.

Literature Review

While there is concern that developing and least-developed countries (LDCs) may not have the technical and financial resources necessary to meet the SPS requirements in major export markets in developed countries, *ex post* empirical assessments of SPS regulations have not received much attention in the literature and are generally limited to case studies (Peterson and Orden, 2008; Calvin, Krissoff and Foster 2008).

Recent studies employing the gravity model of international trade typically find a negative impact of SPS regulations on agricultural exports, especially for developing countries. Otsuki, Wilson, and Sewadeh (2001) and Gebrehiwet, Ngqangweni and Kirsten (2007) analyzed the impacts of stricter aflatoxin standards adopted by developed countries on food exports from African countries.[1] Otsuki, *et al* consider the expected effects of 15 EU countries adopting a stricter aflatoxin B1 standard (2 ppb) than the standard suggested by the Codex (9 ppb). They found that the stricter measures reduced exports of dried fruits, edible nuts, and cereals from nine African countries to the EU countries by an estimated $670 million, while leading to a decrease in 2.3 cancer deaths per billion.

[1] The three international organizations which set international benchmark standards for SPS measures are: L'Office International des Epizooties (OIE), the International Plant Protection Convention (IPPC), and the Codex Alimentarius Commission (Codex).

Gebrehiwet, Ngqangweni and Kirsten (2007) analyzed the impact of the total aflatoxin standard adopted by the U.S., Germany, Italy, Sweden, and Ireland on food exports from South Africa. They found a negative trade effect of food safety standards. In addition, they found that if these countries would have adopted the total aflatoxin standard suggested by the Codex, it would have led to an additional $69 million in food exports annually from South Africa during the period 1995-1999.

Chen, Yang, and Findlay (2008) assessed the trade effects of the use of the pesticide Chlorpyrifos MRL and the medicated fish feed Oxytetracycline MRL during the period 1992-2004 on Chinese exports of fresh vegetables and fish and aquatic products, respectively. They found a negative and statistically significant impact of food safety standards adopted by importing countries on Chinese agricultural exports. In addition, they found a greater trade impact of changes in food safety standards as compared to a relative change in the import tariff.

Jayasinghe, Beghin, and Moschini (2009) examine trade costs related to US exports of seed corn to 48 countries, and find that tariffs, distance, and SPS measures all have a statistically significant and negative impact on exports. The authors find that the effects of trade costs related to tariffs and distances outweigh the effects of phytosanitary measures, such as testing and field inspection. However, the authors used a simple count variable to identify the impact of SPS regulations affecting seed corn exports.

Disdier, Fekadu, Murillo and Wong (2008) examined the trade effects of technical regulations adopted by the US, EU-25, Japan, Canada, Australia and Switzerland (based on the SPS and TBT Agreements). They found a negative effect of SPS and TBT measures on tropical and diversification products exports of African, Caribbean and Pacific (ACP), Latin American and Asian countries. However, their results vary by exporting-country sub-groups. For example, ACP countries are more negatively affected than Eight Latin American countries (LA8), while the effect on Asian and other Latin American countries is not statistically significant.

A more comprehensive study of the effects of technical measures on agri-food trade by Disdier, Fontaigné and Mimouni (2008) found that regulations employed by OECD countries negatively influence international trade in agricultural products, especially exports of developing and LDCs. Their findings also suggest that international trade in agricultural products among OECD countries isn't significantly impacted because of these regulations. Moreover, the authors argue that agricultural imports of EU countries are more negatively influenced because of these regulations as compared to other OECD countries. In addition, the authors calculate coverage ratios for OECD countries and conclude that EU countries have some of the lowest coverage ratios among OECD countries.

One drawback of this more comprehensive empirical analysis is the reliance on the Trade Analysis and Information Systems (TRAINS) dataset, which is based in large part on notification of measures to the WTO.[2] Researchers have noted that the TRAINS data are extremely fragmentary and subject to large measurement error with respect to SPS measures (Anderson and van Wincoop (2004); Roberts and Krissoff (2004)). One shortcoming of the data set is that WTO Members have only been obliged to notify *changes* to SPS measures since the WTO came into force. As a consequence, a large number of the most trade-restrictive SPS measures adopted in the first decades of the 20th century have never been notified.

A second drawback of the above mentioned empirical studies is their use of coverage ratios and frequency indices (Disdier, *et al* 2008; Jayasinghe, Beghin, and Moschini 2009).

[2] WTO members are required to submit notifications of new measures under the SPS Agreement on Technical Barriers to Trade in order to provide an opportunity for trading partners to raise questions or objections to proposed measures before they are adopted. Each notification indicates, among other things, what the proposed measure is, which product or products it is applied to, if it is based on an international standard, and when it is expected to come into force.

These count variables are often based on aggregate trade. Most SPS measures, particularly for OECD imports, are defined at a much greater level of product/commodity disaggregation. For example, the commodities identified in the APHIS SPS regulations correspond to the HS-6 digit categories (e.g., strawberries), HS-8 digit level (e.g., carrots), and in some cases, commodities are identified even at the HS-10 digit level (e.g., broccoli).

Finally, coverage ratios or frequency counts cannot capture the effect of differing *types* of treatments on trade. The TRAINS database reports measures that can either restrict or facilitate trade. For example, a maximum residue level for use of a new pesticide on a fruit may in fact expand the production technology available to producers in exporting countries, thereby potentially increasing trade.

Regulating Imports of Fresh Fruits and Vegetables: An Overview

Federal efforts to prevent the entry of foreign pests and diseases date back to the early 20th century when Congress passed the Plant Quarantine Act of 1912 to address increasing concern over pest outbreaks in nursery stock (USDA, APHIS, 2005). Currently, APHIS has the authority to promulgate import regulations under the Plant Protection Act of 2000 to reduce risk due to the entry of plant pests into the US and to implement domestic control programs in the event of outbreaks.[3] Agricultural products can be imported into the US only after successfully completing USDA's approval process. After a country petitions USDA to allow importation of a specific commodity, APHIS conducts a risk assessment to identify the economic and environmental damage pests associated with the commodity might cause if they were to enter the US. APHIS will recommend that the commodity be allowed to enter only if measures can be identified that will reduce pest risk to acceptable levels.

[3] Authority to administer port-of-entry inspections was transferred from USDA to the Department of Homeland Security in 2003, but these activities are still funded through inspection fees collected by the USDA.

All eligible imports are subject to inspection and must meet general documentation requirements upon arrival in the US, but are also often required to comply with additional phytosanitary measures as a condition of entry. These measures fall into five categories, as described in 7 CFR § 319.56-4 in the US Code of Federal Regulations: origin restrictions; treatments; destination restrictions; pre-clearance in the exporting country; and systems approaches (Table 1).

Figures 1a and 1b show the percentage of global production eligible for entry into the US in 2008 for the ten most important fresh fruits and vegetables in the American diet. The shares range from 6 percent (watermelons) to 83 percent (strawberries) of world fresh fruit production, and from 1 percent (potatoes) to 84 percent (onions) of global fresh vegetable production (USDA, ERS, 2009). Table 2 indicates the percent of eligible countries and production with treatment requirements for admission to the US for the most economically significant fresh fruits and vegetables. In general, requirements vary widely across commodities, and are applied to fruit far more than vegetables. More than 90 percent of the production of apples, grapes, oranges, peaches, pears and quinces, and plums from eligible countries require chemical or non-chemical treatments (e.g., vapor treatments, cold treatment) as a condition of entry into the US.

The US granted new market access for country/commodity trade flows over the 1996-2007 period, with the vast majority for fresh vegetables from developing countries (Table 3). Of the countries that received new market access for produce, the top 10 countries (Argentina, Chile, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Peru, South Africa, and Spain) accounted for 57.2 percent of all the new access as measured by the number of commodity/country combinations. Nicaragua was the largest recipient gaining access for 21 commodities, followed by Mexico with 18 commodities, and El Salvador and Peru with 15 commodities.

Empirical Model

To investigate the impacts of existing phytosanitary regulations and granting of new market access on the importation of fresh fruits and vegetables into the US, we employ a product-level gravity equation applied to the US fresh fruits and vegetables imports. The gravity equation has become the workhorse for empirical international trade studies (Eichengreen and Irwin 1998). Originally developed by Tinbergen (1962), the gravity model is akin to Newton's law of universal gravitation, whereby larger and closer countries trade more with one another than smaller and more distant countries. In its basic form, the model predicts that trade flows from country *i* to country *j* in year *t* are proportional to the multiplicative interaction (in levels) of each country's size, often measured by GDP, and inversely proportional to the distance between them.

(1) $$V_{ijt} = \alpha_0 Y_{it}^{\alpha_1} Y_{jt}^{\alpha_2} D_{ij}^{\alpha_3} \varepsilon_{ijt}$$

where, α_0, α_1, α_2, and α_3 are unknown parameters and ε_{ijt} is a multiplicative, stochastic error term. Taking logs of both sides yields a traditional, linear in parameters, gravity equation that can be easily estimated:

(2) $$\ln(V_{ijt}) = \alpha_0 + \alpha_1 \ln(Y_{it}) + \alpha_2 \ln(Y_{jt}) + \alpha_3 \ln(D_{ij}) + \gamma Z_{ij(t)} + \varepsilon_{ijt} ,$$

where, Z_{ij} is a vector of additional controls of interest. Common variables include whether the countries share a common language, a common currency, or if both countries are members of a particular trade agreement.

In the present study, we modify the traditional gravity equation in several respects. First, our dataset contains product line variation denoted as *k* ($k \in$ fresh fruit & vegetable products).

Second, whereas typical gravity equations are estimated for all *ij* pairs in world trade, our dataset focuses on US product line imports (i.e., j = US). Thus, a trade flow observation in our dataset includes an exporter (i) shipping a particular fresh fruit and vegetable commodity (k), in time period (t). Finally, we replace traditional GDP and distance proxies for country size and transport costs in the gravity equation with more appropriate exporter production levels of product k in year t, and transport and tariff costs, respectively.

Our benchmark specification is:

(3) $$\ln V_{itk} = \alpha_0 + \alpha_t + \alpha_1 \ln PR_{itk} + \alpha_2 \ln Trs_{itk} + \alpha_3 \ln Tar_{itk} + \alpha_4 FTA_{it} + \alpha_5 MAIN_{itk} + \lambda_1 TREAT_{itk} + \lambda_2 NMA_{itk} + \varepsilon_{itk}$$

where, V_{itk} is the value of imports of product k ($k \in$ fresh fruit & vegetable products) from exporter i into the US at time t, α_t is a comprehensive set of time fixed effects, PR_{ikt} is the production capacity of exporter i in year t calculated as total fruit or vegetable production; Trs_{itk} (Tar_{itk}) is the transportation (tariff) cost faced by exporter i on product k in year t; FTA_{it} is a dummy variable equal to one if country i is in a free trade agreement with the US in year t, and $MAIN_{itk}$ is a dummy variable equal to one if country i is permitted to ship fresh fruit or vegetable products to the continental US (some exporters face destination/port restrictions to ship product k in year t).

The coefficients of interest are λ_1 and λ_2 measuring the impact of exports that are subject to treatment (see table 2) and exports that have received new market access (*NMA*), respectively. $TREAT_{ikt}$ is a dummy variable equal to one if exporter-and-commodity pair (*ik*) was subject to any one treatment in year t listed in table 2. NMA_{itk} is a dummy variable equal to one if exporter i received new market access to ship product k in year t.

Equation (3) alone is rather restrictive for at least two reasons. First, there may be considerable country and commodity variation in the data that is not captured by the standard right-hand-side variables in equation (3). To control for potential country and commodity specific variation in the data, we specify a comprehensive set of country and commodity fixed effects. Second, equation (3) only tells us how treatments and new market access impact trade flows more generally. Yet, policy makers and exporters may be more interested in how treatments and new market access affect fresh fruit or vegetable product trade or whether new market access is beneficial for developing or developed countries. To shed light on these questions we augment equation (3) by disaggregating the treatment and new market access dummy variables to capture the trade flow impacts for: (i) fruit and vegetable categories; and (ii) developed or developing countries.

Finally, equation (3) is a linear in parameters, logarithmic, product-line gravity equation that assumes zero trade flows do not exist. However, this is typically not the case, particularly when considering HS6- or HS8-digit trade flows. It is common for researchers to either drop zero trade flow observations, add one to all zero trade flows so the logarithmic function is well defined, or to estimate the model using a threshold-Tobit estimator (Pham and Martin 2008). In the current paper, we drop zero trade flow observations. However, in subsequent analysis, we will return to the issue of zero trade flows in order to properly address the identification of new market access where an exporter does not export to the US in time t, but begins to export in year $t+1$ and all subsequent years after receiving new market access.

Data

Data on fresh fruit and vegetable import values, trade costs and tariffs for the US for the 1996 – 2007 period, representing the post-Uruguay Round time period when the WTO SPS agreement has been in effect, are obtained from the United States International Trade Commission (USITC, 2009). To avoid problems associated with explaining "low" trade values when estimating the empirical model, only countries that exported at least $100,000 annually of at least one fruit or vegetable commodity for at least three years were included in the sample. Overall, 89 exporting countries are included.[4] We develop a concordance between the commodity identifiers in the APHIS manuals and the corresponding HS 6, 8, or 10 digit codes to analyze the effects of phytosanitary regulations on US imports of fresh fruits and vegetables. For example, avocados are defined at the 6-digit level, bananas at the 8-digit level, and broccoli at the 10-digit level. Other commodities, such as mangoes and carrots, are defined as the combination of several 8-digit product lines. Overall, 23 fresh fruit and 23 fresh vegetables are included in this study.

Information on country eligibility and treatment requirements for a given year is obtained from several sources. The main source is the *Fresh Fruits and Vegetables Import Manual* (USDA/APHIS) which contains information, by exporting country, on the fresh fruits and vegetables approved for importation in the US and the additional requirements, if any, for entry of each commodity.[5] As indicated in Table 3, there are 330 instances where APHIS granted new market access for a specific country/commodity combination.[6] However, only 50 of these

[4] Serbia and Montenegro are treated as a single country because the trade data for the separate countries were only available beginning in 2007.

[5] Because most, but not all, changes in US phytosanitary regulations are initially published in the Federal Register and the Code of Federal Regulations, and because of time lag between the effective dates of a new regulation and its publication in the import manual, we use the last updated version of the import manual for a given year as our source for required phytosanitary treatments and lists of approved fresh fruit and vegetable commodities by exporting country. This ensures that we capture all changes in regulations within a given year without having to inspect each version of the import manual.

[6] Exporting countries that gained new market access for a specific commodity are identified by comparing the list of approved commodities in the *Fresh Fruits and Vegetable Import Manual* across two consecutive years. This information was cross-checked with notifications published in the Federal Register, codified in the Code of Federal Regulations, and APHIS staff reports (USDA/APHIS, various years) to ensure comprehensive coverage and accuracy.

instances are included in our sample. There are four reasons for this. First, some countries do not export to the US even though they may have new market access for a particular commodity and time period. Second, the data trimming process described earlier excludes observations where exporters shipped fresh fruits and vegetables less than three years in the sample period (1996-2007) and those shipments that totaled less than $100,000 in value. Third, a concordance between the APHIS identifier and a product line in the HS code could not be established, as in the case of individual herbs or exotic fruit such as rambutan. Fourth, all products currently admissible into the US markets for fresh fruits and vegetables under a systems approach (e.g., Mexican fresh Hass avocados) are excluded from the database.[7]

For the years 1996 through 2007, there are 737 instances where a positive import flow from a specific country/commodity pair into the US is subject to a treatment, out of 5,518 total positive country/commodity pair import flows. Thus, approximately 13.4 percent of all country/commodity pairs from eligible countries were subject to treatment. Table 4 lists the frequency for each specific treatment identified in the *Fresh Fruits and Vegetable Import Manual* for the 737 trade flows subject to a treatment. The three most common treatments are: cold treatment (37.18 percent), methyl bromide fumigation (33.65 percent), and water treatment (13.57 percent). Regulations that require a combination of treatments, groups 7 and 8 in Table 4, are not common, accounting for only 8.68 percent of all occurrences.

Because the frequency count in Table 4 is based on country/commodity/time triplets, there are only 119 unique country/commodity treatment pairs. There are 31 different commodities and 38 different countries that are subject to required treatments in our sample. Fresh fruits are subject to treatments more than twice as often as fresh vegetables, with 77

[7] The economic treatment of these country-commodity-year combinations will be addressed at a later date and a future version of the paper.

occurrences for fruits compared with 42 occurrences for vegetables. The group of commodities with the most treatment requirements is citrus (grapefruit, lemon, limes, mandarins and clementines, and oranges) with 26 country occurrences. The individual commodities with the most required treatments are mangoes with 14 occurrences, oranges with 11, garlic with 9, fresh beans with 8 and apples with 7. Of the countries subject to required treatments, 8 are in South America, 7 are in Central America and Europe, and 6 are in Asia. The countries that face the largest number of required treatments are Israel with 9 commodities, Argentina with 8 commodities, South Africa and Peru with 7 commodities, and Mexico, Australia and Chile with 6 commodities.

Because of destination restrictions in phytosanitary regulations, some fruits and vegetables are not eligible to be shipped to continental US. There are thirteen different ports of entry identified in the *Fresh Fruits and Vegetable Import Manual*. We assume that the following ports of entry are not part of the continental US: the State of Alaska (ALASKA), Puerto Rico (PR), US Virgin Islands (USVI), the State of Hawaii (HAWAII), Guam (GUAM), the Northern Mariana Islands (CNMI), and any ports specified as (SoP) or (LTD). Roughly two percent of our sample observations were not eligible to be exported to the continental US.

To control for market size of the exporting country, data on production and producer prices for fresh fruits and vegetables was obtained from the Food and Agricultural Organization of the United Nations (FAO, 2009; FAO, 2009b).[8] Because data on producer prices is not available for many low-income exporting countries, we consider total fruit and vegetable production for each exporter and time-period as a proxy for production capacity.

[8] Since no data is available for leeks in the FAO data, but leeks is one of the traded vegetable products, we use green onion (including shallots) data as a proxy for leeks in the summation to get total vegetable production for each exporter.

US free trade agreements are taken from the WTO's RTAs dataset (available at: http://www.wto.org/english/tratop_e/region_e/region_e.htm). Thirteen exporters in the sample have a free trade agreement with the US. These exporting countries are Australia, Canada, Chile, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Israel, Mexico, Nicaragua, Morocco, and Singapore.[9]

Finally, in the empirical specifications we test whether treatments and new market access impact trade flows originating in developed and developing countries. To map exporters into developed or developing countries we use the World Bank classification of low, middle, or high income economies. High income economies which we classify as developed countries are defined by the World Bank as countries with a Gross National Income per capita of $11,456 or more. Low and middle income economies which we classify as developing countries are defined by the World Bank as countries with a Gross National Income per capita in the range ($0, $11,455).[10]

Table 5 provides summary statistics for our data. The average trade flow is $10.9 million. However, the standard deviation around this is $47.8 million. *Ad valorem* tariff rates are low for fresh fruits and vegetable imports in the US with an average tariff rate of 1.76 percent ((1-1.018)*100). The average transportation cost on an *ad valorem* equivalent basis averaged 30.04 percent. 6.57 percent of all observations involve an FTA between the exporter and the U.S.

As noted previously, commodity treatments (e.g., methyl bromide, irradiation, cold treatment) occur in 13.4 percent of all observations. However, developing countries account for 9.3 percent of these treatments, followed by developed countries at 4 percent, and LDCs making

[9] The U.S.-Costa Rica FTA came into force on January 1, 2009 (under CAFTA-DR) and is not included in the study since our period of analysis is from 1996 to 2007.

[10] It should be noted that some relatively high income countries may be classified as developing countries under this definition (e.g., the United Arab Emirates, South Korea, the Bahamas, Taiwan, Hungary, Estonia).

up only 0.1 percent of the observations (Haiti being the only low-income country subject to treatments).

New market access occurs in 3.4 percent of all observations, again with middle-income countries making up the lion's share (2.9 percent). Looking at the commodity breakdown, fruits account for 56.76 percent and vegetables for 43.24 percent of this 3.4 percent share.

The average fruit and vegetable production quantity across all exporters and time periods is 13 mmt, with a standard deviation of 49.8 mmt. However, there are differences in exporter production of fruits and vegetables. Fruit production averaged 7.6 mmt while vegetables production averaged 18.1 mmt. China dominates both fruit and vegetable world production totaling 94 and 449 mmt, respectively, followed by India as a distant second.

Empirical Results

The results are organized in three sections. Section one presents the results after estimating equation (3) using a generic treatment and new market access (henceforth NMA) variables. Section two presents results for estimating equation (3) with separate treatment and NMA effects by exporter development status. In section 3, we estimate equation (3) while allowing for dynamics in the NMA variable and for differences in product type. All econometric models are estimated using only year fixed effects, and using year, country, and commodity fixed effects.

Treatments and NMA by Sector

The gravity equation performed quite well, particularly when country, commodity and time specific fixed effects (columns 2 and 4) are specified, explaining 56 percent of the variation in fresh fruit and vegetable imports. The elasticity of economic size of the exporting country as measured by exporter production is consistently positive and significant. Tariffs and transport costs have negative and significant effect, as expected. Moreover, the coefficient on the tariff rate (which can be interpreted as an elasticity of substitution among imports), particularly in columns 2 and 4, is consistent with previous findings in the literature (see Hertel et. al 2007; Grant, Hertel and Rutherford 2009) related to other sectors.

NAFTA has a large and significant effect, especially when compared to other FTAs. Using columns 2 and 4 in Table 6, NAFTA has resulted in a eighteen-fold increase (exp(2.92)) in US imports of fresh fruits and vegetables compared to non-NAFTA countries. What's even more interesting is the fact that all other FTAs that have entered into force since 1996 resulted in an insignificant (when including country and commodity fixed effects) trade effect. However, the insignificance of the these coefficient may not come as a surprise since the US imports a lot of fresh fruits and vegetables from countries like China, India, and Central and South American countries where very few FTAs exist. As expected, the ability to ship to the continental US has a large and significantly positive effect (columns 1 and 3). However, these results are not robust to specifications with exporter and country fixed effects. Using the results from column 1, US imports to the mainland were 3.59 times larger (exp(1.28)) compared to exporters that faced destination restrictions (e.g., shipments that were only allowed to enter Hawaii or Guam).

The generic impact of treatments on US imports appears to have conflicting results: negative effect when only year fixed effects are included (column 1), and a positive effect when country and commodity fixed effects are also included (column 2). However, this 'treatment effect' is not significant in any of the fixed effects specifications. Additional insight is gained by disaggregating this variable into fruit treatments ($TREAT^{FRT}$) and vegetable treatments ($TREAT^{VEG}$). In a specification with year fixed effects (column 3), both $TREAT^{FRT}$ and $TREAT^{VEG}$ have negative coefficients. Moreover, $TREAT^{VEG}$ is significant at the 5 percent level.

However, when exporter and commodity fixed effects are included, both $TREAT^{FRT}$ and $TREAT^{VEG}$ have small positive, but not statistically significant coefficients (column 4).

Finally, we consider the effects of NMA. Interestingly, the NMA coefficient is negative and significant across all scenarios (columns 1-4). Is this effect due to the fact that exporters are indeed shipping smaller quantities of fresh fruits and vegetables or is it due to the fact that exporters (particularly developing countries) need time to invest in capacity and pest mitigation production and export strategies required by APHIS? We address this question in section three. It is also plausible that NMA effects could differ depending on the development status of the exporter and the type of product being shipped. However, it is likely that developed country exporters are more capable of overcoming APHIS standards when NMA is granted. We shed light on this question below.

Treatments and NMA by Development Status

Do SPS treatments and NMA affect developed and developing exporters differently? In this scenario, we allow the effect of treatments and NMA to vary by sector (i.e., fruits or vegetables) and the development status of the exporter (developed (DC) or developing (DGC)). As described in the data section, developed exporters are those countries with GDP per capita greater than $11,456 as defined by the World Bank classification of high income countries. Developing country exporters are defined as those countries with less than $11,456 in per capita GDP.[11] Table 7 reports the econometric results. In the first two estimations (columns 1 and 2), we consider treatment and NMA effects by development status, but not by sectors. Columns 3 and 4 consider treatments and NMA effects by both development status and product sectors.

[11] Least-developed countries (LDC), or low-income economies as defined by the World Bank, are not included as a separate category because there is only one LDC (Haiti) that received NMA or was subject to treatment. Thus we were unable to identify with any precision the NMA and treatment effects of US imports from LDC countries.

Treatments have a negative impact on imports from developed countries, and a positive effect on imports from developing countries. However, these effects are significant in a scenario with year fixed effects only. Using the results from column1, developing countries exports with SPS standards were 29.69 percent higher as compared to the average trade flow with no SPS standards.[12] In columns 3 and 4, we vary the treatment variable by sector and development status. The results suggest that treatments have a negative trade effect on imports from developed countries for both product groups. This effect is significant in a specification with year fixed effects only. On the other hand, treatments have a positive trade effect on developing countries fruit imports (significant in column 3), and a negative and significant effect for developing countries vegetable imports under the same scenario. However, when time and country fixed effects are included (column 4), the later effect becomes positive, but not significant. Using the results from column 3, treatments reduce US imports from developing countries by 47.69 percent on average.[13]

Under the first two scenarios (columns 1-2), NMA has a negative and significant trade effect for both developed and developing countries. Examples of NMA for high-income developed countries include Spain exporting eggplants, head lettuce and kiwi fruit (since 2001), and peppers (since 1998); Korea shipping apples (since 1997); and New Zealand shipping lemons, mandarins, and clementines (since 2007). When accounting for development status and product sector (columns 3-4), this negative effect is significant under all specification for developing countries and only for fresh vegetable imports from developed countries when year, country and commodity fixed effects are included (column 4).

[12] Calculated as (exp(0.26)-1))*100=29.69
[13] Calculated as (exp(|-0.39|-1)*100=47.69

Dynamics of New Market Access

In this section we investigate whether exporters need time to build capacity and invest in procedures and marketing channels such that the cumulative effect of new market access occurs over time. To do so, alternative model specifications that include new market access variables that are lagged for 2, 4, and 6 time periods are estimated. The estimated coefficients from these models are reported in Table 8. Across model specifications with only year fixed effects and with year, country, and commodity fixed effects, none of the estimated coefficients for the lagged new market access variables are statistically different than zero. Because the new market access variable (non-lagged) has a statistically significant negative coefficient across all model specifications, this indicates that the exports of commodities from countries that have been granted new market access remain low relative to commodities exported from countries that had market access throughout the sample period. This suggests that it may be difficult for countries that are granted new market access to compete with established suppliers. Future specifications will consider whether the dynamics of new market access differ by product type (e.g., fruits or vegetables) and possibly by the development status of the exporter.

Conclusions

The growth in US imports of fresh fruits and vegetables has been impressive over the last two decades. However, trade is thought to be one of the main pathways for pest and disease transmission. Thus, while increased imports of fresh produce provides consistent supplies year-round and increases the number of varieties available to consumers, it also increases the risk of pest and disease outbreaks when products enter the domestic market.

As a result, imports of fresh produce into the US are highly regulated by the Animal Plant Health Inspection Service of the USDA. In 1995, WTO Members established the Agreement on the Application of Sanitary and Phytosanitary Measures to ensure that measures used to protect domestic markets from the introduction of pests and disease are minimally trade distorting and are based on ‘appropriate science’.

What are the nature, size, and scope of SPS regulations affecting trade? What types of SPS measures do countries enforce? How and to what extent do SPS measures affect trade flows? Surprisingly, there is very little empirical evidence that has attempted to answer these questions. One reason for this is the lack of data documenting the implementation and application of SPS regulations in world trade. In this study, we provide an important first step in answering these questions. Using very detailed fruit and vegetable import manuals obtained from USDA/APHIS, we constructed a novel dataset for empirical work that matches product line SPS applications with US import flows.

While this work is still ongoing, our initial results suggest that NAFTA has played a prominent role in stimulating fresh fruit and vegetable trade with the US. In terms of SPS measures, the results suggest that SPS treatments appear to have conflicting effects on US imports of fresh fruits and vegetables under different scenarios. The generic treatment effect in a specification with year, exporter and commodity fixed effects appears not have importantly influenced US imports. However, unexpectedly, across all specifications, treatments have a negative effect of US imports for both fruits and vegetables from developed countries. In addition, treatments have a negative and significant effect for vegetables import from developing countries in a specification with year fixed effects only. In future work, the impact of specific treatments will be examined, as well as the trade effect of other risk-mitigation practices, such as systems approaches and preclearance.

Finally, countries that have gained new market access for a given fruit or vegetable commodity have lower exports to the US than do exporters that have always been able to ship to the United States. This suggests that it may be difficult for countries that are granted new market access to compete with established suppliers. However this result may be tenuous since we have not included products that are shipped in the US under a systems approach in our sample. Some of these instances, such as the exports of fresh Mexican Hass avocados, represent new market access with significant increases in trade volumes. For example, US imports of fresh Mexican Hass avocados have increased from $28.1 million in 1997 to more than $550 million in 2007.

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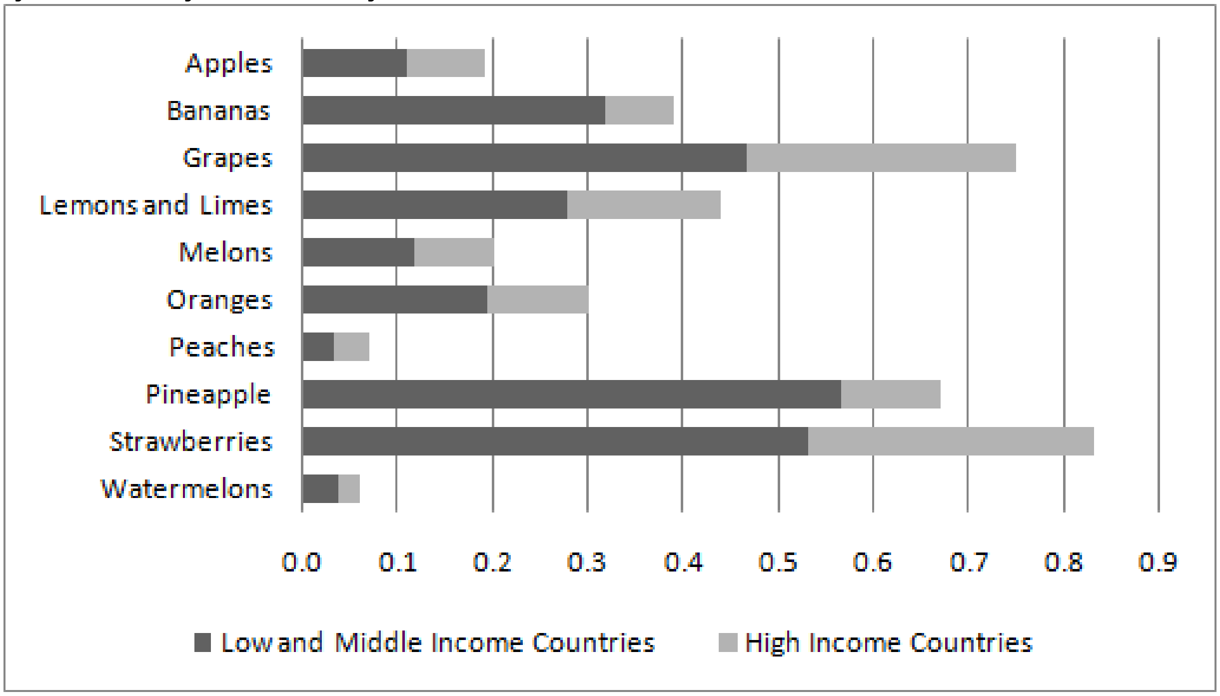
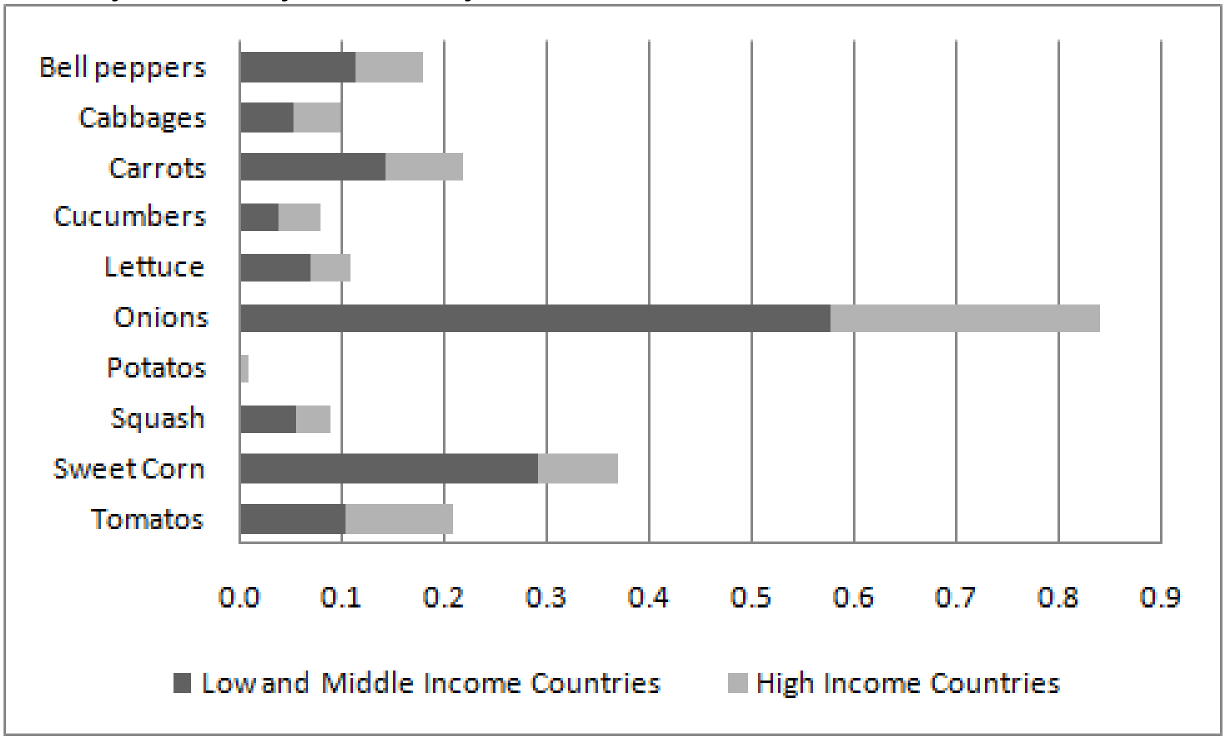
Figure 1a: Access to US Markets for Fruits under USDA Phytosanitary Regulations Varies by Commodity and Country[14]



Source: USDA, ERS, *Phytosanitary Regulation of the Entry of Fresh Fruits and Vegetables into the United States*

[14] Percent of Global Export Volume Eligible for Entry into the United States as of June 2008, by Exporting Country Income Level Status.

Figure 1b: Access to US Markets for Vegetables under USDA Phytosanitary Regulations Varies by Commodity and Country[15]



Source: USDA, ERS, *Phytosanitary Regulation of the Entry of Fresh Fruits and Vegetables into the United States*

[15] Percent of Global Export Volume Eligible for Entry into the United States as of June 2008, by Exporting Country Income Level Status.

Table 1: Phytosanitary Measures Applied to US Imports of Fruits and Vegetables from Eligible Countries

Type	Description	Example
Origin restrictions	Fruits and vegetables must be grown in areas that are recognized as free of quarantine pests by APHIS or in greenhouses.	Tomatoes from Israel must be grown in registered greenhouses in the Arava Valley.
Pre-clearance requirements	A quarantine pest is associated with the commodity in the country or region of origin, but the commodity is subject to inspection in the country of origin, and the commodity is to be accompanied by a phytosanitary certificate that the commodity has been inspected and found free of such pests in the country or region of origin.	Mangoes from Peru must be pre-cleared at an approved facility by APHIS in the country of origin.
Destination restrictions	Allowable ports of entry are designated which may include or exclude regions in the continental United States, Alaska, Hawaii, or U.S. territories.	Pineapples from Thailand are allowed importation into Guam and the Commonwealth of the Northern Mariana Islands only.
Treatments	Chemical and non-chemical treatments authorized for use under provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, for the prevention of the movement of agricultural pests into or within the United States. The five main post-harvest treatment types are fumigation with methyl bromide, water treatment, heat treatment, cold treatment, and irradiation.	Grapes from Chile must be fumigated with methyl bromide according to a specified time/temperature regime.
Systems approaches	The integration of different pest risk management measures, at least two of which act independently, and which cumulatively achieve the desiresd level of phytosanitary protection.	Avocados from Mexico must be grown in the state of Michoacan and are subject to a number of pre- and post-harvest safeguards in production areas as well as at numerous points in the international supply chain.

Sources: *U.S. Code of Federal Regulations 7 CFR 319.56-13, Revised as of January 1, 2008* (US Government).

Table 2: Treatment Requirements for Fresh Fruits and Vegetables

Commodity	Eligible Countries Requiring Treatments	Eligible Production Requiring Treatment
	percent	*percent*
Fruits		
Apples	90	91
Avocados	18	88
Banana	0	0
Grapes	89	94
Lemon and Lime	4	21
Melon	0	0
Oranges	50	93
Peaches	60	97
Pears and Quinces	86	98
Pineapple	1	18
Plums	80	99
Strawberries	0	0
Vegetables		
Asparagus	4	41
Carrot	0	0
Cauliflower and Broccoli	1	1
Celery	0	0
Corn	0	0
Cucumber	0	0
Lettuce	6	52
Onions and shallots	0	0
Pepper	6	8
Potatoes	0	0
Tomato	2	5

Source: Authors' calculations from USDA, APHIS *Fresh Fruit and Vegetable Import Manual* and USDA, FAS *US Trade Internet System*.

Table 3: New Market Access for Fresh Fruits and Vegetable Imports Into the United States, 1996-2007

	Commodities		
Country Type	**Fruits**	**Vegetables**	**Total**
	Number of Countries		
Developed	8	11	19
Developing	89	215	304
LDC	0	7	7
Total	97	233	330

Table 4 Observed Treatment Requirement Frequency

Treatment Description	Frequency	Percent
Group 1: Methyl bromide	**248**	**33.65%**
Fumigation	121	16.42%
Optional fumigation	127	17.23%
Group 2: Water	**100**	**13.57%**
Group 3: Heat	**14**	**1.90%**
High temperature forced air	0	0.00%
Vapor heat	14	1.90%
Group 4: Specific pest/host	**34**	**4.61%**
Pest specific/host variable	14	1.90%
Optional pest specific/host variable	20	2.71%
Group 5: Irradiation	**3**	**0.41%**
Group 6: Cold	**274**	**37.18%**
Cold treatment/quick freeze	213	28.90%
Optional cold treatment/quick freeze	61	8.28%
Group 7: Fumigation/cold	**20**	**2.71%**
Methyl bromide fumigation plus refrigeration	7	0.95%
Cold treatment plus methyl bromide fumigation	13	1.76%
Group 8: Combination of groups 1-7	**44**	**5.97%**
Methyl bromide or refrigeration or methyl bromide plus cold	1	0.14%
Cold treatment or methyl bromide or refrigeration	41	5.56%
Water or methyl bromide	2	0.27%
Totals	**737**	**100.00%**

Sources: US Department of Agriculture, APHIS *Fresh Fruit and Vegetable Import Manual* and US Department of Agriculture, FAS *US Trade Internet System*.

Table 5: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Trade Flows ($ mil)	5518	10.9	47.8	0.00	960
Transportation (1 + rate)	5518	1.300	0.315	1.010	3.000
Tariff (1+rate)	5518	1.018	0.055	1.000	1.857
FTA (count)	5518	0	0	0	1
Mainland US (count)	4450	0.981	0.138	0	1
Treatment	5518	0.134	0.340	0	1
Treatment Developed	1637	0.040	0.372	0	1
Treatment Developing	3831	0.093	0.323	0	1
Treatment LDC	50	0.001	0.431	0	1
New Market Access (NMA)	5518	0.034	0.180	0	1
NMA Developed	1637	0.010	0.115	0	1
NMA Developing	3831	0.023	0.202	0	1
NMA LDC	50	0.000	0.000	0	0
NMA-fruit	5518	0.019	0.137	0	1
NMA-vegetable	5518	0.014	0.120	0	1
Exporter Production (mmt)	5518	13.0	49.8	10	449
Exporter Production – Fruits (mmt)	2678	7.6	13.2	10	94.4
Exporter Production – Vegetables (mmt)	2840	18.1	67.8	940	449

Sources: *Fresh Fruits and Vegetables Import Manual* (USDA/APHIS); Federal Register; USITC, 2009; FAO, 2009; FAO, 2009b; WTO, n.d.; The World Bank, 2008;

Table 6. Treatments and New Market Access, 1996-2007

Variable	(1) Year FE	(2) Year, Country & Commodity FE	(3) Year FE	(4) Year, Country & Commodity FE
Exporter Production	0.36***	0.69***	0.36***	0.69***
	(0.00)	(0.00)	(0.00)	(0.00)
Transport Cost	-0.68***	-1.97***	-0.64***	-1.96***
	(0.01)	(0.00)	(0.01)	(0.00)
Tariff Rate	-8.33***	-3.71***	-8.22***	-3.71***
	(0.00)	(0.00)	(0.00)	(0.00)
NAFTA	1.08***	2.92**	1.12***	2.92**
	(0.00)	(0.04)	(0.00)	(0.04)
All Other FTAs	0.33**	0.12	0.31**	0.12
	(0.03)	(0.42)	(0.04)	(0.45)
Mainland US	1.28***	0.32	1.21***	0.33
	(0.00)	(0.33)	(0.00)	(0.33)
TREAT	-0.12	0.03	-----	-----
	(0.24)	(0.79)	-----	-----
$TREAT^{FRT}$	-----	-----	-0.02	0.04
	-----	-----	(0.89)	(0.79)
$TREAT^{VEG}$	-----	-----	-0.49**	0.03
	-----	-----	(0.02)	(0.85)
NMA	-0.76***	-1.08***	-----	-----
	(0.00)	(0.00)	-----	-----
NMA^{FRT}	-----	-----	-0.79***	-1.16***
	-----	-----	(0.00)	(0.00)
NMA^{VEG}	-----	-----	-0.80**	-0.94***
	-----	-----	(0.02)	(0.00)
N	2732	2732	2732	2732
R^2	0.21	0.56	0.21	0.56
F-Statistic	36.96	28.43	33.68	27.94

Note: The dependent variable is the natural logarithm of the U.S. imports of fresh fruits and vegetables expressed as the Customs Value. Only Customs Values above $100,000 are included. P-values are in parentheses. FE denotes fixed effects and FRT (VEG) denotes fruits (vegetables). FTA is a dummy variable denoting free trade agreements and Mainland US is a dummy variable denoting shipments that may enter the continental US. TREAT is a dummy variable if the export shipment was subject to any kind of treatment (listed in table 2). NMA is a dummy variable denoting new market access. The sample contains 95 countries, 12 years, and 46 fresh fruit and vegetable product lines.

Table 7. Treatments and New Market Access by Development Status, 1996-2007

	(1)	*(2)*	*(3)*	*(4)*
Variable	***Year FE***	***Year, Country & Commodity FE***	***Year FE***	***Year, Country & Commodity FE***
Exporter Production	0.37***	0.67***	0.36***	0.67***
	(0.00)	(0.00)	(0.00)	(0.00)
Transport Cost	-0.89***	-2.01***	-0.84***	-1.98***
	(0.00)	(0.00)	(0.00)	(0.00)
Tariff Rate	-8.29***	-3.85***	-8.11***	-3.86***
	(0.00)	(0.00)	(0.00)	(0.00)
NAFTA	1.01***	2.95**	1.08***	2.96**
	(0.00)	(0.04)	(0.00)	(0.04)
All Other FTAs	0.49***	0.13	0.47***	0.12
	(0.00)	(0.39)	(0.00)	(0.44)
Mainland US	1.21***	0.36	1.20***	0.36
	(0.00)	(0.27)	(0.00)	(0.31)
$TREAT^{DC}$	-1.12***	-0.37**	-----	-----
	(0.00)	(0.05)	-----	-----
$TREAT^{DC\&FRT}$	-----	-----	-1.13***	-0.35
	-----	-----	(0.00)	(0.11)
$TREAT^{DC\&VEG}$	-----	-----	-0.88**	-0.41
	-----	-----	(0.04)	(0.27)
$TREAT^{DGC}$	0.26**	0.21	-----	-----
	(0.03)	(0.14)	-----	-----
$TREAT^{DGC\&FRT}$	-----	-----	0.48***	0.27
	-----	-----	(0.00)	(0.17)
$TREAT^{DGC\&VEG}$	-----	-----	-0.39*	0.17
	-----	-----	(0.09)	(0.43)
NMA^{DC}	-0.80*	-1.24***	-----	-----
	(0.08)	(0.00)	-----	-----
$NMA^{DC\&FRT}$	-----	-----	-1.46	-1.30
	-----	-----	(0.27)	(0.21)
$NMA^{DC\&VEG}$	-----	-----	-0.69	-1.23***
	-----	-----	(0.15)	(0.01)
NMA^{DGC}	-0.99***	-1.11***	-----	-----
	(0.00)	(0.00)	-----	-----
$NMA^{DGC\&FRT}$	-----	-----	-1.13***	-1.22***
	-----	-----	(0.00)	(0.00)
$NMA^{DGC\&VEG}$	-----	-----	-0.96**	-0.81**
	-----	-----	(0.04)	(0.04)

N	2732	2732	2732	2732
R^2	0.22	0.56	0.23	0.56
F-Statistic	36.77	28.06	31.45	27.13

Note: The dependent variable is the natural logarithm of the U.S. imports of fresh fruits and vegetables expressed as the Customs Value. Only Customs Values above $100,000 are included. P-values are in parentheses. FE denotes fixed effects and FRT (VEG) denotes fruits (vegetables). FTA is a dummy variable denoting free trade agreements and Mainland US is a dummy variable denoting shipments that may enter the continental US. TREAT is a dummy variable if the export shipment was subject to any kind of treatment (listed in table 2). NMA is a dummy variable denoting new market access. The sample contains 95 countries, 12 years, and 46 fresh fruit and vegetable product lines.

Table 8. Treatments and Lagged New Market Access, 1996-2007

Variable	*(1)* *Year FE*	*(2)* *Year, Country & Commodity FE*	*(3)* *Year FE*	*(4)* *Year, Country & Commodity FE*	*(5)* *Year FE*	*(6)* *Year, Country & Commodity FE*
Exporter Production	0.36***	0.69***	0.36***	0.69***	0.36***	0.69***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Transport Cost	-0.68***	-1.97***	-0.68***	-1.97***	-0.68***	-1.97***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Tariff Rate	-8.30***	-3.71***	-8.31***	-3.71***	-8.28***	-3.70***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
NAFTA	1.08***	2.92**	1.08***	2.93**	1.09***	2.93**
	(0.00)	(0.04)	(0.00)	(0.04)	(0.00)	(0.04)
All Other FTAs	0.33**	0.12	0.33**	0.12	0.33**	0.12
	(0.03)	(0.42)	(0.03)	(0.43)	(0.03)	(0.42)
Mainland US	1.27***	0.32	1.27***	0.32	1.26***	0.32
	(0.00)	(0.33)	(0.00)	(0.33)	(0.00)	(0.33)
TREAT	-0.12	0.03	-0.12	0.03	-0.12	0.03
	(0.24)	(0.78)	(0.24)	(0.82)	(0.22)	(0.82)
NMA	-0.78***	-1.08***	-0.78***	-1.09***	-0.80***	-1.09***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
NMA_{t-2}	0.12	0.06	0.12	0.06	0.11	0.06
	(0.51)	(0.68)	(0.50)	(0.71)	(0.56)	(0.71)
NMA_{t-4}	-----	-----	-0.02	-0.18	-0.04	-0.18
	-----	-----	(0.93)	(0.27)	(0.86)	(0.27)
NMA_{t-6}	-----	-----	-----	-----	0.20	-0.06
	-----	-----	-----	-----	(0.31)	(0.70)
N	2732	2732	2732	2732	2732	2732
R^2	0.21	0.56	0.21	0.56	0.21	0.56
F-Statistic	35.12	28.18	33.44	27.96	31.97	27.72

Note: The dependent variable is the natural logarithm of the U.S. imports of fresh fruits and vegetables expressed as the Customs Value. Only Customs Values above $100,000 are included. P-values are in parentheses. FE denotes fixed effects and FRT (VEG) denotes fruits (vegetables). FTA is a dummy variable denoting free trade agreements and Mainland US is a dummy variable denoting shipments that may enter the continental US. TREAT is a dummy variable if the export shipment was subject to any kind of treatment (listed in table 2). NMA is a dummy variable denoting new market access. The sample contains 95 countries, 12 years, and 46 fresh fruit and vegetable product lines.