Trade Barriers or Trade Catalysts? The Effects of Phytosanitary Measures on U.S. Fresh Fruit and Vegetable Imports

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Abstract

U.S. imports of fresh fruits and vegetables have increased sharply since the late 1980's. With increased imports come increased concerns that pests and diseases may infest shipments of fresh agricultural products. To address this concern, USDA's APHIS implements phytosanitary measures that mitigate pest and disease risks. These regulations vary from documentation requirements, inspection, or requiring that shipments receive a phytosanitary treatment.

A growing body of literature attempts to assess the generic trade flow effects of SPS measures. Still, little evidence is available to shed light on the nature, size, and scope of SPS standards and their role as "trade barriers" versus "trade catalysts."

This thesis fills the void in the literature in two respects. First, a novel database on phytosanitary measures pertaining to U.S. imports of 47 fresh fruit and vegetable products from 95 countries is developed for the period 1996-2007. This disaggregated approach allows for the effects of specific phytosanitary treatments to be identified. Second, following recent literature, the issue of "zeros" is addressed while estimating a gravity model of international trade.

The findings suggest that phytosanitary treatments initially inhibit fresh fruit and vegetable imports. However, their trade reducing effects are uneven across product sectors, development status categories and treatment types. Finally, globally large exporters facing a treatment requirement ship more fresh fruits and vegetable relative to small exporters facing the same regulation, suggesting the role of SPS measures as "trade barriers" versus "trade catalysts" depends on the relative size of the exporter in the global market.

Dedicated to my family

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Chapter 1: Introduction

United States (U.S.) imports of fresh fruits and vegetables (henceforward FF&Vs) have increased sharply since the late 1980's. As illustrated in Table 1, the value of U.S. fresh vegetable imports increased from $801.4 million in 1989 to $4.28 billion in 2007, with an average annual growth rate of 10.5 percent. During the same period, the value of U.S. fresh fruit imports increased from nearly $1.5 billion to $5.47 billion, with an average annual growth rate of 7.6 percent.[1] Imports of fresh vegetables have grown faster than total U.S. agricultural imports, with the share of fresh vegetables in total agricultural imports increasing from 3.7 percent in 1989 to six percent in 2007. Imports of fresh fruits have grown nearly as fast as total agricultural imports, with the fresh fruit share of total agricultural imports remaining constant at around 7.5 percent (USDA, FASonline, 2009).[2]

In terms of value, tomatoes, peppers, and cucumbers and gherkins are the largest categories of imported fresh vegetables, accounting for 58.1 percent of the total U.S. fresh vegetable imports in 2007. Other important fresh vegetable imports include asparagus, onions and shallots, garlic and potatoes. Because of their perishable nature, a large portion of fresh vegetable imports are sourced from contiguous countries such as Mexico, and to some extent, Canada. Other key fresh vegetable suppliers include Peru, China, the Netherlands, Costa Rica, Guatemala and the Dominican Republic (USDA, FASonline, 2009).

Bananas are traditionally the largest imported fresh fruit by value. However, in recent years, banana imports have stagnated at about $1.1 billion per year, resulting in a decline in

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[1] U.S. statistics for total agricultural products and FF&V imports as defined under the Bulk, Intermediate, and Consumer Oriented (BICO) foods and beverages are used. Under BICO, total U.S. fresh fruit imports are defined as the sum of bananas/plantains and other fresh fruits. The United States Department of Agriculture's (USDA's) Foreign Agricultural Service (FAS) definition of FF&Vs includes 156 fresh vegetables and 95 fresh fruits constructed from the Harmonized Tariff Schedule (HTS) ten-digit codes (USDA, FASonline, 2009).

[2] During the period 1989 through 2007, U.S. fresh fruit imports have grown at an average rate of 7.6 percent, 0.9 percentage points lower as compared to the average rate of growth in total agricultural imports.

Table 1: United States Fresh Fruit and Vegetable Imports

	Fresh Fruit Imports		Fresh Vegetable Imports	
year	Value ($ millions)	Share of Agricultural Imports	Value ($ millions)	Share of Agricultural Imports
1989	$1,496.1	6.8%	$801.4	3.7%
1990	$1,693.1	7.4%	$1,032.8	4.5%
1991	$1,829.2	8.0%	$928.6	4.1%
1992	$1,901.1	7.7%	$798.1	3.2%
1993	$1,874.6	7.5%	$1,103.0	4.4%
1994	$1,979.9	7.3%	$1,206.5	4.5%
1995	$2,174.3	7.2%	$1,444.8	4.8%
1996	$2,402.8	7.2%	$1,709.0	5.1%
1997	$2,477.1	6.9%	$1,711.2	4.7%
1998	$2,681.6	7.3%	$2,166.4	5.9%
1999	$3,102.4	8.2%	$2,022.8	5.4%
2000	$3,023.5	7.8%	$2,156.9	5.5%
2001	$3,147.5	8.0%	$2,440.0	6.2%
2002	$3,377.0	8.1%	$2,545.5	6.1%
2003	$3,529.6	7.4%	$2,986.5	6.3%
2004	$3,778.2	7.0%	$3,357.6	6.2%
2005	$4,351.0	7.3%	$3,566.2	6.0%
2006	$4,803.0	7.4%	$3,989.2	6.1%
2007	$5,470.5	7.6%	$4,282.2	6.0%

Source: USDA, FASonline, 2009

bananas' share of total U.S. fresh fruit imports from nearly 50 percent in 1989 to almost 20 percent in 2007. Imports of grapes and tropical fruits, such as mangoes, papayas, and pineapples, have grown notably during this period. Because fresh fruits may be stored for longer periods than fresh vegetables, U.S. fresh fruit imports can be sourced from more distant countries such as Southern Hemisphere countries (Argentina, Australia, Brazil, Chile, New Zealand, South Africa and Peru) and banana-exporting countries (Colombia, Costa Rica, Ecuador, Guatemala, Honduras and Panama). Between 1989 and 2007, these countries accounted for 71 percent of the annual U.S. fresh fruit imports. However, this share has shrank from more than 80 percent in 1989 to 62 percent in 2007, mainly due to increased U.S. imports of specialty fruits such as avocados, mangoes, and papayas that are sourced from other trade partners including Mexico and India (USDA, FASonline, 2009; Huang and Huang, 2007).

The growth in FF&V imports has allowed U.S. consumers to have access to greater product varieties and year-round consumption of fresh produce. Huang and Huang (2007) have suggested a number of factors that have influenced the growth in U.S. FF&V imports, such as improvements in handling and shipping methods, increasing consumer earnings and nutritional concerns, the proliferation of free trade agreements (FTAs), including the North American Free Trade Agreement (NAFTA) and the Central America-Dominican Republic-U.S. FTA (CAFTA-DR), increasing ethnic diversity in the U.S. population, changing consumer tastes, and the desire for product variety.

1.1 United States Regulation of Fresh Fruit and Vegetable Imports

Because of the possibility for pests and diseases to infest shipments of agricultural products, imports of FF&Vs into the U.S. are regulated by the USDA's Animal and Plant Health

Inspection Service (APHIS). In addition to meeting general documentation requirements and possibly being subject to inspection prior to entry, imports may also be required to comply with additional phytosanitary measures, such as phytosanitary treatments (e.g., methyl bromide fumigation), system approaches to pest risk management, restrictions on origin and/or destination, mandatory or optional preclearance procedures in the exporting country, or some combination of these requirements. APHIS, along with the Food and Drug Administration (FDA), also has the authority to ban the importation of a product from a foreign country that has an identified pest risk, and has not developed approved pest mitigation practices. However, as a member of the World Trade Organization (WTO), all U.S. phytosanitary regulations must comply with the Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures. These measures, whose purpose is to protect human, animal, and plant life and health, are to be based on scientific evidence, be equally applied to domestic and foreign producers, and be the least trade impeding measures needed to achieve the desired level of phytosanitary protection.[3]

As illustrated in Figures 1 and 2, which show the percentage of global export volume eligible for entry into the U.S., the use of import bans by APHIS is common for FF&Vs. With the exception of mushrooms, all FF&V categories have import restrictions in place. However, there is substantial variation in the magnitude of the import restrictions across different FF&V categories. For example, no imports of fresh dates, olives or sweet potatoes are allowed while there are few import bans for cranberries and blueberries, grapes, and strawberries. Across the 25 fresh fruits listed in Figure 1, the average level of eligible exports is approximately 52 percent, and the average level of eligible exports for the 18 fresh vegetables in Figure 2 is 60 percent.

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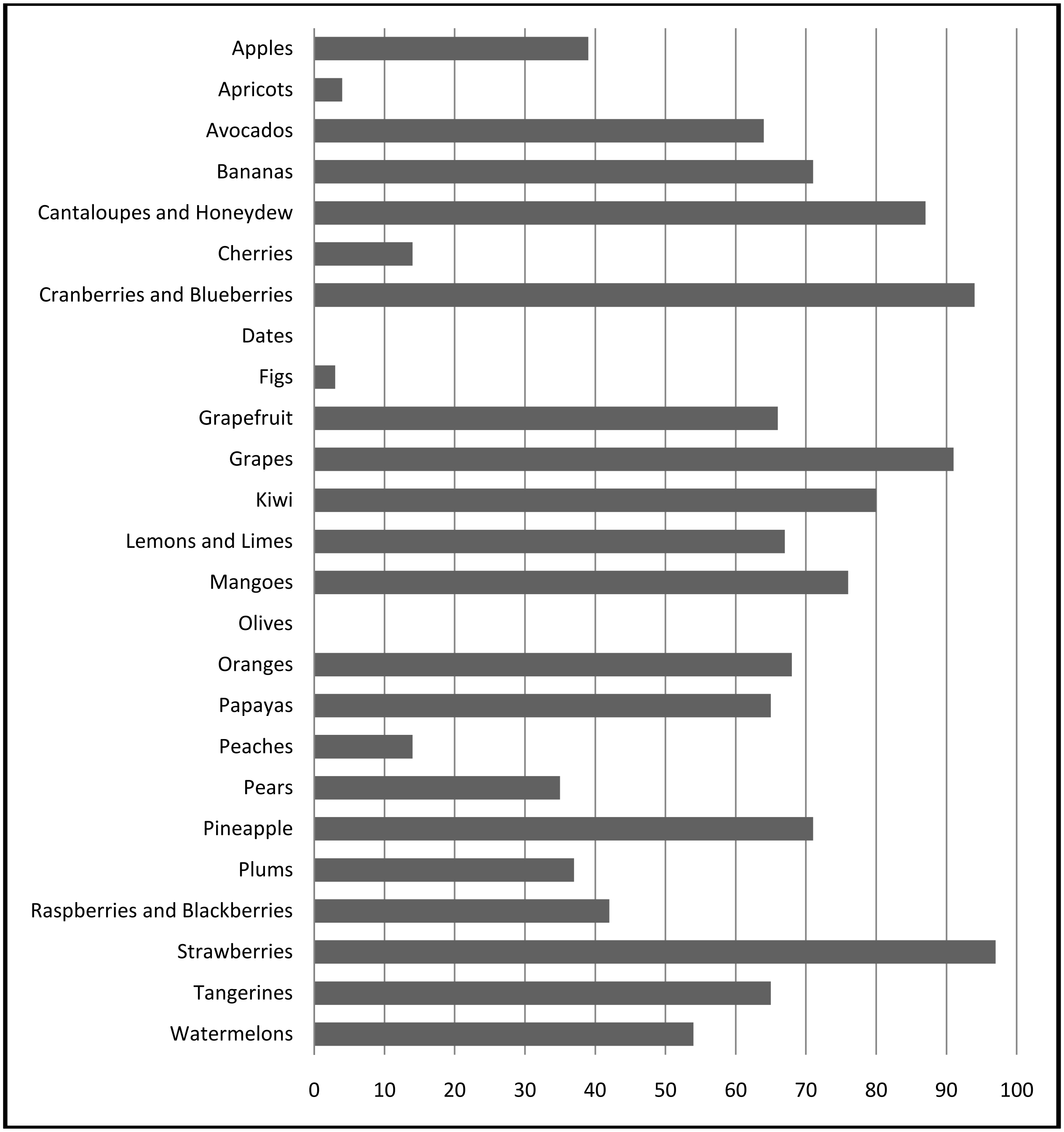
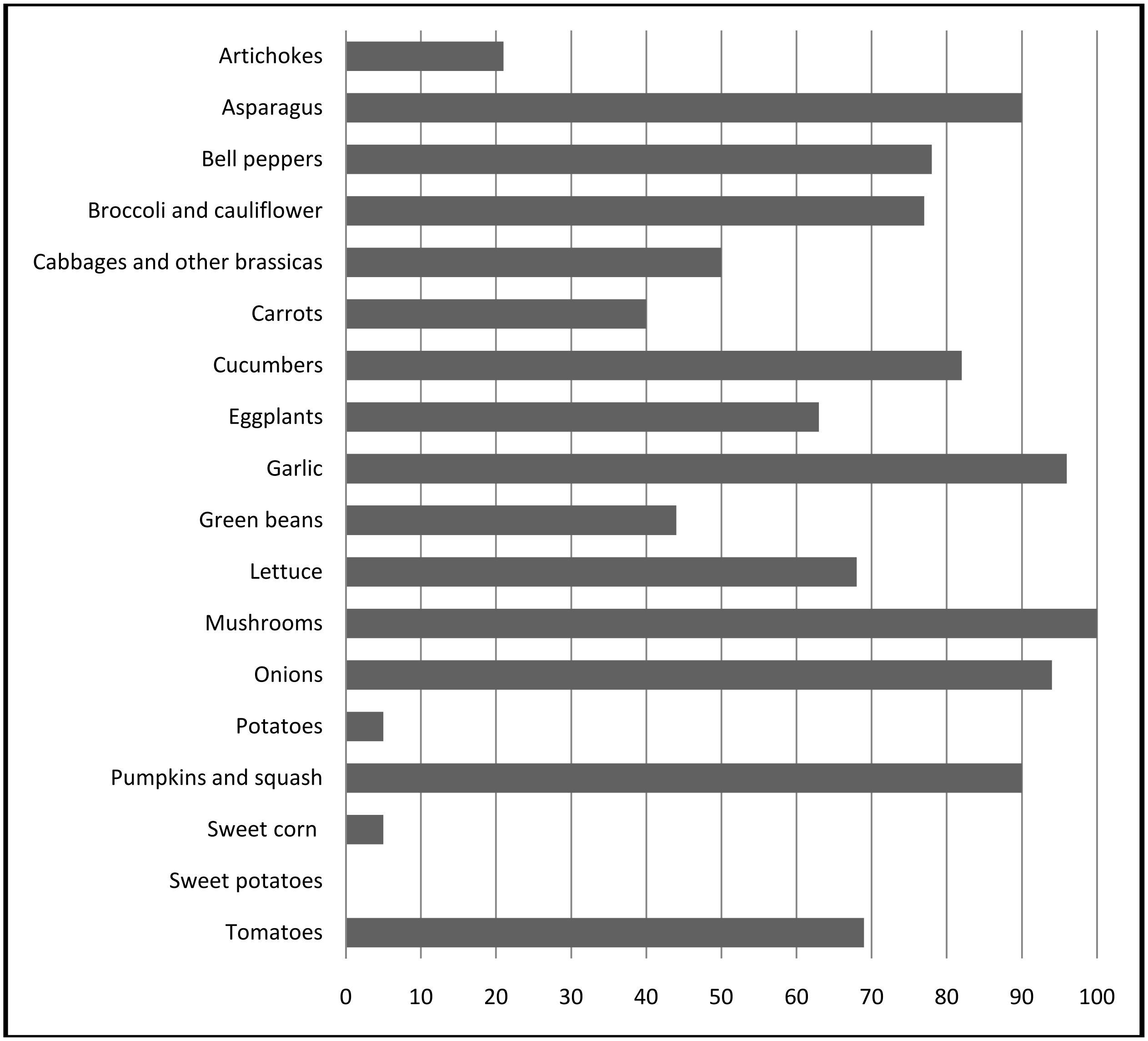
[3] For a complete definition of SPS measures, see Annex A of the SPS Agreement itself (WTO, 1994, p.77). Available online at: http://www.wto.org/english/docs_e/legal_e/15-sps.pdf.

Figure 1: Percent of Global Fresh Fruit Export Volume Eligible for Importation to the United States



Source: USDA, ERS, 2008.

Figure 2: Percent of Global Fresh Vegetable Export Volume Eligible for Importation to the United States



Source: USDA, ERS, 2008.

Phytosanitary treatments, such as methyl bromide fumigation or cold treatment, are less frequently applied than import bans. Between 1996 and 2007, phytosanitary treatments were required on approximately 15 percent of all observed exporter/commodity/year pairs of FF&V imports into the United States.[4] Phytosanitary treatments on fresh fruits occurred almost three times more often as phytosanitary treatments on fresh vegetables. Cold treatment, water treatment, and methyl bromide fumigation were the most commonly required phytosanitary treatments for fresh fruits, accounting for nearly 80 percent of all phytosanitary treatments. Methyl bromide fumigation was the most commonly required phytosanitary treatment for fresh vegetables, accounting for nearly 85 percent of all phytosanitary treatments on fresh vegetables.[5]

Developing countries' exports to high-income countries in product groups less affected by traditional trade barriers (e.g., tariffs), such as tropical fruits, have been increasing (Unnevehr and Roberts, 2003). However, because of concerns about the introduction of pests and food safety, the safety protocols implemented by high-income countries in their SPS regulations are often more stringent than internationally recognized benchmarks (Otsuki, Wilson, and Sewadeh, 2001a). As a result, developing countries have feared that SPS regulations in high-income countries may represent export obstacles. In addition, developing countries have expressed their dissatisfaction with the implementation of the SPS Agreement, and the time allowed for them to comply with new SPS measures required by developed countries (Henson and Loader, 2001). Interestingly, during the period 1996-2007, U.S. phytosanitary treatments pertaining to FF&V imports were required more often for developed than for developing and least-developed countries (LDCs). In fact, more than 17 percent of the observed import flows from developed countries, and just below 14 percent of the observed import flows from developing/LDCs were

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[4] Chapter 5 provides an in-depth discussion of the database and sample summary statistics.

[5] Chapter 2 discusses phytosanitary treatment requirements and frequency of treatment applications in the sample.

subject to at least one phytosanitary treatment.[6] One may argue that imports from developed countries are more strictly regulated due to political reasons or trade tensions. On the other hand, imports from developing/LDCs may more often be sourced from FTA partners where the frequency of SPS barriers is lower, or developing/LDCs are often granted special and differential treatment under the generalized system of preferences (GSP) for these countries which might reduce the frequency with which SPS measures are erected.

1.2 Thesis Objectives

Concern over how and to what extent SPS measures impact trade is gaining traction in the empirical trade literature. However, relatively few *ex post* empirical assessments of specific SPS measures have been completed to date (Beghin and Bureau, 2001). One reason for this is the difficulty in developing accurate and comprehensive databases on SPS regulations. Wilson (2003) notes that such an endeavor likely requires a joint effort by professionals in different fields, such as economists, food scientists and policy makers.

There is now an established literature that attempts to assess the generic trade flow effects of SPS measures (e.g., Disdier, Fekadu, Murillo and Wong, 2008; Disdier, Fontaigné and Mimouni, 2008; Anders and Caswell; 2009). Recent empirical studies, often employing the gravity model of international trade, mainly find a negative impact of SPS regulations on agricultural exports, particularly for developing countries (e.g., Otsuki, Wilson, and Sewadeh, 2001a; Otsuki, Wilson, and Sewadeh, 2001b; Wilson and Otsuki, 2003; Wilson, Otsuki and Majumdar, 2003; Wilson and Otsuki, 2004; Scheepers, Jooste and Alemu, 2007; Gebrehiwet,

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[6] Due to the small number of LDCs in the sample, the study combines developing and LDCs into one development status category. This protocol is followed throughout the thesis. A list of developed countries is obtained from the International Trade Centre (ITC) (ITC, 2008) and a list of LDCs from the United Nations (UN) (UN, 2008). Countries that do not appear on these two lists are considered developing countries.

Ngqangweni and Kirsten, 2007; Chen, Yang and Findlay, 2008; Ardakani, Yazdani and Gilanpour, 2009). Most of these studies focus on a single commodity (e.g., Wilson and Otsuki, 2004), or a single regulation (e.g., Otsuki, Wilson, and Sewadeh, 2001a), making it difficult to generalize the impacts of SPS regulations on agricultural trade, much less a particular sector such as FF&Vs. Moreover, it is impossible to differentiate the trade flow impacts of specific types of SPS measures in these studies.

In most gravity models, the presence of SPS regulations are modeled using coverage ratios and/or frequency indices based on an "inventory approach" (e.g., Disdier, Fontaigné and Mimouni, 2008). Coverage ratios are defined as the share of imports affected by non-tariff barriers (NTBs) to trade in a particular sector, while a frequency index is defined as the number of product lines affected by NTBs within a product category also expressed as a share (Beghin and Bureau, 2001). Count-style variables are also used to estimate the impact of SPS barriers. In a recent study by Jayasinghe, Beghin and Moschini (2009), the authors employ a count variable that sums the number of SPS measures applied to a particular product (corn seed trade in this case). Other studies have relied on dummy variables. For example, Disdier, Fekadu, Murillo and Wong (2008) employ a generic dummy variable equal to one if at least one SPS measure is notified within a given product category, and zero otherwise.

The main problem with using share, count and generic dummy variables to represent SPS regulations in models of international trade is that the effects of individual measures cannot be identified. In fact, individual SPS measures (or other NTBs) may hinder or boost trade. For example, a SPS regulation may lead to increased exports due to increased consumer confidence in the importing country and/or improved product characteristics (Liu and Yue, 2009). Similarly, a restriction on the maximum residue limit (MRL) for use of a new pesticide on a fresh product may potentially stimulate exports by expanding the available technology to farmers in foreign countries. In cases where individual regulations have offsetting effects, the estimated coefficient for the share, count or generic dummy variable may not be statistically significant or its interpretation may not be meaningful.

Second, most empirical studies use more aggregate trade data relatively to the one used in this study, that is typically obtained from the United Nations Conference on Trade and Development's (UNCTAD's) Trade Analysis and Information Systems (TRAINS) database. However, this database was created based on notifications to the WTO, is subject to large measurement error (Anderson and van Wincoop, 2004), and most NTBs identified in this database are outdated because they are based on traditional NTBs such as quotas, embargoes, or variable levies and exclude most (if not all) "new" forms of NTBs such as SPS regulations and food safety standards. In addition, many SPS measures, particularly those required by high-income Organisation for Economic Co-operation and Development (OECD) countries, such as the U.S., are defined at the detailed product line level which necessitates a product line approach (USDA, APHIS, 2009a).

Finally, recent empirical studies, with the exception of Jayasinghe, Beghin and Moschini (2009), do not properly address the issue of zero trade flows that are usually frequent in a product-level analysis. As recently noted by Santos Silva and Tenreyro (2006) and Martin and Pham (2008), omission of the "zeros" may lead to biased estimates of the parameters due to sample selection bias. The main reason for this is that excluding zero trade flows leads to a conditional trade model where the dependent variable is no longer a measure of bilateral trade but bilateral trade conditional on a trade relationship actually existing.

This study extends previous research in two ways. First, the problems associated with share and count variables are avoided by the creation of a novel database of eleven specific U.S. phytosanitary treatments applied to the imports of 47 FF&V product lines for the years 1996-2007. The database contains detailed information on regulatory requirements that foreign exporters must meet in order to access the U.S. market. These requirements may vary by product, exporter, and year. Collecting data at the product-level is important since it allows us to shed light on the nature, size, scope, and impact of SPS measures and their long-debated role as "trade barriers" versus "trade catalysts." Second, in light of recent literature (Santos Silva and Tenreyro, 2006; Martin and Pham, 2008) emphasizing the importance of zero trade flows in product-level analyses, this problematic issue is properly tackled by estimating a Poisson pseudo-maximum-likelihood (PPML) model.

The specific objectives of this thesis are:

1) To develop a novel and comprehensive database of phytosanitary measures pertaining to U.S. imports of FF&Vs.
2) To determine the impacts of phytosanitary treatments on U.S. imports of FF&Vs. More specifically, this thesis attempts to answer three policy questions:
    a) What is the effect of phytosanitary treatments on U.S. imports both generically and across product sectors and exporter development status categories?
    b) Do the effects of phytosanitary treatments differ by specific phytosanitary treatment types?

c) Does the long-debated issue of whether SPS regulations are trade barriers or trade catalysts depend on the relative size of the exporting country in the global market?

1.3 Thesis Organization

This thesis is organized as follows. Chapter 2 discusses U.S. regulation of FF&V imports. Chapter 3 discusses the literature and relevant empirical applications. Chapter 4 develops the empirical method used to estimate the trade flow effects of phytosanitary treatments. Chapter 5 discusses the data. Chapter 6 presents the results, and Chapter 7 concludes with some policy implications, and discusses limitations and future areas for research.

Chapter 2: United States Fresh Fruit And Vegetable Import Regulation

Increased FF&V imports raise concerns about the introduction of non-indigenous plant pests and diseases, such as fruit flies, and other pathogens into the U.S. via shipments of these products from abroad. Alternative pathways through which pests and diseases may be introduced include natural spreading by wind or birds, sale of plants and seeds, imports of non-native species for horticulture and herbal medicine, and human actions such as intentional or accidental smuggling. Humans account for most non-indigenous specie and pathogen introductions, although most introductions occur accidentally. Even though it is hard to rank all causes influencing the introduction of pests and diseases due to the lack of data, international trade and travel are considered as key factors (National Research Council, 2002). Efforts to prevent pest and disease introductions into the U.S. date back to the Plant Quarantine Act (PQA) of 1912, which addressed the issue of pest outbreaks from the importation of nursery stock (USDA, APHIS, 2005). Currently, under the Plant Protection Act (PPA) of 2000, U.S. FF&V imports are regulated by APHIS, which has the authority to set phytosanitary measures to reduce risks from the entry of pests and diseases to acceptable levels, to implement safety protocols in cases of outbreaks, and to assemble principles for application of civil penalties in cases of violations (USDA, APHIS, 2002).

All eligible FF&V imports are possibly subject to inspection and must meet general documentation requirements upon arrival in the U.S. (e.g., phytosanitary certificates). In addition, shipments may also be required to comply with additional phytosanitary measures as a condition of entry. Title 7, Chapter III, part 319 of the U.S. Code of Federal Regulations (7 CFR § 319.56-4) identifies five main phytosanitary categories pertaining to U.S. imports of FF&Vs: phytosanitary treatments; geographical restrictions on origin; geographical restrictions on destination; preclearance procedures in the exporting country; and systems approaches to pest risk management (U.S. Government, 2008). Table 2 provides a succinct description of each of these categories as well as specific examples.

2.1 Phytosanitary Treatments

Phytosanitary treatments are designed to control a specific pest or disease and are applied to all commodities that are a host to that pest or disease, and to all exporting countries where that pest or disease is known to exist. The USDA/APHIS *Treatment Manual* lists ten phytosanitary treatments currently used to prevent the spread of agricultural pests (e.g., fruit flies) from the importation of FF&Vs (USDA, APHIS, 2009b).[7] These treatments, including specific examples, are described in Table 3.

The length of the treatment period as well as the treatment dose varies by the targeted pest or disease. Treatment subcategories typically describe the commodity, pest, exporter, and allowed dose that are specific to each treatment. For example, avocado imports from the Philippines must be fumigated with methyl bromide (T101-c-1) at a dosage of 2 lbs/1000 ft^3 at or above 70^0F to control for Mediterranean fruit flies. Similarly, asparagus imports from Thailand must be fumigated with methyl bromide (T101-b-1-1) with a dosage of 4 lbs/1000 ft^3 at a temperature between $60\text{-}69^0$F to control for *Scirtothrips dorsalis*, which is only one of the three available treatment dose/exposure period combinations.[8] In some instances, an exporter may choose between different phytosanitary treatments or treatment groups that achieve the desired level of phytosanitary protection. For example, grape imports originating in the Chilean Arica

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[7] The latest publication of the USDA/APHIS *Treatment Manual* pertaining to phytosanitary treatment schedules for FF&Vs is available online at: http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment_pdf/05_02_t100schedules.pdf

[8] According to Wikipedia's online encyclopedia, the common name of *Scirtothrips dorsalis* is chilli (yellow tea) thrips. Available online at: http://en.wikipedia.org/wiki/Scirtothrips_dorsalis

Table 2: Five Main Categories of United States Phytosanitary Measures for Fresh Fruit and Vegetable Imports

Phytosanitary Measure	Description	Example
Phytosanitary Treatments	Phytosanitary 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 U.S. and its territories.	Fresh mangoes from India must be irradiated before being shipped to the United States.
Geographical Restrictions on Origin	Products must be grown in greenhouses or in areas/regions that are recognized as pest-free by APHIS.	Papayas from Brazil must be grown in the state of Bahla, Espirito Santo, and Rio Grande do Norte.
Geographical Restrictions on Destination	APHIS distinguishes between 13 different U.S. ports of entry. However, some ports, including Puerto Rico and Alaska are not considered part of the continental United States.	The United States allows the importation of squash from New Zealand only into Hawaii.
Preclearance Procedures in the Exporting Country	Preclearance procedures involve inspection on the territory of the exporting country by APHIS authorities of a product which is associated with quarantine pests. In addition, the product is accompanied by a phytosanitary certificate stating the product has been inspected and found free of pests.	Mangoes from the Philippines must be precleared prior to export.
Systems Approaches to Pest Risk Management	A group of different pest risk-mitigation techniques which cumulatively achieve the desired level of phytosanitary protection, at least two of which act independently.	Fresh Hass avocados grown in approved orchards in the Mexican state of Michoacán are subject to a number of risk-mitigation practices at numerous points in the supply chain that cumulatively achieve the desired level of phytosanitary protection.

Sources: U.S. Government, 2008; USDA, APHIS, 2009a.

Table 3: Summary of United States Fresh Fruit and Vegetable Phytosanitary Treatments, Respective T100 Series Codes, and Specific Examples

T100 Series Code	Phytosanitary Treatment	Example
T101	Methyl Bromide Fumigation	To control Mediterranean fruit flies in avocado imports from the Philippines. Example dose: 2 lbs/1000ft^3 at 70^{0}F or above.
T102	Water Treatment	To control Mexican or Mediterranean fruit flies. Procedure: Hot water immersion performed at least 4 inches under water at a temperature of at least 115^{0}F.
T103	High Temperature Forced Air	To control Oriental and Mediterranean fruit flies, or melon flies in papaya imports from Belize. Procedure: heating of the product for 4 hours with a minimum pulp temperature at the end of the process of 117^{0}F. Cooling follows.
T104	Pest Specific/Host Variable	To control hitchhikers and various surface pests, such as ants or leafminers, found in a wide range of imported commodities (e.g., apples, apricots, and plums). Example fumigation dose: 4 lbs/1000ft^3 at 40^{0}F or above.
T105	Irradiation	To control fruit flies and insect pests in mango imports from India. Mangoes are treated with a minimum (maximum) irradiation dose of 400 (1000) Gray (Gy).
T106	Vapor Heat	To control Mexican fruit flies in grapefruit imports. Procedure: heating of the product for 8 hours with a minimum pulp temperature at the end of the process of 110^{0}F. Cooling follows.
T107	Cold Treatment	To control Mediterranean and Natal fruit flies in various product imports (e.g., blueberries and cherries). Procedure: products are exposed to cold temperature of at least 34^{0}F for 14 days.

Table 3 Continued

T100 Series Code	Phytosanitary Treatment	Example
T108	Fumigation Plus Refrigeration of Fruits	To control light brown apple moth complexes, Queensland and the Mediterranean fruit flies in apple, grape and pear imports. Procedure: Fumigation with methyl bromide. Example dose: 1.5 lbs/1000ft^3 at 50^{0}F or above, followed by cold treatment of at least 33^{0}F for 21 days.
T109	Cold Treatment Plus Fumigation of Fruits	To control Queensland fruit flies in apple, grape and pear imports from Australia. Procedure: products are exposed to cold temperature of at least 33^{0}F for 21 days, followed by methyl bromide fumigation. Example dose: 2 lbs/1000ft^3 at 70^{0}F or above.
T110	Quick Freeze	To maintain the quality of fresh product imports that in most cases will be processed at a later stage. Procedure: product temperature is lowered to at least 0^{0}F followed by a temperature of at least 20^{0}F for at least 48 hours.

note: The USDA/APHIS *Fresh Fruits and Vegetables Import Manual* identifies phytosanitary treatments based on their specific T100 Series codes (USDA, APHIS, 2009a).

Source: USDA, APHIS, 2009b.

province must either be fumigated with methyl bromide (T101-i-2-1) and cold treated (T107-a), or be subjected to fumigation plus refrigeration of fruits (T108-a) to control for external feeders, Mediterranean fruit flies and Natal fruit flies. Similarly, blueberry imports from South Africa must be fumigated with methyl bromide (T101-i-1-1) or cold treated (T107-a) to control for Mediterranean fruit flies and Natal fruit flies (USDA, APHIS, 2009a; USDA, APHIS, 2009b).

Irradiation (T105) was added to the list of eligible phytosanitary treatments in 2002 as an alternative to other approved treatments, or as a part of broader pest-risk mitigation techniques, such as systems approaches. While criticized for potential environmental and human health risks, irradiation controls pests and pathogens while not causing any damage to the product, which can occur for other phytosanitary treatments (U.S. Government, 2002). However, as of 2007, irradiation was required by just three exporting countries to treat a total of ten products (eggplant, okra and peppers from Ghana; mangoes from India; and mangoes, pineapples, litchi, longan, mangosteen and rambutan from Thailand) (USDA, APHIS, 2009a).

Information on phytosanitary measures pertaining to U.S. FF&V imports is published in the USDA/APHIS *Fresh Fruits and Vegetables Import Manual* (USDA, APHIS, 2009a). Data on phytosanitary treatments are collected for the period 1996 through 2007, which corresponds to the post-Uruguay Round time period when the WTO SPS Agreement has been in effect. Over this time period, there were a total of 5,777 observations on import flows, counting an exporter/product/year combination as a single observation. There is roughly an equal split between fresh fruit imports and fresh vegetable imports with the former totaling 2,891 observations and the latter totaling 2,886 observations. Phytosanitary treatments are required on 14.8 percent (or 858 observations) of these import flows, with 21.7 percent (or 627 observations) of the total fresh fruit imports being subject to a phytosanitary treatment while only 8 percent (or 231 observations) of total fresh vegetable imports are being subject to a phytosanitary treatment.

As illustrated in Table 4, this is considerable variation in the frequency that each phytosanitary treatment is applied. Across all FF&V product categories, fumigation with methyl bromide and cold treatment are dominantly required and jointly account for (79+195+331+0)/(627+231)=70.5 percent of all treatment applications. Fumigation with methyl bromide and cold treatment are followed by water treatment with a frequency of application of 11.7 percent .When only fresh fruits are considered, cold treatment accounts for 52.8 percent of all treatments, followed by water treatment with 15.9 percent, and methyl bromide fumigation with 12.6 percent. When considering fresh vegetables only, fumigation with methyl bromide accounts for 84.4 percent of all phytosanitary treatment requirements, followed by pest specific/host variable with 13.9 percent.

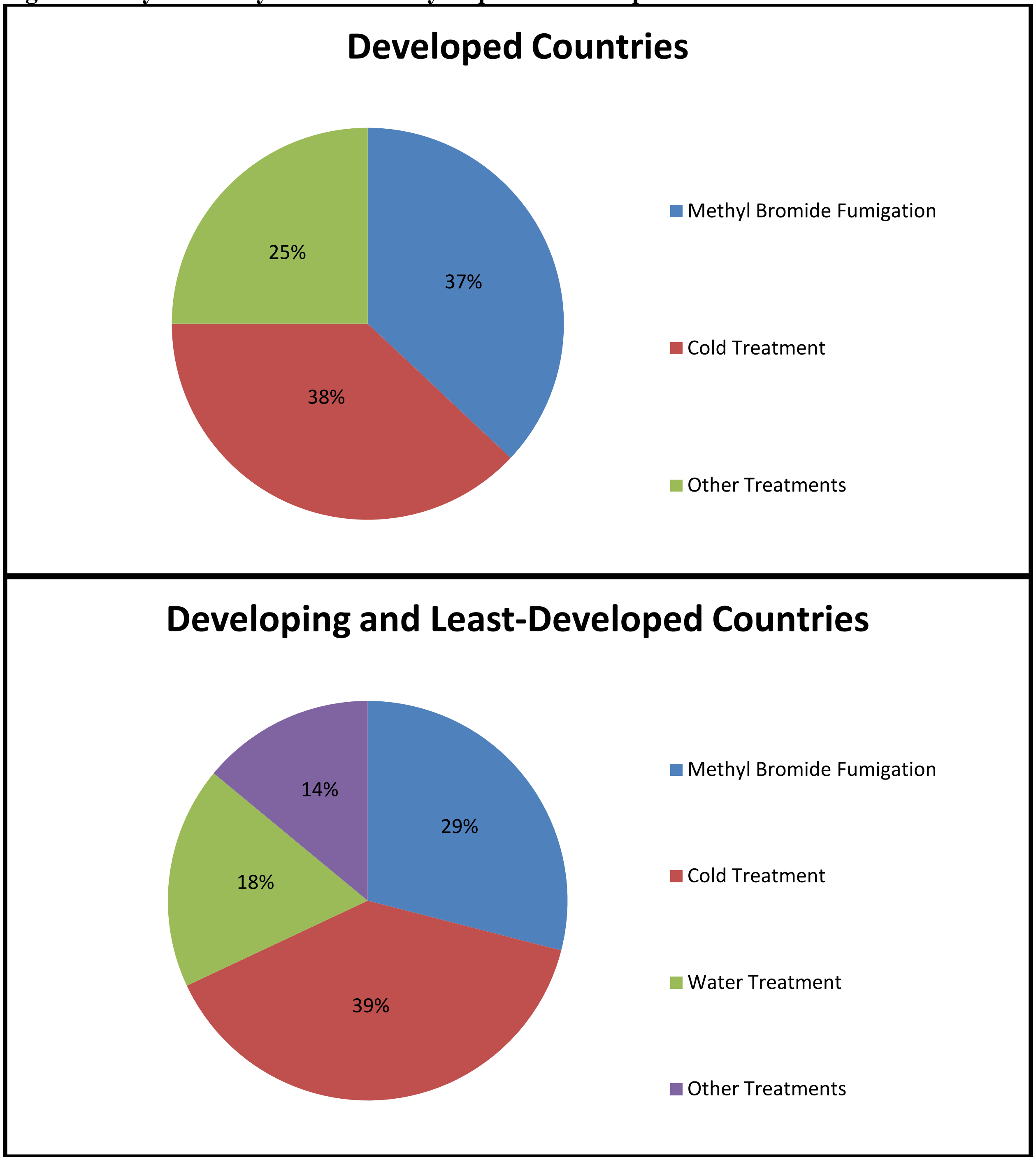
The frequency of required phytosanitary treatments also varies across the development status of the exporting countries. Phytosanitary treatments are more often required for exporters from developed countries than for developing/LDCs with 17.4 percent of all import flows from developed countries being subject to at least one phytosanitary treatment compared to 13.8 percent of all import flows originating in developing/LDCs. In addition, as illustrated in Figure 3, there is variation in the types of phytosanitary treatments required of imports from developed versus developing/LDCs. For imports from developed countries, methyl bromide fumigation and cold treatment are the dominantly required treatments and account for 37 and 38 percent of all treatment requirements, respectively. For imports from developing/LDCs, cold treatment accounts for 39 percent of all required treatments, followed by methyl bromide fumigation with 29 percent, and water treatment with 18 percent.

Table 4: Frequency of Phytosanitary Treatments

Phytosanitary Treatment	Frequency		Percent	
	Fresh Fruits	Fresh Vegetables	Fresh Fruits	Fresh Vegetables
Methyl Bromide Fumigation	79	195	12.6	84.4
Cold Treatment	331	0	52.8	0.0
Water Treatment	100	0	15.9	0.0
Methyl Bromide Fumigation and Cold Treatment	31	0	4.9	0.0
Cold Treatment or Fumigation Plus Refrigeration of Fruits	39	0	6.2	0.0
Pest Specific/Host Variable	11	32	1.8	13.9
Fumigation Plus Refrigeration of Fruits	20	0	3.2	0.0
Heat Treatment	10	4	1.46	1.7
Water Treatment or Methyl Bromide Fumigation	2	0	0.3	0.0
Irradiation	3	0	0.5	0.0
Methyl Bromide Fumigation or Cold Treatment	1	0	0.2	0.0
Totals	627	231	100.0	100.0
Percent of Total Observed Import Flows Subject to at Least One Treatment	21.7	8		

Source: USDA, APHIS, 2009a; USITC, 2009.

Figure 3: Phytosanitary Treatments by Exporter Development Status



Source: USDA, APHIS, 2009a; USITC, 2009; ITC, 2008; UN, 2008.

Phytosanitary treatment requirements vary widely across FF&V product categories eligible for importation to the United States. Tables 5 and 6 illustrate the shares of eligible exporting countries and respective exports (by value) that are subject to at least one phytosanitary treatment for the 24 fresh fruit and 23 fresh vegetable products included in the sample in 2007, respectively.[9] In terms of eligible fresh fruit exporting countries, phytosanitary treatment requirements range from zero percent (e.g., on bananas), to more than 40 percent for grapefruit, oranges and mangoes, and 63.2 percent for grapes, the highest in this category. When considering fresh fruit imports by value, treatment applications range from zero percent (e.g., for melons), to more than 90 percent for peaches and nectarines, mandarins and clementines, and plums and sloes. On the other hand, in terms of eligible fresh vegetable exporting countries, treatment requirements vary from zero percent (e.g., for mushrooms and truffles), to 22.5 percent for garlic, and nearly 39 percent for okra. When considering fresh vegetable imports by value, treatment applications range from zero percent (e.g., for potatoes) to more than 90 percent for broccoli and Brussels sprouts. Comparing fresh fruit and fresh vegetable phytosanitary treatment shares in Tables 5 and 6 reveals that phytosanitary treatment requirements are more pervasive for the former rather than the latter. On average, across all fresh fruits, nearly 17 percent of the eligible exporters (standard deviation of 18 percent) and 33 percent of the respective exports (standard deviation of 39 percent) are subject to at least one phytosanitary treatment. However, across all fresh vegetables, only 7 percent of the eligible exporters (standard deviation of 10 percent) and 15 percent of the respective exports (standard deviation of 31 percent) are subject to at least one phytosanitary treatment requirement on average.

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[9] Chapter 5 provides a more in-depth discussion of how lists of eligible exporters to the U.S. are compiled for each year during the sample period.

Table 5: Shares of Exporters and Imports (Value) Subject to at Least One Phytosanitary Treatment Requirement for United States Fresh Fruit Markets[j]

Commodity	Share of Exporters With at Least One Required Phytosanitary Treatment (%)	Share of Imports (value) With at Least One Required Phytosanitary Treatment (%)
Apples	29.2	2.9
Apricots	18.8	71.1
Avocados[k]	13.3	80.2
Bananas	0.0	0.0
Cherries	4.5	3.2
Cranberries & Blueberries	12.5	0.5
Currants	0.0	0.0
Grapefruit	40.0	7.3
Grapes	63.2	72.5
Kiwifruit	37.5	54.6
Lemons	7.9	32.6
Limes	4.5	0.1
Mandarins & Clementines	39.1	97.3
Mangoes	41.9	40.3
Melon	0.0	0.0
Oranges	40.7	86.8
Papayas	0.0	0.0
Peaches & Nectarines	12.5	97.2
Pears & Quinces	20.0	40.0
Pineapples	2.7	1.3
Plums & Sloes	16.7	99.7
Raspberries & Blackberries	0.0	0.0
Strawberries	0.0	0.0
Watermelons	0.0	0.0

Sources: USDA, APHIS, 2009a; USITC, 2009.

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[j] All calculations are for the year of 2007. See Chapter 5 for a discussion on the database development process. Percentages of exporters subject to at least one treatment are calculated as follows: (number of exporters subject to at least one treatment)/(total number of countries exporting the product to the U.S. in 2007)*100. Percentages of imports by value subject to at least one treatment are calculated as follows: (sum of total exports to the U.S. subject to at least one treatment)/(sum of total exports to the U.S. in 2007)*100.

[k] In this case, phytosanitary treatments and systems approaches are counted in order to capture the effect of phytosanitary measures on Mexican Hass avocado exports to the U.S. that are not subject to any treatment requirements, but are required to comply with a number of phytosanitary measures as a part of a systems approach.

Table 6: Shares of Exporters and Imports (Value) Subject to at Least One Phytosanitary Treatment Requirement for United States Fresh Vegetable Markets[1]

Commodity	Share of Exporters With at Least One Required Phytosanitary Treatment (%)	Share of Imports (value) With at Least One Required Phytosanitary Treatment (%)
Asparagus	12.0	57.7
Broccoli	10.0	92.0
Brussels Sprouts	12.5	99.7
Cabbage	13.6	37.0
Carrots	0.0	0.0
Cauliflower	0.0	0.0
Cucumbers	3.7	0.1
Eggplants	3.7	0.1
Fresh Beans	18.4	0.6
Garlic	22.5	0.3
Globe Artichoke	0.0	0.0
Head Lettuce	13.3	0.1
Jicamas, Pumpkins, Breadfruit	0.0	0.0
Leaf Lettuce	5.3	5.0
Leeks	0.0	0.0
Mushrooms & Truffles	0.0	0.0
Okra	38.9	63.2
Onions	0.0	0.0
Peppers	1.9	0.1
Potatoes	0.0	0.0
Spinach	0.0	0.0
Squash	3.2	0.3
Tomatoes	3.8	0.1

Sources: USDA, APHIS, 2009a; USITC, 2009.

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[1] All calculations are for the year of 2007. See Chapter 5 for a discussion on the database development process. Percentages of exporters subject to at least one treatment are calculated as follows: (number of exporters subject to at least one treatment)/(total number of countries exporting the product to the U.S. in 2007)*100. Percentages of imports by value subject to at least one treatment are calculated as follows: (sum of total exports to the U.S. subject to at least one treatment)/(sum of total exports to the U.S. in 2007)*100.

2.2 Geographical Restrictions on Origin and Destination

As outlined in Article 6 of the SPS Agreement, WTO members have agreed that phytosanitary measures may be applied to specific regions/areas within a country that are susceptible to a specific pest or disease while placing no restrictions on imports from regions of the country that are not susceptible to that pest or disease (WTO, 1994; Josling, Roberts, and Orden, 2004). For example, as shown in Table 2, all Brazilian papayas exported to the U.S. must be grown in the states of Bahla, Espirito Santo, or Rio Grande do Norte. Similarly, U.S. fragrant pear imports from China must be grown in either the Korla Region or the Xinjiang Province (USDA, APHIS, 2009a).

Phytosanitary measures, required by WTO Members, are also set based on the phytosanitary characteristics of the region/area of destination. As a result, the importation of some FF&Vs are restricted to certain U.S. ports of entry. The USDA/APHIS *Fresh Fruits and Vegetables Import Manual* identifies 13 categories of U.S. ports of entry through which foreign FF&V exports may arrive: All ports of entry (ALL), the entire State of Alaska (ALASKA), North Atlantic ports (NA), Northern Pacific ports (NP), South Atlantic and Gulf ports (SAG), Puerto Rico (PR), U.S. Virgin Islands (USVI), U.S. land border ports along the Mexican border (MB), the entire State of Hawaii (HAWAII), the U.S. territory of Guam (GUAM), the Commonwealth of the Northern Mariana Islands (CNMI), ports as specified on the permit (SoP), and limited ports (LTD). For instance, as illustrated in Table 2, the U.S. allows the importation of squash from New Zealand only into Hawaii, and not into the continental United States. However, destination restrictions are far less common than origin destinations. Over 98 percent of all observed import flows in the sample may arrive at ports of entry that are specified as being part of the continental United States (USDA, APHIS, 2009a).

2.3 Preclearance Procedures in the Exporting Country

In order to expedite imports of FF&Vs and facilitate trade, under supervision of USDA/APHIS officers, preclearance procedures, such as phytosanitary treatments and inspection, are often performed on the territory of the exporting country. For example, as shown in Table 2, fresh Indian mangoes may be imported into the U.S. if they have been subject to a preclearance procedure involving treatment with irradiation prior to export at an USDA/APHIS-approved facility in India. In addition, a phytosanitary certificate and a Preclearance Form 203 must accompany the shipment of fresh Indian mangoes at the port of entry. According to a risk assessment prepared by APHIS before mangoes from India were approved for importation to the U.S. in 2007, 14 pests (e.g., *Bactrocera caryeae*, *Sternochetus mangiferae*, and *Coccus viridis*), five fungi and one bacteria were found likely to accompany the shipments of fresh Indian mangoes and pose risks in the United States (USDA, APHIS, 2006). Similarly, Brazilian mangoes are subject to a preclearance protocol that involves treatment with hot water dip at an USDA/APHIS-approved facility in Brazil. In addition, a Preclearance Form 203, completed and signed by APHIS personnel at the site of origin, must accompany the shipment of Brazilian mangoes at the port of entry (USDA, APHIS, 2009a).

2.4 Systems Approaches to Pest Risk Management

As stated in the SPS Agreement, in order to achieve the desired level of phytosanitary protection, an importing country may adopt a combination of pest risk-mitigation methods based on appropriate science that cumulatively achieve this goal and are least trade distorting (WTO, 1994; Josling, Roberts, and Orden, 2004; Peterson and Orden, 2008). For instance, in order to mitigate risks posed by fruit flies and avocado-related pests, Mexican Hass avocados are currently imported in the U.S. under a systems approach. Specific requirements include field surveys, trapping activities targeting fruit flies, field sanitation, detailed post-harvest procedures and inspection at the port of arrival (Peterson and Orden, 2008). Similarly, in order to control the spread of a leafminer pest (*Tuta absoluta*), tomato exports from Spain, Morocco and France to the U.S. are also subject to a systems approach since March, 2009. In this case, specific measures include packaging in insect-proof cartons (or cartons covered with an insect proof tarpaulin), a phytosanitary certificate, and additional declarations stating that the tomatoes were grown in registered greenhouses, are originating from a *Tuta absoluta* free-region, and that the tomatoes have been produced in concordance with the systems approach, have been inspected, and found free of *Tuta absoluta* (USDA, APHIS, 2009a).

Although systems approaches are important and their complexity will surely have an impact on U.S. FF&V import flows, this phytosanitary measure type (along with geographical restrictions on origin and preclearance procedures in the importing country) are not considered in the empirical analysis for two reasons. First, systems approaches involve a wide variety of different specific phytosanitary requirements (e.g., field surveys and inspection), many of which are not considered in this analysis or are not easily coded into the database without detailed information on costs of phytosanitary compliance among exporters. Second, systems approaches as a broad phytosanitary measure category account for a small share of all applied phytosanitary requirements. Thus, identifying their impact is difficult both in terms of complexity and degrees of freedom issues.

Chapter 3: Literature Review

Two empirical approaches are commonly employed to assess the impact of SPS measures: simulation models and econometric gravity equations (Maskus, Otsuki and Wilson, 2001; Beghin and Bureau, 2001). Partial equilibrium models (e.g., Peterson and Orden, 2008) are used to identify the potential impacts of a recent or proposed change in SPS regulations for a specific commodity by a given importing country or region. This choice reflects the fact that little or no data exist for the post-policy period, rendering econometric analyses ineffective in quantifying the impacts of the policy change on trade. In these studies, the trade effects of tariff-rate equivalents of SPS measures are assessed in terms of total welfare changes in consumer and producer surplus, and in some cases increases in utility due to improved product characteristics.

Econometric approaches used to quantify the trade effects of SPS measures often use gravity models in which case historical trade flow data is matched to policy regulations to recover estimates of the impact of these policies on bilateral trade (e.g., Jayasinghe, Beghin and Moschini, 2009). The effect of regulatory regimes in these studies is indentified by comparing a test group (trade flows subject to SPS measures) and a control group (trade flows not being a subject to SPS measures). As opposed to partial equilibrium models, econometric gravity equations are typically used to assess the impacts of existing SPS measures when sufficient data is available across time and regions.[13]

While there is concern that developing and LDCs may not have the financial and technical resources to meet SPS requirements in high-income export markets (Henson and Loader, 1999; Michalopoulos, 1999; Henson and Loader, 2001; Athukorala and Jayasuriya,

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[13] In addition to the two main approaches, a price wedge method, as discussed in Beghin and Bureau (2001), that calculates a tariff rate equivalent based on the price discrepancy between a domestic product in the importing region and the equivalent imported product due to the impact of a NTB is also used, but in a small number of studies (e.g., Calvin and Krissoff, 1998; Yue, Beghin and Jensen, 2006; Liu and Yue, 2009).

2003), little empirical evidence is available to support this belief even though there has been a growing body of literature on this subject (e.g., Disdier, Fontaigné and Mimouni, 2008). One reason for this is the difficulty of constructing comprehensive databases on SPS measures which tend to be exporter/product/year specific, contain numerous restrictions on origin and/or destination, seasonal restrictions on exports, and involve a host of pest mitigation phytosanitary treatments.

The remainder of this chapter is organized into four main sections. The first focuses on partial equilibrium models that have been used to identify the impacts of SPS measures. The second section focuses on econometric gravity models. In the third section, limitations of the currently available academic literature are discussed. The final section focuses on the main contributions of this study.

3.1 Partial Equilibrium Models

Using a partial equilibrium (simulation) model, Peterson and Orden (2008) examined the trade effects of a November 2004 APHIS phytosanitary regulation that partially removed seasonal and destination restrictions on U.S. imports of fresh Hass avocados from approved orchards in Michoacán, Mexico. They found that under the adopted systems approach to pest risk management, risks of pest outbreaks in the U.S. remain low. In addition, due to the removed trade barriers, U.S. welfare annually increases by an estimated $77.4 million when pest risks and compliance costs are taken into consideration. Finally, when analyzing the effects of eliminating compliance measures which are part of the adopted systems approach, further gains to U.S. welfare are small and may be negative depending on the probabilities of a pest outbreak. Thus, elimination of these measures would not be in the best interest of the United States.

Calvin, Krissoff and Foster (2008) analyzed the effects of an August 2005 change in Japan's phytosanitary requirements for U.S. apple exports, namely a less restrictive fire blight (a bacterial plant disease) protocol. This change is a result of a WTO ruling which found Japan to be incompliant with the WTO's SPS Agreement.[14] The authors estimated an economic cost of 15 cents/pound for U.S. growers attributable to Japan's more restrictive phytosanitary standards, which is 10 cents/pound greater than the accounting (observed) cost. This additional cost is due to the uncertainty associated with the Japanese market participation program that required U.S. growers to incur costs in the spring before they knew if their apples would be exported to Japan. By using a partial equilibrium model, they also found that a removal of the fire blight protocol would lead to an increase in U.S. apple exports of $31.3 million or 27,639 metric tons. In addition, a removal of both fire blight and codling moth protocol would lead to an increase in U.S. apple exports of $82.7 million or 72,924 metric tons.

3.2 Gravity Models

The gravity model of international trade is an *ex post* econometric model of bilateral trade flows that has been extensively used in policy analyses. Gravity models are often able to explain most of the variation in bilateral trade flows with only three regressors: Gross Domestic Product (GDP) of the importing and exporting country, and geographical distance. When estimating the trade flow effects of multilateral trade agreements, Rose (2004, p.99) found it successful in two ways *"First, the estimated effects of distance and output (the traditional gravity effects) are sensible, economically and statistically significant, and reasonably consistent across studies. Second, the gravity model explains most of the variation in international trade. That is, the*

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[14] Another long standing coddling moth protocol on U.S. apple exports adopted by Japan has never been challenged in the WTO.

model seems reliable and fits the data well." Often using the gravity model, recent empirical studies identifying generic effects of SPS measures on agricultural exports mainly find a negative relationship, especially for developing countries. The following three subsections provide review of this academic literature. The first subsection focuses on studies that have attempted to identify the trade effects of aflatoxin standards. The second subsection discusses studies that quantify the trade impacts of MRL protocols. The final section reviews studies that assess the trade effects of SPS measures and technical barriers to trade (TBTs). In order to compare and contrast between different studies, the literature discussed in the first two subsections is summarized in Table 7.

3.2.1 Aflatoxin Standards using Gravity Models

Aflatoxins, mycotoxins typically produced by fungi growth that contaminate food product groups such as F&Vs, nuts, and cereals, may pose a threat to consumer health by introducing liver carcinogens. Aflatoxin B1, the most potent aflatoxin, is common in groundnuts, corn and cereal products, milk, tree nuts, and peanuts. Other health-treat posing aflatoxins to human's health include aflatoxins B2, G1, and G2 (Josling, Roberts, Orden, 2004; Otsuki, Wilson, and Sewadeh, 2001a; Pitt, 1998). In addition to setting a total aflatoxin standard, countries may set maximum allowable standard levels for specific aflatoxins, such as B1. The Expert Committee on Food Additives (JECFA), mutually organized by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), assessed the potential effects of aflatoxins on human health for two hypothetical standard levels of 20 parts per billion (ppb) and ten ppb. The committee found that in countries whose population has a low percentage of hepatitis B carriers, such as members of the European Union (EU), a

Table 7: Summary of Empirical Studies using the Gravity Model on the effects of Aflatoxin Standards and Maximum Residue Limits

Study	Policy Regulation	Product/Region	Trade Impact
Otsuki, Wilson, and Sewadeh (2001a)	Aflatoxin B1 standard level	Edible and oilseed groundnut exports from nine African to 15 EU countries	a) A ten percent stricter standard leads to an eleven percent decrease in edible groundnut exports. b) Harmonization of the standard at EU level leads to a 36 percent decrease ($430,000) in edible groundnut exports.
Otsuki, Wilson, and Sewadeh (2001b)	Aflatoxin B1 standard level	Dried fruit, edible nuts and cereal exports from nine African to 15 EU countries	A stricter EU standard (two ppb) as compared to the Codex standard (nine ppb) reduces exports by 64 percent ($670 million).
Wilson and Otsuki (2003)	Aflatoxin B1 standard level	Dried fruit, edible nuts and cereal exports from 31 exporters to 15 EU countries	a) If all importers adopt the Codex standard (of 7.5-10.5 ppb), cereal and nut exports would increase by $38.8 billion. b) If the EU standard (two ppb) is adopted by all importers, cereal and nut exports would decrease by $3.1 billion. c) Harmonized adoption of the Codex standard leads to a $6.1 billion increase in nuts and cereals trade among sample importers.
Gebrehiwet, Ngqangweni and Kirsten (2007)	Total aflatoxin standard level	Total food exports from South Africa to five developed importers	a) A one percent stricter standard leads to a 0.41 percent decrease in exports. b) If all importers adopted the Codex standard, it would have led to an additional $69 million in exports annually for the period 1995-1999.
Wilson, Otsuki and Majumdar (2003)	MRL of tetracycline antibiotics	Beef exports from 16 exporters (five OECD) to six developed importers	a) A one percent decrease in the MRL leads to a 0.59 percent decrease in exports. b) If all importers adopt the international standard (0.6 parts per million (ppm)), exports would increase by $3.2 billion (57 percent).
Wilson and Otsuki (2004)	MRL of chlorpyrifos	Banana exports from 21 developing exporters to eleven OECD importers	a) A one percent stricter regulation leads to a 1.63 percent decrease in exports. b) A global adoption of the EU standard leads to a $5.5 billion decrease in exports annually.
Scheepers, Jooste and Alemu (2007)	MRL of Prochloraz	Avocado exports from South Africa to the EU	a) A stricter standard leads to a decrease of $15.27 million in revenue for South African producers. b) If all importers adopted the Codex standard, exports would increase by $91.65 million.
Chen, Yang and Findlay (2008)	MRL of Chlorpyrifos; MRL of Oxytetracycline	Chinese fresh vegetable and fish and aquatic product exports to 12 importers	a) A ten percent decrease in the Chlorpyrifos MRL level leads to a reduction in vegetable exports by 2.8 percent, spinach exports by ten percent, onion exports by 2.1 percent and garlic exports by 3.2 percent. b) A ten percent reduction in the Oxytetracycline MRL level leads to a 2.7 percent decrease in fish and aquatic product exports.

decrease in the total aflatoxin standard level from 20 ppb to ten ppb leads to a reduction in the risk of cancer deaths by only two lives per billion people annually (Otsuki, Wilson, and Sewadeh, 2001a; Otsuki, Wilson, and Sewadeh, 2001b; FAO-WHO, 1997).

Otsuki, Wilson, and Sewadeh (2001a) used the gravity model to identify the trade effects from the adoption of a more stringent aflatoxin B1 standard by 15 European counties on edible groundnut and oilseed (intended for processing) groundnut exports from nine African countries.[15] The importing countries require the level of aflatoxin B1 in groundnut imports to be much lower than the standard level recommended by the Codex Alimentarius Commission (Codex): two ppb for edible groundnuts and eight ppb for oilseed groundnuts as compared to around ten ppb as suggested by the Codex.[16] The authors find that a ten percent decrease in the maximum allowed aflatoxin B1 level leads to an eleven percent decrease in edible groundnut exports. However, the authors did not find a significant effect of the aflatoxin B1 standard on oilseed groundnut exports. In addition, a simulation based on EU harmonization of the aflatoxin B1 standard at two ppb leads to a 36 percent decrease ($430,000) in edible groundnut exports as compared to a scenario in which the Codex benchmark is adopted.

Otsuki, Wilson, and Sewadeh (2001b) assessed the expected effects of 15 EU countries adopting a stricter aflatoxin B1 standard (two ppb) than the standard level suggested by the Codex (nine ppb) on African dried fruit, edible nuts and cereal exports.[17] The authors find the stricter standard level to reduce exports of dried fruits, edible nuts, and cereals from nine African

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[15] The nine exporting sample countries are: Chad, Egypt, the Gambia, Mali, Nigeria, Sudan, Senegal, South Africa, and Zimbabwe, and the 15 importing sample countries are: Austria, Belgium, Luxemburg, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, the United Kingdom, and Switzerland.

[16] The three international organizations which set international benchmark standards for SPS compliance are: L'Office International des Epizooties (OIE), the International Plant Protection Convention (IPPC), and the Codex (Josling, Roberts, and Orden, 2004).

[17] The stricter aflatoxin B1 standard was announced in 1998.

countries to the EU countries by an estimated $670 million, while leading to a decrease in 2.3 cancer deaths per billion people.[18]

Wilson and Otsuki (2003) extended the work of Otsuki, Wilson, and Sewadeh (2001b) by considering a larger number of exporting and importing countries: 31 exporters (ten developed) and 15 importers (eleven developed). The authors find that the adoption of a stricter aflatoxin B1 standard level leads to a reduction in nut and cereal exports, but does not have a significant effect on preserved and dried fruit exports. If all importing regions adopt the aflatoxin B1 standard recommended by the Codex (of 7.5-10.5 ppb), cereal and nut exports would increase by $38.8 billion. However, if the stricter EU aflatoxin B1 standard level of two ppb is adopted by all importers, cereal and nut exports would decrease by $3.1 billion. When considering the 15 importing sample countries only, the harmonized adoption of an aflatoxin B1 standard as suggested by the Codex leads to a $6.1 billion increase in nuts and cereals trade among them, or a 51 percent increase from 1998 trade values.

Gebrehiwet, Ngqangweni and Kirsten (2007) analyzed the impacts of the total aflatoxin standard level adopted by the U.S., Germany, Italy, Sweden, and Ireland on total food exports from South Africa. The authors find that a one percent decrease in the allowable aflatoxin level leads to a 0.41 percent decrease in South African total foods exports. In addition, the authors find that if these countries would have adopted the aflatoxin standard level suggested by the Codex, it would have led to an additional $69 million in total food exports annually from South Africa during the period 1995-1999.

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[18] The 15 EU sample countries are: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom. The nine African exporting sample countries are: Chad, Egypt, Gambia, Mali, Nigeria, Senegal, South Africa, Sudan and Zimbabwe.

3.2.2 Maximum Residue Limit Standards using Gravity Models

SPS regulations may stipulate the MRL of chemicals (e.g., pesticides or antibiotics) contained in food products. Even though international MRL standards are suggested by the Codex Committee on Pesticide Residues (CCPR) and are within the range of the Acceptable Daily Intake (ADI) of residues, countries may set MRL standards that deviate from internationally recommended norms (Wilson and Otsuki, 2004).

Wilson, Otsuki and Majumdar (2003) assess the trade effects from the adoption of a more stringent MRL of tetracycline antibiotics on beef exports from 16 exporting (five OECD) countries to six developed importing countries.[19] The authors find that a one percent decrease in the MRL by the six importing countries leads to a 0.59 percent decrease in beef exports. In addition, if all importing countries adopt the internationally recommended MRL standard of 0.6 ppm, the value of beef exports would increase by $3.2 billion, or 57 percent. Beef exports from Argentina, Brazil, and South Africa increase by more than $300 million, $200 million, and $160 million, respectively.

Wilson and Otsuki (2004) identify the effects on trade from the adoption of a maximum allowed pesticide residue level of chlorpyrifos on banana exports from 21 developing exporting countries to eleven OECD importing countries.[20] The authors find that a one percent reduction in the chlorpyrifos pesticide residue standard level leads to a 1.63 percent decrease in banana exports. In addition, a uniform global adoption of the stricter EU chlorpyrifos pesticide residue

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[19] The six importing countries in the sample are: the U.S., Canada, Australia, New Zealand, Japan and the EU. The 16 exporting countries in the sample are: the U.S., Canada, Mexico, Australia, Argentina, Brazil, Chile, China, Hungary, New Zealand, Nicaragua, South Africa, Switzerland, Thailand, Ukraine and Uruguay.

[20] The eleven OECD importing sample countries are: Belgium, France, Germany, Luxemburg, the United Kingdom, Netherlands, the United States, Canada, New Zealand, Japan, and Switzerland, and the 21 developing exporting countries in the sample are: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Panama, Jamaica, St. Lucia, Cameroon, South Africa, Morocco, Cote d'Ivoire, China, India, Indonesia, Philippines, and Taiwan.

standard level, as compared to a global adoption of the less strict standard level recommended by the Codex, leads to a staggering \$5.5 billion decrease in banana exports annually.

Scheepers, Jooste and Alemu (2007) quantify the trade effects from the adoption of a stricter MRL of Prochloraz, a chemical used during the avocado production process, on South African avocado exports to the EU. The authors find that this stricter standard leads to a decrease of \$15.27 million in revenue for South African avocado producers. In addition, if the EU countries adopt the less stringent Codex standard level, South African avocado exports to the EU would increase by a total of \$91.65 million, with France and the Netherlands having the largest increases in imports, \$13.68 million and \$75.78 million, respectively.

Chen, Yang and Findlay (2008) assess the effects of Chlorpyrifos MRL on Chinese fresh vegetable exports and the medicated fish feed Oxytetracycline MRL on Chinese fish and aquatic product exports between 1992 and 2004.[21] Some sample countries regulate the Chlorpyrifos MRL in vegetables at levels much lower than the 0.52 ppm suggested by the Codex. For example, during the period 2002-2005, Japan's regulation was set at 0.11 ppm, and Australia's and EU's at 0.10. In addition, some sample countries regulate the Oxytetracycline MRL in fish and aquatic products at levels lower than the 0.20 ppm benchmark suggested by the Codex. For instance, during the period 1992-2005, EU's and New Zealand's regulation was set at 0.10 ppm. Interestingly, in both cases, U.S. regulations were set at levels higher than the internationally suggested ones. The authors find that a more stringent standard, such as a ten percent decrease in the Chlorpyrifos MRL level of regulation leads to a reduction in Chinese vegetable exports by 2.8 percent, spinach exports by ten percent, onion exports by 2.1 percent, and garlic exports by 3.2 percent. On the other hand, a ten percent reduction in the level of Oxytetracycline MRL

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[21] Both aggregate (vegetables and fish and aquatic products) and disaggregate (garlic, onions and spinach) agricultural product groups are used in the study. Sample importing countries include: Japan, the U.S., the EU, Australia, Korea, Malaysia, Hong Kong (China), Russia, Vietnam, Indonesia, New Zealand, and Thailand.

standard leads to a 2.7 percent decrease in Chinese fish and aquatic product exports. In addition, the authors find a greater trade impact of changes in food safety standards relatively to a change in the import tariff in the case of China's vegetable exports to the EU and Japan in 2002.

3.2.3 SPS and TBT Measures using Gravity Models

Disdier, Fekadu, Murillo and Wong (2008) identify the trade effects of technical measures adopted by the U.S., EU-25, Japan, Canada, Australia and Switzerland (based on the WTO's SPS and TBT Agreements). Their sample includes 134 products (e.g., cut flowers; peppers; avocados; coffee) defined at the 6 digit level of HS 1996 code classification.[22] In the econometric specification, a generic NTB dummy variable (equal to one if the importer notifies at least one measure at the HS-six digit level, and zero otherwise) based on data obtained from the UNCTAD's TRAINS database is used. The authors find a negative effect of NTBs on tropical and diversification product[23] exports of African, Caribbean and Pacific (ACP), Latin American and Asian countries.[24] The findings suggest that NTBs have a larger negative effect on exports from ACP countries than eight Latin American countries (LA8), while the impact on Asian and other Latin American countries is not statistically significant.

Disdier, Fontaigné and Mimouni (2008) find that SPS regulations and other TBT measures adopted by OECD countries negatively affect agricultural exports from developing and LDCs while not significantly impacting trade between OECD trade partners. In addition, based

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[22] At the HS-two level, sample products from chapters 06-33 are included, with the exception of chapters 16,19, and 25-32.

[23] The authors (p.117) define diversification products as "*products of particular importance to the diversification of production from the growing of illicit narcotic crops.*"

[24] The eight Latin American sample countries (LA8) are: Bolivia, Colombia, Costa Rica, Ecuador, Guatemala, Nicaragua, Panama and Peru. Asian countries are: Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand, and Vietnam. The group of other Latin American countries includes: Brazil, El Salvador, Honduras, Mexico, Paraguay, and Venezuela. Finally, the ACP group includes 79 sample countries (e.g., Congo, the Dominica Republic, Belize, Angola).

on the so-called “inventory approach” (as discussed in Beghin and Bureau, 2001), the authors calculate coverage ratios, defined as the percent of import value at the HS-six digit level impacted by SPS and TBT measures, and conclude that EU countries have some of the lowest coverage ratios among OECD countries. Interestingly enough, however, despite EU countries notifying fewer SPS and TBT measures to the WTO relative to other OECD countries, agricultural exports by developing and LDCs to the EU are more negatively affected because of these regulations as compared to other OECD countries. In order to assess the trade effects of SPS and TBT measures, this study employs three different variables. First, a generic NTB dummy variable is employed as in Disdier, Fekadu, Murillo and Wong (2008). Second, based on the “inventory approach”, a frequency index is calculated, which is defined as the share of affected HS-six digit level products (by SPS and TBT measures) within a certain HS-four digit level product category. Finally, *ad valorem* equivalents of SPS and TBT measures are employed.

A working paper by Jayasinghe, Beghin, and Moschini (2009) examines the trade costs related to U.S. seed corn exports to 48 countries for the period 1989-2004. Data on SPS measures (e.g., seed testing; import permits; quarantine) is obtained from the USDA/APHIS Export Certification Project Demonstration (EXCERPT) database constructed by Purdue University. In the econometric specification, SPS regulations are represented by a single count variable that sums the number of specific measures. The authors find that tariffs, distance, and SPS measures all have a statistically significant and negative impact on U.S. corn seed exports. However, the effects of tariffs and distances outweigh the effects of phytosanitary measures, such as testing and field inspection.

Ardakani, Yazdani and Gilanpour (2009) assess the trade effects of NTBs on Iranian shrimp, raisin, and pistachio exports during the period 1996-2005.[25] Following a formula developed by Linkins and Arce (2002), this study calculates a NTB proxy variable represented as an *ad valorem* tariff rate equivalent that is calculated as the ratio of Free on Board (FOB) price and the world price (net of retail/wholesale margins). The authors find that a one percent increase in NTBs on average leads to a reduction in the value of Iranian shrimp and pistachio exports by 0.56 percent and 2.24 percent, respectively. On the other hand, Iranian raisin exports are positively affected by NTBs with an estimated elasticity of export of 1.13. Finally, when comparing the effects on trade of NTBs and tariffs, estimated tariff rate elasticities of export for shrimp and pistachios (0.34 and 0.11, respectively) are lower relatively to the estimated NTB elasticities of export for the same products.

Anders and Caswell (2009) quantify the effects of the 1997 mandatory adoption of a Hazard Analysis Critical Control Points (HACCP) food safety protocol for U.S. seafood product imports. The authors find the generic trade effect from the adoption of this regulation to be negative and significant for the 33 largest seafood product exporters to the U.S. during the period 1990-2004. However, when controlling for exporter development status, the trade effect from HACCP adoption is negative for developing countries and positive for developed countries. Finally, analysis at the individual country-level suggests that larger exporters have benefited from the adoption of the HACCP protocol as compared to smaller exporters which exports have been negatively affected.

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[25] Pistachio importing sample countries are: Germany, the United Arab Emirates, Hong Kong, Russia, Turkey, Italy, Spain, Syria, and India. Raisin importing countries in the study are: the United Arab Emirates, Russia, Ukraine, Pakistan, Germany, Canada, Poland, United Kingdom and Turkey. Shrimp importers in the sample are: Spain, the United Arab Emirates, Japan, United Kingdom, Portugal and Italy.

3.3 Limitations of the Current Literature

Most of the recent *ex post* econometric studies focus on a single commodity or product sector (e.g., Wilson, Otsuki and Majumdar, 2003 (beef); Wilson and Otsuki, 2004 (bananas); Jayasinghe, Beghin, Moschini, 2009 (corn seed); Anders and Caswell, 2009 (seafood)), or a single SPS measure (e.g., Wilson and Otsuki, 2003 (aflatoxin B1 standard); Chen, Yang and Findlay, 2008 (Chlorpyrifos MRL)). Even though one may argue such studies provide superior insight due to being able to identify the effects of SPS measures with greater precision, estimated trade effects in such cases cannot be necessarily generalized to the agricultural sector as a whole, other specific agricultural sectors (such as FF&Vs), as well as to other specific measures.

Another limitation of the recent work is the reliance on an "inventory approach" based on notifications to the WTO under which coverage ratios and frequency indices are calculated (e.g., Disdier, Fontaigné and Mimouni, 2008). In addition, single count variables that sum the total number of SPS measures are employed in which case same "weight" is assigned to different specific measures (e.g., Jayasinghe, Beghin and Moschini, 2009).[26] Moreover, some studies use a single generic dummy variable equal to one if at least one SPS measure is notified to the WTO at the HS-six digit level, and zero otherwise (e.g., Disdier, Fekadu, Murillo and Wong, 2008; Disdier, Fontaigné and Mimouni, 2008).

In these studies, share variables (coverage ratios and frequency indices), count, and dummy variables are typically calculated based on more aggregate trade data obtained from the UNCTAD's TRAINS database as compared to the more disaggregated trade data employed in this study. One major problem, as noted by Anderson and van Wincoop (2004), is that the information on SPS requirements contained in this database, which is mostly based on WTO

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[26] The only exception is made is cases where bans on U.S. corn seed exports exist (e.g., China; Australia), in which case a very high count is assigned.

notifications, is extremely fragmentary and is a subject to a large measurement error with respect to NTBs. A major reason for this problem in the TRAINS data is that WTO Members are only required to notify changes to their regulations since 1995, which means that some of the most trade-restrictive measures adopted before 1995 have never been notified to the WTO. In addition, the TRAINS database is mostly outdated, containing information on old NTBs (e.g., import quotas; anti-dumping cases). However, new SPS regulations, such as specific phytosanitary treatments, are not recorded. In addition, most SPS measures, particularly those adopted by high-income OECD countries, such as the U.S., are defined at the detailed product line level. For example, phytosanitary treatments adopted by APHIS pertaining to U.S. imports of FF&Vs often correspond to the HS-eight digit categories (e.g., carrots), and in one case to the HS-ten digit categories (broccoli). As a result, a disaggregated product level empirical approach is required, rendering results obtained from empirical analyses based on TRAINS data unsuitable to inform policy makers of the trade effects of specific types of SPS regulations since in most studies it is not possible to distinguish between important and unimportant measures.

Finally, most studies (with the exception on Jayasinghe, Beghin and Moschini, 2009) do not properly tackle the issue of zero trade flows that are typically frequent in a product-level analysis. As noted by Santos Silva and Tenreyro (2006), such occurrences may be due to different reasons. For example, it may be the case that two countries do not trade with each other. In addition, "zeros" may be a result of coding and rounding errors. However, zero trade flows in some cases may be attributed to trade barriers, such as transport and information costs, tariffs, quotas and NTBs. In light of this discussion, excluding zero trade flows from the analysis may lead to biased estimates due to sample selectivity ignited bias (Santos Silva and Tenreyro, 2006; Martin and Pham, 2008).

3.4 Contributions of This Study

This study fills the gap in the current academic literature in the following respects. First, a novel and comprehensive database on U.S. phytosanitary measures pertaining to 47 FF&V product categories from 95 countries is developed. The sample period is 1996 through 2007, and corresponds to the post-Uruguay Round era in which the WTO SPS Agreement has been into force. The database contains detailed information on the conditions under which an exporter can supply the U.S. market, and contains information on new market access cases awarded to foreign countries. Even though one may argue the study focuses on a single importing region (the U.S.) and a single agricultural product sector (FF&Vs), the novelty and academic contribution of this work originates in the detailed recording of specific phytosanitary treatment types that vary by time, product, and exporting country. In contrast to recent empirical studies, this detailed approach allows for the heterogeneity in specific phytosanitary treatments to be explored and their trade effects to be identified. As a result, this study strives to fill the void in the literature and shed some light on the academic discussion on SPS measures' role as "trade barriers" versus "trade catalysts." Finally, following a recent influential paper by Santos Silva and Tenreyro (2006), the "zeros" issue is resolved by using a PPML estimator to estimate a gravity model of international trade in order to identify the trade flow effects of phytosanitary treatments on U.S. FF&V imports. The next chapter develops this empirical approach.

Chapter 4: Empirical Model

Newton's "Law of Universal Gravitation" of 1687 defines the attractive force between two objects as a positive function of their masses and a negative function of the distance between them. Carey (1858) first noted the importance of gravity in the social sciences. Historically, the gravity equation has been used in many fields, such as foreign direct investment (FDI) (e.g., Bevan and Estrin, 2004), health planning (e.g., Lowe and Sen, 1996), migration (e.g., Karemera, Oguledo and Davis, 2000), consumer choice (e.g., Cadwallader, 1981), and international trade (e.g., Bergstrand, 1985).

The gravity equation has been a highly-praised empirical tool in international economics. Eichengreen and Irwin (1998, p.33) referred to it as the "*workhorse*" model for empirical econometric studies to the virtual exclusion of other approaches. Anderson (1979, p.106) praised the gravity equation by stating "*Probably the most successful empirical trade device of the last twenty-five years is the gravity equation.*" As a result, the gravity model has been used extensively to estimate the trade flow effects of FTAs (e.g., Zahniser, Pick, Pompelli, and Gehlhar, 2002; Furtan and van Melle, 2004; Vollrath, Hallahan, and Gehlhar, 2006; Baier and Bergstrand, 2007; Grant and Lambert, 2008; Jayasinghe and Sarker, 2008), membership in the WTO (e.g., Rose, 2004; Subramanian and Wei, 2007; Grant and Boys, 2009), and NTBs to trade (e.g., Moenius, 1999).

First adopted by Tinbergen (1962) and Pöyhönen (1963), the functional form of the gravity equation applied to empirical trade resembles Newton's basic formula for Universal Gravitation (Bergstrand, 1985; Head, 2003). In its most basic multiplicative form, the gravity model of international trade predicts that bilateral trade flows are proportional to the economic mass of the importing and exporting country, and inversely proportional to the distance between the two countries:

$$V_{ijt} = \beta_0 \frac{Y_{it}^{\beta_1} Y_{jt}^{\beta_2}}{D_{ij}^{\beta_3}} \varepsilon_{ijt} , \tag{1}$$

where, V_{ijt} is the real or nominal value of bilateral trade from exporter (i) to importer (j) in year (t), Y_{it} (Y_{jt}) is the GDP of (i) ((j)), and D_{ij} is the distance between (i) and (j); $\beta_0, \beta_1, \beta_2,$ and β_3 are unknown parameters that are econometrically estimated; and ε_{ijt} is a multiplicative stochastic error term. Taking the natural logarithm of both sides yields the traditional gravity equation that is linear in parameters and can be easily estimated, typically by ordinary least squares (OLS):

$$\ln(V_{ijt}) = \beta_o + \beta_1 \ln(Y_{it}) + \beta_2 \ln(Y_{jt}) + \beta_3 \ln(D_{ij}) + \varepsilon_{ijt} \tag{2}$$

One of the main reasons the gravity equation has become a popular tool in international economics is because Y_{it}, Y_{jt} and D_{ij} often explain more than 60 percent of the variation in bilateral trade flows. However, researchers often augment the gravity equation with other factors (typically specified as dummy variables) which are known to either stimulate or impede trade, such as dummy variables for colonial relationships, common languages, common borders, and country-specific geographical characteristics (e.g., landlocked/island countries; country areas).

4.1 Theoretical Developments

While empirically successful, the gravity equation was often criticized as the "ugly duckling" of international economics because it lacked a strong theoretical foundation (Anderson, 1979; Bergstrand, 1985; Anderson and van Wincoop, 2003; Baier and Bergstrand, 2007). Anderson (1979) derived the gravity equation from the properties of the constant elasticity of substitution (CES) expenditure system and provided the first formal theoretical foundation.[27] Additional contributions were provided in Bergstrand (1985; 1989), Helpman and Krugman (1985), and Deardorff (1998). In most of these theoretical models, international prices play an important role, but were largely omitted due to the lack of reliable price data across regions and time. Indeed, Anderson and van Wincoop (2003) argued succinctly that the traditional gravity equation (2) does not have a theoretical foundation due to omitted variable bias caused by omission of international prices from most empirical specifications. The authors show that trade depends not only on bilateral barriers between (*i*) and (*j*), but also on the average trade barriers faced with their partners in the rest of the world.

The Anderson and van Wincoop (2003) model is a one sector, general equilibrium model that differentiates goods by country of origin in the spirit of Armington (1969), and predicts a country's total merchandise trade flows. However, it provides a useful framework from which to extend the analysis to the product line level (FF&Vs here), similar to the framework in Chen and Novy (2009). Assume there are $k = 1 \ldots J$ discrete varieties of goods (*k*) that are produced in an increasing returns to scale (IRS) setting and a monopolistically competitive industry. Abstracting from any preferences parameters for varieties that may exist, consumers in the importing region (*j*) (the U.S. in this study) maximize the familiar CES utility function for different varieties (*k*):

$$C_j^k = \left(\sum_{i=1}^{J} (c_{ij}^k)^{\frac{\sigma_k - 1}{\sigma_k}}\right)^{\frac{\sigma_k}{\sigma_k - 1}} , \tag{3}$$

subject to their budget constraint for variety (*k*) imports:

$$y_i^k = \sum_{i=1}^{J} p_{ij}^k c_{ij}^k \, , \tag{4}$$

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[27] Earlier, such efforts were made by Linnemann (1966) and Leamer and Stern (1970).

where c_{ij}^{k} is the consumption of each variety (*k*) in (*j*) imported from (*i*); and σ_k is the elasticity of substitution between different (*k*)'s and is assumed to be greater than one.[28] In the classic Helpman and Krugman (1985) monopolistic competition models, variation in pricing across export markets is determined entirely by transport costs, so if p_i^k is the exporter's price exclusive of trade barriers ("out-of-the-factory gate" price) and $t_{ij}^{k} \geq 1$ is the *ad valorem* trade cost, the price faced by importer (*j*) is $p_{ij}^{k} = t_{ij}^{k} p_i^{k}$. Each country is assumed to produce a unique variety (*k*) in such a way that consumers from importing region (*j*) are able to recognize the difference in quality between fresh tomatoes imported from Mexico and greenhouse tomatoes imported from the Netherlands, for example, granting a certain monopoly power to each exporting region (*i*) for their own variety (*k*). Each exporter (*i*) expresses this power as a price markup over marginal cost. Finally, the demand function for each (*k*) by (*j*) from (*i*) is $x_{ij}^{k} = p_{ij}^{k} c_{ij}^{k}$.

Maximizing (3) subject to (4) yields:

$$x_{ij}^{k} = \left(\frac{p_{ij}^{k}}{P_j^{k}}\right)^{1-\sigma_k} x_j^{k} = \left(\frac{t_{ij}^{k} p_i^{k}}{P_j^{k}}\right)^{1-\sigma_k} x_j^{k} \quad , \tag{5}$$

where:

$$P_j^{k} = \left(\sum_{i=1}^{J} (p_{ij}^{k})^{1-\sigma_k}\right)^{\frac{1}{1-\sigma_k}} \quad , \tag{6}$$

and represents a price index over all (*k*)'s (or (*j*)'s inner trade barriers).

The market clearing conditions impose that:

$$y_i^{k} = \sum_{i=1}^{J} x_{ij}^{k} \tag{7}$$

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[28] In cases where two products (*k*) are perfectly homogeneous, σ_k is expected to be equal to infinity.

Plugging the demand function (5) into the market clearing condition (7) yields:

$$p_i^k = \left(\sum_{j=1}^{J} \left(\frac{t_{ij}^k}{P_j^k} \right)^{1-\sigma_k} \frac{x_j^k}{y_i^k} \right)^{\frac{1}{\sigma_k - 1}} \tag{8}$$

Plugging (8) into (5) yields the average trade barriers (*i*) faces with its partners from the rest of the world, where y^k is the global output of (*k*):

$$\Pi_i^k = \left(\sum_{j=1}^{J} \left(\frac{t_{ij}^k}{P_j^k} \right)^{1-\sigma_k} \frac{x_j^k}{y^k} \right)^{\frac{1}{1-\sigma_k}} \tag{9}$$

Rearranging yields the gravity equation for (*k*):

$$x_{ij}^k = \frac{y_i^k x_j^k}{y^k} \left(\frac{t_{ij}^k}{\Pi_i^k P_j^k} \right)^{1-\sigma_k} , \tag{10}$$

where:

$$P_j^k = \left(\sum_{i=1}^{J} \left(\frac{t_{ij}^k}{\Pi_i^k} \right)^{1-\sigma_k} \frac{y_i^k}{y^k} \right)^{\frac{1}{1-\sigma_k}} \tag{11}$$

Solving (9) and (11), while assuming bilateral trade barriers are symmetric, yields:

$$P_i^k = \Pi_i^k , \tag{12}$$

with:

$$P_j^{\;1-\sigma_k} = \sum_i P_i^{\;\sigma_k - 1} \theta_i \, t_{ij}^{\;1-\sigma_k} , \tag{13}$$

for all importers (j), where $\theta_i = \frac{x_i^k}{y^k}$ and represents (i)'s income share of the total global output for (k). Conclusively, in (13) and (8), inner trade barriers for (j) and outer barriers for (i) are expressed as functions of bilateral trade barriers and income shares, respectively.

Substituting (12) into (10) yields:

$$x_{ij}^k = \frac{y_i^k x_j^k}{y^k}\left(\frac{t_{ij}^k}{P_i^k P_j^k}\right)^{1-\sigma_k} \tag{14}$$

As suggested by (10) and (14), (k) imports by (j) depend on the production of (k) goods in region (i) and the expenditure for (k) imports by (j). In addition, bilateral trade costs between the two countries inhibit trade, while the average trade barriers (i) faces with its partners from the rest of the world and (j)'s inner trade barriers stimulate it.

Taking the natural logarithm of both sides of (14) results in a gravity equation that explicitly contains (i)'s outer trade barriers and (j)'s inner trade barriers, is linear in parameters and can be estimated by OLS:

$$\ln\left(\frac{x_{ij}^k}{y_i^k x_j^k}\right) = \beta_0 + \beta_3 \ln(t_{ij}^k) - \ln P_i^{1-\sigma_k} - \ln P_j^{1-\sigma_k} + \varepsilon_{ijt}, \tag{15}$$

where the (1- σ_k) term is embedded in the β_3 coefficient.

4.2 The "Zeros" Issue

Recent papers by Santos Silva and Tenreyro (2006) and Martin and Pham (2008) argue that omitting zero trade flows, as is in many empirical applications (e.g., Disdier, Fekadu, Murillo and Wong, 2008), may lead to biased estimates due to sample selection issues. "Zeros" may define an equilibrium and their exclusion results in a conditional model in the sense that the dependent variable is no longer a measure of bilateral trade but bilateral trade conditional on a trade relationship actually existing. For instance, in a study by Santos Silva and Tenreyro (2006), nearly half of all trade flows are "zeros." Similarly, a study by Helpman, Melitz, and Rubinstein (2008) finds that about one-half of the (*ij*) pairs in a sample of 158 countries do not trade with each other. Zero trade flows are even more frequent in disaggregated analyses such as the FF&Vs sector where geography and climatic conditions may dictate whether a product can be produced by (*i*). In this study, 56.9 percent of all imports flows into the U.S. are zero trade flows.

In light of this literature, an econometric specification including "zeros" may be preferred. Other remedies to the zero trade flows issue is adding one to the dependent variable (1+ V_{ijt}), and then estimating the model with OLS (e.g., Disdier, Fontaigné and Mimouni, 2008). However, this atheoretic modification yields inconsistent estimates of the model's parameters (Santos Silva and Tenreyro, 2006). To address the problem of high frequency of "zeros", as is the case in this study, two estimators can be employed: a PPML estimator (Santos Silva and Tenreyro, 2006) and a Tobit model (Martin and Pham, 2008). Even though a Tobit model may be more appropriate to deal with the issue of a left-censored sample due to high density (frequency) of "zeros", a PPML better fits the data in this study.

4.3 Econometric Approach

This study employs the PPML model of Santos Silva and Tenreyro (2006) augmented with additional controls to capture industry and country-specific factors in the U.S. FF&V sector. As discussed by the authors, even though the PPML estimator is typically employed in cases of count data, it yields consistent estimates for trade flow data where "zeros" are frequent. Moreover, the PPML model is robust to heteroskedasticity of unknown form which makes its use particularly appealing over a Tobit model. Of course, one could estimate the non-linear version of equation (14) with "zeros" included using non-linear least squares (NLLS). However, as in OLS, NLLS assigns greater weight to observations with larger absolute errors, while the PPML estimator assigns equal weights to all observations, which may be most appropriate method considering the unknown pattern of heteroscedasticity.

The PPML estimator, specified as:

$$\sum_{i=1}^{n}\left[y_i - \exp(x_i \tilde{\beta}) \right] x_i = 0, \tag{16}$$

is a consistent estimator under the assumption that the conditional mean is specified as:

$$\mathrm{E}\left[y_i \middle| x \right] = \exp(x_i \beta) \tag{17}$$

Therefore, the data does not need to be a Poisson distribution nor does the dependent variable need to be an integer. Finally, the dependent variable is entered in level form (and not in natural logarithm form as under OLS) that grants the ability for the PPML estimator to estimate a gravity model containing "zeros." Even though the dependent variable is entered in level form and some regressors in natural logarithm form, coefficient estimates may still be interpreted as elasticities.

4.4 Benchmark Specification

This thesis proposes various specifications of the gravity model to identify the impact on U.S. FF&V import flows of phytosanitary treatments. Following Santos Silva and Tenreyro (2006), the estimated benchmark specification is:

$$V_{ikt} = \exp(A_{ikt}\beta) + \varepsilon_{ikt}, \tag{18}$$

where $V_{ikt} \geq 0$, $E[\varepsilon_{ikt}|V_{ikt}] = 0$, and A_{ikt} is a vector of independent variables. The typically estimated gravity model is modified in two main respects. First, while most studies consider more aggregate bilateral trade flows between (*ij*) country pairs, this study disaggregates the U.S. FF&V sector into product varieties (*k*). This fact allows for a product-line variation in U.S. phytosanitary treatments to be incorporated in the analysis since these measures are applied at the HS-six, eight and in one case at the HS-ten digit level. Therefore, a typical trade flow observation includes U.S. (*j*) imports (*k*) in (*t*) from (*i*), expressed as the customs value excluding tariffs and transport costs (FOB price). Second, typically used economic mass proxies (GDP_{it} and GDP_{jt}) are replaced with production quantities ($lusprod_{jkt}$ and $lrowprod_{ikt}$) expressed in metric tons that are defined at the variety-level (*k*) which allows for a greater variation in these two regressors.

Table 8 lists all benchmark specification variables, and provides variable definitions as well as expected signs. The variable $ldist_i$ denotes the natural logarithm of the geographical distance in kilometers between the U.S. and its exporter partners (*i*) and is used to capture the effect of trade costs (primarily transportation costs). Greater geographical distance between the U.S. and its partners is expected to decrease trade. The distance measures, obtained from The Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), are calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations in terms of population.[29]

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[29] CEPII is an independent research institution on the international economy. CEPII's web site and databases can be accessed at: www.cepii.org.

Table 8: Definition of Benchmark Specification Model Variables

Variable	Variable Definition	Expected Sign
	Dependent Variable	
$cvalue_{ikt}$	Value of U.S. FF&V product (*k*) imports from exporter (*i*) in year (*t*) ,expressed as the customs value excluding tariff and freight costs	
	Independent Variables	
$ldist_i$	Geographical distance between the U.S. and exporting country (*i*), expressed in kilometers	<0
$lusprod_{jkt}$	U.S. production of product (*k*) in year (*t*), expressed in metric tons	<0
$lrowprod_{ikt}$	Exporter (*i*)'s production of product (*k*) in year (*t*), expressed in metric tons	>0
$trend_t$	Trend variable	>0
$fruit_k$	Dummy variable equal to one if imported product (*k*) is a fresh fruit, and zero otherwise	>0
ler_{it}	Exchange rate expressed as the value of one U.S. dollar in terms of foreign currency	>0
$nafta\_frt_{ik}$	Dummy variable equal to one if exporter (*i*) in year (*t*) is Canada or Mexico and imported product (*k*) is a fresh fruit, and zero otherwise	>0
$nafta\_veg_{ik}$	Dummy variable equal to one if exporter (*i*) in year (*t*) is Canada or Mexico and imported product (*k*) is a fresh vegetable, and zero otherwise	>0
$cafta\_dr_{it}$	Dummy variable equal to one if exporter (*i*) in year (*t*) is the Dominican Republic, El Salvador, Guatemala, Honduras, or Nicaragua, and zero otherwise	>0
fta_{it}	Dummy variable equal to one for all other FTAs, and zero otherwise	>0
nma_all_{ikt}	Dummy variable equal to one if exporter (*i*) gained new market access for product (*k*) in year (*t*), and for each additional year (*t*) in which (*i*) kept the market supply eligibility rights, and zero otherwise	<0
$mainland_{ikt}$	Dummy variable equal to one if product (*k*) imports from exporter (*i*) in year (*t*) are eligible for shipping to the continental U.S., and zero otherwise	>0
$treat_{ikt}$	Dummy variable equal to one if product (*k*) imports from exporter (*i*) in year (*t*) are subject to at least one phytosanitary treatment requirement, and zero otherwise.	>0<
$lshare_{ikt}$	Exporting country (*i*)'s exports of product (*k*) in year (*t*) as a share of the total global exports of product (*k*) in year (*t*) *100 (in terms of value)	>0
$treat\_lshare_{ikt}$	Interaction term between $treat_{ikt}$ and $lshare_{ikt}$	>0

As discussed earlier, $lusprod_{jkt}$ is a proxy for the economic mass of importer (j) and denotes the natural logarithm of the U.S. production of product (k) imports expressed in metric tons. Even though the traditional gravity equation suggests that economic mass proxies positively affect bilateral trade flows between (ij) pairs, it is expected that greater production in the U.S. would reduce product (k) imports from foreign suppliers. The variable $lrowprod_{ikt}$ proxies for exporter (i)'s economic mass, and it denotes the natural logarithm of the production in the exporting country expressed in metric tons. Greater production in the exporting countries should stimulate U.S. FF&V imports due to assumed economies of scale in production and export. In order to control for growth and inflationary factors, a trend variable is used.

As discussed in Chapter 1, fresh fruit imports account for 58 percent of the total U.S. FF&V imports over the sample period. To control for this possible level effect in the data, a dummy variable ($fruit_k$) is introduced that equals one if imported variety (k) is fresh fruit, and zero otherwise. This dummy variable allows for a different intercept for fresh fruits and fresh vegetables, suggesting the average fresh fruit import flow is different from the average fresh vegetable import flow. One of the reasons why fresh fruits account for a larger share of the sample relative to fresh vegetables is that the sample includes 24 fresh fruit categories as compared to 23 fresh vegetable categories.

The theoretical structure of the gravity model predicts that prices affect U.S. FF&V imports. Following Anders and Caswell (2009), in order to control for variation in exporters' price competitiveness, an exchange rate variable is employed (ler_{it}), expressed as the natural logarithm of the value of one U.S. dollar in terms of exporter (i)'s currency in year (t). Even though one may argue that exchange rates are only one of the sources affecting price uncertainty, including ler_{it} is important since annual exchange rate changes are influenced by monetary/fiscal policies in exporter (*i*), which are to some extent exogenous to the underlying supply/demand conditions affecting the price of product (*k*). A stronger U.S. dollar is expected to stimulate U.S. FF&V imports due to increased purchasing power for U.S. importing firms.

The findings of Anders and Caswell (2009) and Grant and Lambert (2008) support the hypothesis that FTAs have a positive and significant impact on agricultural trade. Thus, in Table 8, four distinct FTA variables are included to control for regional biases for U.S. imports of FF&Vs. As discussed in Chapter 1, NAFTA trade partners account for a much larger share of the annual U.S. fresh vegetable than fresh fruit imports. This fact motivates the inclusion of two separate dummy variables to control for NAFTA's effect on U.S. FF&V imports. Considering that NAFTA came into force in 1994, the dummy variables $nafta\_frt_{ik}$ and $nafta\_veg_{ik}$ equal one if exporting country (*i*) is Mexico or Canada and imported product (*k*) is fresh fruit or fresh vegetable, respectively, and zero otherwise. As suggested by the data, we expect the coefficient on $nafta\_veg_{ik}$ to be stronger than on $nafta\_frt_{ik}$. On the other hand, some of the larger fresh fruit exporters to the U.S. are banana exporters and members of CAFTA-DR (the Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua). A separate dummy variable ($cafta\_dr_{it}$) is included to capture the effect this group of exporters may have on U.S. FF&V imports. The trade effects of all other FTAs enforced during the sample period are captured by fta_{it}. This groups of exporters includes Australia, Chile, Israel, Morocco and Singapore (WTO, 2009b).

During the period 1996 through 2008, 204 new market access cases were awarded to foreign countries to ship FF&Vs to the United States.[30] New market access is defined as a unique exporter/product/year combination, whereby similar products from different sources are treated as different varieties (*k*) in the manner of Armington (1969), such that eggplants from Nicaragua

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[30] Table A1 (Appendix A) provides a complete list of all these instances.

represent a different variety than eggplants from Spain. The variable nma_all_{ikt} is used to control for these instances. It is equal to one in year (*t*) if exporter (*i*) was awarded a new market access to ship product (*k*) to the U.S. and for each additional year it kept the market supply eligibility privileges, and zero otherwise. Because it takes time for a new exporter to build production capacity and marketing channels to take advantage of the new market access instance, this variable is hypothesized to have a negative sign.

The variable $mainland_{ikt}$ is used to control for product shipments that APHIS allows to enter the U.S. mainland. It is equal to one if (*k*) imports from (*i*) may enter through ports that are considered part of the continental U.S., and zero otherwise. As discussed in Chapter 2, nearly 98 percent of all observed FF&V import flows in the database are eligible for entry into the U.S. mainland. As a result, $mainland_{ikt}$ is expected to have a strong and positive coefficient estimate.

The independent variable of interest is $treat_{ikt}$ which is a variable used to capture the trade flow effects of phytosanitary treatments. Under the first estimated scenario (see discussion below), this dummy variable equals one if at least one phytosanitary treatment is required on U.S. imports of (*k*) from (*i*) in (*t*), and zero otherwise. Following recent empirical studies (e.g., Jayasinghe, Beghin and Moschini, 2009), it is expected the generic treatment effect on U.S. FF&V imports will be negative as discussed previously in section 1.2. However, at the specific treatment type level, the effect of treatments may be positive in cases where exporter (*i*) controls a large share of the global market and due to economies of scale is able to spread the fixed cost of phytosanitary compliance.

We expect U.S. FF&V imports to be sourced from large and established global exporters that likely have developed massive production capacities and global marketing channels, and are able to export FF&Vs at more competitive prices relative to small exporters. The variable that controls for this possibility is $lshare_{ikt}$, which is expressed as the natural logarithm of exporter (i)'s product (k) exports (by value) in (t) as a share of the total global exports of (k) in (t)*100. For example, in 2002, Chile accounted for 38 percent of the global grape exports (($658.8 million)/($1.731 billion)*100) (FAO, 2009c).

Since the generic trade effect of phytosanitary treatments is expected to be negative, and the effect of $lshare_{ikt}$ positive, a threshold level may be calculated at which the negative treatment effect becomes positive. To accomplish this goal, the phytosanitary treatment dummy variable ($treat_{ikt}$) is interacted with $lshare_{ikt}$, resulting in $treat\_lshare_{ikt}$. Considering findings of the recent literature (e.g., Disdier, Fontaigné and Mimouni, 2008; Anders and Caswell, 2009), we expected large global FF&V exporters to meet U.S. phytosanitary treatment requirements more easily as compared to small exporters due to availability of financial resources, institutional capacity, technical expertise, and their ability to spread these fixed production costs while exporting FF&V to the U.S. at more competitive prices relative to small exporters. In addition, it may be the case that large global exporters export higher-valued FF&V products to the U.S. so that costs of phytosanitary compliance ultimately represent a low share of their revenues.

4.5 Hypotheses Tests

There are many different ways in which phytosanitary treatments may affect U.S. FF&V imports. For example, in addition to the general impact these measures may have, their effects may vary by product sector (fresh fruit; fresh vegetable), exporter development status (developed countries; developing/LDCs), and treatment types (e.g., cold treatment; irradiation).

With this in mind, while considering the objectives of this thesis laid down in Chapter 1, four main hypotheses are developed to provide information on the channels through which phytosanitary treatments may affect U.S. FF&V imports:

Hypothesis 1 states that phytosanitary treatments have no effect on U.S imports.

Hypothesis 2 states that all types of phytosanitary treatments affect U.S. imports equally.

Hypothesis 3 states that the size of exporter has no effect on its ability to meet U.S. phytosanitary treatment requirements.

Hypothesis 4 states that product sector, exporter development status, and type of phytosanitary treatment have no affect on threshold levels.

Under each main hypothesis, we test specific sub-hypotheses relating to the factors determining whether phytosanitary treatments effect U.S. imports. Accordingly, these sub-hypotheses examine empirical evidence on the nature, size, and scope under which the treatment measures operate. Overall, six gravity equations based on equation (18) are specified, resulting in a total of six scenarios.

H_1: *Phytosanitary treatments do not affect U.S. imports of FF&Vs*.

Does a generic phytosanitary treatment requirement matter? Following the recent work of Disdier, Fekadu, Murillo and Wong (2008) and Disdier, Fontaigné and Mimouni (2008), the first scenario employs a single dummy variable equal to one if an exporter faces at least one phytosanitary treatment when shipping a product to the U.S., and zero otherwise. The specific sub-hypothesis tested under this scenario is that *a generic phytosanitary treatment requirement initially does not affect U.S. FF&V imports* (H_{1A}:λ_1=0). In order to test this hypothesis, the estimated equation is equivalent to (18), but explicitly states the generic phytosanitary treatment dummy variable and the interaction term *treat_lshare*$_{ikt}$:

$$V_{ikt} = \exp\left(A_{ikt} + \lambda_1 treat_{ikt} + \chi_1 treat\_lshare_{ikt}\right) + \varepsilon_{ikt} \tag{19}$$

The second scenario tests the sub-hypothesis that *the initial effects of phytosanitary treatments do not vary by product sector* (H_{1B}:δ_1=δ_2). As discussed in Chapter 2, phytosanitary treatments are required far more often for fresh fruits than for fresh vegetables. To allow the generic treatment effect to differ across product sectors, the generic phytosanitary treatment variable is replaced by two dummy variables, one relating to fresh fruits and one to fresh vegetables. Scenario two estimates the following equation:

$$V_{ikt} = \exp\left(A_{ikt} + \sum_{v=1}^{2} \delta_v treat_{ikt}^{v} + \sum_{v=1}^{2} \tau_v treat\_lshare_{ikt}^{v}\right) + \varepsilon_{ikt}\,, \tag{20}$$

where v ϵ (fresh fruit; fresh vegetable).

The third scenario addresses the fact that phytosanitary treatments are required more often for developed than for developing/LDCs. In this scenario, the generic phytosanitary treatment effect is replaced by two dummy variables, one for developed countries and one for developing/LDCs. The specific sub-hypothesis tested is that that *the initial effects of phytosanitary treatments do not vary by development status* (H_{1C}:ϕ_1=ϕ_2). The empirically estimated equation under this third scenario is:

$$V_{ikt} = \exp\left(A_{ikt} + \sum_{d=1}^{2} \phi_d treat_{ikt}^{d} + \sum_{d=1}^{2} \varphi_d treat\_lshare_{ikt}^{d}\right) + \varepsilon_{ikt}\,, \tag{21}$$

where *d* ϵ (developed countries; developing/LDCs).

Scenario four is a combination of scenarios two and three where the generic phytosanitary treatment effect is allowed to vary by product sector *and* development status.

Under this scenario, two sub-hypotheses are tested. The first sub-hypothesis is that *phytosanitary treatment requirements initially affect fresh fruit and fresh vegetable imports from developed countries equally* (H_{1D}:$\gamma_1=\gamma_2$). The second sub-hypothesis is that *phytosanitary treatments initially affect fresh fruit and fresh vegetable imports from developing/LDCs equally* (H_{1E}:$\gamma_3=\gamma_4$). Scenario four estimates the following equation:

$$V_{ikt} = \exp\left(A_{ikt} + \sum_{v=1}^{2} \sum_{d=1}^{2} \gamma_{vd} treat_{ikt}^{vd} + \sum_{v=1}^{2} \sum_{d=1}^{2} \eta_{vd} treat\_lshare_{ikt}^{vd} \right) + \varepsilon_{ikt} \tag{22}$$

H_2: *The way in which phytosanitary treatments initially affect U.S. FF&V imports does not depend on the specific type of phytosanitary treatment applied.*

As discussed in Chapter 2, the frequency with which specific phytosanitary treatments are applied varies significantly across specific treatment types. For this reason, in scenario five, the generic phytosanitary treatment effect is decomposed into a specific effect for each treatment type. Based on information provided in Table 4 (Chapter 2), eight phytosanitary treatment groups are included in this estimation: methyl bromide fumigation, water treatment, heat treatment, pest specific/host variable, cold treatment, fumigation plus refrigeration of fruits, methyl bromide fumigation and cold treatment, and cold treatment or fumigation plus refrigeration of fruits.[31] The specific sub-hypothesis tested under this scenario is that *the initial effects of phytosanitary treatments are equal across specific treatment types* (H_{2A}:$\mu_1=\mu_2=\mu_3=\mu_4=\mu_5=\mu_6=\mu_7=\mu_8$). The empirically estimated equation under scenario five is:

$$V_{ikt} = \exp\left(A_{ikt} + \sum_{\psi=1}^{8} \mu_{\psi} treat_{ikt}^{\psi} + \sum_{\psi=1}^{8} \varpi_{\psi} treat\_lshare_{ikt}^{\psi} \right) + \varepsilon_{ikt} \quad , \tag{23}$$

where ψ is one of the eight specific treatment types.

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[31] Chapter 6 provides more details and justification on why three phytosanitary treatment groups are excluded.

Scenario 6 combines scenarios three and five. This final scenario considers whether the phytosanitary treatment effects vary by specific treatment types *and* development status. As Chapter 6 discusses in more detail, only three treatment types are included in this scenario: methyl bromide fumigation, cold treatment, and methyl bromide fumigation and cold treatment. Three sub-hypotheses are tested under this scenario.

The first sub-hypothesis is that *methyl bromide fumigation initially affects FF&V exports to the U.S. originating in developed and developing/LDCs equally* (H_{2B}:$\vartheta_1=\vartheta_2$). The second sub-hypothesis is that *cold treatment initially affects FF&V exports to the U.S. from developed and developing/LDCs equally* (H_{2C}:$\vartheta_3=\vartheta_4$). The third sub-hypothesis is that *methyl bromide fumigation and cold treatment initially impact FF&V exports to the U.S. originating in developed and developing/LDCs equally* (H_{2D}:$\vartheta_5=\vartheta_6$). To test these sub-hypotheses, scenario six estimates the following equation:

$$V_{ikt} = \exp\left(A_{ikt} + \sum_{\psi=1}^{3} \sum_{d=1}^{2} {}_{\psi d}\vartheta treat_{ikt}^{\psi d} + \sum_{\psi=1}^{3} \sum_{d=1}^{2} {}_{\psi d}\rho treat\_lshare_{ikt}^{\psi d} \right) + \varepsilon_{ikt} \qquad (24)$$

H_3: *Globally large and established FF&V exporters cannot more easily overcome U.S. phytosanitary treatment requirements relative to small exporters.*

As previously discussed, it is expected that U.S. FF&V imports are sourced from large global exporters of these products. However, do we have enough empirical evidence to suggest that globally large exporters are more capable of meeting U.S. phytosanitary treatments than small exporters? The hypothesis H_3 is tested throughout scenarios one-six to shed some light on this question.

H_4: *Calculated threshold levels do not vary by product sector, exporter development status categories, or specific types of phytosanitary treatments applied.*

Scenarios two through six calculate threshold levels across product sectors, exporter development status categories, and treatment types. Under Hypothesis 4, nine sub-hypotheses are tested in order to examine whether or not computed threshold ratios are different across various categories, by using a Wald test of nonlinear parameter estimate combinations.

Following scenario two, the sub-hypothesis that *threshold levels do not vary across product sectors* is tested: (H_{4A}:$\delta_1/\tau_1 = \delta_2/\tau_2$).

Based on scenario three, the sub-hypothesis that *threshold levels do not vary across exporter development status categories* is tested: (H_{4B}:$\phi_1/\varphi_1 = \phi_2/\varphi_2$).

Under scenario four, four sub-hypothesis are tested. The first two sub-hypotheses are that *threshold levels do not vary within each exporter development status category:* (H_{4C}:$\gamma_1/\eta_1 = \gamma_2/\eta_2$; H_{4D}:$\gamma_3/\eta_3 = \gamma_4/\eta_4$). The second two tested sub-hypotheses are that *threshold levels do not vary across different exporter development status categories:* (H_{4E}:$\gamma_1/\eta_1 = \gamma_3/\eta_3$; H_{4F}:$\gamma_2/\eta_2 = \gamma_4/\eta_4$).

Based on scenario five, the sub-hypothesis that *threshold levels do not vary across different treatment types* is tested: (H_{4G}:$\mu_1/\omega_1 = \mu_2/\omega_2 = \mu_3/\omega_3 = \mu_4/\omega_4 = \mu_5/\omega_5 = \mu_6/\omega_6 = \mu_7/\omega_7 = \mu_8/\omega_8$).

Finally, using scenario six, two sub-hypotheses are tested; that *threshold levels for specific phytosanitary treatment types do not vary within the same exporter development status categories*: (H_{4H}:$\vartheta_1/\rho_1 = \vartheta_3/\rho_3 = \vartheta_5/\rho_5$; H_{4I}: $\vartheta_2/\rho_2 = \vartheta_4/\rho_5 = \vartheta_6/\rho_6$).

4.6 Exclusion of the "Zeros"

Would the exclusion of the "zeros" make a difference in terms of estimated phytosanitary treatment effects on U.S. FF&V imports? How would calculated threshold levels vary in such cases? As discussed in Chapter 3, most studies exclude all zero trade flows from their econometric analyses (with the exception of Jayasinghe, Beghin and Moschini, 2009), resulting in truncated samples that, as argued earlier, may lead to biased estimates of the model's parameters.

In order to shed some light on this issue, a log-linear specification of scenarios one through six is estimated dropping all zero trade flows and using OLS. The estimated benchmark specification is:

$$\ln(V_{ikt}) = \beta' x_{ikt} + \varepsilon_{ikt} \ , \tag{25}$$

where x_{ikt} is a vector of gravity model regressors, and ε_{ikt} is a stochastic error term.

As compared to the benchmark PPML equation (18), the OLS benchmark equation (25) is modified in two respects. First, the dependent variable (V_{ikt}) is represented as the natural logarithm of the FOB price, which successfully eliminates all "zeros." Second, *ldist*$_i$ is replaced by the total trade cost ($ltt\cos t_{ikt}$), which combines *ad valorem* rates of tariffs (TAR_{ikt}) and transport costs (TC_{ikt}) as $1 + TAR_{ikt} + TC_{ikt}$.[32] Finally, in order to eliminate "low" trade flows that may be hard to explain and may be quite frequent, particularly in a disaggregated product-level analysis, all scenarios are estimated based on a U.S. FF&V import flow benchmark of $20,000.

Do we expect a model including zero trade flows to produce higher or lower phytosanitary treatment parameter estimates as compared to a model excluding the "zeros"? First, in cases where zero trade flows are included, as under the PPML, it may be more difficult to identify the trade flow effects of phytosanitary treatments since the share of sample trade flows subject to these regulations will likely diminish. However, coefficient estimates obtained from an OLS model may be expected to be lower relative to a PPML model since zero trade flows, in some cases attributable to trade barriers such as phytosanitary treatments, are excluded. As a result, a

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[32] See Chapter 6 for justification on why this variable is not used under the PPML.

model of existing trade relationships is estimated, in which case bilateral trade flows included in the sample are likely less negatively affected by trade barriers.

Chapter 5: Data

This study collects data on U.S. phytosanitary measures for the period 1996 through 2007, which corresponds to the post-Uruguay Round era in which the WTO SPS Agreement has been in effect. Information on phytosanitary regulations is obtained from several sources. The main data source is the USDA/APHIS *Fresh Fruits and Vegetables Import Manual*, which is published several times during the course of a year after the implementation of new phytosanitary measures or amendments to existing regulatory regimes. The information published in this manual is used by regulatory officials, such as Plant and Protection Quarantine (PPQ) officers with APHIS and U.S. Agricultural Specialists with the Customs and Border Protection (CBP) stationed at land borders, airports, and sea ports of entry. These publications contain information (organized by exporting country) on the regulatory regime and the conditions under which an exporter can supply U.S. FF&V markets. As discussed in Chapter 2, the requirements for each exporter may consist of phytosanitary treatments, geographical restrictions on origin/destination, system approaches to pest risk management, preclearance procedures in the exporting country, or some combination of these five main categories of phytosanitary measures (USDA, APHIS, 2009a).[33]

Most, but not all, new and proposed amendments in U.S. phytosanitary measures pertaining to FF&V imports are also published in the Federal Register (U.S. Government, 2009) and the U.S. Code of Federal Regulations (U.S. Government, 2008). However, because of time lags between the effective date of a new regulation and its publication in the USDA/APHIS *Fresh Fruits and Vegetables Import Manual*, the last publication of this source for a given year is used to compile the phytosanitary regimes and lists of approved products for that year. Unless a

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[33] Archived copies of the USDA/APHIS *Fresh Fruits and Vegetables Import Manuals* are obtained from the APHIS Manuals Unit Branch stationed in Frederick, MD. The latest publication is available online at: http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/fv.pdf

regulatory regime is changed twice (or more) during the course of a year, this ensures that all changes in phytosanitary measures and market access within a given year are captured without having to inspect each publication.[34]

Changes in phytosanitary measures and new market access cases for a specific product are identified by comparing the list of approved products in the USDA/APHIS *Fresh Fruits and Vegetables Import Manual* across two consecutive years. For example, the list of approved FF&Vs for Argentina in 2007 was compared with the same list in 2006. Any phytosanitary measures pertaining to a given product that appear in 2007 but not in 2006 are considered changes in regulatory regimes. Similarly, any products that appear in the approved list in 2007 that were not included in 2006 are considered the result of new market access. All instances of new market access identified in the USDA/APHIS *Fresh Fruits and Vegetables Import Manual* were also cross-checked with notifications published in the U.S. Code of Federal Regulations and the Federal Register.

5.1 Recording Phytosanitary Measures

From the five main groups of phytosanitary measures pertaining to U.S imports of FF&Vs, only geographical restrictions on destination and phytosanitary treatments are recorded in the database. As discussed in Chapter 2, the main reason for this is that coding the other three categories of phytosanitary measures is nearly impossible. For example, geographical restrictions on origin are variety (*k*) (exporter/product) specific, requiring the use of a large number of binary variables to capture these restrictions. The same logic applies to systems approaches and preclearance procedures.

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[34] One drawback of this approach is that it does not capture the effects of changes in regulatory regimes occurring at different times in a given year (e.g., January versus December).

As shown in Table 3, the USDA/APHIS *Treatment Manual* lists ten approved phytosanitary treatments. However, some treatment types use similar procedures and some regulatory regimes require the combination of two approved treatments. Thus, eleven commodity treatment groups, listed in Table 9, are defined to capture any similarity in procedures and to account for all treatment combinations. For example, high temperature forced air (T103) and vapor heat (T106) are combined in a single group defined as "heat treatment." Similarly, cold treatment (T107) and quick freeze (T110) are merged into a single group defined as "cold treatment." Some regulatory regimes (Groups 7 and 8) require both cold treatment/refrigeration and fumigation of the product. However, Group 7 (fumigation plus refrigeration of fruits) represents single phytosanitary treatments, while Group 8 (methyl bromide fumigation and cold treatment) represents cases in which both of these phytosanitary treatments are required. In other cases, the exporter can choose between different phytosanitary treatments that each achieve the desired level of phytosanitary protection in the United States. These cases are identified as Groups 9, 10, and 11 in Table 9 (USDA, APHIS, 2009a; USDA, APHIS, 2009b).[35]

As discussed in Chapter 2, 13 different U.S. ports of entry are identified in the USDA/APHIS *Fresh Fruits and Vegetables Import Manual* through which FF&V imports may arrive. After consultations with staff at the USDA's Economic Research Service (ERS), the following ports of entry are assumed not to be a part of the continental U.S.: ALASKA, PR, USVI, HAWAII, GUAM, CNMI, and any ports of entry specified as SoP and LTD (USDA, APHIS, 2009a).

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[35] Table B1 (Appendix B) discusses the assumptions and provides justifications in cases where complex phytosanitary regimes are recorded in the database.

Table 9: Commodity Treatment Groups

Group	Definition	T100 Series Code
Group 1	Methyl Bromide Fumigation	T101
Group 2	Water Treatment	T102
Group 3	Heat Treatment	T103; T106
Group 4	Pest Specific/Host Variable	T104
Group 5	Irradiation	T105
Group 6	Cold Treatment	T107; T110
Group 7	Fumigation Plus Refrigeration of Fruits	T108; T109
Group 8	Methyl Bromide Fumigation and Cold Treatment	T101 and T107; T110
Group 9	Cold Treatment or Fumigation Plus Refrigeration of Fruits	T07; T110 or T108; T109
Group 10	Water Treatment or Methyl Bromide Fumigation	T102 or T101
Group 11	Methyl Bromide Fumigation or Cold Treatment	T101 or T107; T110

Sources: USDA, APHIS, 2009a; USDA, APHIS, 2009b.

5.1.1 Recording New Market Access Cases

During the period 1996-2008, APHIS granted a total of 204 instances of new market access for FF&V products, where each instance is defined as a unique exporter/product/year combination. However, only 80 of these instances are included in the sample due to several factors. First, some products, such as herbs and exotic fruits are not included in the sample (see discussion below). Second, some new market access cases are for products that correspond to a single sample product category. For example, in 1995, Chile was awarded new market access for three distinct products: clementines, mandarins, and tangerines. Such cases are counted as a single instance to avoid double counting. Some countries that received new market access are not included in the sample. For example, Namibia received new market access for fresh grapes in 1996 but it did not consistently ship significant FF&V quantities to the U.S. and was not included in the sample. Finally, instances granted in 2008 are excluded since the sample period is 1996 through 2007.

5.2 Sample Countries

To avoid problems of explaining “low” import values that are frequent in product-level analyses, only countries that exported at least $100,000 of at least one fresh fruit or vegetable product category defined at the HS six digit level for at least three years during the sample period are included in the sample. In terms of trade and production data, Serbia and Montenegro are treated as a single country because trade data for the two as separate countries are available only since 2007. Similarly, these data for Belgium are recorded as the joint data for Belgium (2000-2007), and Belgium-Luxemburg (1996-1999). Six countries, Albania, Algeria, Kenya, Malawi, Samoa, and Tunisia, are excluded from the sample because they exported only dried, frozen, or preserved products. Overall, 89 exporting countries are included in the sample. Table 10 lists all sample exporters by development status, including respective International Organization for Standardization (ISO) 3-digit country codes. Of the 89 sample countries, 63 are developing, 18 are developed, and only 8 are least-developed (LDCs). As discussed in Chapter 1, data on which exporters are developed countries are obtained from the ITC (ITC, 2008), and data on which exporters are LDCs from the UN (UN, 2008). Countries that do not appear on either list are considered developing countries.

5.3 Sample Products

To link information on U.S. phytosanitary measures to trade data on U.S. imports of FF&Vs, a concordance between the APHIS commodity identifiers and their appropriate six, eight, and ten-digit level HS codes is developed. As shown in Table 11, most FF&V sample products can be identified by a single HS category. For example, potatoes, tomatoes, and onions are defined at the HS six-digit level; bananas, cabbage, and fresh beans at the HS eight-digit level; and broccoli at the HS ten-digit level. Other products are defined as a combination of several HS categories. Carrots, mangoes, lemons, and limes are defined as a combination of several HS eight-digit product categories to avoid including trade data for dried, frozen, or preserved products, and to include product categories for which the HS code has changed over the years. For example, globe artichoke is defined as a combination of HS 070910 (Globe artichokes, fresh or chilled) and HS 07099065 (Globe artichokes, fresh or chilled) since the HS code for this category changed in 2007. Not all categories of FF&Vs in HS chapters 07 and 08 are included in the sample. For example, the “not elsewhere specified” (or nes) categories are not included in the sample due to the heterogeneity of products included in those categories. Other

Table 10: Sample Exporting Countries by Development Status[jj]

#	Country	ISO3	#	Country	ISO3	#	Country	ISO3
				Developed Countries				
1	Australia	AUS	7	Greece	GRC	13	New Zealand	NZL
2	Belgium	BEL	8	Ireland	IRL	14	Portugal	PRT
3	Canada	CAN	9	Israel	ISR	15	Spain	ESP
4	Denmark	DNK	10	Italy	ITA	16	Sweden	SWE
5	France	FRA	11	Japan	JPN	17	Switzerland	CHE
6	Germany	DEU	12	Netherlands	NLD	18	United Kingdom	GBR
				Developing Countries				
19	Argentina	ARG	40	Grenada Is	GRD	61	Poland	POL
20	Bahamas	BHS	41	Guatemala	GTM	62	Romania	ROU
21	Belize	BLZ	42	Honduras	HND	63	Russia	RUS
22	Bolivia	BOL	43	Hong Kong	HKG	64	Saudi Arabia	SAU
23	Bosnia-Hercegov.	BIH	44	Hungary	HUN	65	Serbia/Montenegro	SCG
24	Brazil	BRA	45	India	IND	66	Singapore	SGP
25	Bulgaria	BGR	46	Indonesia	IDN	67	South Africa	ZAF
26	Cameroon	CMR	47	Iran	IRN	68	Sri Lanka	LKA
27	Chile	CHL	48	Jamaica	JAM	69	St Lucia Is	LCA
28	China	CHN	49	Korea	KOR	70	St Vinc. & Gren.	VCT
29	Colombia	COL	50	Lebanon	LBN	71	Syria	SYR
30	Costa Rica	CRI	51	Macedonia	MKD	72	Taiwan	TWN
31	Cote d`Ivoire	CIV	52	Malaysia	MYS	73	Thailand	THA
32	Croatia	HRV	53	Mexico	MEX	74	Tonga	TON
33	Dominican Rep	DOM	54	Morocco	MAR	75	Trin. & Tobago	TTO
34	Ecuador	ECU	55	Nicaragua	NIC	76	Turkey	TUR
35	Egypt	EGY	56	Nigeria	NGA	77	United Arab Em	ARE
36	El Salvador	SLV	57	Pakistan	PAK	78	Uruguay	URY
37	Estonia	EST	58	Panama	PAN	79	Venezuela	VEN
38	Fiji	FJI	59	Peru	PER	80	Vietnam	VNM
39	Ghana	GHA	60	Philippines	PHL	81	Zimbabwe	ZWE
				Least-Developed Countries				
82	Afghanistan	AFG	86	Haiti	HTI			
83	Bangladesh	BGD	87	Madagascar	MDG			
84	Cambodia	KHM	88	Mozambique	MOZ			
85	Ethiopia	ETH	89	Tanzania	TZA			

Sources: USITC, 2009; FAO, 2009a; ITC, 2008; UN, 2008.

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[m] ISO 3-digit country codes are obtained from the FAO (FAO, 2009a). When FAO ISO 3-digit country codes were unavailable, Wikipedia's encyclopedia was used. Available online at: http://en.wikipedia.org/wiki/ISO_3166-1_alpha-3

Table 11: Sample Products by Sector

#	Product	HS Code
	Fresh Fruits	
1	Apples	80810
2	Apricots	80910
3	Avocados	80440
4	Bananas	8030020
5	Cherries	80920
6	Cranberries & Blueberries	81040
7	Currants	81030
8	Grapefruit	80540
9	Grapes	80610
10	Kiwifruit	81050
11	Lemons	8053020+ 8055020
12	Limes	8053040 + 8055030 + 8055040
13	Mandarins & Clementines	80520
14	Mangoes	8045040+8045060
15	Melon	80719
16	Oranges	80510
17	Papayas	80720
18	Peaches & Nectarines	80930
19	Pears & Quinces	80820
20	Pineapples	80430
21	Plums & Sloes	80940
22	Raspberries & Blackberries	81020
23	Strawberries	81010
24	Watermelons	80711
	Fresh Vegetables	
25	Asparagus	70920
26	Broccoli	704904020
27	Brussels Sprouts	70420
28	Cabbage	7049020
29	Carrots	7061005+7061010+7061020
30	Cauliflower	70410
31	Cucumbers	70700
32	Eggplants	70930
33	Fresh Beans	7082090
34	Garlic	70320
35	Globe Artichoke	70910+7099065
36	Head Lettuce	70511
37	Jicamas, Pumpkins, Breadfruit	7099005

Table 11 Continued

#	Product	HS Code
38	Leaf Lettuce	70519
39	Leeks	70390
40	Mushrooms And Truffles	70951 + 70959 + 70952
41	Okra	7099014
42	Onions	70310
43	Peppers	70960
44	Potatoes	70190
45	Spinach	70970
46	Squash	7099020
47	Tomatoes	70200

Source: USITC, 2009.

minor product categories in terms of U.S. imports by value (e.g., fiddlehead greens) are also excluded from the sample. Finally, products for which data on other variables in the gravity model could not be obtained, such as production in the exporting country are also excluded (e.g., celery (70940); durians (81060)). Overall, 47 product categories are included in the sample: 24 fresh fruits and 23 fresh vegetables.[37]

5.4 Data Sources and Independent Variables

Values of annual FF&V imports, tariffs, and transport costs are obtained from the U.S. International Trade Commission (USITC) (USITC, 2009). Production data for the U.S. and all exporting countries in the sample are obtained from the FAO (FAO, 2009b), with the exception of U.S. production data for onions which is obtained from the National Agricultural Statistics Service (NASS) (USDA, NASS, 2009).[38]

Table 12 lists the sample products and respective production categories used in cases where there was not a clear match with the FAO production data. For both U.S. and exporting countries, production data on cabbages and other brassicas are used for two sample products, brussels sprouts and cabbage. Similarly, joint data on cauliflowers and broccoli are used for the separate sample products broccoli and cauliflowers, joint lemons and limes data for both lemons and limes, lettuce and chicory data for both head and leaf lettuce, and pumpkins, squash, and gourds data for both jicamas, pumpkins, and breadfruit; and squash. For all exporting countries only, green onions (including shallots) production data are used for the two sample products onions and leeks. For U.S. product/year combinations for which production data were

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[37] Tables B.2a and B.2b (Appendix B) provide details and state the assumptions based on which the concordance between the APHIS commodity identifiers and the HS product categories is developed.

[38] The reason for this is that U.S. onion production data are not available from the FAO. For the U.S., production data on onions are also used as a proxy for leeks since these data are not available.

Table 12: Sample Products and Production Categories

Product	Country	Production Category Used
Leeks	U.S.	Data on onions are used as a proxy
Cranberries and Blueberries	U.S./Exporters	Data on cranberries and blueberries are reported separately and are combined
Fresh Beans	U.S./Exporters	Data on string beans and green beans are reported separately and are combined
Pears and Quinces	Exporters	Data on pears and quinces are reported separately and are combined
Brussels Sprouts	U.S./Exporters	Cabbages and other brassicas
Cabbage	U.S./Exporters	Cabbages and other brassicas
Broccoli	U.S./Exporters	Cauliflowers and broccoli
Cauliflowers	U.S./Exporters	Cauliflowers and broccoli
Lemons	U.S./Exporters	Lemons and limes
Limes	U.S./Exporters	Lemons and limes
Head Lettuce	U.S./Exporters	Lettuce and chicory
Leaf Lettuce	U.S./Exporters	Lettuce and chicory
Jicamas, Pumpkins, and Breadfruit	U.S./Exporters	Pumpkins, squash and gourds
Squash	U.S./Exporters	Pumpkins, squash and gourds
Onions	Exporters	Green onions (including shallots)
Leeks	Exporters	Green onions (including shallots)

Sources: FAO, 2009b; USDA, NASS, 2009.

unavailable, the production average of all other sample years for that same product is used. For example, raspberry and blackberry, and cranberry and blueberry average production data during the period 1996-2005 are used for the years 2006 and 2007. Similarly, jicamas, pumpkins, and breadfruit average data for the period 2000-2007 are used for the years 1996-1999, and leeks and onions average data for the period 1998-2007 are used for the years 1996-1997.

Geographical distances data are obtained from CEPII, as discussed in Chapter 4. Exchange rates data are obtained from the United Nations Statistics Division (UN, 2009). In the case of Taiwan only, exchange rate data are obtained from the USDA's ERS since data are unavailable from the United Nations Statistics Division (USDA, ERS, 2009). Data on FTAs are collected from the WTO (WTO, 2009b). Finally, as shown in Table 10, ISO 3-digit country codes are obtained from the FAO (FAO, 2009a) and Wikipedia's online encyclopedia.

The exporter shares of global exports are computed using FAO trade data (FAO, 2009c) for the years 1996 through 2006. For 2007 only, these shares are calculated using data obtained from the UN Commodity Trade Statistics Database (UNcomtrade, 2009), since FAO trade date are not available.[39] For 2007, export data on raspberries are used for currants; pumpkins, squash, and gourds data for globe artichokes, jicamas, pumpkins, and breadfruit, okra, and squash; and cabbages and other brassicas data for broccoli, cauliflower, cabbage, and brussels sprouts.

5.5 Ineligible and Zero Observations in the Sample

Overall, the database includes 13,404 observations, with a total number of 1,117 exporting country/commodity (variety (*k*)) pairs. The main reason why the sample does not contain the total possible number of (89 countries)*(12 years)*(47 products)=50,196 observations is that some exporters never export some of the 47 products to the U.S. during the

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[39] For the year of 2007, shares of global exports for Mexico could not be calculated due to missing data.

sample period. For example, during the period 1996-2007, Tanzania and Cambodia each exported only one of the 47 sample products to the U.S., peppers and garlic, respectively.

By comparing the lists of approved products and actual trade data for each sample year, ineligible FF&V exports to the U.S. are detected. After consultations with staff at the USDA's ERS, 172 cases of ineligible exports greater than $50,000 were recorded as being eligible (e.g., Thailand-bananas; India-peppers). Overall, the database contains 5,049 ineligible trade flows, or 37.7 percent of all observations.

Consistently with the work of Santos Silva and Tenreyro (2006), the database contains 7,627 "zeros", or 56.9 percent of all sample trade flows. However, since FF&V production is dictated by climate and biological factors in the exporting country, it is important to exclude the zero trade flows from the analysis for which the exporter simply cannot produce the product. Only 112 of the 7,627 "zeros" are a result of a biological or a climate barrier (e.g., Northern Hemisphere countries do not produce tropical fruits). However, production data are missing for an additional 3,098 import flow observations. As suspected, the main reason for this is that some of the exporting countries do not produce a given product (e.g., Canada-bananas). After first dropping 112 production "zeros" attributable to biological and climate factors, then dropping 3,098 import flows for which production data are missing, and finally dropping 2,372 ineligible import flows, 2,045 "legitimate zeros" are left that may or may not be attributed to trade barriers, such as phytosanitary treatments. These "zeros" are included in all estimations.

As later discussed in Chapter 6, under all six scenarios, the PPML is run on a total of 4,789 observations. The following section presents summary statistics for these sample observations.

5.6 Summary Statistics

Table 13 provides sample summary statistics for the 4,789 observations included in the model. In 2007, the largest imported fresh vegetable product categories (by value) were tomatoes ($257 million) and peppers ($207 million). For the same year, other important fresh vegetable imports included potatoes ($106 million), garlic ($103 million), cucumbers ($85.5 million) and mushrooms and truffles ($82.1 million). Overall, Mexico is the dominant fresh vegetable supplier to the United States. Other notable fresh vegetable exporters include Canada, the Netherlands, Peru, China, Israel and Spain. The largest imported fresh fruit categories (by value) in 2007 were bananas ($845 million) and grapes ($646 million). Other important fresh fruit imports for the same year included pineapples ($399 million), melons ($180 million), apples ($170 million), pears and quinces ($125 million), and mandarins and clementines ($117 million). Overall, Mexico, Chile and Costa Rica were dominant fresh fruit suppliers to the United States. Other important suppliers included Guatemala, Ecuador, Honduras and Colombia.

There are twenty-two transport cost outliers with value greater than 300 percent, and 76 outliers with value less than 1 percent. These outliers do not impact the results and are included in all six OLS estimations.

In 2007, tomatoes led U.S. fresh vegetable production with 161 million metric tons (mmt), followed by potatoes with 53 mmt, head lettuce with 40.8 mmt, leeks with 19.9 mmt and peppers with 10.3 mmt. Oranges and grapes led U.S. fresh fruit production with nearly 67 mmt, followed by apples with 38.1 mmt, strawberries with 16.7 mmt, and melons with 13.8 mmt.

China led all exporters with a total fresh vegetable production of 14.5 mmt in 2007, followed by Spain with 7.46 mmt, Italy with 6.78 mmt and Canada with 6.62 mmt. In terms of fruit, Italy and Spain dominated fresh fruit production for the same year (13 mmt each), followed

Table 13: Sample Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Import Flow ($ millions)	4,789	12.80	53.50	0.00	919.00
Distance	4,789	6440.50	3814.56	548.39	16180.32
Tariff (1+rate)	3,107	1.02	0.05	1.00	1.79
Transport Cost (1+rate)	3,107	1.33	0.47	1.00	11.29
Total Trade Cost (1+rate)	3,107	1.35	0.47	1.00	11.29
Trend	4,789	6.44	3.36	1	12
Fruit	4,789	0.55	0.50	0	1
U.S. Production (mmt)	4,789	2.02	3.48	0.00	23.30
Exporter Production (mmt)	4,789	0.44	1.15	0.00	12.70
Exchange Rate	4,789	144.17	542.00	0.01	10260.85
Global Export Share (*100)	4,789	7.16	12.91	0.00	87.79
NAFTA_FRT	4,789	0.07	0.25	0	1
NAFTA_VEG	4,789	0.06	0.25	0	1
CAFTA-DR	4,789	0.02	0.12	0	1
All other FTAs	4,789	0.06	0.23	0	1
New Market Access	4,789	0.05	0.22	0	1
Mainland	4,789	0.97	0.17	0	1
Commodity Treatments	4,789	0.22	0.41	0	1
Commodity Treatments_FRT	4,789	0.17	0.38	0	1
Commodity Treatments_VEG	4,789	0.05	0.21	0	1
Commodity Treatments_DPED	4,789	0.08	0.27	0	1
Commodity Treatments_DPING	4,789	0.14	0.35	0	1
Commodity Treatments_DPED&FRT	4,789	0.06	0.23	0	1
Commodity Treatments_DPED&VEG	4,789	0.02	0.15	0	1
Commodity Treatments_DPING&FRT	4,789	0.12	0.32	0	1
Commodity Treatments_DPING&VEG	4,789	0.02	0.15	0	1
Methyl Bromide Fumigation	4,789	0.06	0.23	0	1
Water Treatment	4,789	0.02	0.14	0	1
Heat Treatment	4,789	0.00	0.05	0	1
Pest Specific/Host Variable	4,789	0.01	0.08	0	1
Irradiation	4,789	0.00	0.02	0	1
Cold Treatment	4,789	0.10	0.29	0	1
Fumigation Plus Refrigeration of Fruits	4,789	0.01	0.08	0	1
Methyl Bromide Fumigation and Cold Treatment	4,789	0.02	0.13	0	1
Cold Treatment or Fumigation Plus Refrigeration	4,789	0.01	0.11	0	1
Water Treatment or Methyl Bromide Fumigation	4,789	0.00	0.05	0	1
Methyl Bromide Fumigation or Cold Treatment	4,789	0.00	0.00	0	0

Table 13 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
Global Export Share (GES)_Treatments	4,789	0.09	1.21	-8.81	4.32
GES_ Commodity Treatments_FRT	4,789	0.14	0.95	-8.45	4.32
GES_ Commodity Treatments_VEG	4,789	-0.05	0.74	-8.81	4.29
GES_ Commodity Treatments_DPED	4,789	0.08	0.72	-8.81	4.32
GES_ Commodity Treatments_DPING	4,789	0.01	0.98	-8.45	3.93
GES_ Commodity Treatments_DPED&FRT	4,789	0.07	0.60	-8.45	4.32
GES_ Commodity Treatments_DPED&VEG	4,789	0.01	0.40	-8.81	4.29
GES_ Commodity Treatments_DPING&FRT	4,789	0.07	0.75	-8.26	3.93
GES_ Commodity Treatments_DPING&VEG	4,789	-0.06	0.62	-8.45	3.69
GES_ Methyl Bromide Fumigation	4,789	0.01	0.75	-8.81	4.29
GES_ Water Treatment	4,789	0.01	0.26	-3.80	3.93
GES_ Heat Treatment	4,789	0.00	0.22	-8.45	2.50
GES_ Pest Specific/Host Variable	4,789	-0.01	0.29	-6.39	2.52
GES_ Irradiation	4,789	0.00	0.05	-0.23	3.42
GES_ Cold Treatment	4,789	0.06	0.71	-8.26	4.32
GES_ Fumigation Plus Refrigeration of Fruits	4,789	0.00	0.08	-1.83	1.34
GES_ Methyl Bromide Fumigation and Cold Treatment	4,789	0.00	0.39	-8.45	3.59
GES_ Cold Treatment or Fumigation Plus Refrigeration	4,789	0.01	0.21	-2.68	3.76
GES_ Water Treatment or Methyl Bromide Fumigation	4,789	0.00	0.06	0.00	1.99
GES_ Methyl Bromide Fumigation or Cold Treatment	4,789	0.00	0.00	0.00	0.00

note: Import flow is expressed as the customs value (excludes tariffs and transport costs); Total Trade Cost is defined as (1+tariff rate+transport cost rate); mmt stands for million metric tons; FRT(VEG) denotes fruit(vegetable); DPED(DPING) denotes developed(developing); GES stands for Global Export Share and represents exporting country (*i*)'s exports of product (*k*) in year (*t*) as a share of the total global exports of product (*k*) in year (*t*) (in terms of value); Distance is expressed in kilometers; Fruit is a dummy variable equal to 1 if the imported product is fruit, and zero otherwise. The exchange rate is expressed as the value of one dollar in terms of foreign currency; Mainland is a dummy variable equals to 1 if a product is eligible for export to the continental U.S., a zero otherwise; New Market Access is a dummy variable equals to 1 if an exporting country was awarded an access to U.S. FF&V markets in a given year, and for all additional years in which it maintained the market eligibility, and zero otherwise; Treatments is a dummy variable equal to 1 if a product is subject to at least one commodity treatment, and zero otherwise. In all interaction terms between phytosanitary treatment dummy variables and global export share, the latter is expressed in natural logarithm form.

Sources: USITC, 2009; FAO, 2009b; USDA, NASS, 2009; FAO, 2009c; UNcomtrade, 2009; UN, 2009; USDA, ERS, 2009; WTO, 2009b; ITC, 2008; UN, 2008; USDA, APHIS, 2009a.

by China with 12.7 mmt. For fresh vegetable product categories, tomatoes led all sample products with a total production of 14.7 mmt in 2007, followed by garlic with 13.2 mmt and potatoes with 8.8 mmt. Grapes dominated fresh fruit exporter production with 32.3 mmt in 2007. Pears and quinces were a distant second with 14.8 mmt, followed by oranges with 9.23 mmt, bananas with 6.2 mmt and apples with 5.7 mmt.

There are nine exchange rate outliers in the sample greater than 2909.38. As in the case of transport cost outliers, these observations are not excluded from any of the six PPML and OLS estimations since they do not impact the results.

Of the total number of 4,789 import flows included in the model, 20.4 percent are realized under a FTA. Based on these observations, 11 sample countries were in a FTA with the U.S. during the sample period: Mexico, Canada, El Salvador, Guatemala, Honduras, Nicaragua, Australia, Chile, Israel, Morocco, and Singapore (WTO, 2009b).

The exporter shares of global exports range from zero percent (e.g., Uruguay/garlic/2007) to 87.8 percent (Mexico/squash/2001) when only fresh vegetables are considered. When considering fresh fruits only, the shares of global exports range from zero percent (e.g., El Salvador/pineapples/2007) to 87.7 percent (Mexico/watermelons/1996).

New market access occurs in nearly five percent of all observations included in the model. As a reminder, all foreign countries that were granted new market access in a certain year for a given product are assigned a value of one in that specific year, and a value of one for each additional sample year in which the exporter kept the market supply eligibility privileges.

Just below 97 percent of all import flows included in the model are eligible for entry at ports that are considered part of the continental United States. This statistic is consistent with the statistic reported in Chapter 2 that is based on all observed imports flows.

Finally, 21.9 percent of all import flows included in the model are subject to at least one phytosanitary treatment requirement. However, nearly 31.2 percent of all fresh fruit import flows are subject to at least one phytosanitary treatment, as compared to just above ten percent of all fresh vegetable import flows. In terms of exporter development status, 20.6 percent of all import flows originating in developed countries are facing a phytosanitary treatment requirement as compared to 22.7 percent of all imports flows from developing/LDCs. Based on the 1,047 import flows requiring phytosanitary treatments included in the model, cold treatment accounts for 44 percent of all treatment requirements, followed by methyl bromide fumigation with 26 percent, and water treatment with nine percent.

Chapter 6: Results

The results are organized in two sections. Section 6.1 presents the results for the six scenarios identified in Chapter 4 for a gravity model with zero trade flows that is estimated using the PPML estimator of Santos Silva and Tenreyro (2006). The six scenarios considered are summarized as follows: scenario one allows for a generic phytosanitary treatment effect; scenario two tests whether the generic treatment effect differs by product sector; scenario three tests whether the generic treatment effect differs by development status of the exporting country; scenario four tests whether the generic treatment effect differs by product sector *and* development status; scenario five tests whether there are differences in the effects of individual treatment types; and the final scenario tests whether the effects of the specific treatment types differ by development status of the exporting country.

Section 6.2 re-estimates all six scenarios using an OLS estimator to estimate a log-linear gravity model where all import values under $20,000, including all zero import flows, are excluded from the sample. The purpose of this exercise is to determine whether excluding small trade flows, as done in most empirical studies using the gravity model, would have resulted in significant differences in the estimated effect of phytosanitary treatments. Stata code for all results presented in each of the following two sections is provided in Appendix C.

6.1 Poisson Pseudo-Maximum Likelihood Estimation Results

Following an influential paper by Santos Silva and Tenreyro (2006), a preferred PPML model is estimated. All trade flows, including the “zeros”, are incorporated in scenarios one through six, with two exceptions. First, ineligible exports are dropped from the sample. Second, zero trade flows for which production in the country of origin is also a “zero”, are also excluded.

Directly following Santos Silva and Tenreyro's (2006) Stata code, all specifications are run with heteroskedasticity-robust standard errors.

Table 14 presents the estimated coefficients for the independent variables that are common across all scenarios. Table 15 presents the estimated coefficients for the treatment effects across scenario one through six. The PPML model performed quite well, explaining from 55 (scenario one) to 61 percent (scenario five) of the variation in U.S. FF&V imports.[40] After first dropping 5,049 ineligible trade flows, then 103 exporter production "zeros", 25 U.S. production "zeros" (this variable is entered in natural logarithm terms), 2,858 missing exporter production values, and 580 missing global export share values, 4,789 observations are included under all six estimations. The estimated coefficients are robust in sign and magnitude for most of the independent variables in Table 15. The exception is *FTA* (impact of all other FTAs except NAFTA and CAFTA-DR) whose estimated coefficient, while statistically significant and positive in all scenarios, decreases in value by almost 50 percent from scenario one to scenario six. *Distance* and *U.S. Production* have the expected negative signs and are statistically significant in all scenarios. *Exporter Production*, *Trend*, *Fruit*, *Exchange Rate*, *CAFTA-DR*, *FTA*, *Mainland U.S.* and *Global Export Share* all have the expected positive signs and are statistically different from zero across scenarios one through six.

The new market access (*NMA)* coefficient estimate is consistently negative and significant at the one percent level. Using results from scenario five, holding everything else constant, foreign countries that have been awarded new market access on average export 65 percent less FF&Vs to the U.S. relative to long standing suppliers. As discussed in Chapter 4, this suggests that it may take time for new trade partners to build production capacities and

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[40] Even though Stata output reports Pseudo R-squares for a PPML estimation, code obtained from Santos Silva and Tenreyro's "The Log of Gravity" web site allows for R-squares to be calculated. This web site is available online at: http://privatewww.essex.ac.uk/~jmcss/LGW.html

Table 14: Poisson Pseudo-Maximum Likelihood Estimation Results for Common Independent Variables

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Distance	-0.21***	-0.21***	-0.21**	-0.19**	-0.14*	-0.21**
	(0.00)	(0.00)	(0.01)	(0.01)	(0.05)	(0.01)
U.S. Production	-0.06***	-0.07***	-0.05**	-0.06***	-0.08***	-0.07***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Exporter Production	0.56***	0.56***	0.56***	0.56***	0.60***	0.59***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trend	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fruit	1.11***	1.15***	1.33***	1.40***	1.40***	1.28***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exchange Rate	0.25***	0.26***	0.20***	0.21***	0.18***	0.18***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$NAFTA^{FRT}$	0.51***	0.53***	0.30**	0.33**	0.39***	0.42***
	(0.00)	(0.00)	(0.04)	(0.02)	(0.00)	(0.00)
$NAFTA^{VEG}$	2.60***	2.68***	2.60***	2.74***	2.76***	2.63***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CAFTA-DR	1.29***	1.30***	1.16***	1.19***	1.15***	1.18***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FTA	0.53**	0.52**	0.46**	0.45**	0.30**	0.29**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.03)
NMA	-0.98***	-1.13***	-1.09***	-1.09***	-1.04***	-1.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Mainland U.S.	2.17***	2.19***	2.08***	2.07***	2.18***	1.99***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Global Export Share	0.47***	0.47***	0.48***	0.48***	0.46***	0.48***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	4,789	4,789	4,789	4,789	4,789	4,789
R^2	0.55	0.56	0.57	0.58	0.61	0.60

Note: The dependent variable is the annual value of U.S. imports of fresh fruits and vegetables expressed as the FOB price. P-values>|z| are in parentheses. Distance is represented as the natural logarithm of the geographical distance between the U.S. and the exporting country expressed in kilometers. Fruit is a dummy variable indicating whether or not the imported product is fruit. FTA is a dummy variable denoting all free trade agreements other than NAFTA and CAFTA-DR. NMA is a dummy variable denoting new market access. Mainland U.S. is a dummy variable denoting imports eligible for shipping to the continental United States. The sample contains 89 countries, 12 years (1996-2007), and 47 fresh products. *, **, *** denote significance at the ten, five, and one percent level, respectfully. Heteroskedasticity-robust standard errors are used in all scenarios.

Table 15: PPML Estimation Results for Phytosanitary Treatments

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
TREAT	-1.75***	_____	_____	_____	_____	_____
	(0.00)	_____	_____	_____	_____	_____
$TREAT^{FRT}$	_____	-1.58***	_____	_____	_____	_____
	_____	(0.00)	_____	_____	_____	_____
$TREAT^{VEG}$	_____	-8.86***	_____	_____	_____	_____
	_____	(0.00)	_____	_____	_____	_____
$TREAT^{DPED}$	_____	_____	-2.80***	_____	_____	_____
	_____	_____	(0.00)	_____	_____	_____
$TREAT^{DPING}$	_____	_____	-2.49***	_____	_____	_____
	_____	_____	(0.00)	_____	_____	_____
$TREAT^{DPED\&FRT}$	_____	_____	_____	-2.83***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
$TREAT^{DPED\&VEG}$	_____	_____	_____	-1.11***	_____	_____
	_____	_____	_____	(0.01)	_____	_____
$TREAT^{DPING\&FRT}$	_____	_____	_____	-2.18***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
$TREAT^{DPING\&VEG}$	_____	_____	_____	-21.81***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
MBF	_____	_____	_____	_____	-2.37***	_____
	_____	_____	_____	_____	(0.00)	_____
WTR	_____	_____	_____	_____	-0.75***	_____
	_____	_____	_____	_____	(0.00)	_____
HEAT	_____	_____	_____	_____	-0.15	_____
	_____	_____	_____	_____	(0.79)	_____
PS/HV	_____	_____	_____	_____	-0.36	_____
	_____	_____	_____	_____	(0.14)	_____
CLD	_____	_____	_____	_____	-1.66***	_____
	_____	_____	_____	_____	(0.00)	_____
FPRF	_____	_____	_____	_____	-3.77***	_____
	_____	_____	_____	_____	(0.00)	_____
MBF&CLD	_____	_____	_____	_____	-3.99***	_____
	_____	_____	_____	_____	(0.00)	_____
CLD or FPRF	_____	_____	_____	_____	-2.82***	_____
	_____	_____	_____	_____	(0.00)	_____

Table 15 Continued

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
MBF^{DPED}	_____	_____	_____	_____	_____	-5.21***
	_____	_____	_____	_____	_____	(0.00)
MBF^{DPING}	_____	_____	_____	_____	_____	-3.26***
	_____	_____	_____	_____	_____	(0.00)
CLD^{DPED}	_____	_____	_____	_____	_____	-0.92**
	_____	_____	_____	_____	_____	(0.01)
CLD^{DPING}	_____	_____	_____	_____	_____	-2.77***
	_____	_____	_____	_____	_____	(0.00)
MBF&CLD^{DPED}	_____	_____	_____	_____	_____	-9.51***
	_____	_____	_____	_____	_____	(0.00)
MBF&CLD^{DPING}	_____	_____	_____	_____	_____	-3.25***
	_____	_____	_____	_____	_____	(0.00)
Global Export Share_TREAT	0.49***	_____	_____	_____	_____	_____
	(0.00)	_____	_____	_____	_____	_____
Global Export Share_TREAT^{FRT}	_____	0.45***	_____	_____	_____	_____
	_____	(0.00)	_____	_____	_____	_____
Global Export Share_TREAT^{VEG}	_____	2.67***	_____	_____	_____	_____
	_____	(0.00)	_____	_____	_____	_____
Global Export Share_TREAT^{DPED}	_____	_____	0.49***	_____	_____	_____
	_____	_____	(0.00)	_____	_____	_____
Global Export Share_TREAT^{DPING}	_____	_____	0.82***	_____	_____	_____
	_____	_____	(0.00)	_____	_____	_____
Global Export Share_TREAT$^{DPED\&FRT}$	_____	_____	_____	0.51***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
Global Export Share_TREAT$^{DPED\&VEG}$	_____	_____	_____	-0.01	_____	_____
	_____	_____	_____	(0.90)	_____	_____
Global Export Share_TREAT$^{DPING\&FRT}$	_____	_____	_____	0.73***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
Global Export Share_TREAT$^{DPING\&VEG}$	_____	_____	_____	6.71***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
Global Export Share_MBF	_____	_____	_____	_____	0.90***	_____
	_____	_____	_____	_____	(0.00)	_____
Global Export Share_WTR	_____	_____	_____	_____	0.04	_____
	_____	_____	_____	_____	(0.43)	_____
Global Export Share_HEAT	_____	_____	_____	_____	-0.92***	_____
	_____	_____	_____	_____	(0.00)	_____

Table 15 Continued

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Global Export Share_PS/HV	_____	_____	_____	_____	-0.16	_____
	_____	_____	_____	_____	(0.12)	_____
Global Export Share_CLD	_____	_____	_____	_____	0.26***	_____
	_____	_____	_____	_____	(0.00)	_____
Global Export Share_FPRF	_____	_____	_____	_____	-0.23	_____
	_____	_____	_____	_____	(0.40)	_____
Global Export Share_MBF&CLD	_____	_____	_____	_____	-0.08	_____
	_____	_____	_____	_____	(0.61)	_____
Global Export Share_CLD or FPRF	_____	_____	_____	_____	0.39***	_____
	_____	_____	_____	_____	(0.00)	_____
Global Export Share_MBF^{DPED}	_____	_____	_____	_____	_____	1.34***
	_____	_____	_____	_____	_____	(0.00)
Global Export Share_MBF^{DPING}	_____	_____	_____	_____	_____	1.22***
	_____	_____	_____	_____	_____	(0.00)
Global Export Share_CLD^{DPED}	_____	_____	_____	_____	_____	0.07
	_____	_____	_____	_____	_____	(0.49)
Global Export Share_CLD^{DPING}	_____	_____	_____	_____	_____	0.79***
	_____	_____	_____	_____	_____	(0.00)
Global Export Share_MBF&CLD^{DPED}	_____	_____	_____	_____	_____	1.61***
	_____	_____	_____	_____	_____	(0.00)
Global Export Share_MBF&CLD^{DPING}	_____	_____	_____	_____	_____	0.23
	_____	_____	_____	_____	_____	(0.42)

Note: The dependent variable is the annual value of U.S. imports of fresh fruits and vegetables expressed as the FOB price. P-values>|z| are in parentheses. TREAT is a dummy variable denoting whether or not U.S. imports are subject to any phytosanitary treatments. FRT (VEG) denotes fruits (vegetables). DPED(DPING) denotes developed (developing/LDC). MBF denotes methyl bromide fumigation; WTR denotes water treatment; HEAT denotes heat treatment; PS/HV denotes pest specific/host variable; CLD denotes cold treatment; FPRF denotes fumigation plus refrigeration of fruits. The sample contains 89 countries, 12 years (1996-2007), and 47 fresh products. *, **, *** denote significance at the ten, five, and one percent level, respectfully. Heteroskedasticity-robust standard errors are used in all scenarios.

marketing channels before they can compete with long-standing suppliers. Also, exporting countries awarded new market access have not reached their export potential and may ship more FF&Vs to the U.S. in future.

NAFTA has played an important role in stimulating U.S. FF&V imports. As expected, the NAFTA effect is greater for U.S. fresh vegetable than fresh fruit imports because NAFTA trade partners account for a much larger share of the annual U.S. fresh vegetable than fresh fruit imports. Using results from scenario five, NAFTA has led on average to a 48 percent increase in U.S. fresh fruit imports and nearly 16-fold increase in vegetable imports as compared to non-NAFTA members, ceteris paribus.

Before discussing each individual scenario, it is interesting to note that parameter estimates for the treatment effects are mostly negative and significant at the one percent level across all scenarios. While this might initially suggest that phytosanitary treatments negatively affect U.S. FF&V imports, this hypothesis cannot be tested without considering the effects of the phytosanitary treatment-*Global Export Share* interaction terms. In most cases, the coefficient estimate on the interaction term is positive and significant. The results reject the hypothesis that globally large FF&V exporters have no advantage relative to small exporters in meeting U.S. phytosanitary treatment requirements (H_3). When statistically significant, this interaction term is positive across all scenarios except for the interaction between heat treatment (*HEAT*) and *Global Export Share* in scenario five. Thus, even though treatment effects initially may be negative, they become positive after an exporter reaches a certain threshold global export market share. By comparing threshold levels across different scenarios, it will be possible to identify the treatments that are the most trade restrictive. Ultimately, even though one should be cautious when interpreting computed threshold ratios, they are certainly suggestive of the overall restrictiveness of phytosanitary treatments.

6.1.1 Treatments-A Generic Impact

Do phytosanitary treatments, in general, affect the level of U.S. FF&V imports? Using the mean value of the natural logarithm of global export share of -0.72 percent, the imposition of a phytosanitary treatment results in imports being 88 percent lower than imports not facing a phytosanitary treatment, ceteris paribus, implying the rejection of the hypothesis that treatments do not affect U.S. FF&V imports (H_{1A}). Other related empirical studies also produced negative coefficients for this coefficient. Anders and Caswell (2009) for example, in their benchmark specification estimate a significant HACCP elasticity of -0.59 percent. Disdier, Fekadu, Murillo and Wong (2008) estimate a significant coefficient of SPS measures and TBTs of -0.30, and Disdier, Fontaigné and Mimouni (2008) estimate an SPS measure and TBTs coefficient of -0.15.

Because of the positive and significant coefficient on the interaction between treatments and global export share (*Global Export Share_TREAT*), after an exporter reaches a market share of 36 percent, the treatment effect becomes positive.[41] An explanation for this result is that there are likely significant fixed costs associated with phytosanitary treatments. For example, facilities must be available to fumigate, irradiate, or refrigerate the commodities. A larger exporter will be able to spread out these fixed costs over a larger export volume, thereby reducing the per-unit treatment costs. Eventually, the per-unit treatment costs are reduced to a low enough level that treatments no longer pose an economic barrier. However, the number of exporters that have

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[41] Table 16 summarizes estimated phytosanitary treatment effects across all six scenarios, as well as computed threshold levels, while ranking specific phytosanitary treatment types from the least to the most trade restrictive.

Table 16: Phytosanitary Treatment Effects and Threshold Levels

	Treatment Effect	Threshold Level
Scenario 1		
Generic Treatment Requirement	-88%***	36%***
Scenario 2		
Generic Treatment Requirement-Fruits	-85%***	34%***
Generic Treatment Requirement-Vegetables	-100%***	28%***
Scenario 3		
Generic Treatment Requirement-Developed Countries	-96%***	_____
Generic Treatment Requirement-Developing/LDCs	-95%***	21%***
Scenario 4		
Generic Treatment Requirement-Fruits&Developed Countries	-96%***	_____
Generic Treatment Requirement-Vegetables&Developed Countries	-67%	_____
Generic Treatment Requirement-Fruits&Developing/LDCs	-93%***	20%***
Generic Treatment Requirement-Vegetables&Developing/LDCs	-100%***	26%***
Scenario 5		
Methyl Bromide Fumigation	-95%***	14%***
Cold Treatment	-84%***	_____
Cold Treatment or Fumigation Plus Refrigeration of Fruits	-95%***	_____
Water Treatment	-54%***	_____
Pest Specific/Host Variable	-22%	_____
Fumigation Plus Refrigeration of Fruits	-97%***	_____
Methyl Bromide Fumigation and Cold Treatment	-98%***	_____
Heat Treatment	67%	_____
Water Treatment or Methyl Bromide Fumigation	_____	_____
Irradiation	_____	_____
Methyl Bromide Fumigation or Cold Treatment	_____	_____
Scenario 6		
Methyl Bromide Fumigation-Developing/LDCs	-98%***	15%***
Cold Treatment-Developing/LDCs	-96%***	33%***
Methyl Bromide Fumigation-Developed Countries	-100%***	48%***
Cold Treatment-Developed Countries	-62%**	_____
Methyl Bromide Fumigation and Cold Treatment-Developed Countries	-100%***	_____
Methyl Bromide Fumigation and Cold Treatment-Developing/LDCs	-97%***	_____

note: Threshold levels are calculated as follows: (|estimated treatment dummy variable coefficient|)/(estimated interaction term between *Global Export Share* and the relevant treatment variable coefficient)*100; The sample contains 89 countries, 12 years (1996-2007), and 47 fresh products. *, **, *** denote significance at the ten, five, and one percent level, respectfully. Heteroskedasticity-robust standard errors are used in all scenarios.

achieved a global export share greater than 36 percent for a given commodity and time period is relatively low. Only 65 (five percent) of the exporter/product/year combinations that are subject to a phytosanitary treatment are observed in the database. Within these 65 instances, products for which foreign suppliers most often meet this threshold level are citrus categories: oranges and mandarins and clementines, each with 12 instances, and grapefruit with 8.

6.1.2 Treatment Effects by Product Sector

Do phytosanitary treatments, in general, affect fresh fruits differently than fresh vegetables? Even though treatments are applied nearly three times as often to fresh fruits than to fresh vegetables (see Chapter 2), at the sample mean of *Global Export Share*, phytosanitary treatments have a greater negative impact on U.S. fresh vegetable than fresh fruit imports. All else constant, a phytosanitary treatment reduces fresh fruit imports by 85 percent and fresh vegetable imports by 100 percent. These estimates are in contrast to findings in Disdier, Fontaigné and Mimouni (2008) and Disdier, Fekadu, Murillo and Wong (2008) who do not estimate a significant impact of standards on vegetable exports. On the other hand, both studies find a negative and significant effect of standards on fruit exports. The difference between the $TREAT^{FRT}$ and $TREAT^{VEG}$ coefficient estimates is supported by a chi-squared test, which supports rejecting the hypothesis that the initial phytosanitary treatment effects do not vary across product sectors (H_{1B}).

For fresh fruits, the treatment effect becomes non-negative after an exporter reaches a global export market share of 34 percent. About six percent of all fresh fruit country/product/year combinations subject to a phytosanitary treatment in the database have achieved this threshold level. Again, citrus fruit categories account for most of these 57 instances: oranges and mandarins and clementines, each with 12, and grapefruit with nine. On the other hand, the effect for fresh vegetables becomes positive after an exporter reaches a global export market share of 28 percent. In this case, only three percent of all fresh vegetable country/product/year combinations subject to a phytosanitary treatment have achieved the computed threshold ratio. However, a Wald test fails to reject the hypothesis that the threshold levels do not vary across product sectors (H_{4A}). Thus, effects of phytosanitary treatments are the same for fruits and vegetables.

6.1.3 Treatment Effects by Development Status

Does a phytosanitary treatment requirement affect developed countries differently than it does developing/LDCs? Surprisingly, the initial treatment effect is almost the same on FF&V exports from developed countries as on developing/LDCs. U.S. FF&V imports from developed countries subject to at least one treatment are on average 96 percent lower, and imports from developing/LDCs are 95 percent lower relative to imports not facing that requirement, ceteris paribus. These findings are inconsistent with the work of Disdier, Fontaigné and Mimouni (2008) and Anders and Caswell (2009) who find a much greater negative impact of standards on exports from developing countries. The difference between the $TREAT^{DPED}$ and $TREAT^{DPING}$ coefficient estimates is not supported by a chi-squared test. Therefore, we fail to reject the hypothesis that the initial effects of phytosanitary treatments do not vary by development status (H_{1C}).

$Global\ Exports\ Share\_TREAT^{DPED}$ and $Global\ Exports\ Share\_TREAT^{DPING}$ are positive and significant at the one percent level. However, the latter coefficient estimate is stronger than the former. In this case, the calculated threshold level for developed FF&V exporters is at 307 percent, suggesting that developed exporters are never affected by a positive phytosanitary treatment effect. On the other hand, developing/LDC FF&V exporters are not negatively affected by a generic treatment requirement only after achieving a 28 percent global export market share. Of the 948 developing/LDC exporter/year/product sample combinations subject to treatments, 33 satisfy this threshold. A Wald test suggests that the difference between the two threshold ratios is significant, rejecting the hypothesis that the threshold levels do not vary across different development status categories (H_{4B}). Thus, a generic phytosanitary treatment requirement differently affects U.S. FF&V imports from developed countries and developing/LDCs.

Why do treatment requirements have a different impact on FF&V imports from developed countries than on those from developing/LDCs? Looking at the data, developed countries are subject to different treatments from developing/LDCs. For example, nearly 37 percent of the 299 developed country/product/year combinations that require treatment must use methyl bromide fumigation while only 29 percent of the 559 developing/LDC country/product/year combinations require it. In addition, water treatment accounts for nearly 18 percent of all requirements in developing/LDC countries while it is never required for developed countries. On the other hand, cold treatment or fumigation plus refrigeration of fruits accounts for 13 percent of all applied treatments on exports from developed countries, and for none of the treatment applications for developing/LDCs. Finally, as subsequently discussed in scenario five, initial treatment effects and computed threshold levels vary across specific treatment types, which may explain the difference between the treatment effects on imports from developed and developing/LDCs.

Findings in scenarios two and three suggest that the non-negative impact of a generic treatment requirement may only hold for a small number of globally large and established FF&V

exporters. Additionally, FF&V market opportunities may exist in the U.S. for globally large developing/LDC FF&V exporters that are currently ineligible to supply the U.S. market. As noted in Romberg and Roberts (2008), for example, only five of the ten largest global mango producers have market supply eligibility rights to the United States.

6.1.4 Treatment Effects by Product Sector and Development Status

Does a generic treatment requirement differently affect fresh fruit (vegetable) exports from developed countries than fresh fruit (vegetable) exports from developing/LDCs? In order to answer these questions, scenario four, a combination of scenarios two and three, disaggregates the generic treatment dummy variable into four dummy variables: $TREAT^{DPED\&FRT}$, $TREAT^{DPED\&VEG}$, $TREAT^{DPINGD\&FRT}$ and $TREAT^{DPINGVEG}$.

On average, a generic treatment requirement reduces U.S. fresh fruit imports from developed countries by 96 percent and fresh vegetable imports by 67 percent, ceteris paribus. The difference between $TREAT^{DPED\&FRT}$ and $TREAT^{DPED\&VEG}$ is supported by a chi-squared test. Therefore, we reject the hypothesis that the initial treatment impact is equal for fresh fruit and fresh vegetable imports from developed countries (H_{1D}). For imports from developing/LDCs, holding everything else constant, a generic treatment requirement reduces U.S. fresh fruit imports by 93 percent and fresh vegetable imports by 100 percent. A chi-squared test supports the difference between the $TREAT^{DPING\&FRT}$ and $TREAT^{DPING\&VEG}$ coefficient estimates. As a result, we reject the hypothesis that a generic phytosanitary treatment requirement initially affects fresh fruit and fresh vegetable imports from developing/LDCs equally (H_{1E}).

Of all four interaction terms, only $Global\ Exports\ Share\_TREAT^{DPED\&VEG}$ has an unexpected negative sign and is statistically insignificant. Based on a calculated threshold level of 269 percent, developed fresh fruit exporters are always negatively affected by a generic phytosanitary treatment requirement. Because $\textit{Global Exports Share\_TREAT}^{DPED\&VEG}$ is negative and insignificant, the treatment effect on fresh vegetable imports from developed countries is also always negative. Therefore, we conclude that there is not a difference in the treatment effect on fresh fruit and fresh vegetable imports from developed countries. More interestingly, calculated threshold levels are low for FF&V exports originating in developing/LDCs, confirming scenario three findings. First, fresh fruit developing exports are positively affected by a generic treatment requirement if they account for at least 20 percent of the global export market share. Second, fresh vegetable developing exporters are negatively impacted by a generic treatment requirement only if they account for less than 26 percent of the global export market share. A Wald test provides evidence to reject the hypothesis that fresh fruit and fresh vegetable imports from developing/LDCs are equally affected by a generic treatment requirement (H_{4D}). At the same time, empirical evidence exists to reject H_{4E}, suggesting a generic treatment requirement has a different impact on fresh fruit imports from developed than from developing/LDCs.

6.1.5 Treatment Effects of Specific Treatment Types

While scenarios one through four determine the effects of phytosanitary treatments in general, it may be the case that there are differences in the effects across the individual treatment types. In order to distinguish between "important" and "unimportant" treatments, and to explore the differing degree of effect among specific treatment types, scenario five tests the trade effect of each specific type of treatment. Three of the eleven treatment groups listed in Table 9 (Chapter 5), methyl bromide fumigation or cold treatment, irradiation, and water treatment or methyl bromide fumigation, are excluded due to small number of observations based on all observed import flows (one, three, and two, respectively).

Six of the eight treatment groups initially have a negative and significant effect, with the exception of *HEAT* which has a positive but insignificant impact, and *PS/HV* which has a negative but insignificant effect. All else constant, *MBF* on average reduces U.S. FF&V imports by 95 percent, *WTR* by 54 percent, *CLD* by 84 percent, *FPRF* by 97 percent, *MBF&CLD* by 98 percent, and *CLD or FPRF* by 95 percent, ceteris paribus. These findings illustrate the inequalities among different types of treatments. For example, the joint initial negative effect of the two most commonly applied treatments (*MBF&CLD*), is greater than their separate effects. At the same time, across all import flows, *CLD* has a stronger initial negative impact than *MBF* does. The difference between the coefficient estimates of the significant phytosanitary treatment types is supported by a chi-squared test, allowing the rejection of the hypothesis that the initial effects of phytosanitary treatments are equal across specific treatment types (H_{2A}).

Only three of the eight interaction terms are positive and significant, suggesting that threshold levels can be calculated for only three treatment types. First, the effect of *MBF* becomes positive after an exporter reaches a 14 percent global export market share. Interestingly, 15 percent of the 525 country/product/year combinations in the database subject to fumigation with methyl bromide have achieved this threshold. Plums and sloes, and grapes account for most of these 78 instances, each with 12, followed by garlic with eight. Second, FF&V exporters subject to *CLD* cannot be affected by its positive effect since the calculated threshold level is much greater than 100 percent of the global export market share, again suggesting the significant constraint of this treatment type. Third, FF&V exporters subject to *CLD or FPRF* also cannot be positively impacted by its positive effect since the computed threshold ratio is again much higher than 100 percent of the global export market share. For all other cases, calculated interaction terms are either negative or insignificant, suggesting that U.S. FF&V imports are always negatively affected by these specific treatment types.

For the positive and statistically significant interaction terms, a Wald test supports the rejection of the hypothesis that calculated threshold levels do not vary across specific treatment types (H_{4G}). In addition, methyl bromide fumigation is the only treatment type for which globally large FF&V exporters can benefit from a positive treatment effect.

Findings under scenario five contradict scenario two results that the trade flow effects of phytosanitary treatments do not vary across product sectors. The main reason for this is that under scenario five, methyl bromide fumigation, a dominant required treatment type for fresh vegetables, has a low computed threshold ratio. On the other hand, cold treatment and cold treatment or fumigation plus refrigeration of fruits, which are dominant required treatment types for fresh fruits, have very high calculated threshold levels. This contradiction may be due to aggregation of treatments into a generic variable under scenario two, which then further suggests the importance of identifying the trade flow effects of specific treatment types.

6.1.6 Treatment Effects of Specific Types of Treatments by Development Status

Do specific treatment types differently affect U.S. FF&V imports originating from exporters belonging to different development status categories? To properly tackle this question, the generic treatment variable is disaggregated by treatment types *and* development status.

From the eight treatment groups included in scenario five, three cannot be included in scenario six (water, heat, and pest specific/host variable), since these treatment groups are only required for developed exporters. In addition, due to the small number of observations for developing/LDCs, fumigation plus refrigeration of fruits, and cold treatment or fumigation plus refrigeration of fruits are not included in the estimation (one observation in both cases based on all observed import flows in the sample). As a result, only methyl bromide fumigation, cold treatment, and methyl bromide fumigation and cold treatment are included.

The coefficients on all six treatment dummy variables are negative and statistically different than zero. First, *MBF* has a greater negative effect on imports from developed than from developing/LDCs. Holding everything else constant, *MBF* on average reduces U.S. FF&V imports from developed countries by 100 percent and imports from developing/LDCs by 98 percent. However, a chi-squared test does not provide evidence to reject (H_{2B}). Therefore, *MBF* equally affects FF&V imports from developed and developing/LDCs, at least initially. Second, *CLD* has a greater negative effect on imports from developing/LDCs than from developed countries. On average, *CLD* reduces imports from developed countries by 62 percent and imports from developing/LDCs by 96 percent, ceteris paribus. In addition, a chi-squared test allows the rejection of H_{2C}. As a result, the initial effect of *CLD* is different for imports from developed and developing/LDCs. Finally, although methyl bromide fumigation and cold treatment almost equally reduce imports from developed (100 percent) and developing/LDCs (97 percent), a chi-squared test rejects the hypothesis that methyl bromide fumigation and cold treatment initially affect imports from developed and developing/LDCs equally (H_{2D}).

Four of the six interaction terms are positive and statistically different from zero. Overall, computed threshold levels again suggest that globally large developing/LDC FF&V exporters respond more to the positive effect of treatments than do globally large developed FF&V exporters (see scenarios three and four). First, large global developing FF&V exporters are only negatively affected by *MBF* until they account for 15 percent of the global export market share while large global developed FF&V exporters are negatively affected by *MBF* until they reach a 48 percent global export market share for a given product. Second, large global developing FF&V exporters are negatively affected by *CLD* only if they account for less than 33 percent of the global export market share. Finally, large global developed FF&V exporters are always negatively affected by *MBF&CLD* since the calculated threshold level is 365 percent of the global export market share. Due to insignificant and negative interaction term coefficient estimates, H_{4H} and H_{4I} cannot be tested.

6.2 Ordinary Least Squares Estimation Results

Will the exclusion of the “zeros” affect estimated phytosanitary treatment effects on U.S. FF&V imports? As discussed in Chapter 4, exclusion of the “zeros” might theoretically lead to biased parameter estimates since the dependent variable is no longer a measure of bilateral trade but rather of bilateral trade conditional on a trade relationship actually existing. Moreover, zero trade flows are quite frequent in product level analyses, which makes addressing this question even more appealing. Since most related empirical studies exclude zero trade flows from their samples, dropping the “zeros” might suggest whether or not parameter estimates from other empirical studies are biased. The PPML includes zero trade flows to control for selectivity bias. However, as a result, the percentage of import flows subject to phytosanitary treatments is reduced, implying that it may be easier to identify the treatment effects under OLS.

Unlike in the preferred PPML model, the dependent variable in the OLS model is entered as the natural logarithm of the FOB price that successfully eliminates all “zeros”, and *Distance* is replaced with *Total Trade Cost*, which combines tariffs and transport costs and is entered as the natural logarithm of $(1+TAR_{ikt}+TC_{ikt})$. This variable could not be used in the PPML specifications since tariffs and transportation costs are unobserved in cases of "zeros" under the method this study uses to calculate these two values. *Ad valorem* tariff rates are calculated as (landed-duty-paid value (LDPV))/(cost, insurance and freight (CIF) value), and transport cost rates as (CIF value)/(FOB price). As in the PPML estimation, heteroskedasticity-robust standard errors are used in all estimations. To eliminate "low" U.S. FF&V imports that may be hard to explain, all scenarios are run for an import flow benchmark of $20,000.

The treatment and interaction term estimates from the OLS estimation are presented in Table 17. The same six scenarios as in the PPML are presented since the same six policy issues are addressed. The OLS also has performed quite well, explaining from 49 (scenario one) to 51 percent (scenarios four and five) of the sample variation in U.S. FF&V imports, respectively. After first dropping: 5,049 ineligible exports, 3,642 zero trade flows (since the dependent variable now is the natural logarithm of the customs value), 1,377 missing exporter production values, 224 missing global export share values, five U.S. production "zeros" (dropped since the variable is entered as the natural logarithm), and finally 518 import flows less than $20,000, the benchmark estimation is run on a total of 2,589 observations. Overall, coefficient estimates are robust in sign and magnitude. However, *FTA* is positive but insignificant in four of the six scenarios. More importantly, interaction terms between the treatment dummy variables and *Global Exports Share* are mostly negative and insignificant, suggesting that few threshold levels may be computed.

Results in this section again support the hypothesis that treatments initially may have a negative rather than a positive effect on U.S. FF&V imports. Overall, phytosanitary treatment coefficient estimates are nearly always lower relative to PPML estimates, as expected.

Table 17: Ordinary Least Squares Results

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
TREAT	-0.60***	______	______	______	______	______
	(0.00)	______	______	______	______	______
$TREAT^{FRT}$	______	-0.97***	______	______	______	______
	______	(0.00)	______	______	______	______
$TREAT^{VEG}$	______	-0.74***	______	______	______	______
	______	(0.00)	______	______	______	______
$TREAT^{DPED}$	______	______	-1.45***	______	______	______
	______	______	(0.00)	______	______	______
$TREAT^{DPING}$	______	______	-0.20	______	______	______
	______	______	(0.13)	______	______	______
$TREAT^{DPED\&FRT}$	______	______	______	-1.58***	______	______
	______	______	______	(0.00)	______	______
$TREAT^{DPED\&VEG}$	______	______	______	-1.42***	______	______
	______	______	______	(0.00)	______	______
$TREAT^{DPING\&FRT}$	______	______	______	-0.79***	______	______
	______	______	______	(0.00)	______	______
$TREAT^{DPING\&VEG}$	______	______	______	-0.15	______	______
	______	______	______	(0.69)	______	______
MBF	______	______	______	______	-0.36*	______
	______	______	______	______	(0.07)	______
WTR	______	______	______	______	-0.17	______
	______	______	______	______	(0.49)	______
HEAT	______	______	______	______	0.10	______
	______	______	______	______	(0.89)	______
PS/HV	______	______	______	______	0.29**	______
	______	______	______	______	(0.03)	______
CLD	______	______	______	______	-1.11***	______
	______	______	______	______	(0.00)	______
FPRF	______	______	______	______	-2.51***	______
	______	______	______	______	(0.00)	______
MBF&CLD	______	______	______	______	-1.34**	______
	______	______	______	______	(0.01)	______
CLD or FPRF	______	______	______	______	-2.11***	______
	______	______	______	______	(0.00)	______

Table 17 Continued

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
MBF^{DPED}	_____	_____	_____	_____	_____	-1.29***
	_____	_____	_____	_____	_____	(0.00)
MBF^{DPING}	_____	_____	_____	_____	_____	0.43*
	_____	_____	_____	_____	_____	(0.06)
CLD^{DPED}	_____	_____	_____	_____	_____	-0.98***
	_____	_____	_____	_____	_____	(0.00)
CLD^{DPING}	_____	_____	_____	_____	_____	-0.98***
	_____	_____	_____	_____	_____	(0.00)
$MBF\&CLD^{DPED}$	_____	_____	_____	_____	_____	-7.97***
	_____	_____	_____	_____	_____	(0.00)
$MBF\&CLD^{DPING}$	_____	_____	_____	_____	_____	-2.45***
	_____	_____	_____	_____	_____	(0.00)
Global Exports Share_TREAT	-0.02	_____	_____	_____	_____	_____
	(0.64)	_____	_____	_____	_____	_____
Global Exports Share_TREAT^{FRT}	_____	0.23***	_____	_____	_____	_____
	_____	(0.00)	_____	_____	_____	_____
Global Exports Share_TREAT^{VEG}	_____	-0.29***	_____	_____	_____	_____
	_____	(0.00)	_____	_____	_____	_____
Global Exports Share_TREAT^{DPED}	_____	_____	0.04	_____	_____	_____
	_____	_____	(0.64)	_____	_____	_____
Global Exports Share_TREAT^{DPING}	_____	_____	-0.01	_____	_____	_____
	_____	_____	(0.85)	_____	_____	_____
Global Exports Share_TREAT$^{DPED\&FRT}$	_____	_____	_____	0.15	_____	_____
	_____	_____	_____	(0.16)	_____	_____
Global Exports Share_TREAT$^{DPED\&VEG}$	_____	_____	_____	-0.16	_____	_____
	_____	_____	_____	(0.15)	_____	_____
Global Exports Share_TREAT$^{DPING\&FRT}$	_____	_____	_____	0.34***	_____	_____
	_____	_____	_____	(0.00)	_____	_____
Global Exports Share_TREAT$^{DPING\&VEG}$	_____	_____	_____	-0.25**	_____	_____
	_____	_____	_____	(0.01)	_____	_____
Global Exports Share_MBF	_____	_____	_____	_____	0.10	_____
	_____	_____	_____	_____	(0.21)	_____
Global Exports Share_WTR	_____	_____	_____	_____	0.29***	_____
	_____	_____	_____	_____	(0.00)	_____
Global Exports Share_HEAT	_____	_____	_____	_____	-0.60***	_____
					(0.00)	

Table 17 Continued

Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Global Exports Share_PS/HV	_____	_____	_____	_____	-0.06*	_____
	_____	_____	_____	_____	(0.08)	_____
Global Exports Share_CLD	_____	_____	_____	_____	0.06	_____
	_____	_____	_____	_____	(0.57)	_____
Global Exports Share_FPRF	_____	_____	_____	_____	-0.56**	_____
	_____	_____	_____	_____	(0.02)	_____
Global Exports Share_MBF&CLD	_____	_____	_____	_____	-0.26	_____
	_____	_____	_____	_____	(0.11)	_____
Global Exports Share_CLD or FPRF	_____	_____	_____	_____	0.41***	_____
	_____	_____	_____	_____	(0.00)	_____
Global Exports Share_MBF^{DPED}	_____	_____	_____	_____	_____	-0.03
	_____	_____	_____	_____	_____	(0.85)
Global Exports Share_MBF^{DPING}	_____	_____	_____	_____	_____	0.16**
	_____	_____	_____	_____	_____	(0.02)
Global Exports Share_CLD^{DPED}	_____	_____	_____	_____	_____	-0.01
	_____	_____	_____	_____	_____	(0.94)
Global Exports Share_CLD^{DPING}	_____	_____	_____	_____	_____	0.16
	_____	_____	_____	_____	_____	(0.15)
Global Exports Share_MBF&CLD^{DPED}	_____	_____	_____	_____	_____	1.79***
	_____	_____	_____	_____	_____	(0.00)
Global Exports Share_MBF&CLD^{DPING}	_____	_____	_____	_____	_____	2.01***
	_____	_____	_____	_____	_____	(0.00)
N	2,589	2,589	2,589	2,589	2,589	2,589
R^2	0.49	0.50	0.50	0.51	0.51	0.50

note: The dependent variable is the natural logarithm of the annual value of U.S. imports of fresh fruits and vegetables expressed as the FOB price. Total Trade Cost combines tariffs and transportation costs and is entered as the natural logarithm of (1+TAR_{ikt}+TC_{ikt}). P-values are in parentheses. Fruit is a dummy variable indicating whether or not the imported product is fruit. FTA is a dummy variable denoting all free trade agreements other than NAFTA and CAFTA-DR. NMA is a dummy variable denoting new market access. Mainland U.S. is a dummy variable denoting imports eligible for shipping to the continental United States. TREAT is a dummy variable denoting whether or not U.S. imports were subject to any commodity treatments. FRT (VEG) denotes fruits (vegetables). DPED(DPING) denotes developed (developing/LDC). MBF denotes methyl bromide fumigation; WTR denotes water treatment; HEAT denotes heat treatment; PS/HV denotes pest specific/host variable; CLD denotes cold treatment; FPRF denotes fumigation plus refrigeration of fruits. All six scenarios are run on a U.S. FF&V import flow benchmark of $20,000. *, **, *** denote significance at the one, five, and ten percent level, respectfully. The sample contains 89 countries, 12 years (1996-2007), and 47 fresh products. Heteroskedasticity-robust standard errors are used in all scenarios.

Under scenario one, by evaluating the interaction term between the generic treatment dummy variable and *Global Export Share* at the sample mean of the latter of -0.73, the imposition of a generic treatment requirement reduces U.S. FF&V imports by 44 percent, ceteris paribus. This estimate is 44 percentage points lower relative to the PPML estimate. Here, a threshold level cannot be computed since the interaction term is negative and insignificant, suggesting that a generic treatment requirement always negatively affects FF&V imports.

In the second scenario, a generic treatment requirement on average reduces U.S. fresh fruit imports by 68 and vegetable imports by 41 percent, ceteris paribus. Again, initial treatment effects are lower as compared to the PPML. However, in this case, fresh fruits are more negatively affected by the initial generic treatment than fresh vegetables, which is inconsistent with PPML estimates. A threshold level can be computed only for fresh fruit imports since the $Global\ Exports\ Share\_TREAT^{VEG}$ coefficient estimate is negative, suggesting that the generic treatment impact on U.S. fresh vegetable imports is always negative. The computed threshold level for fresh fruit imports is 71 percent, which is 37 percentage points higher than the threshold ratio computed under the PPML. As a result, even though the initial treatment effect on fresh fruit imports is lower under the OLS, in this case foreign fresh fruit exporters are more affected by the positive treatment effect as compared to the PPML.

Under scenario three, a generic treatment effect on average reduces imports from developed countries by 77 percent, ceteris paribus. This estimate is 22 percentage points lower than under the PPML. However, since $TREAT^{DPING}$ is insignificant, a generic treatment effect cannot be computed for imports originating in developing/LDCs. In addition, threshold levels cannot be calculated since both interaction terms in this scenario are insignificant.

In scenario four, a generic treatment requirement initially reduces fresh fruit imports from developed countries by 81 percent and vegetable imports by 73 percent on average, ceteris paribus. For developing/LDCs, this requirement on average initially reduces fresh fruit imports by 65 percent, all else constant. Since $TREAT^{DPING\&VEG}$ is insignificant, an initial treatment effect cannot be computed in this case. As compared to the PPML estimates, initial treatment effects for fresh fruit imports are lower under the OLS, but higher for fresh vegetable imports from developed countries. Since three of the interaction terms are either negative or insignificant, a threshold level of ten percent can be computed for fresh fruit imports from developing/LDCs. For all other cases where a significant initial treatment effect was calculated, exporters are never positively affected by a generic treatment requirement. As compared to the same computed ratio under the PPML, this threshold level is ten percentage points lower.

Under scenario five, methyl bromide fumigation initially reduces imports by 35 percent, cold treatment by 68 percent, fumigation plus refrigeration of fruits by 88 percent, methyl bromide fumigation and cold treatment by 68 percent, and cold treatment or fumigation plus refrigeration of fruits by 91 percent. As compared to PPML estimates, only pest specific/host variable has a positive effect under the OLS (increases trade by 39 percent on average). Only one threshold level can be computed under this scenario, in the case of cold treatment or fumigation plus refrigeration of fruits. However, since the calculated ratio is 176 percent of the global export market share, a foreign exporter is never affected by its positive trade impact.

Under scenario six, fumigation with methyl bromide initially reduces imports from developed countries by 72 percent, but increases imports from developing countries by 36 percent on average, holding everything else constant. Cold treatment, on the other hand, inhibits imports from developed countries by 62 percent and from developing/LDC by 66 percent on average, ceteris paribus. Finally, all else constant, both methyl bromide fumigation and cold treatment on average almost equally reduce imports from developed and developing/LDCs (nearly 100 percent). Threshold levels can only be calculated for this final case. First, developed FF&V exporters are positively affected by methyl bromide fumigation and cold treatment if they account for 85 percent of the global export market. Second, developing/LDC exporters are positively affected by methyl bromide fumigation and cold treatment if they account for only three percent of the global export market share.

Conclusively, under an empirical application excluding the "zeros", even though treatment estimates generally retain their expected signs, in most cases parameter estimates are lower relative to the PPML, suggesting that results obtained from studies excluding the "zeros" from the analysis may be downward biased. One may argue that the main reason for this is that some of the included zero trade flows under the PPML are a result of stringent regulatory barriers, such as the imposition of a phytosanitary treatment. On the other hand, these results suggest that in cases of already existing trade relationships, as in OLS, treatment requirements may be easier to overcome. In only a few cases does OLS produce treatment coefficient estimates that conflict with the PPML estimates. Finally, few threshold levels may be calculated under the OLS since most interaction terms are either negative or statistically insignificant. In rare cases where threshold levels are computed, the OLS produces conflicting results with the PPML.

Chapter 7: Conclusions

U.S. imports of FF&Vs have sharply increased since the late 1980's, which has led to year-round availability of fresh produce and a greater consumer choice in the United States. However, due to increased sourcing of FF&Vs from abroad, the possibility of pest and disease outbreaks in the U.S. and its territories has increased. Because of this, U.S. FF&V imports are regulated by the USDA's APHIS.

In addition to being subject to general documentation requirements and possible inspection prior to entry, U.S. FF&V imports may face at least one of the five main categories of phytosanitary measures implemented by APHIS. Even though developing countries have long feared that SPS measures in high-income export markets might pose trade barriers, currently there is limited evidence to shed light on the size, nature and scope of specific SPS measures.

This thesis tests the trade flow effects of phytosanitary treatments from the five main groups of phytosanitary measures targeting U.S. FF&V imports. In order to achieve this objective, a novel and comprehensive database of phytosanitary treatments at the product line-level is constructed, and different specifications of the international trade gravity model are estimated.

The results support the hypothesis that treatments initially have a negative rather than a positive effect on U.S. FF&V imports. The average treatment effect across all U.S. FF&V trade flows in the sample is to inhibit bilateral imports by 88 percent, or $1.32 billion in 2007 alone. Even though applied more often to fresh fruits than to fresh vegetables, treatments initially have a greater negative impact on the latter. During the sample period, the average treatment impact is to reduce bilateral fresh fruit imports by 85 percent ($1.07 billion in 2007) and bilateral fresh vegetable imports by 100 percent ($238 million in 2007). Treatments initially hamper U.S.

FF&V imports from developed countries almost equally as imports from developing/LDCs. The average treatment effect is to reduce imports from developed countries by 96 percent ($181.4 million in 2007) and imports from developing/LDCs by 95 percent ($1.24 billion in 2007). However, treatments appear to have a different negative impact on FF&V imports within each development status category. For instance, the average initial treatment effect is greater for imports from developed countries of fresh fruit, which decrease of 96 percent, than for fresh vegetable, which decrease of 67 percent. The opposite is true of developing/LDC imports, for which the average initial treatment effect decreases fresh vegetable imports by 100 percent and fresh fruit imports by 93 percent.

Analysis at the treatment type level reveals that the average initial treatment effect of methyl bromide fumigation reduces U.S. FF&V imports by 95 percent; water treatment reduces imports by 54 percent, cold treatment by 84 percent, cold treatment or fumigation plus refrigeration of fruits by 95 percent and fumigation plus refrigeration of fruits by 97 percent. Group 8 (methyl bromide fumigation and cold treatment) proves the most restricting to trade as it reduces imports by 98 percent on average. Specific treatment types in some cases have different effects on FF&V exports to the U.S. depending on the development level of the exporting country. For example, cold treatment reduces exports from developing/LDCs 96 percent, while exports from developed countries only decrease 62 percent. On the other hand, methyl bromide fumigation impacts imports from developed and developing/LDCs similarly, decreasing the former by 100 percent and the latter by 98 percent. When both methyl bromide fumigation and cold treatment are required, the effects on developed and developing/LDCs are similar: 100 percent decrease and 97 percent decrease, respectively.

Based on computed threshold levels, even though the initial effect of phytosanitary treatments is to reduce U.S. FF&V imports, a small number of established and globally large FF&V exporters are positively affected by a phytosanitary treatment requirement. For example, across all FF&V imports, exporters that have achieved a 36 percent share of the global export market are positively affected by a generic treatment requirement. Across product sectors, fresh fruit exporters that have not achieved a 34 percent share of the global export market are negatively affected by a generic treatment requirement, while vegetable exporters with less than a 28 percent share also experience decreased exports.

7.1. Policy Implications

The results suggest that the relative size of the exporter in the global market plays a crucial role in determining how phytosanitary treatments affect U.S. FF&V import flows. This determination leads several policy implications.

First of all, market opportunities exist in the U.S. because both fresh fruit and, to a greater degree, vegetable markets exhibit substantial growth. The findings of this thesis suggest that established and globally large developing/LDC FF&V exporters that are currently ineligible to supply U.S. FF&V markets would benefit by entering these markets, particularly the fresh vegetable market. This opportunity occurs because developing/LDCs can meet APHIS' required phytosanitary treatments for vegetables, especially the most common one, methyl bromide fumigation, with a minimum of negative effect. These larger foreign countries should work closely with USDA/APHIS to establish an export protocol that will allow them to supply the U.S. market. In addition, these countries should invest in fixed start-up costs, such as irradiation and fumigation facilities, as well as technical expertise in order to meet the potential phytosanitary measures required by APHIS. Due to the cost of this type of investment, benefits are unlikely to accrue to smaller exporters. Previous experiences and the estimated effects of phytosanitary treatments on exports from globally small developing/LDC FF&V exporters suggest that it might be hard for them to compete with long standing or globally large suppliers. To counterbalance the size problem, small exporters should export associations. On the other hand, the U.S. should make special allowances for these exporters in order for them to successfully supply the U.S. market.

Second, only a small number of developed countries are major FF&V suppliers to the United States. This is especially true for vegetable exports to the U.S., mainly due to geographic, climate and biological factors affecting these countries that are generally based in the Northern Hemisphere. Overall, the results suggest that developed countries are negatively affected by U.S. phytosanitary requirements. Market opportunities do exist in the U.S. for developed exporters, both globally small and large, particularly when one considers that some of the largest U.S. FF&V imports do not require any phytosanitary treatments (e.g., bananas; potatoes; mushrooms and truffles). Smaller exporters might be able to enter the market in one of these products, despite the challenges associated with size, because there are no costs related to phytosanitary treatments.

Based on the SPS Agreement, WTO members resolved that phytosanitary measures would be: applied equally to domestic and foreign producers, based on scientific evidence, and the least trade restrictive regulations that achieve the necessary level of phytosanitary protection. However, the findings of this thesis illustrate the varying extents to which treatment requirements affect exports. Even though the initial impact of almost all the treatments is negative, calculated threshold levels point to the fact that some treatment types remain restrictive no matter the market share of the exporter while others prove beneficial to exporters with large market shares. To further regulate the implementation of SPS measures, the WTO could use the overall trade restrictiveness rankings of specific treatment types provided in this work to adjudicate trade disputes among countries.

The final recommendation for APHIS is to implement the treatment demonstrated to be the least restrictive for trade in cases where some regulation is needed to mitigate potential pest or disease outbreaks. For example, the results of this work suggest that fumigation with methyl bromide is overall the least trade restrictive phytosanitary treatment type. Therefore, in cases where APHIS can choose between different treatment types that are required on imports of a certain product from abroad, it should opt for methyl bromide fumigation.

7.2 Limitations

There are three potential endogeneity concerns in the model this study uses to quantify the trade effects of phytosanitary treatments that need to be further examined. First, there is a possible endogeneity bias with respect to the *Global Export Share* independent variable in the sense that an existing trade relationship with the U.S. may result in an exporter having a high share of the global export market. If such cases, reverse casualty is implied where exporting FF&Vs to the U.S. determines an exporter's relative size of the global market rather than the relative size of the exporter in the global market explaining trade with the United States.

Second, in cases where the U.S. imports more FF&Vs from a foreign supplier than the natural trade level predicted by the gravity model for this country pair, political pressures in the U.S. may result in a trade barrier protecting domestic producers, which suggests a negative simultaneity bias. On the other hand, due to the high volume of imports from the same exporter, the U.S. may be inclined to require a phytosanitary treatment mitigating potential pest and disease outbreaks, which suggests a positive simultaneity bias. In order to deal with simultaneity bias, typically a two-stage Heckman procedure is used (first-stage Probit function) where trade and the treatment dummy variable are treated as endogenous.

Third, endogeneity concerns may arise due to omitted variables, where one or more of the model's regressors are correlated with the gravity model error term. For example, in cases where an exporter is subject to phytosanitary regulations (hypothesized to be small) that are exogenous to the model, variables that control for these negligent regulatory regimes are unobserved for the econometrician since only phytosanitary treatments and geographical restrictions on destination are recorded in the database. As a result, it follows that such an exporter is able to more easily export FF&V products to the U.S. due to lower trade costs. In addition, in such cases the U.S. is more likely to impose more stringent phytosanitary measures to mitigate potential pest and disease risks that come with increased FF&V imports. Ultimately, the phytosanitary treatment dummy variable in the model and the intensity of U.S. phytosanitary regulation may in fact be negatively correlated. Moreover, the intensity of U.S. phytosanitary regulation and the gravity model error term may be negatively correlated implying that estimated treatment effects and the error term are positively biased.

Another drawback of this work is the limitation of the sample period to the post-Uruguay Round era (1996-2007), prompted by data limitation in the USDA/APHIS *Fresh Fruits and Vegetables Import Manual*s. Although archived copies of the main data source are available as early as 1974, gaps in these publications (1978-1987; 1993-1995) have limited the study's sample period. In addition, the U.S. Harmonized Tariff Schedule (HTS) came into force in 1989

(USITC, n. d). Therefore, even if additional archived copies of the main data source were available, the study would still be limited to 1989-present.

Finally, three of the five main groups of phytosanitary measures (geographical restrictions on origin; preclearance procedures on the territory of the exporting country; and systems approaches to pest risk management) pertaining to U.S. FF&V imports are not recorded in the database. The main reason for this is that these phytosanitary measures are nearly impossible to code without actual cost of phytosanitary compliance data. This is a limitation of the study, especially when considering that phytosanitary treatments may be required by APHIS as a part of a broader pest risk mitigation protocol, such as a preclearance procedure and/or a systems approach. However, documentation and recording of the phytosanitary treatments in this work is a great launch pad for future work.

7.3 Future Research

In order to better capture the impacts of phytosanitary measures on U.S. FF&V imports, an area for future research in the field is to examine monthly trade flow data with a corresponding monthly variation in U.S. phytosanitary regulatory regimes. Such a study would ideally record all five main categories of phytosanitary measures pertaining to U.S. FF&V imports, as described in Table 2 (Chapter 2), and assess their trade effects.

Since the PPML model of Santos Silva and Tenreyro (2006) used is this study may not be the most appropriate model to address the issue of high frequency of zero trade flows, future research should consider using a Tobit model (see Martin and Pham, 2008), a ZIP model or a Poisson Hurdle model.

This study collects data on new market access cases awarded by APHIS to foreign exporters for U.S. FF&V markets following the Uruguay Round. However, not enough empirical attention is devoted to examining the trade flow effects from these cases. This work uses the data to control for the possible trade flow effect of new market access on U.S. FF&V imports while hypothesizing its impact to be negative. An additional question would be: Are we sure that new market access always negatively affects U.S. FF&V imports? Looking at the data, new market access has in some instances led to impressive growth in U.S. imports. For example, U.S. imports of fresh Mexican Hass avocados increased from about $5.9 million in 1997 (when the new market access case occurred) to nearly $444 million in 2007. Therefore, the cumulative trade flow effect of new market access may in fact occur over time. One explanation is that new FF&V exporters to the U.S. need some time to build production capacities and develop marketing channels before they can compete with long-standing FF&V suppliers. To fully address this issue, additional econometric analyses with lagged new market access variables are needed.

Recent empirical trade studies estimating the trade flow effects of specific food standards and regulations have only scratched the surface of this important field of research. Truly comprehensive and detailed databases on SPS measures need to be developed using a "bottom-up" approach, similar to the one constructed for this study. These databases should contain data on SPS requirements targeting not only U.S., but global imports of various agricultural product categories, including FF&Vs, meat, seeds etc. Further research, using these detailed databases at the product-level, would provide additional evidence for the intellectual debate on the role of SPS regulations as "trade barriers" versus "trade catalysts."

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Appendix A: New Market Access Instances for Fresh Fruits and Vegetables

Table A.1: New Market Access Cases Granted to Foreign Exporters of Fresh Fruits and Vegetables (1996-2008), by Year

Year	Country	Product	Sector
1997	Chile	Babaco	Fruit
	Dominican Republic	Eggplant	Vegetable
	Honduras	Hyacinth bean	Vegetable
	Honduras	Yard long Bean	Vegetable
	Korea	Apple, Fuji only	Fruit
	Morocco	Strawberry	Fruit
	Nicaragua	Broad Bean	Vegetable
	Nicaragua	Faba Bean	Vegetable
	Nicaragua	Green Bean	Vegetable
	Nicaragua	Mung Bean	Vegetable
	Peru	Blueberry	Fruit
	South Africa	Globe Artichokes	Vegetable
	South Africa	Grapefruit	Fruit
	South Africa	Lemons	Fruit
	South Africa	Lime	Fruit
	South Africa	Mandarins, clementines, satsumas	Fruit
	South Africa	Orange	Fruit
	Uruguay	Plum	Fruit
1998	Anguilla	Singhara nut	Vegetable
	Antigua and Barbuda	Singhara nut	Vegetable
	Bahamas	Singhara nut	Vegetable
	Barbados	Singhara nut	Vegetable
	Belgium	Leeks	Vegetable
	Brazil	Papaya	Fruit
	Brazil	Watermelon	Fruit
	Cayman Islands	Singhara nut	Vegetable
	Chile	Tomatoes	Vegetable
	Costa Rica	Mango	Fruit
	Dominica	Singhara nut	Vegetable
	Dominican Republic	Singhara nut	Vegetable
	Dominican Republic	Yard long Bean	Vegetable
	Ecuador	Broccoli	Vegetable
	Ecuador	Brussels sprouts	Vegetable
	Ecuador	Cauliflower	Vegetable
	Ecuador	Chicory	Vegetable
	Ecuador	Radicchio	Vegetable
	El Salvador	Eggplant	Vegetable
	France	Tomato (other than green)	Vegetable

Table A.1 Continued

Year	Country	Product	Sector
1998	Grenada Is	Singhara nut	Vegetable
	Guadaloupe	Singhara nut	Vegetable
	Guatemala	Rhubarb	Fruit
	Haiti	Singhara nut	Vegetable
	Jamaica	Singhara nut	Vegetable
	Martinique	Singhara nut	Vegetable
	Mexico	Avocado, Hass	Fruit
	Mexico	Cherry	Fruit
	Mexico	Ethrog	Fruit
	Mexico	Plum	Fruit
	Montserrat	Singhara nut	Vegetable
	Morocco	Tomato (other than green)	Vegetable
	Netherlands	Leeks	Vegetable
	Nicaragua	Chicory	Vegetable
	Nicaragua	Eggplant	Vegetable
	Nicaragua	Radicchio	Vegetable
	Panama	Belgian Endive	Vegetable
	Panama	Chicory	Vegetable
	Panama	Endive	Vegetable
	Peru	Swiss chard	Vegetable
	Romania	Garlic	Vegetable
	Saint Kitts and Nevis	Singhara nut	Vegetable
	Saint Lucia	Singhara nut	Vegetable
	Saint Vincent and the Grenadines	Singhara nut	Vegetable
	South Africa	Pineapple	Fruit
	Spain	Ortanique	Fruit
	Spain	Pepper	Vegetable
	St. Eustatius	Singhara nut	Vegetable
	St. Martin	Singhara nut	Vegetable
	Turks and Caicos Islands	Singhara nut	Vegetable
	Venezuela	Cantaloupe	Fruit
	Venezuela	Honeydew Melon	Fruit
	Venezuela	Watermelon	Fruit
	Virgin Islands, British	Singhara nut	Vegetable
	Western Sahara	Tomatoes	Vegetable
2000	Argentina	Grapefruit	Fruit
	Argentina	Lemons	Fruit
	Argentina	Orange	Fruit

Table A.1 Continued

Year	Country	Product	Sector
2000	Bulgaria	Garlic	Vegetable
	Peru	Radicchio	Vegetable
	Argentina	Kiwi	Fruit
2001	El Salvador	Papaya	Fruit
	Guatemala	Papaya	Fruit
	Honduras	Papaya	Fruit
	Mexico	Carambola	Fruit
	Nicaragua	Papaya	Fruit
	Panama	Papaya	Fruit
	Philippines	Mango	Fruit
	Spain	Eggplant	Vegetable
	Spain	Kiwi	Fruit
	Spain	Lettuce	Vegetable
	Spain	Watermelon	Fruit
2002	Chile	Passion Fruit	Fruit
	Honduras	Mango	Fruit
2003	Belize	Rambutan	Fruit
	Bulgaria	Strawberry	Fruit
	Bulgaria	Vaccinium spp. (Cranberries&Blueberries)	Fruit
	Chile	Pepper	Vegetable
	China	Longan	Fruit
	Colombia	Cape gooseberry	Fruit
	Colombia	Pitahaya, yellow	Fruit
	Costa Rica	Rambutan	Fruit
	El Salvador	Blackberry	Fruit
	El Salvador	Fennel	Vegetable
	El Salvador	Jicama Root	Vegetable
	El Salvador	Rambutan	Fruit
	Guatemala	Fennel	Vegetable
	Guatemala	Rambutan	Fruit
	Honduras	Jicama Root	Vegetable
	Honduras	Rambutan	Fruit
	Mexico	Rambutan	Fruit
	Nicaragua	Fennel	Vegetable
	Nicaragua	Jicama Root	Vegetable
	Nicaragua	Naranjilla	Fruit
	Nicaragua	Rambutan	Fruit
	Nicaragua	Tomato (green only)	Vegetable

Table A.1 Continued

Year	Country	Product	Sector
2003	Nicaragua	Yam Been Root	Vegetable
	Panama	Rambutan	Fruit
	Spain	Persimmons	Fruit
2005	Chile	Clementine	Fruit
	Chile	Kiwanos Melon	Vegetable
	Chile	Mandarin	Fruit
	Chile	Tangerine	Fruit
	Dominican Republic	Mango	Fruit
	Grenada Is	Atemoya	Fruit
	Grenada Is	Cherimoya	Fruit
	Grenada Is	Custard Apple	Fruit
	Grenada Is	Soursop	Fruit
	Grenada Is	Sugar Apple	Fruit
	Korea	Cucumber	Vegetable
	Korea	Oriental melon	Fruit
	Korea	Squash	Vegetable
	Korea	Watermelon	Fruit
	Mexico	Pitaya	Fruit
	Peru	Melon (cantaloupe, honeydew, netted)	Fruit
	Peru	Watermelon	Fruit
	Peru	Winter melon	Vegetable
2006	Belgium	Endive	Vegetable
	China	Fragrant Pear	Fruit
	China	Ya Pear	Fruit
	Colombia	Blueberry	Fruit
	Costa Rica	Pepper	Vegetable
	Costa Rica	Tomato (red or pink)	Vegetable
	El Salvador	Pepper	Vegetable
	El Salvador	Tomato (red or pink)	Vegetable
	Guatemala	Endive	Vegetable
	Guatemala	Pepper	Vegetable
	Guatemala	Tomato (red or pink)	Vegetable
	Honduras	Pepper	Vegetable
	Honduras	Tomato (red or pink)	Vegetable
	Namibia	Grapes	Fruit
	Netherlands	Endive	Vegetable
	Nicaragua	Pepper	Vegetable
	Nicaragua	Tomato (red or pink)	Vegetable
	Panama	Tomato (red or pink)	Vegetable

Table A.1 Continued

Year	Country	Product	Sector
2006	Peru	Grapefruit	Fruit
	Peru	Lime	Fruit
	Peru	Mandarin	Fruit
	Peru	Orange, sweet	Fruit
	Peru	Tangelo	Fruit
	Peru	Tangerine	Fruit
	Spain	Clementine	Fruit
	Spain	Squash	Vegetable
	Zambia	Baby Carrots	Vegetable
	Zambia	Baby Corn	Vegetable
2007	Argentina	Chicory	Vegetable
	Belgium	Belgian Endive	Vegetable
	Bolivia	Chicory	Vegetable
	Brazil	Chicory	Vegetable
	Dominican Republic	Jackfruit	Fruit
	El Salvador	Chicory	Vegetable
	Ghana	Eggplant	Vegetable
	Ghana	Okra	Vegetable
	Ghana	Pepper	Vegetable
	India	Mango	Fruit
	Israel	New Zealand Spinach	Vegetable
	Kenya	Baby Carrots	Vegetable
	Kenya	Baby Corn	Vegetable
	Kenya	Garden Pea	Vegetable
	Mexico	Endive	Vegetable
	Mexico	Persian Lime	Fruit
	Mexico	Yard long Bean	Vegetable
	New Zealand	Grapefruit	Fruit
	New Zealand	Lemons	Fruit
	New Zealand	Lime	Fruit
	New Zealand	Mandarins and clementines	Fruit
	New Zealand	Orange	Fruit
	South Africa	Blueberry	Fruit
	South Africa	Currant	Fruit
	South Africa	Gooseberry	Fruit
	Thailand	Litchi	Fruit
	Thailand	Longan	Fruit
	Thailand	Mango	Fruit
	Thailand	Mangosteen	Fruit

Table A.1 Continued

Year	Country	Product	Sector
2007	Thailand	Pineapple	Fruit
	Thailand	Rambutan	Fruit
	Uruguay	Blueberry	Fruit
	Uruguay	Chicory	Vegetable
	Venezuela	Chicory	Vegetable
2008	Guatemala	Blueberry	Fruit
	Korea	Plantain	Fruit
	Morocco	Nectarine	Fruit
	Netherlands	Nectarine	Fruit
	Panama	Arugula	Vegetable
	United Kingdom	Nectarine	Fruit
	VietNam	Dragon Fruit	Fruit

Sources: USDA, APHIS, 2009a; U.S. Government, 2009.

Appendix B: Coding of Problematic Phytosanitary Measures and Developing a Concordance Between the APHIS Identifiers and the HS Product Categories

The objective of this Appendix is twofold. First, it lays down the assumptions under which complex cases of phytosanitary measures are coded. Second, it describes the established concordance between the HS product categories and the APHIS commodity identifiers based on which phytosanitary measures are linked to FF&V trade data. All decisions are made after consultations with staff at the USDA' ERS, FAS, and APHIS.

As described in Table B.1, in certain cases a product is eligible to be shipped to the U.S. from multiple regions within an exporting country and/or is admissible for entry into the U.S. at multiple ports of entry. As a result, phytosanitary requirements vary based on exporter's decision from which domestic region and/or to which port of entry it ships the product. However, since information on which domestic region/U.S. port of entry combination the exporter chooses is not available, assumptions in terms of recording the regulatory regimes in these cases have to be made. The main idea is to choose the domestic region which accounts for the greatest share of exporting country's production, and the U.S. port of entry at which foreign FF&Vs are most likely to arrive at. For example, all U.S. imports originating from multiple Chilean regions are recorded as being shipped from "all Chilean provinces except the Arica province", and U.S. imports of fresh pears and quinces from China are assumed to be shipped from the Hebei region. On the other hand, Peruvian okra exports are recorded as being eligible for entry at SAG ports.

Table B.2a and Table B2b illustrate the developed concordance between the HS product categories and the APHIS commodity identifiers. This goal is initially achieved by choosing a primary APHIS commodity identifier that perfectly corresponds to an HS product category. For example, all countries that export potatoes to the U.S. (according to the trade data) have the

Table B.1: Recorded Phytosanitary Regulatory Regimes in Cases of Multiple Production Regions in the Exporting Country and Multiple United States Ports of Entry

Country	Commodity	Regulatory Regime	Type of Issue
Australia	Pears And Quinces	1/	a/
Australia	Apples	1/	a/
Belize	Papayas	2/	a/
Belize	Peppers	2/	a/
Chile	Papayas	3/	a/
Chile	Cherry	3/	a/
Chile	Avocado	3/	a/
Chile	Kiwi	3/	a/
Chile	Peach And Nectarine	3/	a/
Chile	Cranberries And Blueberries	3/	a/
Chile	Plums And Sloes	3/	a/
Chile	Mangoes	3/	a/
Chile	Pears And Quinces	3/	a/
Chile	Apples	3/	a/
Chile	Tomatoes	3/	a/
Chile	Grape	3/	a/
China	Pears And Quinces	4/	a/
Mexico	Cherry	5/	a/
Mexico	Peach And Nectarine	5/	a/
Mexico	Plums And Sloes	5/	a/
Mexico	Apples	5/	a/
Bahamas	Okra	6/	b/
Colombia	Okra	6/	b/
Dominican Republic	Okra	6/	b/
Ecuador	Okra	6/	b/
Peru	Okra	6/	b/
Venezuela	Okra	6/	b/
New Zealand	Peppers	7/	b/
New Zealand	Tomatoes	8/	b/
Thailand	Pineapple	9/	b/
Mexico	Mangoes	10/	c/
Mexico	Grapefruit	10/	c/
Mexico	Oranges	10/	c/
Mexico	Mandarins And Clementines	10/	c/

1/ Recorded requirements for "All Areas" of Australia

2/ Recorded requirements for "All districts" of Belize

3/ Recorded requirements for "All Provinces except Arica Province" in Chile

4/ Recorded requirements for Hebei region in China

5/ Recorded requirements for "Fruit Fly Free Areas" in Mexico

Table B.1 Continued

6/ Recorded regimes for products exported to the South Atlantic and Gulf ports (SAG)

7/ Recorded regime for New Zealand peppers that can be exported to all U.S. ports

8/ Recorded regime for tomatoes produced in "All Areas" of New Zealand

9/ Recorded regime for Thai pineapples produced in "All areas" is recorded

10/ Recorded regime for products originating in "Fruit fly free areas of Mexico" and eligible for export to all U.S. ports

a/ Two production regions in the country of origin exist. Products shipped to the U.S. from one of these regions may be or may not be subjected to a commodity treatment. In addition, products originating in different regions may be subjected to different commodity treatment requirement.

b/ The product is eligible for export to multiple U.S. ports of entry, and commodity treatment requirements differ based on which port the product is shipped to.

c/ Two production regions in the exporting country exist. Products exported from one of these regions are facing a commodity treatment requirement, but are not facing this requirement if they are exported from the other. In addition, commodity treatment requirements may differ based on which U.S. port the product may be shipped to.

Source: USDA, APHIS, 2009a.

primary APHIS identifier for this category (potato) listed on their lists of approved products. However, complex problems arise in cases where the primary APHIS commodity identifier is not found on the list of approved products for shipping to the U.S. for a given year while the trade data shows an existing trade relationship between the U.S. and the exporting country for that same product. For this reason, a secondary APHIS commodity identifier is chosen that most closely describes the same HS product category. For example, even though according to the trade data Australia, South Africa and the Dominican Republic export oranges to the U.S., the primary APHIS commodity identifier (oranges, sweet) is not found on the lists of approved products for these three countries. As a result, a second APHIS identifier (citrus spp.) is chosen that most closely describes the concerned product category, and phytosanitary measures are recorded accordingly. Finally, in cases where both primary and secondary APHIS commodity identifiers are eligible for entry into the United States, adopted phytosanitary measures targeting the primary APHIS identifier are recorded.

Table B.2a: Concordance Between Sample Fresh Fruit Products and the Fresh Fruit Product Categories Indentified in the USDA/APHIS Phytosanitary Regulations (1996-2007)

Commodity	Primary APHIS Identifier	Exporters for Which the Primary APHIS Identifier is Used
Bananas	Banana	All
Pineapples	Pineapple	All
Avocados	Avocado	1/
Mangoes	Mango*	All
Oranges	Orange, sweet	2/
Mandarins & Clementines	Clementine, Tangerine, Mandarin**	3/
Lemons	Lemon	4/
Limes	Lime, sour	5/
Grapefruit	Grapefruit	6/
Grapes	Grape	All
Watermelons	Watermelon	7/
Melon	Melon	8/
Papayas	Papaya	All
Apples	Apple	All
Pears & Quinces	Pear	9/
Apricots	Apricot	All
Cherries	Cherry	All
Peaches & Nectarines	Peach; Nectarine***	All
Plums & Sloes	Plum	All
Strawberries	Strawberry	All
Raspberries & Blackberries	Raspberry; Blackberry***	All
Currants	Currant	All
Cranberries & Blueberries	Blueberry; Vaccinium spp***	All
Kiwifruit	Kiwi	All

* Different phytosanitary measures for individual fruits (i.e. mangoes, mangosteens, guavas) cannot be recorded as one single regime for a product category; reported regime is for the product most significant in trade

** Different phytosanitary measures for individual fruits can be recorded as one regime for a product category with more than one fruit (i.e., there are no conflicting measures)

*** Different commodities in category appear to be regulated identically

1/ All except Mexico (Avocado, Hass)

2/ All except South Africa, Australia, and the Dominican Republic (Citrus spp)

3/ All except South Africa, Australia, Japan, and Jamaica (Citrus spp)

4/ All except South Africa and New Zealand (Citrus spp)

5/ All except the Bahamas and the Dominican Republic (Citrus spp)

6/ All except the Bahamas (Citrus spp)

7/ All except Guatemala, Costa Rica, Honduras, Panama, Dominican Republic, and Nicaragua (Cucurbit)

8/ All except Guatemala, Costa Rica, Honduras, Panama, Dominican Republic, and Nicaragua (Cucurbit)
9/ All except South Korea and Japan (Sand Pear), and China (Ya Pear)

Sources: USITC, 2009; USDA, APHIS, 2009a; USDA, FASonline, 2009.

Table B.2b: Concordance Between Sample Fresh Vegetable Products and the Fresh Vegetable Product Categories Indentified in the USDA/APHIS Phytosanitary Regulations (1996-2007)

Commodity	Primary APHIS Identifier	Exporters for Which the Primary APHIS Identifier is Used
Potatoes	Potato	All
Tomatoes	Tomato	1/ & 2/
Onions	Onion	3/ & 4/
Garlic	Garlic	5/ & 6/
Leeks	Leek	7/ & 8/
Cauliflower	Cauliflower	Canada & 9/
Brussels Sprouts	Brussels Sprouts	Canada, Netherlands & 10/
Cabbage	Cabbage	Canada, Japan & 11/
Broccoli	Broccoli	Canada & 12/
Head Lettuce	Lettuce	13/ & 14/
Leaf Lettuce	Lettuce	15/ & 14/
Carrots	Carrot	All
Cucumbers	Cucumber	16/ & 17/
Fresh Beans	Bean	18/ & 19/
Globe Artichoke	Artichokes, globe	All
Asparagus	Asparagus	20/ & 21/
Eggplants	Eggplant	All
Mushrooms & Truffles	Mushrooms; Truffles	All
Peppers	Pepper or Pepper (fruit)	Canada+22 other countries & 22/
Spinach	Spinach	Canada, Mex., and Netherlands & 23/
Jicamas, Pum., Breadfruit	Jicama; pum.; breadfr.; chayote**	24/, 25/, 26/ & 27/
Okra	Okra	All
Squash	Squash	Can., New Z., Chile, and Korea & 28/

** Different phytosanitary measures for individual fruits can be recorded as one regime for a product category with more than one product (i.e., there are no conflicting measures)

1/ Mexico, Canada, Netherlands, Belgium, the Dominican Republic, Chile, Poland, New Zealand, the United Kingdom, Bahamas, Trinidad and Tobago (Tomato)

2/ Spain, Morocco, Costa Rica, Guatemala (Tomato, red or pink); Italy (green only); Israel (Greenhouse grown); France (Tomato, other than green)

3/ Canada, Hong Kong, Indonesia (Onion)

4/ 34 Other countries (Allium spp)

5/ Canada, Spain, Korea, Russia, Israel, France, Germany, Italy, Hong Kong, Turkey, Morocco, Egypt, Taiwan (Garlic)

6/ 21 countries (Allium spp) & Viet Nam (Peeled cloves)

7/ Canada, Netherlands, Belgium (Leek)

8/ 13 countries (Allium spp)

Table B.2b Continued

9/ Mexico, Ecuador, Costa Rica and Peru (Brassica spp); Guatemala, Spain, Belgium, Germany, Italy, and Netherlands (Brassica oleracea)

10/ Mexico and Ecuador (Brassica spp); Belgium, Guatemala, and the United Kingdom (Brassica oleracea)

11/ Mexico, Costa Rica, the Dominican Republic, and Nicaragua (Brassica spp); Netherlands, Chile, Taiwan, Germany, Jamaica, Brazil, Italy, Israel, Korea, and Guatemala (Brassica oleracea)

12/ Mexico, Ecuador, and Honduras (Brassica spp.); Guatemala, Colombia, Spain, and Italy (Brassica oleracea)

13/ Mexico, Canada, Peru, Chile, Netherlands, the Dominican Republic, Guatemala, Spain, Colombia, Belgium, and Ecuador

14/ Israel (Lettuce (leaf) field grown))

15/ Mexico, Canada, Peru, Chile, Ecuador, Belgium, Guatemala, Netherlands, Korea, Bahamas, Colombia, Costa Rica, Nicaragua, Thailand, Honduras, and Japan

16/ Canada, Spain, Belgium, Chile, the United Kingdom, Japan, and Korea

17/ Mexico, Honduras, Spain, the Dominican Republic, Netherlands, Guatemala, Costa Rica, Panama, Jamaica, Nicaragua, Bahamas, Japan, Korea, and New Zealand (Cucurbit)

18/ Canada, Mexico, the Dominican Republic, Peru, Ecuador, France, Venezuela, Jamaica

19/ Guatemala, Colombia, Italy, El Salvador, Spain, Belgium, Costa Rica, Honduras (Bean, garden); Korea (Bean, string); Nicaragua (Green bean)

20/ Canada, Mexico, Colombia, Chile, Argentina, Ecuador, Guatemala, New Zealand, Nicaragua, Costa Rica, Australia, Panama, the Dominican Republic, Jamaica, and Brazil

21/ France, South Africa, Netherlands, Spain, Germany (Asparagus, shoot (white)); Peru (Asparagus, shoot (green))

22/ Chile (Pepper (Capsicum annuum only) (fruit))

23/ Israel (New Zealand spinach)

24/ Canada, Mexico, Costa Rica, the Dominican Republic, Jamaica, Honduras, Haiti, Bahamas, Nicaragua, China, Tonga, Guatemala (Jicama)

25/ Canada, Chile, and Tonga (Pumpkin)

26/ Canada, Trinidad and Tobago, Belize, St. Vincent, St. Lucia, and Grenada (Breadfruit)

27/ Canada and Panama (Chayote)

28/ Mexico, Costa Rica, Honduras, Panama, Guatemala, Nicaragua, the Dominican Republic, Netherlands, Belize, Trinidad and Tobago, Jamaica, El Salvador, Haiti, and Bahamas (Cucurbit)

Sources: USITC, 2009; USDA, APHIS, 2009a; USDA, FASonline, 2009.

Appendix C: Stata Code

```
*PPML*
set memory 500m
use "C:\Users\vkarov\Desktop\Thesis Changes\Database\database.dta", clear
drop if ineligible2==1
drop if rowprod==0
poisson cvalue ldist lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat lshare2_treat, rob
poisson cvalue ldist lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat_frt treat_veg lshare2_treatfrt lshare2_treatveg, rob
poisson cvalue ldist lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat_dped treat_dping lshare2_treatdped lshare2_treatdping, rob
poisson cvalue ldist lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat_dped_f- treat_dping_v lshare2_treatdpedfrt lshare2_treatdpedveg lshare2_treatdpingfrt lshare2_treatdpingveg, rob
poisson cvalue ldist lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland methylbrom water heat pestspecific cold fum_refri mb_cold or_fum_refri lshare2_methylbrom lshare2_water lshare2_heat lshare2_pestspecific lshare2_cold lshare2_fum_refri lshare2_mb_cold lshare2_or_fum_refri, rob
poisson cvalue ldist lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland methylbrom_dped methylbrom_dping cold_dped cold_dping mb_cold_dped mb_cold_dping lshare2_methylbrom_dped lshare2_methylbrom_dping lshare2_cold_dped lshare2_cold_dping lshare2_mb_cold_dped lshare2_mb_cold_dping, rob

*Following Santos Silva and Tenreyro's "The Log of Gravity" web site,
R-squares can be obtained after estimating any of scenarios one-six
in the PPML estimation by using the following code:*
predict fitted
qui cor fitted cvalue
di as txt " R-squared   "  (`r(rho)')^2



* WALD TESTS *
nlcom (ratio1: _b[treat]/_b[lshare2_treat]), post
nlcom (ratio1: _b[treat_frt]/_b[lshare2_treatfrt]) (ratio2: _b[treat_veg]/_b[lshare2_treatveg]), post
test _b[ratio1] = _b[ratio2]
nlcom (ratio1: _b[treat_dped]/_b[lshare2_treatdped]) (ratio2: _b[treat_dping]/_b[lshare2_treatdping]), post
test _b[ratio1] = _b[ratio2]
nlcom (ratio1: _b[treat_dped_f]/_b[lshare2_treatdpedfrt]) (ratio2: _b[treat_dped_v]/_b[lshare2_treatdpedveg]), post
test _b[ratio1] = _b[ratio2]
nlcom (ratio1: _b[treat_dping_f]/_b[lshare2_treatdpingfrt]) (ratio2: _b[treat_dping_v]/_b[lshare2_treatdpingveg]), post
test _b[ratio1] = _b[ratio2]
nlcom (ratio1: _b[treat_dped_f]/_b[lshare2_treatdpedfrt]) (ratio2: _b[treat_dping_f]/_b[lshare2_treatdpingfrt]), post
test _b[ratio1] = _b[ratio2]
nlcom (ratio1: _b[methylbrom]/_b[lshare2_methylbrom]) (ratio2: _b[cold]/_b[ lshare2_cold]) (ratio3: _b[or_fum_refri]/_b[ lshare2_or_fum_refri]), post
test _b[ratio1] = _b[ratio2] = _b[ratio3]
nlcom (ratio1: _b[ methylbrom_dped]/_b[ lshare2_methylbrom_dped]) (ratio2: _b[ methylbrom_dping]/_b[ lshare2_methylbrom_dping]) (ratio3: _b[ cold_dping]/_b[ lshare2_cold_dping]), post
```

```
*OLS*
set memory 500m
use "C:\Users\vkarov\Desktop\Thesis Changes\Database\database.dta", clear
drop if ineligible2==1
reg lcv lttcost lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat
lshare2_treat if cvalue>20000, rob
reg lcv lttcost lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat_frt
treat_veg lshare2_treatfrt lshare2_treatveg if cvalue>20000, rob
reg lcv lttcost lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland treat_dped
treat_dping lshare2_treatdped lshare2_treatdping if cvalue>20000, rob
reg lcv lttcost lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland
treat_dped_f- treat_dping_v lshare2_treatdpedfrt lshare2_treatdpedveg lshare2_treatdpingfrt lshare2_treatdpingveg
if cvalue>20000, rob
reg lcv lttcost lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland methylbrom
water heat pestspecific cold fum_refri mb_cold or_fum_refri lshare2_methylbrom lshare2_water lshare2_heat
lshare2_pestspecific lshare2_cold lshare2_fum_refri lshare2_mb_cold lshare2_or_fum_refri if cvalue>20000, rob
reg lcv lttcost lusprod lrowprod trend fruit ler lshare2 nafta_frt nafta_veg cafta_dr fta nma_all mainland
methylbrom_dped methylbrom_dping cold_dped cold_dping mb_cold_dped mb_cold_dping
lshare2_methylbrom_dped lshare2_methylbrom_dping lshare2_cold_dped lshare2_cold_dping
lshare2_mb_cold_dped lshare2_mb_cold_dping if cvalue>20000, rob
```