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Hidden Trade Costs? Maximum Residue Limits and US Exports of Fresh Fruits and Vegetables

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Contents

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Abstract

Consecutive rounds of trade negotiations at the multilateral and regional level have resulted in significant reductions to agricultural tariffs. However, agricultural economists and policy makers alike agree that non-tariff measures (NTMs) are more obscure in nature and have the potential to be more trade distorting. Among the list of NTMs, Sanitary and Phytosanitary (SPS) measures play an influential role in agri-food product trade. In this article we focus on a specific type of SPS measure known as maximum residue limits (MRLs) that features prominently in multilateral and regional trade negotiations. The purpose of this research project is threefold. First, we construct a comprehensive database of country-and-product specific MRLs for global fresh fruit and vegetable trade that varies by pesticide chemical type: herbicides, insecticides and fungicides. Second, we develop a new index summarizing the extent of bilateral MRL stringency between importing and exporting countries on pesticide tolerances focusing specific attention on the U.S. and its bilateral trading partners. Third, formal econometric models are developed to quantify and test the degree to which more stringent MRL standards in importing countries as compared to comparable domestic standards that exist in exporting countries restrict fresh fruit and vegetable trade. The results suggest importer MRL standards that are stricter than exporter MRLs can impart significant reductions in bilateral fresh fruit and vegetable trade.

Keywords: *fruit and vegetable trade, bilateral trade, non-tariff measures, maximum residue limits, gravity mode, intensive and extensive margins of trade.*
JEL Codes: *F13, Q17*

I. Background

Most agricultural economists and policy-makers alike agree that new 21st century obstacles to trade, such as Sanitary and Phytosanitary (SPS) measures, are more obscure in nature and have the potential to be more trade distorting in comparison to traditional instruments of import protection such as tariffs (Josling et al. 2004; OECD 2005; WTO 2012; Beghin et al. 2015). SPS measures are playing a more influential role in shaping agricultural and food product trade, both positively and negatively, and the ability of the U.S. and other countries to secure meaningful agricultural market access depends increasingly on more strict regulatory standards maintained by importing countries (Disdier and van Tongeren 2010; Disdier and Marette 2010; Grant et.al. 2015). In 2015, a record of 1,691 SPS notifications was received by the WTO concerning food safety, animal or plant health regulations, more than 4-fold growth since 2000 (WTO 2016). In principle, SPS regulations are aimed to facilitate production and trade by helping to maintain plant, animal and human health and through quality signaling (Beghin et al. 2015). However, these measures can deliberately or unintentionally impede trade (Center for International Development, 2004). The *2016 National Trade Estimate on Foreign Trade Barriers Report* (USTR 2016) highlighted SPS measures not only as serving an important function in facilitating international trade but also emphasized the lack of transparency and discriminatory measures which can act as significant barriers to US trade.

Under the Agreement on SPS measures of the World Trade Organization (WTO), countries are allowed to set their own standards provided regulations are science-based, not discriminatory between countries with similar conditions, and not used as instruments for protectionism (Grant and Arita 2017; Peterson et.al. 2013). While there is some evidence that countries may use SPS measures as instruments to protect domestic producers (Crivelli and Groeschl 2016), the current literature has not lead to a consensus about the impact of SPS measures on trade nor has it led to a unified framework from which to address SPS policy reforms in multilateral and bilateral trade negotiations. In particular, some regulations facilitate trade, since they represent important quality and/or safety enhancements of the product (Xiong and Beghin 2014; Ishaq et al. 2016). Thus, evidence on the trade impacts of SPS measures to date has been mixed (Swann et al. 1996; Disdier, Fontagne, and Mimouni 2008; WTO 2012; Xiong and Beghin 2012; Beghin, Maertens and Swinnen 2015; Crivelli and Groeschl 2016).

Among many SPS regulations in place to protect animal and plant health from imported pests and disease, a particular type of SPS regulations known as Maximum Residue Limits

(MRLs) or tolerances, are designed to safeguard human health, and have become a focal point of a growing body of empirical literature and SPS specific trade concerns raised in the WTO's SPS committee (Otsuki et al. 2001; Wilson and Otsuki 2004; Wilson, et al. 2003; Disdier and Marette 2010; Winchester 2012; Xiong and Beghin 2013; Xiong and Beghin 2014; Ferro et al 2015; Ishaq et al. 2016; Shingal et al. 2017; Grant and Arita 2017). MRLs describe the maximum legal level of concentration of pesticides or feed additives that a country is willing to accept in, or on the surfaces of, food products. Although MRLs have become a key regulatory measure to limit human exposure to chemicals and veterinary drug residue, overly restrictive tolerances/limits set by importing countries that deviate significantly from international standards, or those maintained by exporting countries, may provide incremental reductions to human and environmental chemical exposure but increase compliance costs for foreign and domestic producers, consumer prices of food products in importing countries, and in some cases may shut off trade as products are rejected at the border (Xiong and Beghin, 2012). Moreover, because of growing consumer concerns to promote a natural environment and safeguarding human health, most developed countries establish their own MRLs standards systems. Other countries are in the process of establishing nationally based MRLs, which create more heterogeneous regulations that can act as significant trade barriers. Given the widespread use of pesticides in agricultural production globally (Yeung et al. 2017), differing tolerances for pesticide residues among countries can create obstacles to trade, expecially for developing countries (Otsuki et al. 2001; Otsuki, Wilson and Sewadeh, 2001; Wilson and Otsuki 2004).

However, these obstacles are not limited to developing countries. Figure 1 plots U.S. exports of apples (left axis) and pears (right axis) to the EU and Trans-Pacific Partnership countries (excluding Canada and Mexico as NAFTA members) over the 2008-2015 period. The pattern of U.S. exports of apple and pear exports to EU members point to a significant decline in U.S. exports to the EU post-2008. This decline in exports coincided with the EU reviewing and ultimately setting a lower MRL standard for diphenylamine (DPA), Morpholine, and Ethoxyquin, post-harvest regulators applied to preserve the appearance of the fruit products (scalding and shining).[1] While causality is an open empirical issue (i.e., what would US apple and pear exports to the EU look like without the tighter EU MRL standard), it appears from Figure 1 that U.S. apple and pear exports to the EU dropped 80% and 44%, respectively, between 2008 and 2015 (*UN Comtrade*, 2016).

Key obstacles precluding a comprehensive empirical assessment of MRLs between

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[1] See: http://www.capitalpress.com/content/djw-applepearMRL-060413

trading partners are data limitations and the plethora of MRLs that have been established for any given country. In particular, there are often hundreds of residue limits that apply to any given product depending on the chemicals registered for use in the production process. For example, the US has established tolerances for 131 pesticides for apples (using MRL data for 2013-2014). In addition, the number of registered tolerances are not identical across countries. For apples, the number of established pesticide tolerances varies from 45 in China, 79 in Canada, to 112 in Japan. This compares to 68 MRLs registered by Codex (international standard).[2] Thus, assessing the degree of regulatory stringency of MRLs between countries for all pesticides is difficult. Often previous studies will adopt a case-study approach by considering a single MRL such as the EU's Aflatoxin residue limit on African groundnut exports. Wilson and Otsuki (2004) evaluated MRLs on chlorpyrifos (an insecticide) in banana exports; Wilson, et al. (2003) on the effect of residue limit standards on tetracycline in beef exports; Chen, et al. (2008) on food safety standards impacting China's exports of vegetables, fish and aquatic products, and Disdier and Marette (2010) on antibiotics impacting crustaceans exports. These studies tend to find significant negative effects of more stringent maximum residue limits and food safety standards.

Li and Beghin (2014) developed a targeted stringency index that captures and summarizes the spectrum of a country's MRL standards for a given product. However, they compared an importers' MRL to those established by Codex for international standards without focusing attention on regulatory differences between origin and destination countries themselves. For example, there are many cases where an exporter's MRL policy is more restrictive than the international Codex standard. Thus, even if an importer's MRL policy is more stringent than the international standard, if exporting firms face a more stringent MRL policy in their domestic market compared to either the international or importer's standard, the importer's MRL policy may not be overly trade distorting if firms are already complying with a more stringent domestic standard. Furthermore, Codex establishes a limited number of MRLs for pesticides which means that comparisons to the international standard may miss a number of important regulatory differences that exist bilaterally (i.e., between origin and destination market). Burnquist et al.' 2011 index is defined for cases when an importer has stricter MRL compared to an exporter, and Achterbosch et al. (2009) construct stringency levels of MRLs using averages of the actual difference in MRLs for each pesticide divided by the sum of the limits for the two trading partners. Drogue and DeMaria (2012) compute the respective distance between each country's MRL standards for apples and pears by subtracting the

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[2] Codex standards are established by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO).

Pearson's coefficient correlation from one and Winchester et al' 2012 indices assumed that heterogeneity always imposes compliance costs regardless of which direction if more stringen. Thus, in many of these studies the indices do not provide information about which trading partner (importer or exporter) has the stricter MRL.

In this article, we construct a novel dataset of MRLs and develop a targeted bilateral stringency index of MRL heterogeneity between trading partners not based on the stringency of members' MRLs with respect to the international standard (Li and Beghin 2014; Xiong and Beghin (2014) or on the stringency of importers' MRLs alone (Ferro et al 2015), but rather an index based on regulatory differences between origin and destination countries for a given product. The decision to export and the intensity with which exports occur with a given bilateral partner likely depends more on the stringency of MRL standards in the importing nation *relative to* the origin country. Such an approach has two advantages. First, the index is fully bilateral in the sense that we can pay attention to hidden trade obstacles facing U.S. exports and identify importing countries where MRLs are more stringent. Second, the index is computed on a product-by-product basis (i.e., apples, pears, grapes, lettuce, etc.) between all trading partners by considering only the pesticides used in production in the U.S. as reported by the National Agricultural Statistics Service (NASS) producer surveys (discussed in the data section).

Second, we are able to disaggregate pesticide MRLs into three chemical classes to evaluate their trade restrictive nature individually – herbicides, fungicides and insecticides. Thus, our indices vary not only by product and/or country but also by the type of chemical applied in the production process. To our best knowledge, this is the first study to disaggregate the stringency index by chemical class to investigate which class of pesticides are most trade distorting.

Third, we develop a formal empirical model to quantify the impact of MRL regulatory differences on global and U.S. fruit and vegetable trade. The analysis explores whether more stringent MRL policies in destination markets affect not only the value of agricultural exports along the intensive margin of trade but also whether exporters actually trade at all (extensive margin of trade). We use the bilateral stringency indices in the empirical model to shed light on key regulatory differences between the U.S. and EU as well as potential partner countries in the Trans Pacific Partnership (TPP).[3]

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[3] It should be noted that the U.S. formally withdrew from the TPP in January 2017. However, the results of this research are useful for any bilateral trade agreement between the US and TPP countries individually (i.e., with Japan).

II. MRL Policy Setting

While the SPS Agreement allows WTO Members to adopt their own set of regulations, it encourages countries to apply internationally accepted science-based standards established by the Codex Alimentarius Commission (henceforth CAC or Codex).[4] The Codex Committee on Pesticide Residues (CCPR) is the primary body responsible for establishing MRLs for pesticide residues. While the CCPR's responsibility is to establish MRLs for pesticides in specific food items or in groups of food, the Joint Food and Agricultural Organization (FAO)/World Health Organization (WHO) Meeting on Pesticide Residues (JMPR) is responsible for reviewing the appropriate toxicology and residue field data, conducting dietary risk assessments, and recommending specific MRLs to the CCPR. Thus, human health risk assessments must be conducted to ensure food safety before a Codex MRL can be established (Epstein, 2013; Madden, 2014; WHO 2009).

The CCPR follows a three-step process to establish a Codex MRL. First, a member country nominates a chemical/commodity to the CCPR. Second, the JMPR reviews the data provided for this chemical/commodity. Finally, according to the WHO (2009), the establishment of the MRL will be considered by the CCPR, if the JMPR's review confirms that there are no issues or concerns. Although the CAC sets the MRLs for most agricultural and livestock products, WTO members are not legally bound to adopt such standards and there is no means to enforce equivalency with the international standard. As such, MRLs vary widely across countries as discussed shortly because of differences in residue definitions, usage patterns, formulations used in the residue field experiments that may differ from pesticide use in actual production settings, and in the procedures used to determine MRL levels (Madden, 2014). In such circumstances, countries can adopt standards that differ from Codex as long as they are science-based, non-discriminatory, and minimally trade-distorting (Beghin, 2014).

Thus, no official harmonized level of MRL exists globally (Achterbosch et al., 2009; Drogue and DeMaria, 2010; Van der Meulen and van der Velde, 2004). For example, the European Union (EU) and the United States (US) have established different MRLs for the chemical Methidathion - a widely used organophosphate insecticide used in the production of oranges and other citrus fruits. Because the insecticide can be toxic to humans, avian species, and honeybees, the EU's harmonized SPS policy sets a more stringent residue limit of 0.02 parts per million (ppm), compared to the US which establishes a less stringent standard of four ppm. For comparison, the CAC international standard for Methidalthion in

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[4] The Codex Alimentarius Commission (CAC) "develops harmonized international food standards to protect health of consumers and ensure fair practices in food trade" (http://www.fao.org/fao-who-codexalimentarius/en/).

oranges is two ppm.[5]

In the US, the Environmental Protection Agency (EPA) is responsible for establishing residue limits on pesticides that have been registered and approved for use (e.g., have been determined with “reasonable certainty” not to pose a harmful threat to human or environment health). In setting the tolerance, the EPA considers: the toxicity of the pesticide and its break-down products, how much of the pesticide is applied and the frequency of application; and how much of the pesticide (i.e., the residue) remains in or on the surfaces of food by the time it is prepared for retail markets. Pesticide manufacturers, or registrants, are required to submit a variety of scientific trials that identify possible harmful effects the chemical could have on humans (its toxicity), and the amount of the chemical (or breakdown products) likely to remain in or on the surface of food. This information is then used in the EPA’s risk assessment and determination of the tolerance. Once an EPA tolerance is established, the limit applies both to domestically produced and imported products. In addition, established MRLs can be updated if new information regarding toxicity or residue data warrants a revision to the existing tolerance (EPA website, 2014).

In the EU, MRLs apply to 315 fresh and processed agricultural products. In cases where pesticides have not been registered, the EU maintains a default MRL of 0.01 mg/kg. The EU’s standard setting MRL process first involves estimating residue levels in or on a crop when the pesticides are applied under the Good Agricultural Practice (GAP). Second, the total daily intake of the specific pesticide is estimated using consumer intake models and the established residue level. Third, an acceptable daily intake (ADI) is established using information based on toxicological tests. Sensitive groups of consumers such as children are considered in order to determine a safe ADI limit as well as a second limit referred to as the Acute Reference Dose[6] (ARFD). Once these intake limits are computed, the European Commission (EC) establishes a new MRL or revises the existing MRL based on the condition that the daily consumer intake of residues is less than the ADI. For crops and chemicals produced and used outside of the EU, MRLs are established upon request of the exporting country (EC website, 2014; Smolka, 2006).

As such, MRLs vary widely across countries because of differences in residue definitions, usage patterns, formulations used in the residue field experiments that may differ

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[5] It should be noted that international and country-specific MRL standards for a given chemical differ depending on the product. For example, the CAC international MRL standard for pears and table grapes is 1 ppm compared to 0.1 ppm for onions and tomatoes and 0.01 ppm for Macadamia nuts. In the empirical exercise, we develop an index to measure dissimilarities in two trading partners MRL standards for a given product.

[6] ARFD is the pesticide dose that can be consumed during one day (short time), without considerable health hazard (Smolka, 2006).

from pesticide use in actual production settings, and in the procedures used to determine MRL levels (Madden, 2014). In such circumstances, countries can adopt standards that differ from Codex as long as they are science-based, non-discriminatory, and minimally trade-distorting (Beghin, 2014). Thus, no official harmonized level of MRL exists globally (Achterbosch et al., 2009; Drogue and DeMaria, 2010; Van der Meulen and van der Velde, 2004). For example, the EU and the US have established different MRLs for the chemical Methidathion - a widely used organophosphate insecticide used in the production of oranges and other citrus fruits. Because the insecticide can be toxic to humans, avian species, and honeybees, the EU's harmonized SPS policy sets a more stringent residue limit of 0.02 parts per million (ppm), compared to the US which establishes a less stringent standard of 4 ppm. For comparison, the CAC international standard for Methidalthion in oranges is two ppm.[7]

III. Indices of Regulatory Heterogeneity

Constructing a measure encapsulating the degree of regulatory MRL heterogeneity remains an open empirical issue. Achterbosch et al. (2009) constructed stringency levels of MRLs affecting Chile's exports of fruits to the EU over the period of 1996-2007 using averages of the actual difference in MRLs for each pesticide divided by the sum of the limits for the two trading partners. Shingal et al. 2017 builds on Achterbosch et al.'s (2009) framework by separating the stringency index into two measures – one when the exporter maintains a stricter limit and the second when the importer maintains a stricter limit – with the goal of testing the claim that regulatory heterogeneity always creates compliance costs for countries no matter where this heterogeneity comes from. Drogue and DeMaria (2012) compute the respective distance between each country's MRL standards for apples and pears by subtracting the Pearson's coefficient correlation from one, which gives an index with domain [0, 2]. When the index value is close to zero (two), the two trading partners have the same (dissimilar) MRL standards. However, a major shortcoming of the Pearson index is that it does not provide information about which trading partner (importer or exporter) has the stricter MRL. For reasons discussed previously, we believe such information is important to the question of whether differences in MRLs represent barriers or catalysts to trade.

Winchester et al. (2012) develop the heterogeneity index of trade regulation (HIT), as defined by Rau et al. (2010), based on the Gower index of (dis)similarity (Gower 1971). The standards investigated, however, include import requirements concerning food safety, animal

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[7] It should be noted that international and country-specific MRL standards for a given chemical differ depending on the product. For example, the CAC international MRL standard for pears and table grapes is 1 ppm compared to 0.1 ppm for onions and tomatoes and 0.01 ppm for Macadamia nuts. In the empirical exercise, we develop an index to measure dissimilarities in two trading partners MRL standards for a given product.

and plant health, labeling, traceability, conformity assessment, process requirements and certification requirements. Thus, the number of measures involved in the computation of the HIT is very large, and they weight all NTMs equally in their index, arguing that using all of the information is a better alternative than focusing on just a few NTMs, which is equivalent to putting a weight of zero on all but those few. Indices over a large number of NTMs; however, makes it difficult to determine which measures are responsible for trade disruptions and the direction of stringency (can not determine which one of the importer or exporter has more stringent standard). Further, Winchester et al. (2012) extend the HIT to account for directional HIT relationships that are capable of capturing the MRL stringency differences between two trading partners. In particular, between two trading partners if the importing country has more stringent MRLs as compared to the exporting country, then the (dis)similarity measure is calculated. But, if the exporting country has more stringent MRLs as compared to the importing country, then the (dis)similarity will be zero; in this case, there is no trade barrier between two trading partners.

Burnquist et al. (2011) modify Winchester et al. (2012) (dis)similarity formulation of the directional HIT index, which reflects only the case where an importing country has more stringent MRLs than an exporting country. The directional HIT index covers both sides of the case where an importing and an exporting country has more stringent MRLs; however, Burnquist et al. (2011) ignore heterogeneity when the exporter is more strict. Therefore, their (dis)similarity of MRLs will show if there is a higher trade cost for an exporter. Further, the value close to zero implies no difference in the MRLs for both trading partners and value close to one presents a higher stringency of MRLs for an importing country. The latter indicates that an exporting country may have higher compliance costs to adjust its MRLs to be acceptable by an importing country. Winchester et al. (2012), Drogue and DeMaria (2012) Shingal et al. (2017) frameworks have an advantage to the stringency index introduced by Burnquist et al. (2011), which ignores heterogeneity in the case of exporter with more stringent MRL. Ferro et al (2015) develop a restrictiveness index similar to the Winchester et al.' (2012) Gower index with a broader range of countries and over wider time span.

While these measures of heterogeneity attempt to capture the (dis)similarity between trading partners in the case of MRLs for pesticides, many of them assign equal weight in computing the index. However, a liner index may underestimate the impact of more stringent MRLs. With this in mind, the starting point in our analysis is a modification of Li and Beghin's (2013) non-linear exponential index[8] that takes into account the (dis)similarity of MRL policies

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[8] In their study, Li and Beghin (2013) explicitly discuss the desirable properties of the non-linear exponential stringency index.

between country-pairs rather than between a destination's standard relative to the international Codex limit.[9] As described shortly, the Bilateral Stringency Index *(*BSI) is calculated for all countries with established MRL standards and the requirement that the chemical is actively used in production based on data provided by the USDA/NASS surveys of pesticide use for 26 fruits and 25 vegetable crops across producers in the United States. Our aim is to quantify how and to what extent stricter MRLs in the destination country relative to the origin country impact fresh fruit and vegetable trade. In which direction and by how much trade changes for a given incremental increase in the *BSI*, however, is an open empirical question.

IV. Empirical Model

In order to quantify the extent to which MRL policy dissimilarities reduce fruit and vegetable trade between trading partners, a product-level model of bilateral trade is developed based on the work of Anderson and van Wincoop (2003), Baldwin and Taglioni (2006), Peterson et al. (2013) and Grant et al. (2015). The model assumes all varieties of commodity *k* are differentiated by origin region *o* and consumer preferences in destination region *d* for commodity *k* are weakly separable, which can be described by a CES utility function of the following form:

$$(1) \qquad u_{dk} = \left(\sum_{o=1}^{R} \delta_{odk}^{\frac{1}{\sigma_k}} q_{odk}^{\frac{\sigma_k - 1}{\sigma_k}} \right)^{\frac{\sigma_k}{\sigma_k - 1}}$$

where δ_{odk} denotes a preference parameter for commodity *k* exported by region *o* to region *d*. *R* represents the total number of regions. q_{odk} is the quantity of commodity *k* exported by origin region *o* and consumed in destination region *d*. The elasticity of substitution between all varieties of commodity *k* is described by σ_k. Time period subscripts are suppressed as discussed further below due to the limited time-series nature of the MRL data.

A representative consumer in region *d* maximizes its utility (1) conditional on her budget constraint. The following describes the consumers' expenditure function allocated to consumption of commodity *k* in region *d* from region *o*:

$$(2) \qquad V_{odk} = p_{odk} q_{odk},$$

Solving this utility maximization problem and substituting the budget constraint equation (2) in the first order condition gives consumer demand for quantity of commodity *k* in region *d* from region *o*. In equation (2) p_{odk} is consumer price for commodity *k* in region *d* from

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[9] Li and Beghin (2013) compute an index value of MRLs relative to Codex standards and determine whether these indices are trade impeding.

region *o*, which is linked to producer price for commodity *k* in region *o* through the price linkage equation:

$$(3) \qquad p_{odk} = t_{odk} p_{p\_ok},$$

where t_{odk} defines the trade costs of exporting commodity *k* from region *o* into region *d* and p_{p_ok} denotes producer prices in region *o*. Substituting the optimal quantity along with equation (3) in equation (2) yields the following expenditure function for commodity *k* in region *d* from region *o*:

$$(4) \qquad V_{odk} = \frac{\delta_{odk}\left(t_{odk} p_{p\_ok}\right)^{1-\sigma_k} E_{dk}}{PI_{dk}^{1-\sigma_k}},$$

where E_{dk} is commodity *k* specific in region *d*'s expenditure and the denominator in equation (4) is the CES price index (PI_{dk}) defined as follows:

$$(5) \qquad PI_{dk} = \left(\sum_{r=1}^{R} \delta_{rdk} p_{rdk}^{1-\sigma_k}\right)^{\frac{1}{1-\sigma_k}}.$$

Equation (4) illsutrates region *o*'s sales to each destination market that is a function of expenditure in region *d* (E_{dk}), origin prices relative to the overall price index (p_{p_ok} and PI_{ok}), bilateral trade costs and preferences (δ_{odk}). This expenditure function (equation 4) defines the elements of a product line gravity model developed in Anderson and van Wincoop (2003) and Baldwin and Taglioni (2006). Therefore, summation of consumer expenditures across destination markets, including *o*'s market evaluated at the producer price in region *o*, will give the total sales of commodity *k* that is produced in region *o*. Assuming market clearing condition for commodity *k*, the total quantity of commodity *k* produced in region *o* (Y_{ok}) will equal to the quantity demanded in domestic market (*oo*), as well as the quantity demanded across destination markets (*od*).

$$(6) \qquad Y_{ok} = \sum_{d=1}^{R} V_{odk} = \sum_{d=1}^{R} \frac{\delta_{odk}\left(t_{odk} p_{p\_ok}\right)^{1-\sigma_k} E_{dk}}{PI_{dk}^{1-\sigma_k}}$$

Using equation (6), we can solve for $p_{p\_ok}^{1-\sigma_k}$ and substitute the result into equation (4) as suggested by Anderson and van Wincoop (2003). The expenditure function in equation (7) incorporates an explicit commodity dimension developed by Peterson et al. (2013) and Grant et al. (2015), which was a modification of Baldwin and Taglioni's (2006) expenditure function.

$$(7) \qquad V_{odk} = \frac{\delta_{odk} t_{odk}^{1-\sigma_k} Y_{ok} E_{dk}}{\left(\sum_{d=1}^{R} \frac{\delta_{odk} t_{odk}^{1-\sigma_k} E_{dk}}{PI_{dk}^{1-\sigma_k}}\right) PI_{dk}^{1-\sigma_k}} = \frac{\delta_{odk} t_{odk}^{1-\sigma_k} Y_{ok} E_{dk}}{\Omega_{ok} PI_{dk}^{1-\sigma_k}}.$$

Similar to Grant et al. (2015), trade costs in equation (7) are a multiplicative function of transportation margins, and consist of several factors to transport *k* from producers in region *o* to consumers in region *d*. To capture the extent to which bilateral MRL stringency impacts trade costs, we employ a bilateral stringency index as a proxy for trade costs, along with geographical distance and an indicator of free trade agreements. Following Li and Beghin's (2013) non-linear exponential index, the bilateral stringency index (*BSI*) of MRLs between origin region *o* and destination region *d* for the *c* classes of chemicals used in the production of product *k* is defined as follows:

$$BSI_{codk} = \left(\frac{1}{N_{ck}}\right) \sum_{p \in N_{ck}} exp\left(\frac{MRL_{opk} - MRL_{dpk}}{MRL_{opk}}\right) \tag{8}$$

where N_{ck} is the number of chemicals in chemical class *c* used in the production of commodity *k*, MRL_{opk} is the maximum residue limit for the p^{th} chemical in class *c* for commodity *k* in region *o* and MRL_{dpk} is the maximum residue limit for the p^{th} chemical in class *c* for commodity *k* in region *d.* As mentioned above, one of the limitations of previous studies is they often employ an aggregate measure of stringency or dissimilarity over all chemicals. However, this makes it difficult to determine which measures may be responsible for trade disruptions. To address this concern, we disaggregate the BSI index of MRL stringency into separate indices for different chemicals. Thus, we consider three broad classes of pesticides - herbicides, insecticides, and fungicides – to identify whether MRL policy dissimilarities between the destination and origin regions vary systematically across different classes of chemicals (*c*).

The advantages of the exponential function are that it maps heterogeneous *BSI* differences onto the range zero (exp(-∞)) and 2.72 (exp(1)) and penalizes larger MRL differences between *o* and *d* relatively more. For example, if the destination region has a much stricter MRL for chemical *p* in class *c* (i.e., 0.1 ppm) compared with the origin region (i.e., 5 ppm), reflecting a heterogeneous regulatory situation, then the ratio of MRLs will approach a value of unity and the BSI function will approach its upper limit of *exp*(1) = 2.72. Conversely, if the origin region has a much stricter MRL for chemical *p* in class *c* compared to the destination region, then the ratio of MRLs will be negative and in the limit the exponential function will approach zero, reflecting the fact that the destination region MRL is not likely to represent a "barrier" to trade because exporting firms are already required to meet a more stringent domestic tolerance. Finally, if the origin and destination regions have the same MRL for chemical *p* in class *c*, then the ratio equals zero and the BSI is *exp*(0) = 1, reflecting an equivalent or harmonized SPS situation.

As described shortly, the *BSI* is calculated for all countries with established MRL standards and the requirement that the chemical is used in production based on data provided by the USDA/NASS surveys of pesticide use for 26 fruits and 25 vegetable crops across producers in the United States. All else constant, stricter MRLs in the destination country relative to the origin country are expected to have a negative impact on trade. The extent to which trade falls for incremental increases in the *BSI*, however, is clearly an open empirical question.

In equation (9), we initially assume trade costs are variable; however, later in this section we examine the extent to which BSI impacts the probability of exporting. Thus, we will consider bilateral MRL stringency, not only as variable cost of trade, but also as a fixed cost impacting the decision to export:

$$t_{odk}^{1-\sigma_k} = dist_{od}^{\delta_1} \exp\left(RTA_{od}\right) \prod_{c} BSI_{odk}^{\theta_c} z_{odk}^{\theta_0} \tag{9}$$

where, $dist_{od}$ is the geographical distance between regions o and d, RTA_{od} is an indicator of a mutual free trade agreement between o and d, BSI_{odk} is the bilateral stringency index defined in equation 8, and z_{odk} are other potentially unobserved determinants of trade costs.

Finally, to re-write equation (7) as a product line gravity model, some further modifications are necessary. First, the CES utility function is homothetic, so an increase in E_{dk} yields a proportional increase in V_{odk}, holding all other variables constant. Second, in equation (7) E_{dk} is not directly observable and there is a long history of encountering difficulties estimating trade models because most of the variables involved are not directly observable. However, the expenditure for commodity *k* in region *d* is a function of income and the price indices for each commodity. Third, the price indices, Ω_{odk} and PI_{dk}, are also not directly observable. Previous empirical studies such as Peterson et al. (2013), Grant et al. (2015) and many other studies assume expenditure (E_{dk}) is a function of total income (GDP) and employ GDP in their models. Production quantities are used as a proxy for production values (Y_{ok}), since representative producer prices to convert quantities to values are often missing for many countries. Furthermore, these studies use time varying country-specific fixed effects for unobservable price indices as suggested by Baldwin and Taglioni (2006), Anderson and van Wincoop (2003), Feenstra (2004) and many others. In this study, since MRL data availability limits our analysis to two years of data, we adopt an alternative approach, which captures expenditure, production value and price indices using time-invariant country and commodity-specific fixed effects (*o*, *d* and *k*) as consistent alternatives.

The final estimation step is the issue of zero trade flows. Santos-Silva and Tenreyro (2006), Pham and Martin (2008), Helpman, et al. (2008) and Jayasinghe, et al. (2009) show that omitting zero trade flows leads to biased estimates due to sample selection issues, particularly if the reason for the existence of zero trade is correlated with right-hand side variables such as MRL policies. In this article, we first apply an Ordinary Least Squares (OLS) model; however, in order to avoid omitting zero trade flows and as suggested by trade literature, the dependent variable is the natural log of the value of trade flow plus a negligible number (here we use one). A better approach to incorporate zero trade flows is the Poisson pseudo-maximum likelihood (PPML) estimation framework as discussed in Santos-Silva and Tenreyro (2006). Further, we encounter excessive amount of zeros in the sample, because of the nature of our HS6-digit fruit and vegetable trade flows. Therefore, the Poisson model may not address this latter issue because of its restricting assumption of equal dispersion between the conditional mean and variance (Cameron and Trivedi 1990). Thus, the Negative Binomial specification is developed to accommodate problems of over-or underdispersion. Substituting equation (8) into (9), and then equation (9) into equation (7), along with E_{dk} and Y_{ok} yields our baseline model of product line trade flows:

$$\begin{aligned} X_{odk} = \exp\Bigg(& p_o + p_d + p_k + \sum_c q_c BSI_{codk} + /_1 \ln Dist_{od} + /_2 RTA_{od} \\ & + \sum_c q_{c_{US\text{-}EU}} BSI_{codk} I_{US\text{-}EU} + \sum_c q_{c_{US\text{-}TPP}} BSI_{codk} I_{US\text{-}TPP} \Bigg) e_{odk} \end{aligned} \tag{10}$$

where X_{odk} is the export value of bilateral fresh fruit and vegetable trade between *o* and *d*, and $I_{US\text{-}EU}$ and $I_{US\text{-}TPP}$ are indicator variables equal to one if *o* is the US and *d* belongs to the EU or TPP countries, respectively. By including these terms, we allow the EU and TPP MRL policies with respect to US exports to have potentially different trade impacts. π_o, π_d and π_k are exporter, importer and commodity fixed effects, and ε_{odkt} is the multiplicative error term.

While the Poisson model controls for zero trade flows and sample selection bias, based on the nature of our data, a zero trade observation may indicate a more restrictive MRL policy imposed by a destination country. In particular, an important consideration of MRL policies is whether exporting nations facing stringent MRL policies in destination markets actually export at all. While estimating the Poisson model on two sets of data, first on positive export data and then on positive and zero export data, provides some insight, Helpman, et al. (2008) offer an intuitive approach.[10] Helpman, et al. (2008) develop a model of selection into exporting, which considers the fixed costs firms need to cover in order to export commodity *k* from region *o* to region *d*. Based on Melitz's (2003) firm heterogeneity framework, only the most productive firms are able to enter export markets. Furthermore, Crivelli and Groeschl (2016) explain different SPS measures can have heterogeneous effects on trade, particularly

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[10] We also use this approach as a robustness check with our previous findings in the OLS, Poisson and Negative Binomial Models. Our results, as shown in the result section, are consistent across these models.

the costs of trade, including fixed and variable costs. The Helpman, et al. (2008) model developed from Heckman (1979) enables us to first deal effectively with the zero trade observations and further allows us to distinguish the effect of MRL policy on the extensive (i.e., probability of exporting) and intensive (intensity of exports) margins of trade (Cipollina et al. 2010). Thus, the other objective of our empirical modeling is whether exporting nations facing stringent MRL policies in destination markets actually export at all. Heckman's (1979) model retains the log-linear transformation of the model and treats zero trade flows as censored observations. The model includes both a selection and outcome equation as follows:

$$(11) \quad Y^*_{odk} = \pi_o + \pi_d + \pi_k + \sum_c \theta_c BSI_{codk} + \delta_1 \ln Dist_{od} + \delta_2 RTA_{od} + \delta_3 Lang_{od} + \mu_{odk}$$

$$(12) \quad \ln X^*_{odk} = \pi_o + \pi_d + \pi_k + \sum_c \theta_c BSI_{codk} + \delta_1 \ln Dist_{od} + \delta_2 RTA_{od} + \varepsilon_{odk}$$

where Y^*_{odk} is a latent variable predicting whether or not bilateral trade between *o* and *d* is observed and ln (X^*_{odk}) is the natural logarithm of the intensity of bilateral trade. Y^*_{odk} and lnX^*_{odk} are not observable in the selection and outcome equations, respectively, but we do observe $Y_{odk} = 1$ if $Y^*_{odk} > 0$ and $Y_{odk} = 0$ if $Y^*_{odk} \leq 0$ and $lnX_{odk} = lnX^*_{odk}$ if $Y^*_{odk} > 0$ and lnX_{odk} is not observed if $Y^*_{odk} \leq 0$. The model can be estimated by a two-step procedure suggested by Heckman (1979) or the one-step maximum likelihood estimation where the selection and outcome equation are estimated simultaneously. The two-step procedure first estimates the bivariate selection equation using a Probit model and generates the standard inverse of the Mills ratio,[11] which is subsequently included as an additional regressor in the outcome equation.

The advantage of the Heckman model is that it can effectively estimate both the extensive and intensive margins of trade by explicitly modeling zero trade flows. That is, it allows us to determine if stringent MRL policies impact the probability of exporting, the intensity of exports, or both. In this model an appropriate exclusion restriction is often required[12], Helpman, et al. (2008) use regulation costs and common religion as exclusion restriction variables. Crivelli and Groeschl (2016) also include common religion as an excluded variable, while other studies in this line employ an excluded variable based on the availability of data, such as common language, colonial ties, and time.[13] Disdier and Marette

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[11] The inverse Mills ratio is the ratio of the probability density function (PDF) over the cumulative distribution function (CDF) (Cameron and Trivedi, 2010).

[12] While Cameron and Trivedi (2010) note that the system is theoretically just-identified through the non-linearity of the inverse mills ratio, for practical purposes, they suggest the model requires an exclusion restriction in the selection equation.

[13] Xiong and Beghin (2012) include a colonial tie dummy variable as exclusion restriction in their model, while Jayasinghe and Beghin (2010) employ a set of time dummy variable in their selection equation.

(2010) include common language in their selection equation. In this article, we include common language, $Lang_{od}$, as an exclusion restriction because common language may help to facilitate understanding of destination market information on rules and regulations of MRL standards and may help expedite product compliance issues.

V. Data

Information on MRLs during 2013 and 2014 are obtained from the global MRL database maintained by the Foreign Agricultural Service (FAS) (see mrldatabase.com).[14] The established MRL data for each fruit and vegetable by each individual country including CODEX standards were retrieved. Reported countries' MRLs can be divided into six categories – Codex standards, European Union standards, United States standards, Gulf Cooperation Council (GCC) standards, other countries with their own standards, and countries deferring to exporting countries' or Codex standards. Among the 88 countries for which we collected MRL information, 27 countries adopt the Codex standard for all products and 31 countries set their own standards. Sixteen countries defer to the EU's standard, seven countries use their trading partners' (exporting countries) standards, four countries adopt the GCC standards, and Mexico defers to the US standards. With the exception of Peru (Codex deferral) and Mexico (US deferral), the U.S., Trans-Pacific Partnership countries (TPP-11) (Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Vietnam) and the EU set their own MRL standards.[15] Importantly some countries establish a default MRL, which can be used if a specific MRL is not reported, a pesticide has not been registered for use, or is in the process of being registered for use. The default values demonstrate the most stringent residue concentration that is permitted.[16]

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[14] After this, the global MRL database has no longer been available through FAS.

[15] Codex: Algeria, Angola, Bahamas, Bangladesh, Barbados, Bermuda, Cambodia, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Hong Kong, Jamaica, Jordan, Kenya, Lebanon, Morocco, Netherlands Antilles, Nicaragua, Pakistan, Panama, Peru, Philippines, Trinidad and Tobago, Tunisia, United Arab Emirates, Venezuela and Honduras (Some countries may defer to the US or the EU if there is no Codex MRL). European Union: Belgium, Denmark, Finland, France, French Pacific Islands, French West Indies, Germany, Greece, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden and United Kingdom
Exporting countries: Albania, Antigua and Barbuda, Cayman Islands, Haiti, Nevis, Sri Lanka and St. Lucia
Gulf Cooperation Council: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia. Own standards: Argentina, Australia, Brazil, Brunei, Canada, Chile, China, Customs Union of (Belarus, Kazakhstan, and Russia), Cuba, Egypt, Iceland, India, Indonesia, Israel, Japan, Malaysia, New Zealand, Norway, Russia, Singapore, South Africa, South Korea, Switzerland, Taiwan, Thailand, Turkey and Vietnam (Some countries may defer to Codex if there is no own standard). United States: Mexico. Data are collected from MRLdatabase.com.

[16] The default MRL for Japan, Norway, EU and Iceland is 0.01 ppm. Canada's default MRL is 0.1 ppm. For Saudi Arabia, a default MRL of 0.01 ppm applies when no GCC, Codex, US or EU MRL is established. Brazil, Chile, India, Israel, Thailand, Cuba, Singapore and Vietnam defer to Codes as a default values for MRLs. Argentina and Turkey adapt Codex MRL, and if Codex does not establish MRL for a specific chemical, their default MRLs' are 0.01 ppm. New Zealand uses the least restrictive value between MRLs established in their national regulation (0.1 ppm default included) and MRLs established by Codex as a default value. South Africa applies the less restrictive value established in the EU and Codex regulations and there is no MRL reported

The total number of pesticides with established MRLs reported in the global MRL database is 256 chemicals. However, not all pesticides with established MRLs are approved for use. Therefore, we retrieved data from the National Agricultural Statistics Service (NASS) producer surveys that report 162 chemicals used in fruit and vegetable production. NASS develops surveys to determine on-farm chemical use and pest management information for agricultural commodities. Each chemical's biological name is then matched with the chemical identifier reported in the global MRL database. Once the list of active chemicals is created, it is then merged with the global MRL data, leaving us with a three-dimensional database of MRLs that varies by country, commodity, and the pesticide chemical name. Our product sample includes 51 fruit and vegetable products (FVs)[17] at the 6-digit level of harmonized system for 85 countries with reported MRL tolerances for 162 pesticides used in production over the sample period 2013 and 2014. The raw unbalanced dataset has 678,252 observations [18] consisting of a year, country, commodity and pesticide dimension. However, around 42% of observations are missing because an MRL is not registered for use in a given country or an established MRL has not been registered. While some countries maintain default values (e.g. the EU introduces a default value of 0.01 ppm) if no MRL is reported, replacing these missing values with default values does not add much information to our sample (35% of the observations are still missing). When no other information is available, these missing country-commodity-pesticide triplets are dropped.

Table 1 provides a comparison of the MRL data for countries that set their own standards relative to the international standard (Codex) and the United States. Column (1) (table 1) illustrates the share of each country's MRLs that are stricter (i.e., a tighter limit) than Codex. Relative to the international standard, Brazil's MRL standards appear to be the most stringent among all countries in table 1 with 61 percent of its standards being set at stricter limits than those advocated by Codex. Column (2) presents similar results but instead of the Codex we compare MRL stringencies to the United States. Here, Russia appears to set the most restrictive tolerances with 68 percent of established MRLs being more stringent than the

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then applies 0.01 ppm. Dominican Republic uses US's MRLs and EU's MRLs as a default value. Finally, Russia applies MRLs established by Customs Union when there is a conflict between the two regulations. Data are collected from MRLdatabase.com. Further information available at www.globalmrl.com.

[17] Fruits: apples, apricots, avocados, bananas, cherries, citrus, cranberries & blueberries, currants, dates, figs, grapefruit, grapes, kiwifruit, lemons & limes, mandarins & clementine, mangoes, melon, oranges, papayas, peaches & nectarines, pears & quinces, pineapples, plums & sloes, raspberries & blackberries, strawberries, and watermelons

Vegetables: asparagus, broccoli, brussels sprouts, carrots, cauliflower, celery, cucumbers, eggplants, fresh beans, garlic, globe artichokes, head lettuce, leaf lettuce, leeks, legumes except peas beans, mushrooms & truffles, onions, peas, peppers, potatoes, radishes, spinach, squash & pumpkins & artichokes & okra, tomatoes, and witloof chicory

[18] There are 336,510 and 341,742 observations in 2013 and 2014, respectively.

corresponding values set by the United States.[19] Following Russia, Brazil, Turkey, Iceland and Norway with 64 percent and the EU with 63 set their MRLs more stringent than the United States. Columns 3 and 4 in table 1 report the number of established and non-established MRLs in our database. As shown, the US has the highest number of established MRLs (14,311), while Indonesia has the lowest number of established MRLs (384).

Also of interest is the fact that MRL tolerances differ widely across products for the same chemical. For instance, Acetamiprid is an odorless neonicotinoid insecticide, which controls for sucking insects on some fruits such as citrus, pome, and grapes and leafy vegetables. Codex has established 12 different tolerances for this chemical depending on the fruit or vegetable product being traded. However, the EU, Japan and the US set 19, 15 and 14 unique values for this chemical, respectively, and their values are consistent with Codex ranging from 0.01 to around five ppm (with the exception of 15 ppm for the United States). At the other extreme, more generic pesticides such as 2,4-D have a much lower range of Codex tolerances across products ranging from a low of two ppm to a high of ten ppm (and the only other unique tolerances are two and five ppm). Similar ranges exist for 2,4-D MRLs in the EU, Japan and the US.

Pesticides applicable for fruits and vegetables can be divided into several classes of chemicals - herbicide, insecticide and fungicide. Each chemical is mapped to each class of chemical. Our dataset consists of 63 insecticides, 45 herbicides, 42 fungicides, and 12 “other.” If a type of chemical does not belong to one of the three classes of chemicals we label it “other”[20] but ignore this category in the empirical analysis because the number of active chemical in this category were negligible. The correlation coefficient between BSI-herbicides and BSI-fungicides is 0.2 and similar for other pairs 0.5 for BSI-insecticides and BSI-fungicides, and 0.3 for BSI-herbicides and BSI-insecticides. With relatively weak correlations between pesticide chemical classes, disaggregating the BSI across chemical classes may provide more information and results in a more flexible estimation strategy.

Finally, annual bilateral trade of fresh fruits and vegetable products are merged with the constructed MRL database. The bilateral annual export flows of FVs between trading partners are obtained from the United Nations Commodity Trade Statistics Database at 6-digit level of harmonized system. Geographical distance is taken from the *Centre d’Etudes Prospectives et d’Informations Internationales* (CEPII) geo-distance dataset (Mayer and Zignago 2006).[21] Information on Regional Trade Agreements (RTAs) data is obtained from

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[19] While Russia reports a limited number of established MRLs, those established MRLs have the most stringent values compared to the US standards.

[20] Rodenticides, molluscicides, nematicides, plant growth regulators and acaricides

[21] CEPII is an independent European research institute on the international economy stationed in Paris,

Grant (2013) and De Sousa (2012). Table 2 presents the summary statistics for the variables in our econometric model. Our sample contains 95 exporters and importers[22], 51 fruit and vegetable products over a two-year sample period. The final sample includes 257,647 observations, of which 65% observations are zero trade flows.[23]

VI. Results

The results are organized as follows. In section one we present qualitative illustrations of the MRL bilateral stringency index across countries, products and classes of chemicals focusing our attention on the EU and TPP markets. While these results illustrate basic trends and bilateral stringency levels across countries and products, they do not establish a more casual link between MRL policy dissimilarities and trade. Section two presents the formal econometric results to test and quantify the extent to which regulatory heterogeneity in MRL policies affect bilateral trade in fresh fruits and vegetables.

Bilateral Stringency Index

Table 3 presents the simple and trade-weighted averages of the overall BSI across partner countries assuming the US is the exporting nation.[24] Among the countries listed in table 3, Iceland, Norway, Switzerland, the EU, Russia, Turkey, Brazil and the United Arab Emirates have the highest stringency index based on simple averages of the BSI. These countries have a stringency index above 1.5, which shows a potentially high level of MRL stringency on fruit and vegetable imports compared to those in the U.S. Commodities with high stringency indices between the US and Norway include brussels sprouts, cauliflower, broccoli, spinach, avocado and leeks with stringency levels between 1.91 and 2.01. The top imported commodities such as apples and grapes have more moderate stringency levels of 1.45 and 1.29, respectively, but still above one indicating that US firms faces greater MRL stringency against their exports of these products to Norway compared to serving the domestic market. Russian's imports of melons and cherries from the US, have BSIs of 2.17 and 1.92, respectively. The BSIs for the rest of the countries listed in table 3 show moderate stringency levels between one and 1.5. It is also worth mentioning that major importers of US

France. CEPII's research program and datasets can be accessed at www.cepii.com. CEPII uses the great circle formula to calculate the geographic distance between countries, referenced by latitudes and longitudes of the largest urban agglomerations in terms of population.

[22] The number of countries is extended to 95 from the original numbers, which were 85. In particular, we kept those EU members who have fruits and vegetables trade flow but did not report MRLs in the global MRL database. The missing MRL values are replaced with the MRLs reported by EU. EU harmonized its MRL system since 2008.

[23] Zero trade flows are created based on a country's "potential" to trade with a given bilateral partner. In order to explore if a country has the potential to export a given commodity, we assume if an exporter did not export a given commodity at least 3 times over a period of 10 years (2004-2014) with a given partner, we consider that the exporter does not have the potential to export a given commodity.

[24] Recall the BSI is not symmetric and thus the direction of trade flow matters.

FVs such as Canada, Mexico and Japan have MRL stringency levels comparable to the U.S. such that the simple average and trade weighted average BSI are close to unity, on average. Table 3 also displays BSIs for many of the Trans Pacific Partnership (TPP) countries. Among TPP countries, Chile and Australia have higher equally weighted stringency level of BSIs of approximately 1.29. However, Chile's trade weighted BSI is much higher than its unweighted BSI, suggesting that commodities sourced from the US with greater values of imports (i.e., larger trade weights) tend to have stricter MRL tolerances. Conversely, for the EU, the trade-weighted BSI is lower than the equally weighted BSI, indicating that US export intensity is higher in less stringent MRL product categories.

Figure 1a plots the average trade-weighted bilateral stringency indices for different classes of chemicals, where the vertical axis shows the average stringency level faced by U.S. exporters. Again, Brazil, the EU, Iceland, Norway and Russia rank the highest (> 1.5) in stringency among all US trading partners for the BSI index on insecticides. Switzerland has an insecticide index around 1.5 and the remaining countries have moderate levels below 1.5 for insecticides. A broader range of countries/regions, including some in the TPP and T-TIP, have herbicide BSIs above 1.5, including Chile, the EU, Indonesia, Norway, Peru, Saudi Arabia, Switzerland, Turkey and Vietnam. BSI-insecticides and BSI-herbicides for China and Japan, and the BSI-fungicides for New Zealand are the only countries with indices below one. It is also apparent that BSI-fungicides generally have a stricter stringency index compared to other classes of chemicals. While the highest level of stringency belongs to BSI-herbicide for Turkey, the BSI-fungicides are consistently close to or above 1.5.

Figure 1b displays a distribution plot (boxplot) of the range of the BSIs across commodities within a given country and is useful to decipher the variability of MRL policies for select destination countries. The figure shows that although China has a relatively less stringent MRL policy overall, it has the highest variation among the three pesticide indices compared to other countries (the exception being fungicides for Indonesia). On the other hand, Canada, Japan, Australia and Korea have a much narrower MRL policy span.

Table 4 and figure 2 both illustrate average and the variability, respectively, of BSI levels across commodities. Table 4 illustrates that vegetables have stricter BSI levels using both equally and trade weighted averages across US trading partners. Specifically, brussels sprouts, broccoli, cauliflower, avocados and celery are five commodities facing the most restrictive MRL tolerances globally. Among fresh fruits and vegetables, apples, leaf lettuce, strawberries and grapes rank the highest among US exports in 2013 and 2014, but on average face moderate stringency levels ranging between 1.14 (grapes) to 1.32 (strawberries). In figure 2 fresh tomato exports face the smallest range and lowest level of

MRL tolerances for each pesticide class and commodity. For cherries, broccoli, leaf lettuce and onions, however, not only the level but also the variability of MRLs is relatively high.

Given the sensitive nature of NTMs and food safety issues, we next analyze the BSI indices with respect to EU and TPP markets to assess current regulatory heterogeneity faced by US exporters (figures 3a and 3b). For TPP markets (figure 3a), our results indicate that eight commodities (grapefruits, lemons and limes, oranges, leaf lettuce, tomatoes, pears and quinces, apples, peaches and nectarines) out of 48 commodities with significant exports rank in the top 20 *least* stringent indices to TPP countries in 2013 and 2014. Apples, which ranked 17 out of the 20 of the least stringent MRL tolerances, is the top export of US fruits and vegetables to TPP countries. Here the BSIs are close to one which illustrates that TPP MRLs are closer to equivalent with the US compared to those faced in the EU (figure 3b). The top fruit and vegetable exports to the EU are grapefruit, apples, grapes, onions, raspberries and blackberries, strawberries, and cherries. According to our results, three commodities (apples, grapes, and mushrooms and truffles) rank in the top 10 least stringent indices to the EU in 2013 and 2014. On the other hand, avocados and cauliflower rank among the most stringent MRL commodities exported to the EU. Comparing the EU and TPP markets indicates that the stringency levels for the EU are much stricter than those in TPP markets, with values frequently exceeding 1.5 for certain commodities and pesticide classes in the former, compared to values much closer to unity in the latter.

Figure 3c also plots the variations of BSI indices for each chemical class for the EU and TPP markets. The boxplot of the EU indices shows stricter indices and wider dispersion compared to TPP markets, particularly among fungicides indicating room for negotiations that would be subject for committee for scenario investigation over MRLs in this class of pesticides. In addition, we conducted a non-parametric two-sample Wilcoxon rank-sum test to test whether differences between the indices across the EU and TPP markets are significantly different. The equality of the BSI indices was easily rejected. Finally, we simplify the analysis further by categorizing commodities into bin ranges: less than one, between one and 1.5, and greater than 1.5.[25] Interestingly, the majority of BSIs for TPP markets fall into the middle category, with a smaller but still significant number of commodities – 15, 11 and 5 for insecticides, herbicides and fungicides, respectively – exhibiting BSIs less than one. This underscores the important point that for most fruit and vegetable products, TPP countries have roughly similar BSIs to those of the US. In the EU, the majority of BSIs fall into the last

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[25] Note that, some fruits and/or vegetables do not have BSI indices across all the classes of chemicals. Therefore, the total numbers of commodities across different classes of chemicals for the EU and/or TPP markets are not equal.

category - greater than 1.5 – indicating a more stringent MRL policy environment and the potential for MRL harmonization in the trade negotiations.

Econometrics Results

The econometric estimates reported here shed light on the degree to which differences in MRL regulatory stringencies affect bilateral exports of fruits and vegetables between trading partners. The econometric results are organized as follows. First, to get an overall picture we discuss the aggregate impact of the BSI on trade flows across all countries. Second, we discuss the results by augmenting the model with indicators for US exports to TPP and EU markets and the interaction of these with the BSI. In the third section, we distinguish between the different classes of chemicals to determine if the trade flow effects of the aggregate BSI results are systematically driven by a particular class of chemicals. Finally, we examine the effects of MRL policy dissimilarities on the probability of exporting and the intensity of exports using a Heckman model. In all regressions, importer, exporter and commodity fixed effects are included and standard errors are clustered by country-pairs.

OLS, Poisson and Negative Binomial Model

Table 5 considers the aggregate BSI effects across all countries and between the US-EU and US-TPP. The results for geographical distance and belonging to a mutual regional trade agreement are of the correct sign and statistically significant across all specifications. In terms of MRLs, the BSI coefficient is negative and statistically significant across all model specifications, OLS [26], Poisson and Negative binomial models, in columns (1)-(6) suggesting that higher BSIs – indicative of a more stringent tolerance in the destination compared to the origin market – significantly reduces bilateral fresh fruit and vegetable exports. Thus, overall, the impact of MRL tolerances is trade impeding because it likely requires more careful production, testing and compliance costs to serve international markets with stricter food safety guidelines. The economic interpretation is similar to a semi-elasticity since the dependent variable is in logs while the BSI is a levels index. A stricter BSI equivalent to an increase in the BSI by 0.1 at the mean (the BSI mean is 1.039, which is about 10.39% increase) reduces fruit and vegetable exports by 7% in the OLS model (column 1) and 8.8% in the Poisson model (column 2).

However, these results are across all countries and products in the database. When we introduce individual controls for US exports to the EU and TPP markets (table 5, column 4-6), the results paint an asymmetric picture of MRL trade impacts. Here, the BSI coefficient across three models is more negative and statistically significant for US exports to the EU, but

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[26] Table 5, columns (1) and (4) present the results using the OLS specification. In the OLS model, the dependent variable is the log of one plus the value of trade flows to avoid dropping zero trade flows.

has a positive and statistically significant interaction coefficient for US trade with TPP partners (in the OLS and Negative Binomial Models, columns 4 and 6 respectively).[27] The result of F-test for the difference between the estimated coefficients also confirms that the US-EU and US-TPP coefficients are statistically different (p-value = 0.00). Quantitatively, the estimates imply that stricter bilateral stringencies of MRLs (by 0.1 at the mean) declines US export of fruits and vegetables to the EU members by a striking 23.6% in OLS model (table 5, column 4). Thus, the effect of stricter MRLs appears to be quite elastic with respect to its effect on US-EU trade.

In addition to the baseline estimations, we also allow the BSI effect to vary over fungicides, herbicides and insecticides. The results are contained in Table 6. In a similar format to table 5, columns (1)-(3) report the results of chemical class-specific BSIs across all trading partners, while columns (4)-(6) distinguish between US-EU and US-TPP markets. The results are robust. With the exception of fungicides in the Poisson model, more restrictive MRL policies tend to impose negative and statistically significant trade distortions (columns 1-3). Moreover, the effects are largest in the insecticide class of MRLs.

In columns (4)-(6), the impact of BSIs for different classes of chemicals on the US-EU and the US-TPP markets are more sensitive and fragile given the lower number of observations in these categories making identification more challenging. However, some interesting findings emerge. First, the negative BSI effects reported in columns (4)-(6) turns out to be driven almost entirely by insecticides for the US-EU and insecticides in particular for the US-TPP markets. The results have important policy implications because they suggest specific chemical classes on which trade negotiators can focus attention. Second, herbicide indices of MRL stringency appear to enhance US exports. Because the BSIs measure the stringency of MRL heterogeneity for the US-TPP markets, the results for herbicides suggest that tighter restriction boost trade, and the potential demand enhancing impact of MRL policy with respect to herbicide MRLs.

Furthermore, to examine which countries, among TPP countries are driving the fact that the TPP BSI coefficient is much less strict than EU BSI for US exports, we estimate the model with three sub-samples (table 7).[28] First, we exclude Canada and Mexico from the TPP sample (column 2), the TPP BSI for US export coefficient (0.37) magnitude decreases slightly (nothing else changes), and indicates negligible changes of BSI coefficient (from 0.39 to 0.37),

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[27] The mean BSI index for EU and TPP markets are 1.59 and 1.12, respectively.

[28] Because of the excessive amount of zero trade values in our data, we only report the results of Negative Binomial for these model specifications, as suggested by trade literature. It should also be noted that, for these model specifications, we did not estimate the BSI effect over difference class of chemicals due to the limited number of observations in these categories.

excluding Canada and Mexico compared to the full sample. However, if we only exclude Canada from the TPP market data (column 3), interestingly the parameter estimated became even more positive comparing to the full sample (from 0.39 to 0.59). In the third sub-sample, when we exclude Mexico from the TPP market data as most of its MRLS follow US MRLs. An interesting result arises. The TPP BSI coefficient drops from 0.39 (full sample column 1) to 0.18 (column 4). Thus, the less positive BSI reported in column (4) turns out to be driven partially by Mexico.

Intensive and Extensive Margins of Trade

We now turn to the results of the Heckman model, which is presented in table 8. Similar to the previous section, we first discuss aggregate BSI impact on the probability of exporting and the intensity of exports. Second, we discuss the results of aggregate BSI impact on the US exports to EU and TPP markets based on the augmented model. Third, the results of chemical class-specific BSIs across all trading partners are presented. Finally, we report and discuss the results of the dis-aggregate BSIs based on the different classes of chemicals for US exports to EU and TPP markets. In all regressions, importer, exporter and commodity fixed effects are included and standard errors are clustered by country-pairs. Furthermore, through all specifications, we include common language as the exclusion restriction in the selection model. We also use common religion as exclusion restriction[29] and the results are robust.

The results in table 8, columns (1) and (2) suggest that MRL stringency reduces the probability of market entry by -0.03 (selection equation, where the marginal effect [30] of MRL stringency is -0.03) as well as decreases the intensity of exports by -0.51. Thus, MRL policies likely impart significant fixed and variable trade costs of exporting, judging by the negative and significant extensive and intensive margin results. Columns (3) and (5) distinguish the impact of MRL stringency on the probability of exporting and the intensity of export between US-EU and US-TPP markets. While MRL policy indicates a negative impact on the decision to export between US-EU and US-TPP (the marginal effect for the estimated parameter of MRL policy for US export to EU is negative and statistically significant (-0.12), but not statistically significant for US export to TPP markets), the impact of MRL tolerances between US-EU and US-TPP markets is opposite. MRL policy plays an impeding role on the intensity of US exports

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[29] Common religion may also strongly affect the export decision; however, once the new trade relation has been created, it may not impact the amount of trade. Data on common religion across country pairs are collected from Elhanan Helpman's homepage. In their study, Helpman et al. (2008) calculate the index of common religion between trading partners as (% Protestants in region *o* × % Protestants in region *d*) + (% Catholics in region *o* × % Catholics in region *d*) + (% Muslims in region *o* × % Muslims in region *d*).

[30] Since the selection equation is a probit model, we also estimate the marginal effects of the parameter estimated in the selection equation.

to EU (-1.15), while this impact is trade enhancing with respect to the US exports to TPP markets (1.06 and statistically significant). Previous studies in this line also find interesting results. Similar to the former result for US-EU, Jayasinghe, Beghin and Moschini (2010) also find a negative and statistically significant impact of MRLs on the probability and volume of US export demand for corn seeds. However, similar to the latter result for US-TPP markets, Disdier and Marette (2010) find while the impact of MRLs on extensive margin is negative but insignificant, it negatively and significantly affects the intensive margin of imported crustaceans. Furthermore, Crivelli and Groeschl's (2016) find interesting and similar results for their study of the impact of SPS measures on the extensive and intensive margin of trade. Their results (similar to us with respect to the US export to TPP markets) show SPS measures have a negative and significant impact on the market entry, which increase fixed costs of trade. However, SPS standards have positive and significant impact on the intensity of trade. In particular, those exporters who overcome the fixed costs of trade indicate the safety of their products to consumers, and consequently their standards have a positive impact on the intensive of trade.

Additionally, columns (5) and (6) report the results of chemical class-specific BSIs across all trading partners. The results show MRL policy has a negative impact across all chemical classification at both margins of trade. Lastly, columns (7) and (8) report the results of chemical class-specific BSIs while distinguishing MRL policy effects between US-EU and US-TPP markets. While the results are more sensitive and fragile because of the low number of observations in these categories, overall our findings are mostly consistent to our previous specifications. Where for those parameter estimated that are statistically significant, MRL policy has a negative effect on the extensive and intensive margins of trade for US-EU, while negative effect on the extensive margin of trade but positive effect on the intensive margin of trade for US-TPP markets. The coefficients on the gravity control variables are consistent with existing gravity estimates through all specifications. The geographical distance between two trade partners has negative impact on bilateral trades on both the probability of exporting and the volume of trade, while having RTAs fosters exports of fruits and vegetables between trade partners at both margins of trade. Common language reduces the fixed costs of trade and positively affects the probability of exporting.[31]

VII. Conclusions

This article quantifies the bilateral stringency index to assess how regulatory heterogeneity (and convergence) for pesticide tolerances used in the production process of

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[31] The results are consistent when we include common religion as the exclusion restriction in the model.

fresh fruits and vegetables impacts trade between the US and its partner countries in the aggregate and with respect to US and TPP markets. We develop the aggregated bilateral stringency index based on different classes of chemicals, which provides further insight as to the types of pesticides that influence trade flows. In particular, previous studies in this line of work often employ an aggregate measure of stringency or dissimilarity over all chemicals with established MRLs relative to the international standard, whereas we develop a bilateral stringency measure based on the fact that it likely matters more to exporters what the MRL policy is in the destination market as opposed to what tolerance level is advocated by Codex.

The results of the country-level index indicate that Brazil, Iceland, Norway, Switzerland, Turkey, and the EU rank among the most stringent among all US trading partners, Canada and China, two of the top markets for US exports of fruits and vegetables show moderate stringency levels, while Japan is consistently among the least restrictive MRL partners in our database. At the product level, brussels sprouts, avocadoes and celery rank among the highest MRL stringent commodities whereas the top US fruit exports consisting of apples, grapes, oranges, cherries and strawberries, have a moderate stringency index. Further, the results clearly indicate that there is a significant gap in regulations regarding maximum residue limits among several major US foreign markets for fruits and vegetables, particularly EU and TPP. For instance, the BSI-insecticide for apples is stricter than BSI-herbicide and BSI-fungicide between the US and the EU, while there is virtually no difference among the three classes of chemical indices for apple trade between the US and TPP markets. The stringency index results also provide a snapshot of regulatory heterogeneity between the US and its important export markets in the EU and TPP countries. Overall, the bilateral stringency indices suggest much stricter regulations for the EU compared to TPP markets for both fruits and vegetables and across different classes of chemicals, suggesting that trade negotiators will likely want to emphasize the dissimilarity of MRL tolerances in the T-TIP negotiations. It should be noted that T-TIP negotiations are still ongoing, but the US has withdrawn from the TPP agreement. While members of TPP were eager to implement this agreement, the new US administration, on January 23, 2017, removed the US from the TPP negotiations (*Daily News* January 2017), which ended the involvement of the US in this multilateral trade deal. However, the rest of the eleven nations are deciding to move ahead with TPP, with the possibility of expanding to other Asia-Pacific countries (*CNN* January 2017). Surprisingly, as TPP-11 is moving forward, the US administration is considering rejoining TPP (*Inside US Trade* April 2018). Despite the removal of the US from this agreement, the results of this research are useful for any bilateral trade agreement between the US and TPP countries individually (i.e., Japan). The US trade negotiators are seeking to consider some included provisions in the TPP agreement in the future bilateral and regional trade agreements.[32]

In regards to T-TIP, MRLs are very important as in the last round of negotiation, negotiators from both sides (EU and US) have spent a lot of time discussing the regulatory area, including regulatory coherence, technical barriers to trade, plant and animal health including SPS measures. Since 2013, there were fifteen rounds of T-TIP negotiations and the last one was held in October 2016. While the EU is very eager to have a strong trade and investment relationship with the US, the US is in the process of exploring where its trade policy stands (European Commission 2017). As discussed previously, EU and US regulatory approaches are very different. The EU Regulation 1107/2009 regulates based on hazard identification, without taking into account exposure or risk. This method is not consistent with the science-based risk assessment procedures for regulating crop protection products approach at both the U.S. Environmental Protection Agency's (EPA) regulations and the WTO SPS agreement. Therefore, the EU regulation approach blocks US agricultural exports because of heterogeneity in MRL regulations for food and feed, while the EU has a near-zero default value (0.01 ppm) (Crop Life America 2013). Thus, one of the main goals of T-TIP negotiation is to pursue regulatory convergence. In particular, regulatory heterogeneity presents serious economic and trade impacts. Both Crop Life America and the European Crop Protection Association are seeking to move towards U.S. pesticide regulations (Institute for Agriculture and Trade Policy 2016). Thus, the results of this study provide important policy implications as the EU-US negotiations move forward.

Using the bilateral stringency indices, we also empirically develop a formal econometric model to understand the trade restricting nature of these measures for fruits and vegetables. More importantly, our augmented trade model has the characteristic to distinguish the impact of MRL policy on exports across all potential exporters and between the US as an exporter and its main trading partners in the Trans-Pacific and Trans-Atlantic trade negotiations. We contribute to the analysis of SPS measures by estimating the impact of bilateral MRL

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[32] The following highlights some very important provisions impacting agricultural and food trade that are considered in the TPP agreement, which made this agreement different from previous regional and multilateral agreements. The TPP agreement considers the establishment of committees on agricultural trade and SPS measures to lower non-tariff barriers, harmonize regulations, and decrease the associated compliance costs. The general SPS provisions of TPP go beyond the WTO SPS Agreement— namely the rapid response mechanism, which helps quickly resolve SPS problems that lead to shipments being detained at the port of entry (Gonzalez 2016; *Inside U.S. Trade* 2016). This mechanism would require the importing party that stopped a shipment based on an adverse SPS result to provide notification within seven days. The latter is a key provision in TPP's SPS chapter that tightens the WTO standards to make it harder for countries to restrict imports on food safety grounds (*Inside U.S. Trade* 2016). The *2016 National Grain and Feed Association (NGFA)* report highlights "this rapid response to SPS measures and other technical barriers would reduce delays, disputes, rejections and risk" (Gonzalez 2016).

stringency using several specification models. Our findings shed light on the impact of MRL stringency on exports for fruits and vegetables across all trading partners, which impedes trade; it likely requires more careful production, testing and compliance costs to serve international markets with stricter food safety guidelines. However, when we introduce individual controls for US exports to the EU and TPP markets, the results paint a contrasting picture of MRL effects on US exports. The results suggest MRL policy impedes US exports to EU, while it enhances trade with respect to the US exports to TPP markets. The latter result is suggestive of the potentially demand enhancing of MRL policy. Therefore, it is important to take into account the preference of consumer in term of food safety.

Additionally, we also allow the BSI effect to vary over different classes of chemicals, fungicides, herbicides and insecticides. Our findings show the most negative BSI effect turns out to be caused almost entirely by fungicides and insecticides for the US-EU and insecticides for the US-TPP markets. This result is particularly interesting for trade negotiators – it may enable them to focus attention on specific chemical classes. Furthermore, herbicide indices of MRL stringency appear to enhance US exports to TPP markets. This suggests stricter MRL policy of the US may serve as a demand enhancing effect on the US exports to TPP markets, and tighter restriction boost trade. Lastly, an important consideration of MRL policies is whether exporting nations facing stringent MRL policies in destination markets actually export at all. Therefore, we point out the impact of MRL policy on a market entry barrier to all potential exporters, while decomposing exports into extensive and intensive margins of trade. Our results suggest that MRL stringency decreases both the probability of exports as well as the intensity of exports across all trading partners. Thus, MRL policies likely impart significant fixed and variable trade costs of exporting judging by the negative and significant extensive and intensive margin results. Hence, MRL policy constitutes a market entry barrier to all exporters.

VIII. References

Achterbosch, T., A. Engler, and M.L. Rau, M. 2009. Measure the measure : the impact of differences in pesticide MRLs on Chilean fruit exports to the EU. Paper presented at the International Association of Agricultural Economists Conference, Beijing, China, 08.

Anderson, J.E., and E. van Wincoop. 2003. Gravity and Gravitas: A Solution to the Border Puzzle. *American Economic Review* 93(1): 170–192.

Baldwin, R. 2000. Regulatory Protectionism, Developing Nations and a Two-Tiered World Trading System. Brookings Trade Forum. Washington, DC: Brookings Institute Press.

Baldwin, R., and D. Taglioni. 2006. Gravity for Dummies and Dummies for Gravity Equations. National Bureau of Economic Research Working Paper 12516.

Beghin, J. C., and J. C. Bureau. 2001. Quantification of sanitary, phytosanitary, and technical barriers to trade for trade policy analysis. Working Paper 01-WP291. Center for Agricultural and Rural Development, Iowa State University.

Beghin, J. 2014. The Protectionism of Food Safety Standards in International Agricultural Trade. Agricultural Policy Review, Center for Agricultural and Rural Developmnet (CARD), Iowa State University.

Beghin, J., M. Maertens, and J. Swinnen, 2015. Nontariff Measures and Standards in Trade and Global Value Chains, Annual Review of Resource Economics, *Annual Reviews* 7(1): 425-450.

Burnquist, H. L., K. Shutes, M.L. Rau, M.J. Pinto de Souza, and R. Nunes de Faria. 2011. Heterogeneity Index of Trade and Actual Heterogeneity Index – the case of maximum residue levels (MRLs) for pesticides. Poster prepared for presentation at the Agricultural & Applied Economics Association’s 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, 06.

Cameron, A.C. and P.K. Trivedi. 2010. Microeconometrics: Method and Applications. Cambridge University Press, New York.

Center for International Development at Harvard University. 2004. Sanitary and Phytosantary Measures and Technical Barriers to Trade Summary. Global Trade Negotitations Home Page. http://www.cid.harvard.edu/cidtrade/issues/spstbt.html

CEPII (2005), *GeoDist: Distances and Geographical Database* (Paris: CEPII). Available at: http://www.cepii.fr.

Chen, C, J. Yang, and C. Findlay. 2008. Measuring the Effect of Food Safety Standards on China’sAgricultural Exports. *Review of World Economics* 144(1): 83–106.

Cipollina, M., Laborde, D., & Salvatici, L. (2010). Do Preferential Trade Policies (Actually) Increase Exports? A Comparison between EU and US Trade Policies. Paper presented at the European Trade Study Group, Lausanne.

CNN.com. January 2017. TPP unravels: Where the 11 other countries go from here. http://www.cnn.com/2017/01/24/asia/tpp-other-11-countries-what-next/index.html

Crivelli, P. and J. Groeschl. 2016. The impact of Sanitary and Phytosanitary Measures on Market Entry and Trade Flows. *The World Economy*. 39(3): 444-473 doi: 10.1111/twec.12283

Crop Life America. 2013. U.S. Agricultural Exports Threatened by EU Pesticide Regulation. http://www.croplifeamerica.org/u-s-agricultural-exports-threatened-by-eu-pesticide-regulation/

De Sousa, J. 2012. The currency union effect on trade is decreasing over time, *Economics Letters* 117(3): 917-920.

Disdier, A., L. Fontaigné, and M. Mimouni. 2008. The Impact of Regulations on Agricultural Trade: Evidence from the SPS and TBT Agreements. *American Journal of Agricultural Economics* 90(2): 336–350.

Disdier, A.C. and S. Marette (2010), 'The Combination of Gravity and Welfare Approaches for Evaluating Nontariff Measures', *American Journal of Agricultural Economics*, 92, 3, 713–26.

Drogué, S., and F. DeMaria. 2010. Do different regulations in Maximum Residue Levels of pesticides affect trade competitiveness? The case of apples and pears. Presented at 12. Annual conference ETSG 2010, Lausanne, CHE (2010-09-09 - 2010-09-11). http://prodinra.inra.fr/record/40781

Drogué, S., and F. DeMaria. 2012. Pesticide residues and trade, the apple of discord? *Food Policy* 37(6): 641–649.

Epstein, R. 2013. Codex Alimentarius Committee on Pesticide Residues, Science and technology Program, USDA. ftp://ftp.fao.org/codex/alimentarius/a131_24e.pdf

European Commission. May 2014 and July 2017. Overview of FTA and other Trade Negotiations. http://trade.ec.europa.eu/doclib/docs/2006/december/tradoc_118238.pdf

Feenstra, R. 2004. Advanced International Trade:Theory and Evidence. Princeton, NJ: Princeton University Press.

Ferro, E., Otsuki, T., and Wilson, J. 2015. The effect of product standards on agricultural exports. Food Policy, 50:68-79.

Fontagne, L., M. Mimouni, and J.-M. Pasteels. 2005. Estimating the Impact of Environmental SPS and TBT on International Trade. *Integration and Trade* 22: 7–37.

Grant, J. H., E. Peterson, and R. Ramniceanu. 2015. Assessing the Impact of SPS Regulations on U.S. Fresh Fruit and Vegetable Exports. Journal of Agricultural and Resource Economics. 40(1): 144-163. Copyright 2015 Western Agricultural Economics Association. ISSN 1068-5502

Grant, J.H. and S. Arita. 2016 *Forthcoming*. Revealed Concerns: A New Look at the Impact of Non-Tariff Measures on Agri-Food Trade, Commissioned Paper, International Agricultural Trade Research Consortium (IATRC), June 2016.

Grant, J.H. 2013. Is the Growth of Regionalism as Significant as the Headlines Suggest?

Lessons for Agricultural Trade, *Agricultural Economics* 44(1): 93-109

Gonzalez, S. May 31, 2016. NGFA's TPP analysis breaks down impacts for each commodity. National Grain and Feed Association. *https://www.ngfa.org/newsletter/ngfas-tpp-analysis-breaks-impacts-commodity/*

Gower, J.C. 1971. A General Coefficient of Similarity and Some of Its Properties. *Biometrics* 27(4): 857-871.

Heckman,J. J. 1979. Sample Selection Bias and a Specification Error. *Econometrica* 47(1): 153–161.

Helpman, E., Melitz, M., and Y. Rubinstein. 2008. Estimating trade flows:Trading partners and trading volumes. *Quarterly Journal of Economics* 123: 441–487.

Inside U.S. Trade. Februray 2016. Key Innovations In TPP SPS Chapter Carved Out From Dispute Settlement, Vol. 34, No. 6. https://insidetrade.com/inside-us-trade/key-innovations-tpp-sps-chapter-carved-out-dispute-settlement

Institute for Agriculture and Trade Policy. 2016. When elephants dance: potential TTIP impacts on developing-countries' farms. https://www.iatp.org/blog/201606/when-elephants-dance-potential-ttip-impacts-on-developing-countries%E2%80%99-farms

Ishaq, M., Ping, Q., Haq, Z., Li, C., and C. Tong. 2016. Maximum residue limits and agrifood exports of china: choosing the best estimation technique. *Agricultural Economics* (Zeme?de?lská Ekonomika), 62(2):78_92.

Jayasinghe, S., J. Beghin, and G. Moschini. 2009. Determinants of World Demand for U.S. corn Seeds: The Role of Trade Costs. *American Journal of Agricultural Economics* 92 (4): 999–1010.

Josling, T., D. Roberts, and D. Orden. 2004. Food Regulation and Trade:Toward a Safe and Open Global System .Washington,DC: Institute for International Economics.

Kee, H. L., A. Nicita, M. Olarreaga. 2008. Import Demand Elasticities and Trade Distortions. *The Review of Economics and Statistics* 90(4): 666–682, by the President and Fellows of Harvard College and the Massachusetts Institute of Technologyta

Lawrence, R.Z. 1996. *Regionalism, Multilateralism, and Deeper Integration.* Washington, D.C.: The bookings Institution, Integrating National Economics Series.

Li, Y., and J.C. Beghin. 2014. Protectionism indices for non-tariff measures: An application to maximum residue levels. *Food Policy* 45(01): 57–68. http://doi.org/10.1016/j.foodpol.2013.12.005

Madden, B. 2014. MRL Meeting. Office of Pesticide Programs, Registration Division, U.S. Environmental Protection Agency.

Mayer, T., and S. Zignago. 2006. Notes on CEPII's Distance Measures. Unpublished manuscript. Paris, France, May. Available at: http://www.cepii.fr/ anglaisgraph/workpap/summaries/wp_resume.asp?annee=2011&ref=25& NoDoc=3877

Melitz, J. 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71(6): 1695-1725.

Moenius, J. 2004. Information versus Product Adaptation: The Role of Standards in Trade. Working Paper, Kellogg School of Management, Northwestern University.

Orden, D., J.C. Beghin, and G. Henry. 2012. Key Findings of the NTM-IMPACT Project. *The World Economy* 35(8): 967-972.

Organization for Economic Co-operation and Development. 2005. Agricultural Policies in OECD Countries: Monitoring and Evaluation in 2005. Paris, September.

Otsuki, T., J.S. Wilson, and M. Sewadeh. 2001. What Price Precaution ? European Harmonisation of Aflatoxin Regulations and African Groundnut Exports. *European Review of Agricultural Economics* 28(2): 263–284.

Peterson, E., J. Grant, D. Roberts, and V. Karov. 2013. Evaluating the Trade Restrictiveness of Phytosanitary Measures on U.S. Fresh Fruit and Vegetable Imports. *American Journal of Agricultural Economics* 95: 842–858. doi: 10.1093/ajae/aat015.

Pham, C., and W. Martin. 2008. Estimating the Gravity Model When Zero Trade Flows are Important (Economic Series 2008-03). Burwood, VIC, Australia: Deakin University, Faculty of Business and Law.

Preeg, E. H. 1998. *From Here to Free Trade*, University of Chicago Press, Chicago, IL.

Rau, M., K. Shutes, and S. Schlueter. 2010. Index of Heterogeneity of Requirements in International Agri-food Trade. Assesment of the Impacts of Non-Tariff Measures NTM on the Competitiveness of the EU and Selested Trade Partners. NTM Impact Working Paper 10/01.

Rau, M.L., K. Shutes, S. Schlueter, M. Poto, and B. van der. Meulen. 2010. Requirements in International Agri-Food Trade: Constructing an Index of Regulatory Heterogeneity. Assesment of the Impacts of Non-Tariff Measures NTM on the Competitiveness of the EU and Selested Trade Partners. NTM Impact Working Paper 10/03.

Santos Silva, J.M.C., and S.Tenreyro. 2006.The Log of Gravity. *Review of Economics and Statistics* 88 (4): 641–658. Santos Silva, J.M.C.,and S.Tenreyro. 2011. Further Simulation Evidence on the Performance of the Poisson Pseudo-Maximum Likelihood Estimator. *Economic Letters* 112 (2): 220–222.

Shingal, A., Ehrich, M., and L. Foletti. 2017. Re-estimating the Effects of Stricter Standards on Trade: Endogeneity Matters. Working paer EUI RSCAS; 2017/20; Global Governance Programme-262. http://hdl.handle.net/1814/45868. ISSN: 1028-3625

Smolka, S. 2006. The new EU-Regulation on Maximum Residue Levels of Pesticides in Food - An Overview. Paper presented at the Seminar of Pesticide Residues in Food – Regulation, Monitoring, Policy, Modra, Slovakia, 06. www.pan-germany.org, www.pesticide-residues.org

Swann,G.P., P. Temple, and M. Shurmer. 1996. Standards and Trade Performance: The UK Experience. *Economic Journal* 106: 1297–1313.

USDA FAS MRL Global database, https://www.globalmrl.com/home (accessed December 2013 and December 2014).

United States Trade Representative. 2014. Report on Sanitary and Phytosanitary Measures

Van Der Meulen, B.M.J., and M. Van Der. Velde. 2004. Food Safety Law in the European Union. European Food Law Institute serires. Published by Wageningen Academic Publishers, 09.

Wheat, D. 2013. Tighter EU Standards Threaten Exports of U.S. Apples, Pears. Capital Press, 09.

World Health Organization (WHO). 2009. Principles and methods for the risk assessment of chemicals in food. Published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organization and the World Health Organization, ISBN 978 92 4 157240 8 (NLM classification: WA 712), ISSN 0250-863X.

Wilson, J.S., and T. Otsuki. 2004. To Spray or Not to Spray: Pesticides, Banana Exports, and Food Safety. *Food Policy* 29(2): 131–146.

Wilson, J.S., T. Otsuki, and B. Majumdsar. 2003. Balancing food safety and risk: do drug residue limits affect international trade in beef? The Journal of International Trade & Economic Development. *Taylor and Francis Journals* 12(4): 377-402.

Winchester, N., M.L. Rau, C. Goetz, B. Larue, T. Otsuki, K. Shutes, C. Wieck, H.L. Burnquist, H. M.J. Pinto de Souza, and R. Nunes de Faria. 2012. The Impact of Regulatory Heterogeneity on Agri-food Trade. *World Economy* 35(8): 973–993.

Wolff, C. 2014. SPS Issues at the WTO. Thematic SPS Workshop on Risk Analysis, WTO, Centre William Rappard, Geneva, 10.

World Trade Organization. 2012. World Trade Report. Trade and public policies: A closer look at non-tariff measures in the 21st century.

WTO Committee on SPS Measures. 2013. Specific Trade Concerns, G/SPS/GEN/204/Rev.13, 02.

Xiong, B., and J.C. Beghin. 2012. Does European Aflatoxin Regulation Hurt Groundnut Exporters from Africa? *European Review of Agricultural Economics* 39 (4): 589–609

Xiong, B. and J. Beghin. 2013. Stringent maximum residue limits, protectionism, and competitiveness: The cases of the us and canada. In Beghin, J., editor, Frontiers of Economics and Globalization. Emerald Press, Bingley, West Yorkshire, UK.

Xiong, B. and J. Beghin. 2014. Disentangling demand-enhancing and trade-cost effects of maximum residue regulations. *Economic Inquiry*, 52(3):1190-1203.

Yeung, M., W.A. Kerr, B. Coomber, M. Lantz and A. McConnell. 2017. *Declining International Cooperation on Pesticide Regulation*. Palgrave Studies in Agricultural Economics and Food Policy. ISBN 978-3-319-60551-7 ISBN 978-3-319-60552-4 (eBook). DOI 10.1007/978-3-319-60552-4.

Table 1. Comparing MRL Patterns across Countries with Codex and US MRLs

Region	More stringent than Codex % (1)	More stringent than US % (2)	Number of established MRLs (3)	Number of non-established MRLs (4)
Brazil	61	64	2,065	12,246
Turkey	51	64	1,454	12,857
Russia	53	68	904	13,407
Switzerland	42	62	9,167	5,144
Iceland	35	64	10,361	3,950
Norway	35	64	10,361	3,950
Taiwan	45	55	6,271	8,040
European Union	32	63	10,513	3,798
Israel	20	54	5,247	9,064
United Arab Emirates	0	60	10,871	3,440
South Korea	34	45	7,852	6,459
Argentina	10	51	4,530	9,781
Chile	8	46	5,511	8,800
Australia	38	51	5,191	9,120
Indonesia	5	47	384	13,927
Vietnam	5	46	4,242	10,069
Brunei	8	43	4,856	9,455
Thailand	1	45	3,927	10,384
Malaysia	3	44	4,168	10,143
Saudi Arabia	1	43	4,033	10,278
Canada	37	19	5,242	9,069
India	2	40	4,425	9,886
Singapore	5	40	4,514	9,797
South Africa	0	57	10,956	3,355
China	21	43	827	13,484
United States	30	0	14,311	0
New Zealand	0	35	4,704	9,607
Japan	17	32	9,146	5,165
Gulf Cooperation Council[1]	12	26	398	13,913

Note: Codex numbers of established MRLs are 3,839 and non-established MRLs are 10,472.

[1] Gulf Cooperation Council consists of Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia

Table 2. Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Trade flow	$796,281	$11.6 mil.	$0.000	$1660.0 mil.
Log Distance	8.587	1.000	4.394	9.894
RTA	0.372	0.483	0.000	1.000
BSI	1.039	0.317	0.000	2.715
BSI-Fungicides	1.040	0.340	0.000	2.717
BSI-Herbicides	1.051	0.402	0.000	2.711
BSI-Insecticides	1.045	0.367	0.000	2.715

Note: Number of observation equal to 257,647

Table 3. The BSI Indices at Country Level for Different Class of Chemical (assuming the US as origin country)

	BSI	
Region	**Equally weighted**	**Trade weighted**
Iceland	1.679	1.587
Norway	1.673	1.680
Switzerland	1.620	1.518
European Union	1.620	1.567
Russia	1.596	1.559
Turkey	1.570	1.403
Brazil	1.551	1.657
United Arab Emirates	1.507	1.377
South Africa	1.459	1.466
Taiwan	1.426	1.456
Israel	1.360	1.288
Chile	1.288	1.460
Australia	1.277	1.181
Argentina	1.263	1.290
Indonesia	1.252	1.087
South Korea	1.251	1.204
Thailand	1.243	1.201
Saudi Arabia	1.232	1.207
Brunei	1.192	1.206
Vietnam	1.168	1.174
Peru	1.165	1.191
India	1.151	1.157
Singapore	1.144	1.112
Malaysia	1.142	1.131
GCC[1]	1.117	1.131
Canada	1.115	1.121
New Zealand	1.084	1.063
China	1.066	1.054
Mexico	1.000	1.000
Japan	0.952	0.922

[1] GCC: Gulf Cooperation Council

Figure 1a. The BSI Indices at Country Level for Different Class of Chemical- Trade Weighted (assuming the US as origin country)

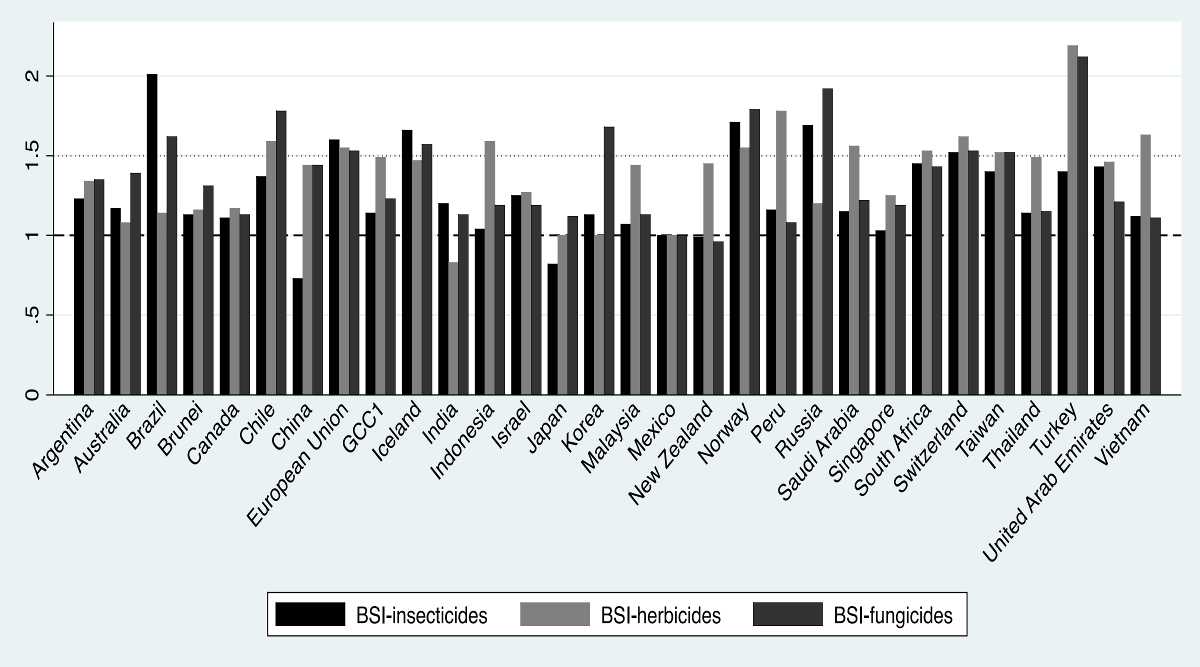

Figure 1b. The Box Plot BSI Indices at Country Level for Different Class of Chemical- Trade Weighted (assuming the US as origin country)

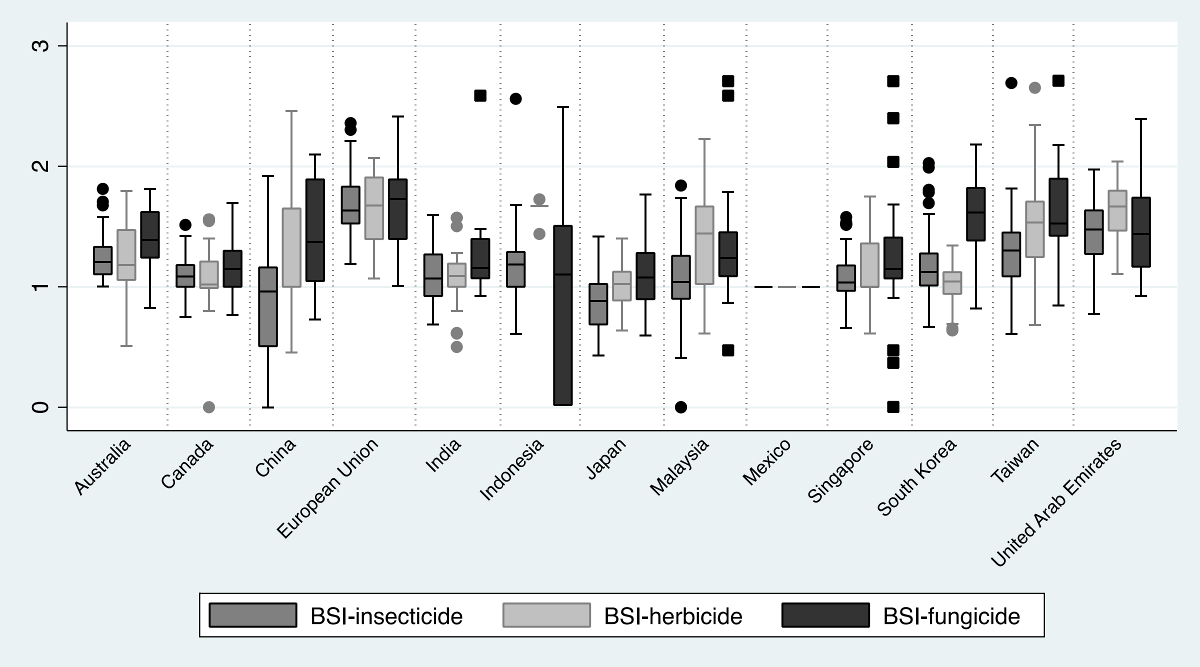

Table 4. The BSI Indices at Commodity Level for Different Class of Chemical (assuming the US as origin country)

	BSI	
Commodity	**Equally weighted**	**Trade weighted**
BRUSSELS SPROUTS	1.618	1.204
BROCCOLI	1.607	1.273
CAULIFLOWER	1.566	1.181
AVOCADOS	1.557	1.300
CELERY	1.557	1.308
MANGOES	1.533	1.750
CARROTS	1.482	1.187
PINEAPPLES	1.478	1.353
ONIONS	1.477	1.306
LEEKS	1.417	1.225
PAPAYAS	1.405	1.088
ASPARAGUS	1.404	1.205
HEAD LETTUCE	1.381	1.196
SPINACH	1.371	1.026
POTATOES	1.344	1.202
EGGPLANTS	1.337	1.023
STRAWBERRIES	1.320	1.187
PEPPERS	1.317	1.225
LEAF LETTUCE	1.296	1.042
FRESH BEANS	1.286	1.169
SQUASH, PUMPKINS ARTICHOKE &	1.279	1.210
BANANAS	1.275	1.309
CUCUMBERS	1.272	1.158
PEAS	1.262	1.182
RASPBERRIES & BLACKBERRIES	1.262	1.205
KIWIFRUIT	1.256	1.223
CHERRIES	1.251	1.161
APPLES	1.248	1.139
MELON	1.231	1.100
PEARS & QUINCES	1.228	1.130
PEACHES & NECTARINES	1.228	1.183
GRAPEFRUIT	1.223	1.103
CRANBERRIES & BLUEBERRIES	1.220	1.140
GARLIC	1.212	1.249
LEMONS & LIMES	1.204	0.953
PLUMS & SLOES	1.199	1.107
ORANGES	1.193	1.052
APRICOTS	1.190	1.137
MANDARINS & CLEMENTINES	1.168	0.959
TOMATOES	1.168	1.049
GRAPES	1.144	1.105
DATES	1.140	1.039
FIGS	1.079	1.004
LEGUMES EXC PEAS BEANS	1.068	1.009
MUSHROOMS & TRUFFLES	0.875	0.868

Figure 2. The Box Plot BSI Indices at Commodity Level for Different Class of Chemical Insecticides, Herbicides and Fungicides

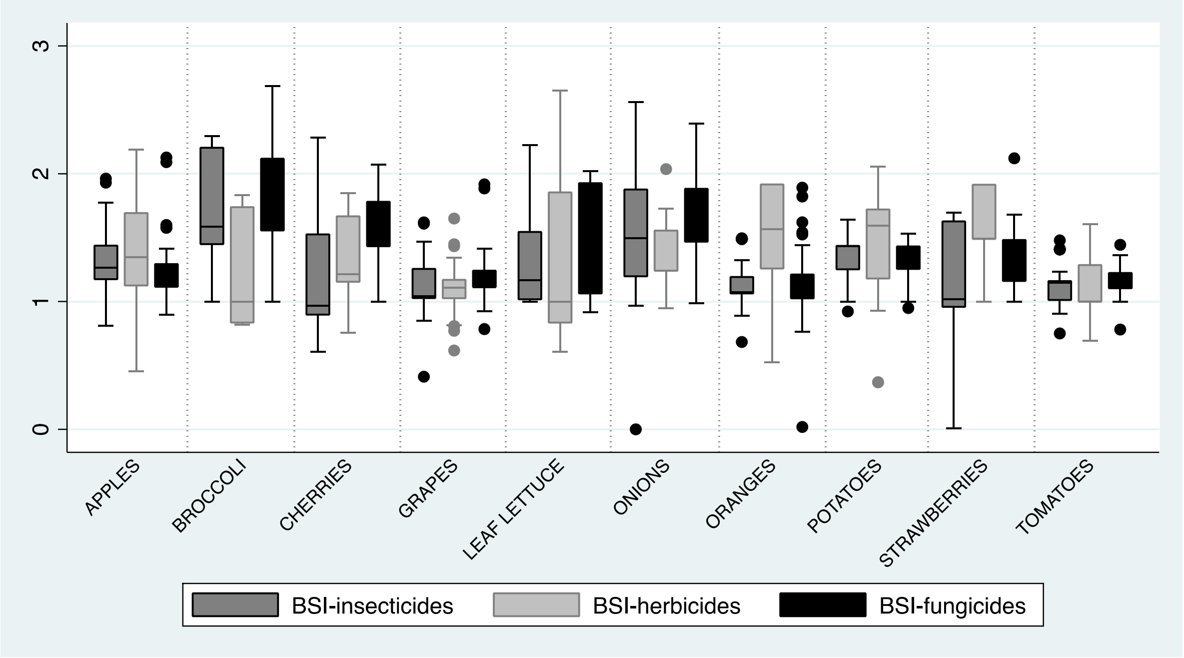

Figure 3a. TPP Stringency indices for Top US Exports – Trade Weighted

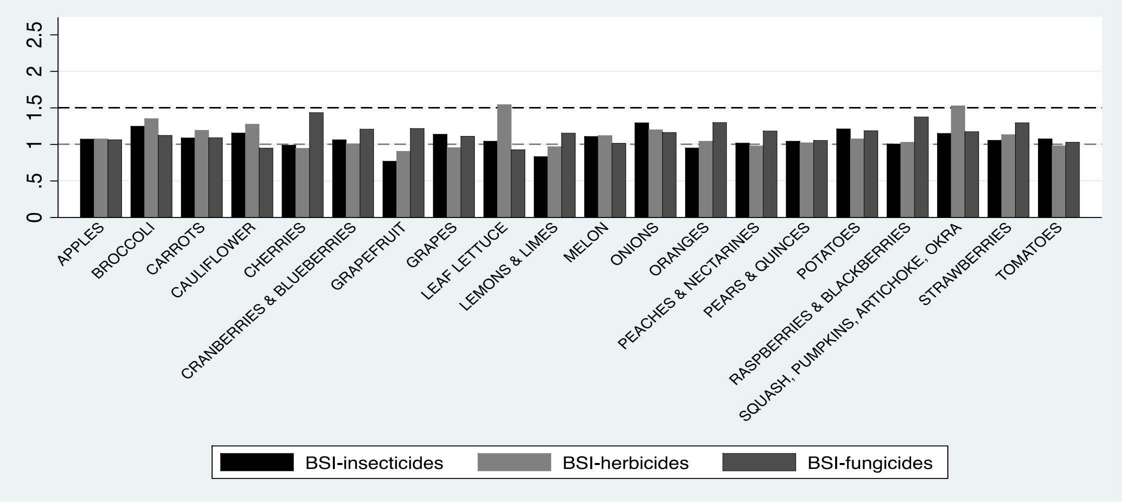

Figure 3b. The EU Stringency Indices for Top US Exports – Trade Weighted

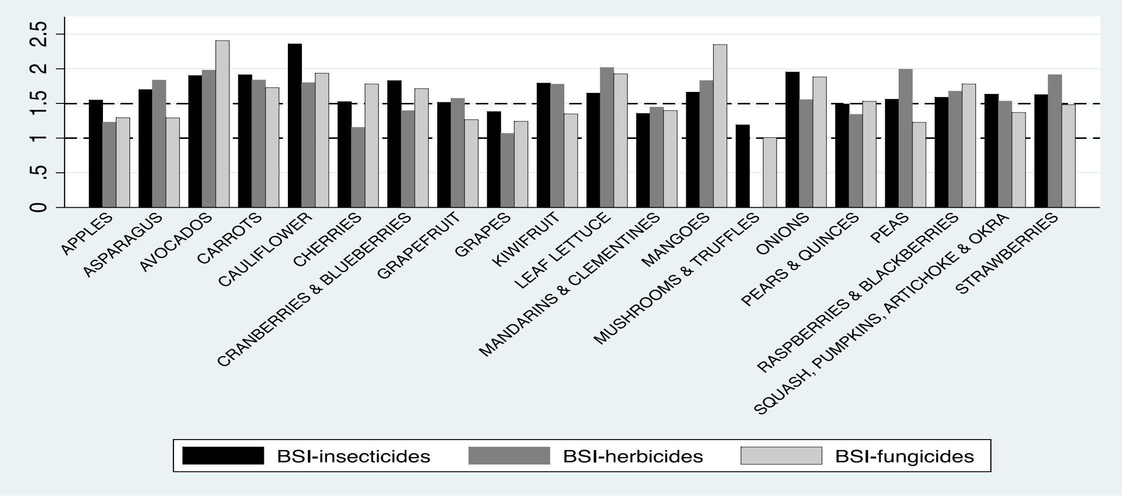

Figure 3c. The box plot BSI indices for different classes of chemicals across the EU and TPP markets – Trade Weighted

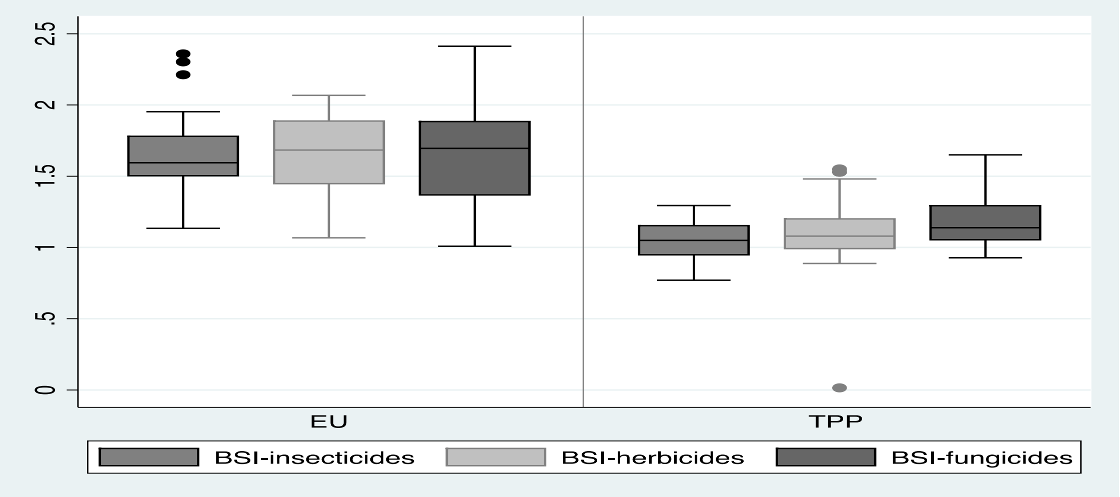

Table 5. Bilateral Stringency Indices Impacts on Exports of Fruits and Vegetables

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Estimation Method	**OLS**	**Poisson**	**Negative Binomial**	**OLS**	**Poisson**	**Negative Binomial**
Fixed Effects Included						
BSI	-0.70***	-0.88***	-0.44***	-0.68***	-0.86***	-0.41***
	(0.03)	(0.15)	(0.08)	(0.03)	(0.15)	(0.08)
BSI $_{\text{US-EU}}$				-2.36***	-1.38***	-1.58***
				(0.08)	(0.14)	(0.09)
BSI $_{\text{US-TPP}}$				0.70***	-0.15	0.39***
				(0.11)	(0.2)	(0.11)
Log Distance	-1.69***	-0.99***	-1.34***	-1.70***	-1.00***	-1.36***
	(0.01)	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)
RTA	0.99***	1.07***	0.80***	0.93***	0.98***	0.73***
	(0.02)	(0.1)	(0.05)	(0.02)	(0.1)	(0.05)
Observations	257,647	257,647	257,647	257,647	257,647	257,647
(pseudo) R^2	0.527	0.572	0.308	0.529	0.598	0.309

Note: The dependent variable is the log of one plus the value of exports in column (1) and (3) and the level of exports in column (2) and (5). The dependent variable in column (3) and (6) are scaled by million. Robust standard errors are in parentheses. One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively. Fixed effects included importer, exporter & commodity.

Table 6. Bilateral Stringency Indices Impacts on Exports of Fruits and Vegetables

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Estimation Method	**OLS**	**Poisson**	**Negative Binomial**	**OLS**	**Poisson**	**Negative Binomial**
Fixed Effects Included						
BSI-Fungicides	-0.27***	0.002	-0.34***	-0.25***	-0.04	-0.32***
	(0.04)	(0.14)	(0.08)	(0.04)	(0.14)	(0.08)
BSI-Herbicides	-0.39***	-0.47***	-0.34***	-0.38***	-0.51***	-0.31***
	(0.03)	(0.09)	(0.06)	(0.03)	(0.1)	(0.06)
BSI-Insecticides	-0.51***	-1.05***	-0.68***	-0.49***	-0.95***	-0.65***
	(0.04)	(0.18)	(0.08)	(0.04)	(0.18)	(0.08)
BSI-Fungicides $_{\text{US-EU}}$				-0.54	-0.33	-0.87**
				(0.44)	(0.91)	(0.38)
BSI-Herbicides $_{\text{US-EU}}$				-0.26	0.55	0.84*
				(0.48)	(0.73)	(0.5)
BSI-Insecticides $_{\text{US-EU}}$				-1.70***	-1.51	-1.46***
				(0.62)	(0.93)	(0.53)
BSI-Fungicides $_{\text{US-TPP}}$				-0.07	0.54	0.5
				(0.39)	(0.33)	(0.33)
BSI-Herbicides $_{\text{US-TPP}}$				0.75***	1.14***	-0.32
				(0.28)	(0.3)	(0.26)
BSI-Insecticides $_{\text{US-TPP}}$				-0.11	-1.61***	0.29
				(0.43)	(0.38)	(0.4)
Log Distance	-1.71***	-1.00***	-1.37***	-1.71***	-1.02***	-1.39***
	(0.01)	(0.04)	(0.02)	(0.01)	(0.04)	(0.03)
RTA	0.93***	1.08***	0.84***	0.86***	0.97***	0.75***
	(0.03)	(0.1)	(0.05)	(0.03)	(0.11)	(0.05)
Observations	207,258	207,258	207,258	207,258	207,258	207,258
(pseudo) R^2	0.542	0.614	0.312	0.544	0.592	0.313

Note: The dependent variable is the log of one plus the value of exports in column (1) and (3) and the level of exports in column (2) and (5). The dependent variable in column (3) and (6) are scaled by million. Robust standard errors are in parentheses. One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively. Fixed effects included importer, exporter & commodity.

Table 7. Bilateral Stringency Indices—Subsample TPP markets

Estimation Method	**Negative Binomial**			
	Full Sample	**Sub-Sample**		
Fixed Effects Included	**(1)**	**(2)**	**(3)**	**(4)**
BSI	-0.41***	-0.41***	-0.41***	-0.41***
	(0.08)	(0.07)	(0.07)	(0.07)
BSI $_{\text{US-EU}}$	-1.58***	-1.60***	-1.53***	-1.63***
	(0.09)	(0.09)	(0.09)	(0.09)
BSI $_{\text{US-TPP}}$	0.39***			
	(0.11)			
BSI $_{\text{US-TPP (excluding Canada and Mexico)}}$		0.37***		
		(0.11)		
BSI $_{\text{US-TPP (excluding Canada)}}$			0.59***	
			(0.10)	
BSI $_{\text{US-TPP (excluding Mexico)}}$				0.18***
				(0.11)
Observations	257,647	257,647	257,647	257,647
(pseudo) R^2	0.309	0.309	0.309	0.309

Note: The dependent variable in all columns are scaled by million. Robust standard errors are in parentheses. One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively. Fixed effects included importer, exporter & commodity.

Table 8. Bilateral Stringency Indices Impacts on Exports of Fruits and Vegetables

Estimation Method	**Heckman Selection Model**							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	Selection Pr(exp_{odk} *>0*	*Outcome Equation*	*Selection Equation*	*Outcome Equation*	*Selection Equation*	*Outcome Equation*	*Selection Equation*	*Outcome Equation*
BSI	-0.17***	-0.51***	-0.17***	-0.49***				
	(0.02)	(0.05)	(0.02)	(0.05)				
BSI $_{\text{US-EU}}$			-0.78***	-1.15***				
			(0.04)	(0.07)				
BSI $_{\text{US-TPP}}$			-0.02	1.06***				
			(0.06)	(0.11)				
BSI-Fungicides					-0.09***	-0.32***	-0.09***	-0.28***
					(0.02)	(0.06)	(0.02)	(0.06)
BSI-Herbicides					-0.11***	-0.23***	-0.11***	-0.21***
					(0.01)	(0.04)	(0.01)	(0.04)
BSI-Insecticides					-0.09***	-0.50***	-0.09***	-0.46***
					(0.02)	(0.07)	(0.02)	(0.07)
BSI-Fungicides $_{\text{US-EU}}$							-0.26	-0.05
							(0.23)	(0.37)
BSI-Herbicides $_{\text{US-EU}}$							-0.03	0.16
							(0.19)	(0.39)
BSI-Insecticides $_{\text{US-EU}}$							-0.46**	-1.30***
							(0.22)	(0.5)
BSI-Fungicides $_{\text{US-TPP}}$							-0.34***	-0.21
							(0.09)	(0.34)
BSI-Herbicides $_{\text{US-TPP}}$							0.21**	0.58**
							(0.07)	(0.25)
BSI-Insecticides $_{\text{US-TPP}}$							0.08	0.68*
							(0.11)	(0.37)
Log Distance	-0.71***	-1.23***	-0.71***	-1.26***	-0.73***	-1.26***	-0.73***	-1.30***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
RTA	0.29***	0.62***	0.29***	0.52***	0.25***	0.69***	0.25***	0.57***
	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.04)
Common Language	0.31***		0.31***		0.29***		0.29***	
	(0.01)		(0.01)		(0.02)		(0.02)	
Observations	257,647		257,647		207,258		207,258	
Estimated rho	0.093***		0.109***		0.096***		0.129***	
	(0.009)		(0.009)		(0.010)		(0.009)	
Estimated lambda	0.275***		0.325***		0.284***		0.383***	
	(0.028)		(0.027)		(0.030)		(0.028)	

Note: Robust standard errors are in parentheses. One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively. Fixed effects included importer, exporter & commodity. Common Language is the exclusion restriction variable in the model.