WP 2010-21
October 2010

Working Paper

Charles H. Dyson School of Applied Economics and Management
Cornell University, Ithaca, New York 14853-7801 USA

How important are sanitary and phytosanitary barriers in international markets for fresh fruit?

Bradley J. Rickard, and Lei Lei

How important are sanitary and phytosanitary barriers in international markets for fresh fruit?

Bradley J. Rickard, Assistant Professor
Charles H. Dyson School of Applied Economics and Management
Cornell University
Ithaca, NY 14853
Tel: +1.607.255.7417
E-mail: bjr83@cornell.edu

and

Lei Lei, Graduate Student
Charles H. Dyson School of Applied Economics and Management
Cornell University
Ithaca, NY 14853

Abstract: International markets for agricultural products are often subject to a range of trade barriers, and horticultural products are no exception. This paper examines the economic implications of tariffs and sanitary and phytosanitary (SPS) regulations that are applied to global markets for fresh apples and fresh oranges. We calculate regional-level tariff rates and ad valorem equivalents for SPS barriers following the price-wedge approach. A simulation model is developed and used to assess the price, quantity, and welfare implications of reducing tariffs, removing SPS barriers, and removing SPS barriers that have been identified as a Special Trade Concern (STC) by the World Trade Organization. Results suggest that a 36% reduction in global tariffs would lead to greater welfare gains than would the elimination of SPS measures in apple markets. However, in orange markets we find that SPS measures have much larger economic implications for producers and consumers. Here a 36% reduction in tariffs would lead to smaller overall welfare effects compared to removal of all SPS measures, and only slightly larger effects than those from removal of STCs alone.

Keywords: Apples; International trade; Oranges; Sanitary and phytosanitary regulations; Simulation model; Tariffs; Trade policy reform.

JEL Classification: K23, Q17, Q18

October 2010

How important are sanitary and phytosanitary barriers in international markets for fresh fruit?

1. Introduction

Horticultural crops represent a large share of the global value of agricultural trade, and international markets for these products are increasingly important in many regions of the world. Table 1 shows import values for the top twenty-five horticultural crops in 2005; the total import value for the crops listed in Table 1 was $68.8 billion, and the total import value for all horticultural commodities was approximately $96 billion in 2005 (FAO 2010). The importance of these crops in total agricultural trade is highlighted when compared to the traded values of major meat and grain products. In 2005, global imports of key meat products (pig meat, chicken meat, and cattle meat) were valued at $21.4 billion and grain products (wheat, corn, soybeans, and rice) were valued at approximately $60 billion (FAO 2010). The final column in Table 1 shows the increases in nominal value of trade between 1991 and 2005; on average, the nominal value of trade across the horticultural commodities listed in Table 1 increased by 117.1% between 1991 and 2005.

Similar to other agricultural commodities, trade in horticultural crops is affected by a range of barriers including domestic support in selected markets, tariffs, and in many cases sanitary and phytosanitary (SPS) measures. Domestic support comprises a substantial share of total revenues for many horticultural crops in the European Union (Stuart, 2005; Roberts and Gunning-Trant, 2006), but elsewhere there is very little domestic support applied in horticultural markets. Tariffs for horticultural products are relatively high compared to other agricultural commodities, and are widely applied in various regions (see Gibson, Whitley, and Bohman 2001). Increasingly, SPS measures have become more prevalent for many horticultural crops imported into the United States (USDA-ERS 2009) and elsewhere (Disdier, Fontagné, and Mimouni 2008). The World Trade Organization (WTO) case that examined the apple trade dispute between Japan and the United States generated much interest in the economic effects of SPS regulations for horticultural crops (e.g., Calvin and Krissoff 1998; Roberts and Krissoff 2004; Yue, Beghin, and Jensen 2006; Calvin, Krissoff, and Foster 2008). In addition, Peterson and Orden (2008) studied the welfare effects of SPS measures applied to avocado trade between the United States and Mexico; Romano and Thornsbury (2006), Sunkist Growers (2006) and USITC (2006) examined the role of SPS measures in selected citrus markets.

Economists have devoted some attention to the implications from potential reductions in subsidies and tariffs for agricultural commodities as both have been included on the negotiating agenda of the WTO (Sumner 2000; Bagwell and Staiger 2001). Much of this work has found that reductions in tariffs would have much larger global welfare effects than would reductions in domestic support (e.g., Hoekman, Ng, and Olarreaga 2004; Rickard and Sumner 2008). This result is driven by the fact that domestic support is predominantly applied to farm commodities and tariffs are applied to farm commodities and value-added food products.

Agricultural economists have long emphasized that the effects of non-tariff barriers need to be studied carefully (e.g., Hillman 1978, Thilmany and Barrett 1997; James and Anderson 1998, Wilson and Antón 2006; Cipollina and Salvatici 2008), and within this effort there is room for work that leads to a better understanding of the relative effects of various trade barriers applied to agricultural products. Research has examined the effects of tariffs and non-tariff barriers in poultry markets (Peterson and Orden, 2005), in seed corn markets (Jayasinghe, Beghin and Moschini 2009), and for cut flowers (Lui and Yue 2009); however, these relative effects have not been assessed in international markets for fruits and vegetables.

We extend research in this arena by simulating the welfare effects that would result from reductions in tariffs and SPS regulations applied to fresh fruit products. Specifically, we focus on trade barriers applied in global markets for apples and oranges, and we chose these crops for two reasons. First, both fruit crops are widely produced and consumed, and international markets are important for apples and oranges. Data from countries in similar geographical areas were aggregated to construct six regions (North America, South America, Europe, Africa, West Asia, and East Asia), and the information in Table 2 outlines production and consumption patterns for both crops in these six regions[1]. In addition to the intra-regional trade flows that exist, Table 2 shows that approximately 9.4% of fresh apples and 9.5% of fresh oranges are traded outside of the producing region. Second, of the SPS disputes for fruit products reported to the WTO between 1995 and 2009, 14.3% were for apples and another 16.3% were for citrus products, including oranges (WTO 2010a). Outside of the trade dispute between Japan and the United States, the effects of SPS measures in global apple markets have not been studied in detail. There is also evidence that SPS measures are important in global markets for citrus yet these effects have not been quantified carefully. Furthermore, because trade barriers applied to oranges are often similar to those applied to other citrus crops, the results for oranges may be able to shed some light on the likely effects of trade barriers applied to other citrus crops.

A simulation model is developed in this paper that allows for differentiated products and is used to examine the effects of trade barriers in global markets for apples and oranges. Including fruit from six different regions enables us to examine the trade diversion effects of trade barriers, and this is a phenomenon that would be missed in an analysis of trade policy that only examines bilateral trade. By also allowing some substitution between the differentiated fruits, we are also able to consider potentially important product diversion effects associated with reductions in various trade barriers. A model that includes substitution between fruit produced in different regions allows international markets to respond more fully to changes in trade policies.

2. A closer look at key SPS measures in fresh fruit markets

Between 1995 and 2009 there were 289 cases reported as a Specific Trade Concern (STC) to the WTO, of which 139 pertained to meat products, 27 to vegetable products, and 49 to fruit products (WTO 2010a). The STCs for fruit products were mostly raised for reasons related to plant health, food safety, and risk assessment. A summary of key SPS disputes applied to apples is provided in Table 3; for each SPS dispute we list the countries involved, the price in the importing country, the producer price in the exporting country, the distance between the countries, and whether the dispute was raised as a STC to the WTO. The United States was the exporting country in seven of the fifteen disputes listed in Table 3, although the United States only raised two of these cases as STCs to the WTO. Table 4 outlines the key SPS disputes that have been applied to fresh orange markets between 1995 and 2009. In Table 4 we see that the United States was the exporting country in seven of the eighteen disputes initiated, and one case was raised as a STC. Many of the SPS disputes involving oranges (and other fresh citrus products) centered on plant health issues involving citrus black spot, citrus canker, and sweet orange scab.

Economists have commonly converted SPS measures and other technical barriers to trade into tariff rate equivalents using the price-wedge approach (*e.g.*, Deardorff and Stern 1998;

Beghin and Bureau 2001). The price-wedge approach quantifies the impact of an SPS barrier as the difference between prices in the importing country and the exporting country, after accounting for various transactions costs. Commonly, transaction costs in the price-wedge method include tariffs and transportation costs, but do not explicitly account for all of the other factors that may create price differences between countries. For example, fruit quality, fruit variety, market power, and retail search costs are expected to influence international price differences for apples and oranges. Data to quantify such factors are not available, and are not included in our price-wedge calculation. We don't expect that fruit variety, market power, and retail search costs are important drivers of international price differences; however, there is some evidence that fruit quality may differ between fruit-producing countries (e.g., xxx 2019) and this may contribute to the observed price differences between regions. Therefore, the ad valorem rates calculated here represent the maximum impact, or an upper bound effect, of SPS measures. The price-wedge approach does assume that the imported product is a substitute for the domestically produced product; however, recent work has extended the framework to accommodate trade of differentiated products (Yue, Beghin, and Jensen 2006).

Others have quantified the effective rate of protection offered by SPS measures following an approach that assesses costs of compliance (*e.g.*, Hooker and Caswell 1999; Calvin, Krissoff, and Foster 2008; Peterson and Orden 2008; Karov, Roberts, and Grant 2009). If various transaction costs are difficult to quantify, or if there is significant heterogeneity between domestic and imported products, the cost approach may offer a more realistic assessment of the effect of an SPS measure. However, cost information associated with specific SPS measures is often difficult to collect, and is likely to vary widely across firms and management practices.

Furthermore, collecting costs of compliance becomes increasingly difficult as additional trade partners are included in the analysis. We employ the price-wedge approach given the number of regions and SPS measures that are included in our analysis. In addition, our simulation model is developed to accommodate substitution possibilities between imported and domestically produced products, but we incorporate substitution directly in the demand elasticities rather than in the price-wedge calculation.

The ad valorem rate for an SPS measure applied by country *k* to product *j* imported from country *h*, denoted as $\theta^{kh}{}_{j}$, is calculated following equation (1). Here the ad valorem rate for an SPS measure is the ratio of the producer price in the exporting country *h* ($P^{h}{}_{j}$) to the imported price in country *k* ($PM^{k}{}_{j}$) less ad valorem rates for tariffs applied by importing country *k* ($\tau^{k}{}_{j}$), and ad valorem rates that reflect domestic transportation costs in the importing country ($\delta^{k}{}_{j}$) and international transportation costs ($\omega^{kh}{}_{j}$). Country-level tariff rates for apples are listed in Table 5 and for oranges in Table 6 (International Customs Tariffs Bureau 2010; International Trade Administration 2010). For simplicity, and following the approach used in Calvin, Krissoff, and Foster (2008), transportation costs are set equal to a share of the import price. Baseline international transportation costs are also adjusted to account for the distances between major ports in the partner countries (Sea Rates 2010).

(1) $$\theta^{kh}{}_{j} = (P^{h}{}_{j}/PM^{k}{}_{j}) - \tau^{k}{}_{j} - \delta^{k}{}_{j} - \omega^{kh}{}_{j}$$

Equation (1) is used to calculate country-level ad valorem rates of support associated with SPS measures for apples and for oranges; these rates are subsequently used to quantify regional-level tariff-equivalent SPS rates. We calculate such rates for key SPS measures that have been documented in the academic literature, in government reports, and by industry stakeholders between 1995 and 2009. In addition, we use equation (1) to calculate the country-level rate of protection for the SPS measures raised as STCs by WTO members. Results from equation (1) are subsequently used to calculate regional-level SPS rates.

3. Simulation Model

A simulation model is developed and used to assess the implications of trade barriers applied to international markets for fresh apples and fresh oranges. A set of basic equations is used to describe the supply, demand, and international market clearing conditions for a selected fruit crop. This equilibrium displacement model includes markets for six outputs differentiated by production region, and accommodates trade flows between the six regions identified in Table 2. Muth (1964) provided the derivations for the one-output, two-input model, and agricultural economists have used equilibrium displacement models to study a wide range of research topics (*e.g.*, Gardner 1987; Alston, Norton, and Pardey 1995; Brester, Marsh, and Atwood 2004; Pendell et al. 2010).

The structure of the model is given in equations (2), (3), (4) and (5). The term Q is used to denote a quantity and P denotes a price; the suffix D denotes a variable on the demand side. Equation (2) represents demand for fresh fruit product j in region y, and is a function of the price of fruit j, prices of all other differentiated fruit products i, and exogenous demand shifters ($\boldsymbol{A_j}$). Equation (3) represents the supply of fruit product j; it depends on its own price and exogenous supply shifters ($\boldsymbol{B_j}$). The internal arbitrage conditions are described in equation (4); wedges between the price in the consuming region and the producing region are introduced through tariffs ($\tau^y{}_j$) and SPS regulations ($\theta^y{}_j$), expressed in ad valorem equivalents, applied to product j by region y. Equation (5) represents the international market clearing condition for fruit product j;

the quantity supplied of product *j* is the sum of the quantities demanded across the regions included in the model.

(2) $QD^y_j = f^y_j(PD^y_j, \boldsymbol{PD^y_i}; \boldsymbol{A^y_j})$

(3) $Q_j = g_j(P_j; \boldsymbol{B_j})$

(4) $PD^y_j = P_j(1 + \tau^y_j + \theta^y_j)$

(5) $Q_j = \sum_y QD^y_j$

Totally differentiating equations (2), (3), (4) and (5) and converting to elasticity form yields the linear elasticity model in equations (6), (7), (8) and (9). The linear transformation framework is convenient as an approximation but none of the results hinge on this simplification. These equations do not involve any explicit or implicit assumptions about the functional forms used, and it is not necessarily assumed that the elasticities are constant. However, it is assumed that the supply-and-demand functions are approximately linear at the initial point of market equilibrium (Alston, Norton, and Pardey 1995). In the following equations, for any variable *X*, E(*X*) represents the relative change in *X*, that is, E(*X*) represents d*X*/*X* where d refers to a total differential.

(6) $E(QD^y_j) = \eta^y_{jj}E(PD^y_j) + \sum_i \eta^y_{ji}E(PD^y_i)$

(7) $E(Q_j) = \varepsilon^y_j E(P_j)$

(8) $E(PD^y_j) = E(P_j) – E(1 + \tau^y_j) – E(1 + \theta^y_j)$

(9) $E(Q_j) = \sum_y[(QD^y_j/Q_j)E(QD^y_j)]$

Simulations are performed by exogenously specifying changes in the trade policy parameters in equation (8). Values for demand elasticities in equations (6), supply elasticities in equation (7), and initial quantity parameters in equation (9) are held constant as exogenous changes to policy are applied. The price elasticity of demand for the product *j* with respect to the price of product *i* in region *y*, is represented by η^{y}_{ji}. The own-price elasticity of supply of product *j* in region *y* is represented by ε^{y}_{j}. The term $E(1 + \tau^{y}_{j})$ represents a change in the regional ad valorem tariff rate and the term $E(1 + \theta^{y}_{j})$ represents a change in the regional ad valorem tax rate that is associated with a specific SPS measure for product *j* in region *y*. The initial quantity parameters in equation (9) are used to identify the shares of product *j* that are consumed in the various regions. Each parameter (QD^{y}_{j}/Q_{j}) is the share of total production of *j* that is consumed in region *y*. Our model with six differentiated products and trade between six regions yields a system of eighty-four equations.

3.1 Model parameters

Several parameters are required in the simulation model including supply elasticities, demand elasticities, changes in policy parameters, and initial quantity shares. Baseline supply elasticities are defined using estimates in the literature, and the own- and cross-price elasticities of demand are calculated following an Armington approach (Armington 1969). Parameters describing changes in tariffs are based on current ad valorem rates (International Customs Tariffs Bureau 2010; International Trade Administration 2010). Changes in SPS regulations are simulated using the country-level measures calculated in equation (1). The simulation model also requires parameters to describe initial quantity shares for the differentiated products in the six regions; these are calculated with the information shown in Table 2 (FAO 2010). Full details about the parameterization of elasticity parameters and policy changes are outlined below.

Following work by Davis and Espinoza (1998) and Zhao et al. (2000), we apply prior distributions to baseline elasticity parameters. We use a central tendency (equal to the baseline parameter) and specify a variance of 0.04 to develop beta (3,3) distributions that are applied to all supply, demand, and substitution elasticities (Brester, Marsh, and Atwood 2004). The beta distribution is a continuous two parameter distribution that is symmetrical when the parameters are equal, and is equivalent to the uniform distribution when the parameters are equal to 1. The beta distribution is often used to model events which are constrained to take place within an interval defined by a minimum and maximum value. The beta distributions selected here constrain demand elasticities to be negative and supply elasticities and substitution elasticities to be positive. The simulation model draws values for these parameters to generate an empirical distribution of results. The empirical distribution includes the results from 1000 iterations of the simulation model.

Several estimates of supply elasticities for fresh fruits, including apples and oranges, exist in the literature. Nerlove and Addison (1958), Askari and Cummings (1977), Gardner (1979), and Shumway and Lim (1993) among others, report estimates of the own-price elasticity of supply for various agricultural products; estimates for fresh fruits were typically less than 0.5 in the short-run and ranged between approximately 0.35 and 2.5 in the long-run. We also expect that the elasticity of supply of fresh fruits is relatively inelastic in response to reductions in trade barriers in the short- to medium-run. We set the baseline supply elasticity parameter for apples and oranges equal to 0.5 in our model. Because apples and oranges are perennial crops, we assume that all cross-price elasticities of supply for fruits produced in different regions are negligible, and these parameters are set equal to zero.

The matrices of own- and cross-price elasticities of demand for the fruit crops are calculated following an Armington-type specification (Armington 1969). The Armington model extends the homogeneous goods model to examine the demand response for a group of related, yet differentiated, goods. An Armington approach is often used to define the matrix of own- and cross-price elasticities of import demand when goods are differentiated by country of production. This specification requires parameters that describe the overall elasticity of demand for the group of goods, consumption shares for specific goods, and the degree of substitutability between goods. Piggott (1992) and Alston, Gray, and Sumner (1994) present an outline of the limitations of the Armington specification, as well as an overview of Armington models that have been used in earlier applications. The calculation used to compute the own-price elasticity of demand for product *j*, represented by η^{y}_{jj}, is shown in equation (10); the calculation used to compute the elasticity of product *j* with respect to the price of product *i*, represented by η^{y}_{ji}, is shown in equation (11).

(10) $\eta_{jj} = \zeta_j \eta - (1 - \zeta_j)\sigma$

(11) $\eta_{ji} = \zeta_i (\eta + \sigma)$

The share of consumption for product *j* is denoted as ζ_j, and the consumption shares used to calculate Armington elasticities are based on the information shown in Table 2. For example, the consumption share of apples produced in South America and consumed in Europe is 10.1%. The elasticity of substitution between the fruits produced in different regions is represented by σ in the Armington calculations. The elasticity of substitution parameter would be equal to zero when no substitution across products is possible, and increases as substitution possibilities increase. Estimates of the elasticity of substitution between fruit crops produced in different regions are not available; however, a range of parameters have been used in the agricultural economics literature to describe such substitution possibilities (e.g., Alston, Gray, and Sumner

1994; Yue, Beghin, and Jensen 2006). We set the baseline elasticity of substitution parameter equal to 1.0 in our simulation model, and as we assume that there is some substitution among fruit crops between regions but that fruit crops are more differentiated than grain or oilseed crops. The overall elasticity of demand for each fruit crop is represented by η in equations (9) and (10); using estimates reported in Huang (1985), Huang and Lin (2000), and USDA-ERS (2010) we set the baseline parameter equal to –0.5 in the apple model and in the orange model.

Policy parameters that describe possible changes in tariffs and SPS measures are used to introduce shocks in the simulation model. Here we consider a 36% reduction in regional-level tariff rates following the commitments agreed to under the Uruguay Round under the auspices of the WTO (WTO 2010b). We also model the effects of eliminating regional-level regulations stemming from SPS concerns, and eliminating regional-level regulations that have been identified at STCs by the WTO.

Country-level tariff rates (τ^{k}_{j}) are weighted by country-level consumption shares to construct regional-level tariff rates following equation (12). The ad valorem rate for an SPS measure applied by country *k* to product *j* imported from country *h*, denoted as θ^{kh}_{j}, is calculated using the price-wedge method introduced in equation (1). In equation (13) we use the calculated country-level ad valorem rates for SPS barriers to develop regional-level measures of protection. Here the country-level SPS measures are weighted by consumption shares in the importing region and by production shares in the exporting region. Country *k* is an importer of product *j* within region *y*, and country *h* is an exporter of product *i* within region *z*; product *j* and product *i* are fresh fruits differentiated by production region. When SPS measures are applied between countries in the same region, product *i* and product *j* are equivalent, as are regions *y* and *z*.

(12) $\tau^{y}_{j} = \Sigma_{k} [(QD^{k}_{j} / QD^{y}_{j}) \tau^{k}_{j}]$

(13) $\theta^{y}_{j} = \Sigma_{h} \Sigma_{k} [(QD^{k}_{j} / QD^{y}_{j})(Q^{h}_{i} / Q^{z}_{i}) \theta^{kh}_{j}]$

Table 5 lists country-level tariff rates for apples in key consuming countries in each region[2], and highlights the regional-level tariff rates that are calculated following equation (12). Regional-level tariffs for apples range between 1.3% and 35.9% across the six regions, and the highest tariff rate is in the West Asia region. For specified exporting countries, Table 5 also lists the country's regional production share and the country-level rate of protection from SPS measures generated using equation (1). Following equation (13), regional-level SPS rates for apples are calculated and shown in the final column of Table 5. Regional-level SPS rates range between 0% and 29.5%. Table 6 shows ad valorem equivalents for tariffs and SPS measures in the six regions for fresh oranges. Here we see regional-level tariff rates ranging between 2.2% and 31.0%, and the rate of protection from SPS measures ranges between 0% and 43.9% at the regional-level. Tables 5 and 6 reveal that the East Asia region applies the greatest number of SPS measures in apple and orange markets. Furthermore, North America employs a relatively high rate of protection from SPS measures, and a relatively low rate of protection from tariffs, for apples and oranges.

The final column in Tables 5 and 6 shows the rate of protection from STCs in parentheses. These regional-level rates range between 0% and 10.0% for apples, and between 0% and 43.8% for oranges. Overall, SPS and STC measures are important between certain trade partners, but because many individual countries comprise a small share of production or consumption regionally, the ad valorem rates for regional-level SPS and STC barriers are relatively modest in most cases. Tables 5 and 6 show the presence of tariffs in all regions, and in some regions they are quite large, whereas SPS are much less widespread.

3.2 Measuring changes in economic welfare

Simulated changes in prices and quantities from reductions in tariffs and rates of protection stemming from SPS measures also yield changes in measures of economic welfare. The changes in economic welfare accruing to consumers and producers are measured using information about initial product prices and quantities, and the simulated changes in product prices and quantities. The mean change in consumer surplus for product *j* in region *y* is calculated using information from 1000 iterations of the simulation model. Individual iterations draw values for elasticity parameters from empirical distributions that rely on estimates in the literature; however, values for initial prices and quantities remain the same across all iterations of the simulation model. Because a range of elasticities are incorporated into the calculations used to simulate changes in prices and quantities, empirical distributions of the changes in welfare measures are generated. Presenting the results in this way provides a range of the most likely effects of reductions in tariffs and elimination of SPS measures, and allows for a better understanding of how potential changes in trade barriers would impact stakeholders in international markets.

In equation (14) we outline the calculation used to assess welfare changes for consumers, which in our case is the first handlers, of product *j* in region *y* (denoted as ΔCS^{y}_{j}). Here the initial consumer price of product *j* in region *y* is denoted by PD^{y}_{j} and the initial quantity consumed of product *j* in region *y* is denoted by QD^{y}_{j}. The initial consumer price for product *j* in an importing region is the average import price; the initial consumer price in the producing region is the import price less any tariffs and transaction costs included in equation (1). The calculation used to characterize a change in producer surplus for product *j* (ΔPS_j) is shown in equation (15). Here the initial quantity supplied of product *j* is denoted by Q_j and the initial producer price for product j is denoted by P_j.

(14) $\Delta CS^y_j = -PD^y_j QD^y_j E(PD^y_j)[1 + 0.5E(QD^y_j)]$

(15) $\Delta PS_j = P_j Q_j E(P_j)[1 + 0.5E(Q_j)]$

The change in net surplus also depends on the change in taxpayer surplus, and we calculate these effects following equation (16). Changes in the taxpayer surplus accrue when tariff rates change or when the quantities to which they apply change. Changes in the taxpayer surplus in region *y*, denoted as ΔTS^y_j, depend on the initial tariff rate for product *j* in region *y*, denoted by t^y_j, initial quantities demanded, and changes in both tariff rates and quantities demanded.

(16) $\Delta TS^y = \sum_j t^y_j PD^y_j QD^y_j \{[1 + E(PD^y_j) + E(QD^y_j) + E(PD^y_j)E(QD^y_j)][E(1 + \tau^y_j)] - 1\}$

Combining the welfare effects from equations (14), (15), and (16), equation (17) shows how the change in net surplus in region *y* (ΔNS^y) is calculated.

(17) $\Delta NS^y = \sum_j(\Delta CS^y_j) + \Delta PS^y_j + \Delta TS^y$

The change in net surplus in region *y* is the sum of changes in consumer surplus across output markets, the change in the producer surplus, and the change in taxpayer surplus. For the simulated changes in tariffs and SPS measures applied to apple markets and orange markets, we report all welfare effects in the six regions, and the overall welfare effects. We also use the simulated changes in welfare to report a set of transfer efficiency ratios; these ratios show the change in producer or consumer surplus as a share of the change in net surplus.

4. Results

We simulate the effects of reducing import tariffs, removing tariff-rate equivalents of SPS measures, and removing tariff-rate equivalents of STCs in global markets for apples and oranges. Regional-level trade barriers are modeled as ad valorem price wedges between the price received by producers in exporting regions and the price paid by first handlers in importing regions. Exogenous policy changes used in our simulations are based on published tariff rates and SPS rates that were calculated following the price-wedge method. Table 7 reports the mean welfare changes for each policy experiment; below the mean change we also show the 95% confidence interval for each welfare change based on 1000 iterations of the simulation model. The range of values in the 95% confidence interval are relatively small and do not change the major thrust of the results, therefore, in the discussion below we will focus on the central values. Results from our analysis will facilitate a comparison of the welfare effects across types of trade barriers in the global market for apples and the global market for oranges. It also allows for a comparison of the relative effects of similar trade barriers in the two fresh fruit markets.

The first column of results in Table 7 shows the simulated effects of reducing global tariffs for apples by 36%. Here we see relatively large effects in Europe and West Asia, and both regions would experience substantial increases in consumer surplus. The overall mean change in global welfare from a 36% reduction in apple tariffs would be $135.3 million; the transfer efficiency ratios indicate that producers would receive 16.8% of the change in net surplus and consumers would receive 130.4%.[3] Our simulation results show that removing SPS barriers in apple markets would have much smaller effects than those from a 36% reduction in tariffs. Removing SPS measures would have important implications in specific regions, notably East

Asia, but the total net welfare effect would be only $27 million. The net effect of SPS measures in global apple markets is approximately 20% of that from a 36% reduction in apple tariffs. Removal of only STC barriers would lead to even smaller effects and a total welfare change of $8.5 million, which represents 6.3% of the change simulated from the tariff reduction. Furthermore, eliminating SPS or STC measures in apple markets would transfer most of the benefits to consumers with negligible transfers to producers.

The final three columns of results in Table 7 show the simulated effects of policy changes in global orange markets. Similar to the simulated results of tariff reductions for apples, a 36% reduction in tariffs applied to oranges has important effects in several regions. The total change in net welfare from a 36% reduction in tariffs would be $89.7 million; the transfer efficiency ratios shows that 32.4% of the net welfare change accrues to producers and 102.8% accrues to consumers. Removal of all SPS barriers in the global orange market would have large welfare effects for producers in North America and South America, consumers in Europe, and would lead to a net change in total surplus of $143.8 million. The net effect for producers and consumers from removing all SPS barriers is approximately 25% larger than the net effect of reducing tariffs by 36%. The simulation that considers removal of STCs in the orange market yields results that are surprisingly large; here we see a total change in net surplus of $70.6 million. The transfer efficiency ratios for the simulations that remove SPS and STC measures indicate that approximately 30% of the total change in net surplus is received by producers and approximately 75% of the total change in net surplus is received by consumers.

5. Industry and policy implications

International trade in fresh fruit is an important part of total agricultural trade. Apples and oranges are two of the most highly traded fruit products; they also face non-trivial tariffs and, in many cases, various SPS barriers. In this article we collect information about SPS regulations applied to apple and orange markets, and develop a framework that uses the price-wedge method to calculate the equivalent ad valorem rates of protection from the non-tariff barriers. A simulation model that accommodates trade between six regions and differentiated products is employed here to examine the welfare effects of reducing tariffs, removing SPS measures, and removing STCs in these markets. Simulation results indicate that modest reductions in tariffs would lead to substantial increases in welfare in most regions, and overall. Our findings also suggest that the welfare effects of SPS regulations are not consistent across the two fruit products, and that it is important to consider the effects of such measures separately for different products.

A 36% reduction in global tariffs would increase total producer and consumer welfare by $199.1 million in apple markets and by $121.3 million in orange markets. Removing SPS regulations would also have important welfare effects for selected trading partners; relative to tariffs, the total impact of SPS barriers appears to be much less important in apple markets and more important in orange markets. In addition, STCs do not appear to be a significant barrier to trade in apple markets, but removing them in orange markets would generate welfare gains that are in the range of the welfare gains associated with a 36% reduction in global tariffs. Because tariffs are applied widely, reductions in tariffs lead to greater trade diversion effects and more widespread welfare implications. However, SPS barriers tend to be less widely applied and our results show that removal of SPS barriers would lead to larger welfare changes for a concentrated subset of stakeholders. We would expect to see the welfare effects of reductions in SPS barriers to be even more concentrated in a bilateral trade framework, or in a model that introduces less trade diversion, or less product diversion.

There is a concern that non-tariff barriers, including SPS measures, are increasingly being used to impede trade in food and agricultural products. The WTO Agreement on the Application of SPS Measures introduced a much needed framework for identifying these non-tariff barriers, defining the appropriate level of protection (or the acceptable level of risk), and providing a mechanism for examining the related economic implications. However, many SPS regulations are used for the reasons they were developed, that is, to protect animal or plant life or health. If we assume that the group of SPS measures labeled as STCs represents those trade barriers that distort trade, and that the price-wedge method provides an upper bound on the ad valorem rate of support for these measures, then there is strong evidence that modest changes in tariffs will lead to larger overall welfare effects than would the removal of the STCs. Continuing with reductions in tariffs, similar to those that were introduced as part of the Uruguay Round, will also generate meaningful increases in producer and consumer surplus in many regions as tariffs are applied widely across countries and regions. Furthermore, if new SPS measures emerge as tariffs continue to decrease, the Agreement on the Application of SPS Measures may become even more effective in identifying potential STC measures that impede trade.

Table 1: Import values for the top 25 most traded horticultural commodities

Commodity	Total import value 2005 ($ billion)	Increase in nominal trade value 1991 to 2005 (%)
Coffee	10.09	29.4
Bananas	8.32	58.7
Tomatoes	5.04	119.9
Cocoa beans	4.86	102.9
Grapes	4.62	134.2
Apples	4.11	46.2
Tea	3.29	26.4
Oranges	3.11	42.3
Peppers	2.77	188.3
Almonds	2.31	238.3
Tangerines and mandarins	2.26	73.7
Lettuce and chicory	1.78	94.2
Pears	1.62	82.9
Pineapples	1.46	313.2
Peaches and nectarines	1.38	37.2
Cucumbers	1.37	67.7
Lemons and limes	1.36	115.2
Hazelnuts	1.34	164.5
Cashew nuts	1.34	199.9
Kiwi	1.33	77.7
Strawberries	1.31	78.7
Pistachios	1.05	121.8
Avocados	0.96	284.9
Cabbages	0.86	85.4
Garlic	0.84	143.2
Total	*68.80*	*117.1*

Source: FAO (2010).

Table 2: Production and consumption patterns for fresh apples and oranges in 2005

Apples	**Quantity Produced**	**Quantity consumed in:**					
		North America	South America	Europe	Africa	West Asia	East Asia
	Thousand metric tons						
North America	4,800	4,225	84	60	28	253	150
South America	4,300	77	3,351	432	140	220	60
Europe	15,400	4	4	15,000	100	160	2
Africa	1,900	6	2	180	1,650	50	3
West Asia	9,300	1	0	80	40	9,000	90
East Asia	26,700	43	1	340	33	715	25,560
Oranges							
North America	8,400	7,900	5	10	0	70	350
South America	26,400	30	26,000	180	2	6	2
Europe	5,800	5	2	5,650	3	80	3
Africa	5,600	100	1	740	4,100	530	120
West Asia	13,400	2	0	70	3	13,200	0
East Asia	3,300	60	0	10	3	100	3,100

Source: FAO (2010).

Table 3: A description of key SPS regulations in the global market for apples

Importing country	Import price ($/ton)	Exporting country	Producer price[a] ($/ton)	Distance[b] (thousand miles)	Source(s) describing SPS regulations	Specific Trade Concern
USA	724	EU[c]	356	3.64	European Commission (2010)	No
USA	724	South Africa	368	7.82	NFAPP (1996)	No
USA	724	China	453	6.47	WTO (2010a)	Yes
Mexico	836	USA	384	3.96	NFAPP (1996)	No
Cuba	600	Argentina	278	6.84	WTO (2010a)	Yes
Slovak Republic	733	Hungary	126	0.10	WTO (2010a)	Yes
S. Africa	704	China	453	9.42	South Africa DOA (2007)	No
Indonesia	522	USA	384	8.51	Becker (2006)	No
China	747	USA	384	6.47	WTO (2010a)	Yes
Japan	2339	USA	384	5.52	WTO (2010a)	Yes
S. Korea	2093	USA	384	6.08	Nogueira and Chouinard (2006)	No
Australia	746	USA	384	7.76	Nogueira and Chouinard (2006)	No
New Zealand	1243	USA	384	6.54	Nogueira and Chouinard (2006)	No
New Zealand	1243	Australia	1237	2.34	WTO (2010a)	Yes

[a] Producer prices represent prices in exporting countries (FAO 2010).

[b] Data taken from Sea Rates (2010); here 1 nautical mile equals 1.1508 miles.

[c] France was the top exporting member state of the EU for apples between 2000 and 2008, and therefore the French producer price for apples is used here.

Table 4. A description of key SPS barriers in the global market for oranges

Importing country	Import price ($/ton)	Exporting country	Producer price[a] ($/ton)	Distance (thousand miles)	Source(s) describing SPS regulations	Specific Trade Concern[b]
USA	992	Mexico	60	3.96	Becker (2006)	No
USA	992	Argentina[c]	121	8.38	WTO (2010a)	Yes
Mexico	245	USA	114	3.96	NFAPP (1996)	No
Barbados	639	Venezuela	143	0.34	WTO (2010a)	Yes
Costa Rica	63	Nicaragua	69	0.30	WTO (2010a)	Yes
EU	625	Brazil	47	3.60	WTO (2010a)	Yes
EU	625	Argentina[c]	121	6.41	WTO (2010a)	Yes
EU	625	Chile	166	7.51	Magalhães (2001)	No
EU	625	South Africa	189	5.84	Magalhães (2001)	No
EU	625	Uruguay	237	5.96	Magalhães (2001)	No
India	502	USA	114	9.35	Becker (2006)	No
Indonesia	534	USA	114	8.51	Becker (2006)	No
China	629	Argentina	121	12.74	WTO (2010a)	Yes
China	629	EU[d]	277	11.12	European Commission (2010)	No
China	629	USA	114	6.47	NFAPP (1996)	No
Japan	915	USA	114	5.52	WTO (2010a)	Yes
Australia	1104	USA	114	7.76	NFAPP (1996)	No
New Zealand	850	USA	114	6.54	Becker (2006)	No

[a] Producer price in the exporting country.
[b] Specific Trade Concerns (WTO 2010a) include seven disputes related to SPS measures for oranges between 1995 and 2009.
[c] Due to currency fluctuations in Argentina in 2005, we report the Argentine producer price in 2002.
[d] Spain has been the top EU exporting member state for oranges, and therefore the Spanish producer price for oranges is used here.

Table 5: Ad valorem rates for trade barriers in global apple markets

Importing region	Importing country	Importing country's regional consumption share	Ad valorem tariff rate[a]	Exporting region	Exporting country	Exporting country's regional production share	Country ad valorem SPS rate[b]	Regional ad valorem SPS rate[c] (STC rate)
North America			**1.3**					
	USA	88.0	1.3	Europe	EU	100	33.5	29.5 (0)
	USA	88.0	1.3	Africa	S. Africa	36.3	24.3	7.8 (0)
	USA	88.0	1.3	East Asia	China	89.9	12.6	10.0 (10.0)
South America			**16.5**					
	Mexico	20.5	33.0	North America	USA	91.5	5.1	1.0 (0)
	Cuba	0.03	4.0	South America	Argentina	28.0	28.9*	0.002 (0.002)
	Brazil	21.6	10.0					
	Argentina	24.6	10.0					
Europe			**16.0**					
	Slovakia	0.3	16.0	Europe	Hungary	4.3	61.6*	0.008 (0.008)
	Other EU-27	72.2	16.0					
Africa			**30.6**					
	South Africa	22.8	19.0	East Asia	China	89.9	5.6	1.1 (0)
	Egypt	33.3	20					
	Morocco	17.2	52.0					
	Algeria	15.1	47.0					
			12.2					
West Asia			**35.9**					
	Indonesia	12.3	15.0	North America	USA	91.5	3.9	0.4 (0)
	India	17.5	15.0					
	Iran	25.4	15.0					
	Saudi Arabia	4.4	0					
East Asia			**22.8**					
	China	90.5	23.0	North America	USA	91.5	4.3*	7.0 (3.6)
	Japan	3.1	25.0	North America	USA	91.5	45.9*	
	South Korea	12.3	50.0	North America	USA	91.5	17.7	
	Australia	1.2	10.0	North America	USA	91.5	15	
	New Zealand	1.4	0	North America	USA	91.5	51.8	
	New Zealand	1.4	0	East Asia	Australia	1.2	5.3*	0.001 (0.001)

[a] Sources: **International Customs Tariffs Bureau, 2010;** International Trade Administration, 2010.
[b] SPS measures that have been identified as STCs by the WTO are denoted with an asterisk.
[c] Country-level ad valorem tariff rates are weighted by the importer's consumption share and exporting production share to calculate regional-level SPS rates.

Table 6: Ad valorem rates for trade barriers in global orange markets

Importing region	Importing country	Importing country's regional consumption share	Ad valorem tariff rate	Exporting region	Exporting country	Exporting country's regional production share	Country ad valorem SPS rate	Regional ad valorem SPS rate (STC rate)
North America			**2.2**					
	USA	97.2	2.2	South America	Mexico	15.8	83.4	14.1 (1.3)
	USA	97.2	2.2		Argentina	2.7	49.0*	
South America			**15.2**					
	Mexico	15.8	38.0	North America	USA	100.0	37.0	5.8 (0)
	Barbados	0.01	35.0	South America	Venezuela	1.4	37.6*	0.003 (0.001)
	Costa Rica	2.0	14.0		Nicaragua	0.3	40.8*	
	Argentina	2.7	10.0					
	Brazil	68.2	10.0					
Europe			**16.0**					
	EU-27	90.6	16.0	South America	Brazil	67.8	68.5*	43.9 (43.8)
	EU-27	90.6	16.0		Argentina	3.4	49.3*	
	EU-27	90.6	16.0		Chile	0.5	38.6*	
	EU-27	90.6	16.0		Uruguay	0.7	27.8	
	EU-27	90.6	16.0	Africa	South Africa	22.3	37.2	7.5 (0)
Africa			**26.2**					
	Egypt	37.8	20.0					
	Morocco	13.9	50.0					
	Ghana	12.0	0.0					
	Algeria	10.5	47.0					
West Asia			**31.0**					
	India	23.9	40.0	North America	USA	100.0	16.0	10.9 (0)
	Indonesia	16.4	15.0		USA	100.0	44.1	
	Pakistan	12.6	25.0					
	Turkey	9.5	72.0					
	Iran	15.0	15.0					
East Asia			**23.1**					
	Japan	5.3	25.0	North America	USA	100.0	50.1*	10.2 (2.5)
	Australia	10.5	10.0		USA	100.0	63.7	
	New Zealand	0.6	0.0		USA	100.0	72.2	
	China	76.4	25.0	South America	Argentina	3.4	41.9	1.1 (0)
	China	76.4	25.0	Europe	EU	99.8	10.9	8.3(0)

Table 7: Effects of reductions in tariffs and SPS barriers in fresh fruit markets[a]

Importing region	Change in economic surplus for:	Apples			Oranges		
		Policy Change:					
		36% Tariff Reduction	**Remove SPS Barriers**	**Remove STC Barriers[b]**	**36% Tariff Reduction**	**Remove SPS Barriers**	**Remove STC Barriers[b]**
		Million USD					
North America	Producers	19.9 (14.3, 28.9)	3.5 (2.7, 4.7)	1.9 (1.4, 2.8)	20.2 (14.0, 30.8)	22.9 (15.9, 34.5)	4.7 (3.3, 7.1)
	Consumers	-17.0 (-21.7, -13.8)	13.0 (12.6, 13.5)	1.4 (1.0, 1.7)	-17.1 (-22.7, -13.1)	-7.2 (-13.3, -2.8)	-3.3 (-4.6, -2.4)
	Taxpayers	-0.003 (-0.008, 0.002)	-0.1 (-0.1, -0.02)	-0.004 (-0.01, 0.01)	-0.1 (-0.1, -0.03)	-0.03 (-0.1, 0.03)	0.002 (-0.004, 0.01)
	Net	2.9 (2.3, 3.6)	16.5 (16.1, 17.0)	3.3 (3.3, 3.4)	3.1 (2.8, 3.5)	15.7 (15.2, 16.3)	1.4 (1.4, 1.5)
South America	Producers	15.6 (11.9, 21.1)	-0.1 (-0.1, -0.001)	0.01 (0.003, 0.01)	3.1 (2.2, 4.0)	23.1 (15.1, 36.5)	20.5 (13.2, 32.7)
	Consumers	-5.6 (-8.4, -3.6)	0.5 (0.5, 0.6)	-0.02 (-0.03, -0.01)	-0.6 (-1.1, -0.04)	-22.1 (-29.2, -16.8)	-20.0 (-26.4, -15.2)
	Taxpayers	-1.1 (-1.3, -0.9)	-0.003 (-0.02, 0.01)	-0.0001 (-0.001, 0.001)	-0.4 (-0.4, -0.3)	0.01 (-0.01, 0.02)	0.01 (0.003, 0.01)
	Net	8.9 (8.2, 9.8)	0.5 (0.5, 0.5)	-0.01 (-0.02, -0.003)	2.1 (2.0, 2.2)	1.0 (0.9, 1.2)	0.5 (0.4, 0.6)
Europe	Producers	-15.2 (-36.5, 3.1)	4.3 (2.9, 6.9)	0.2 (0.1, 0.2)	-2.5 (-6.4, 1.2)	-9.3 (-18.8, -1.6)	-2.5 (-5.2, -0.5)
	Consumers	54.7 (44.0, 65.1)	-3.6 (-4.9, -2.7)	0.4 (0.3, 0.4)	35.7 (33.9, 37.3)	108.5 (102.5, 115.9)	68.7 (65.4, 72.5)
	Taxpayers	-7.9 (-8.7, -7.1)	0.04 (0.01, 0.1)	-0.002 (-0.003, -0.001)	-6.7 (-7.4, -5.8)	-5.0 (-6.5, -3.3)	-4.1 (-4.9, -3.1)
	Net	31.6 (31.0, 32.4)	0.7 (0.6, 0.9)	0.5 (0.5, 0.6)	26.5 (25.8, 27.2)	94.2 (90.7, 98.3)	62.1 (59.2, 65.7)
Africa	Producers	1.9 (1.5, 2.5)	0.1 (0.1, 0.1)	-0.001 (-0.002, -0.001)	20.8 (15.9, 27.8)	9.8 (7.6, 12.8)	-0.4 (-0.8, -0.1)
	Consumers	20.6 (20.1, 21.0)	0.02 (-0.03, 0.1)	-0.01 (-0.01, -0.01)	-11.4 (-14.4, -9.0)	-7.1 (-8.5, -6.0)	0.3 (0.1, 0.4)
	Taxpayers	-7.3 (-8.3, -6.2)	0.006 (-0.01, 0.02)	0.0001 (-0.001, 0.001)	-1.0 (-1.1, -0.8)	0.02 (0.01, 0.03)	-0.001 (-0.002, 0.001)
	Net	15.1 (13.9, 16.6)	0.2 (0.2, 0.2)	-0.01 (-0.01, -0.01)	8.4 (7.4, 9.8)	2.7 (2.2, 3.2)	-0.1 (-0.2, -0.01)

Importing region	Change in economic surplus for:	Apples			Oranges		
		Policy Change:					
		36% Tariff Reduction	Remove SPS Barriers	Remove STC Barriers[b]	36% Tariff Reduction	Remove SPS Barriers	Remove STC Barriers[b]
		Million USD					
West Asia	Producers	-11.5 (-25.0, -0.2)	-0.1 (-0.3, -0.02)	0.01 (0.002, 0.03)	-13.5 (-28.0, -1.6)	-0.5 (-1.1, -0.1)	-0.1 (-0.2, -0.002)
	Consumers	110.4 (103.4, 118.4)	0.7 (0.5, 0.8)	-0.01 (-0.1, 0.04)	53.9 (46.9, 61.3)	2.8 (2.6, 3.1)	0.1 (-0.02, 0.1)
	Taxpayers	-41.3 (-45.0, -36.8)	-0.03 (-0.1, 0.004)	0.01 (0.003, 0.01)	-15.0 (-16.4, -13.3)	-0.2 (-0.3, -0.1)	-0.003 (-0.01, 0.001)
	Net	57.7 (53.3, 62.8)	0.5 (0.4, 0.7)	0.01 (-0.04, 0.1)	25.5 (24.1, 26.8)	2.1 (2.0, 2.3)	-0.008 (-0.03, 0.02)
East Asia	Producers	12.0 (2.8, 21.1)	-7.7 (-16.3, -0.6)	-3.4 (-7.6, 0.1)	1.0 (0.02, 2.0)	-1.9 (-3.8, -0.4)	-0.5 (-0.9, -0.1)
	Consumers	13.3 (7.8, 18.5)	16.8 (12.6, 21.2)	8.1 (6.1, 10.1)	31.7 (31.1, 32.3)	31.0 (30.1, 32.0)	7.3 (7.1, 7.5)
	Taxpayers	-6.2 (-7.0, -5.3)	-0.3 (-0.6, 0.1)	-0.1 (-0.3, 0.1)	-8.4 (-9.5, -7.2)	-1.0 (-1.9, 0.2)	-0.1 (-0.4, 0.2)
	Net	19.1 (18.2, 20.2)	8.8 (8.5, 9.0)	4.6 (4.4, 4.7)	24.3 (23.2, 25.6)	28.1 (27.1, 29.3)	6.7 (6.5, 7.0)
Total	Producers	22.7 (-31.0, 76.5)	0 (-11.0, 11.1)	-1.3 (-6.1, 3.1)	29.1 (-2.3, 64.2)	44.1 (14.9, 81.7)	21.7 (9.4, 39.1)
	Consumers	176.4 (145.2, 205.6)	27.4 (21.3, 33.5)	9.9 (7.3, 12.2)	92.2 (73.7, 108.8)	105.9 (84.2, 125.4)	53.1 (41.6, 62.9)
	Taxpayers	-63.8 (-70.3, -56.3)	-0.4 (-0.8, 0.2)	-0.1 (-0.3, 0.1)	-31.6 (-34.9, -27.4)	-6.2 (-8.8, -3.1)	-4.2 (-5.3, 2.9)
	Net	135.3 (43.9, 225.8)	27.0 (9.5, 44.8)	8.5 (0.9, 15.5)	89.7 (36.5, 145.5)	143.8 (90.3, 204.0)	70.6 (45.7, 99.1)
	Producer Transfer Efficiency Ratio (%)	16.8	0	-1.5	32.4	30.7	30.7
	Consumer Transfer Efficiency Ratio (%)	130.4	101.5	116.5	102.8	73.6	75.2

[a] For each simulated welfare change, the 95% confidence intervals are shown in parentheses below the mean value.
[b] The column labeled STC includes only those SPS measures that were listed as Specific Trade Concerns (WTO 2010a).

References

Alston, J.M., R. Gray, and D.A. Sumner. 1994. "The Wheat War of 1994." *Canadian Journal of Agricultural Economics* 42:231-251.

Alston, J.M., G.W. Norton, and P.G. Pardey, 1995. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Ithaca, New York: Cornell University Press.

Armington, P.S. 1969. A theory of demand for products distinguished by place of production. *IMF Staff Papers* 16: 159–176.

Askari, H., and J.T. Cummings, 1977. Estimating agricultural supply response with the Nerlove model: A survey. *International Economic Review* 18: 257-292.

Bagwell, K., and R.W. Staiger. 2001. "Domestic Policies, National Sovereignty, and International Economic Institutions." *The Quarterly Journal of Economics* 116:519-562.

Becker, G. S. 2006. CRS Reports for Congress: Appendix A. *Selected SPS Concerns Between the United States and Top 25 Agricultural Trade Partners*. Available at: http://ncseonline.org/NLE/CRSreports/06Jul/RL33472.pdf

Beghin, J.C., and J.C. Bureau. 2001. "Quantitative Policy Anlaysis of Sanitary, Phytosanitary and Technical Barriers to Trade." *Economie Internationale* 87: 107–130.

Brester, G.W., J.M. Marsh, and J.A. Atwood. 2004. "Distributional Impacts of Country-of-Origin Labeling in the U.S. Meat Industry." *Journal of Agricultural and Resource Economics* 29:206-227.

Calvin, L., B. Krissoff, and W. Foster. 2008. "Measuring the costs and trade effects of phytosanitary protocols: A U.S.-Japanese Apple example." *Review of Agricultural Economics* 30(1): 120–135.

Calvin, L., and B. Krissoff. 1998. "Technical Barriers to Trade: A case Study of Phytosanitary Barriers and U.S.-Japanese Apple Trade." *Journal of Agricultural and Resource Economics* 23(2): 351–366.

Cipollina, M., and L. Salvatici. 2008. "Measuring Protection: Mission Impossible?" *Journal of Economic Surveys* 22(3): 577 – 616.

Davis, G.C., and M.C. Espinoza. 1998. "A Unified Approach to Sensitivity Analysis in Equilibrium Displacement Models." *American Journal of Agricultural Economics* 80:868-879.

Deardorff, A.V., and R.M. Stern. 1998. *Measurement of Nontariff Barriers: Studies in International Economics*. Ann Arbor: University of Michigan Press.

Disdier, A.-C., L. Fontagné, 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.

European Commission. 2010. The SPS export database. Available at: http://mkaccdb.eu.int/madb_barriers/indexPubli_sps.htm

Food and Agricultural Organization of the United Nations (FAO). 2010. FAOSTAT. Available at: http://faostat.fao.org/

Gardner, B.L., 1976. Determinants of supply elasticity in interdependent markets. *American Journal of Agricultural Economics* 61: 463-475.

Gardner, B.L. 1987. *The Economics of Agricultural Policies.* New York: MacMillan.

Gibson, P., D. Whitley, and M. Bohman. 2001. Profiles of Tariffs in Global Agricultural Markets. Market and Trade Economics Division, Economic Research Service, USDA. Agricultural Economic Report No. 796.

Hillman, J.S. 1978. "Non-tariff barriers: Major problem in agricultural trade." *American Journal of Agricultural Economics* 60(3): 491–501.

Hoekman, B., F. Ng, and M. Olarreaga. 2004. "Agricultural Tariffs or Subsidies: Which are More Important for Developing Economies?" *The World Bank Economic Review* 18:175-204.

Hooker, N.H., and J.A. Caswell. 1999. "A Framework for evaluating non-tariff barriers to trade related to sanitary and phytosanitary regulation." *Journal of Agricultural Economics* 50(2): 234–246.

Huang, K.S., 1985. U.S. Demand for Food: A Complete System of Price and Income Effects. Technical Bulletin Number 1714. Washington DC: United States Department of Agriculture, Economic Research Service.

Huang, K.S., and B. Lin, 2000. Estimation of Food Demand and Nutrient Elasticities from Household Survey Data. Technical Bulletin Number 1887. Washington DC: United States Department of Agriculture, Economic Research Service.

International Customs Tariffs Bureau. 2010. Available at**:** http://www.bitd.org/Search.aspx

International Trade Administration. 2010. *Country-Specific Tariff and Tax Information*. Available at: http://www.export.gov/logistics/eg_main_018142.asp#P130_5867

James, S., and K. Anderson. 1998. "On the need for more economic assessment of quarantine policies." *Australian Journal of Agricultural and Resource Economics* 42(4): 425–444.

Jayasinghe, S., J.C. 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.

Karov, V., D. Roberts, J.H. Grant, and E.B. Peterson. 2009. A Preliminary Empirical Assessment of the Effect of Phytosanitary Regulations on U.S. Fresh Fruit and Vegetable Imports. A selected paper presented at the Annual Meeting of the Agricultural and Applied Economics Association. Milwaukee, WI.

Liu, L., and C. Yue. 2009. "Non-tariff barriers to trade caused by SPS measures and customs procedures with product quality changes." *Journal of Agricultural and Resource Economics* 34(1): 196–212.

Magalhães, J. 2001. Sanitary and phytosanitary issues and the SPS Agreement. China/FAO Citrus Symposium. Beijing, China. Available at: http://www.fao.org/docrep/003/x6732e/x6732e13.htm#m

Muth, R.F. 1964. "The Derived Demand Curve for a Productive Factor and the Industry Supply Curve." *Oxford Economic Papers* 16:221-234.

National Food and Agricultural Policy Project (NFAPP). 1996. Phytosanitary and Sanitary Regulations: The Effect on International Trade of Fruits and Vegetables. Policy Paper Series No. 96-1. Available at: http://nfapp.east.asu.edu/html/pol96-1.htm

Nerlove, M., and W. Addison, 1958. Statistical estimation of long-run elasticities of supply and demand. *Journal of Farm Economics* 40: 861-880.

Nogueira, L., and H. Chouinard. 2006. The effects of reducing sanitary and phytosanitary barriers to trade on the Washington state apple industry. A selected paper presented at the Annual Meeting of the American Agricultural Economics Association. Long Beach, CA.

Pendell, D.L., G.W. Brester, T.C. Schroeder, K.C. Dhuyvetter, and G.T. Tonsor. 2010. "Aninal Identification and Tracing in the United States." *American Journal of Agricultural Economics* 92(4): 927–940.

Peterson, E.B., and D. Orden. 2005. "Effects of tariffs and sanitary barriers on high- and low-value poultry trade." *Journal of Agricultural and Resource Economics* 30(1): 109–127.

Peterson, E.B., and D. Orden. 2008. "Avocado Pests and Avocado Trade." *American Journal of Agricultural Economics* 90(2): 321–335.

Piggott, R.R. 1992. "Some Old Truths Revisited." *The Australian Journal of Agricultural and Resource Economics* 36:117-140.

Rickard, B.J., and D.A. Sumner. 2008. "Domestic Support and Border Measures for Processed Horticultural Products." *American Journal of Agricultural Economics* 90(1): 55–68.

Roberts, D., and B. Krissoff. 2004. Regulatory barriers in international horticultural markets. USDA, Economic Research Service. WRS-04-01.

Roberts, I., and C. Gunning-Trant. (2006). The European Union's Common Agricultural Policy: A Stocktale of Reforms. ABARE Research Report No 3275. Canberra, Australia.

Romano, E., and S. Thornsbury. 2006. "Institutional Uncertainty at Home and Away: The Case of Lemons from Argentina." *Choices* 21:143-147.

Sea Rates. 2010. *Trade and Freight*. Available at: http://www.searates.com/reference/portdistance/

Shumway, C.R., and H. Lim, 1993. Functional form and U.S. agricultural production elasticities. *Journal of Agricultural and Resource Economics* 18: 266-276.

South Africa Department of Agriculture (DOA). 2007. Protocol of Phytosanitary Requirements for the Export of Apple Fruit from China to South Africa. Available at: http://www.nda.agric.za/doaDev/sideMenu/plantHealth/docs/Protocol_%20import_apple_China-SA.pdf

Stuart. L. (2005). Truth or consequences: Why the EU and the USA must reform their subsidies, or pay the price. Oxfam Briefing Paper No 81. Oxfam International, London.

Sumner, D.A. 2000. "Domestic Support and the WTO Negotiations." *The Australian Journal of Agricultural and Resource Economics* 44:457-474.

Sunkist Growers. 2006. A Response to the Federal Register Notice of the Office of the U.S. Trade Representative: Annual National Trade Estimate Report on Foreign Trade Barriers. Sherman Oaks, California.

Thilmany, D.D., and C.B. Barrett. 1997. "Regulatory Barriers in an Integrating World Food Market." *Review of Agricultural Economics* 19(1): 91–107.

United States Department of Agriculture, Economic Research Service. 2009. World production and exports of fresh fruits eligible for importation into the United States. Available at: http://www.ers.usda.gov/Data/FruitVegPhyto/Data/fr-summarysheet.xls

United States Department of Agriculture, Economic Research Service. 2010. Commodity and Food Elasticities: Demand Elasticities from Literature. Available at: http://www.ers.usda.gov/Data/Elasticities/query.aspx

United States International Trade Commission (USITC). 2006. "Conditions of Competition for Certain Oranges and Lemons in the U.S. Fresh Market." USITC Investigation No. 332-469. Available at http://hotdocs.usitc.gov/docs/pubs/332/pub3863.pdf

Yue, C., J. Beghin, and H.H Jensen. 2006. “Tariff equivalent of technical barriers to trade with imperfect substitution and trade costs.” *American Journal of Agricultural Economics* 88(4): 947–960.

World Trade Organization (WTO). 2010a. SPS Information Management System. Specific Trade Concerns: Chapter 8. Available at: http://spsims.wto.org/

World Trade Organization (WTO). 2010b. Understanding the WTO. *The Agriculture Agreement: New rules and commitments*. Available at: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm3_e.htm

Wilson, N.L.W., and J. Antón. 2006. “Combining risk assessment and economics in managing a sanitary-phytosanitary risk.” *American Journal of Agricultural Economics* 88(1): 194–202.

Zhao, X, W.E. Griffiths, G.R. Griffith, and J.D. Mullen. 2000. “Probability distributions for economic surplus changes: The case of technical change in the Australian wool industry.” *The Australian Journal of Agricultural and Resource Economics* 44:83-106.

Footnotes

[1] We follow the system used by FAO (2010) to aggregate countries into regions. A complete listing of the countries in each of our six regions is available from the authors.

[2] We include the countries that represent at least 75% of the total consumption in each region.

[3] Simulations that involve reductions in tariffs yield negative welfare changes for taxpayers, and therefore the transfer efficiency ratios for producers and consumers will sum to more than 100%.

OTHER A.E.M. WORKING PAPERS

WP No	Title	Fee (if applicable)	Author(s)
2010-20	Assessing the utilization of and barriers to farm-to-chef marketing: an empirical assessment from Upstate NY		Schmit, T. and S. Hadcock
2010-19	Evaluating Advertising Strategies for Fruits and Vegetables and the Implications for Obesity in the United States		Liaukonyte, J., Rickard, B., Kaiser, H. and T. Richards
2010-18	The Role of the World Bank in Middle Income Countries		Kanbur, R.
2010-17	Stress Testing for the Poverty Impacts of the Next Crisis		Kanbur, R.
2010-16	Conceptualising Social Security and Income Redistribution		Kanbur, R.
2010-15	Food Stamps, Food Insufficiency and Health of the Elderly		Ranney, C. and M. Gomez
2010-14	The Costs of Increased Localization for a Multiple-Product Food Supply Chain: Dairy in the United States		Nicholson, C.F., Gómez, M.I. and O.H. Gao
2010-13	Wine in your Knapsack?		Conrad, J.M., Gómez, M.I. and A.J. Lamadrid
2010-12	Examining consumer response to commodity-specific and broad-based promotion programs for fruits and vegetables using experimental economics		Rickard, B., Liaukonyte, J., Kaiser, H. and T. Richards
2010-11	Harnessing the Forces of Urban Expansion – The Public Economics of Farmland Development Allowance		Chau, N. and W. Zhang
2010-10	Estimating the Influence of Ethanol Policy on Plant Investment Decisions: A Real Options Analysis with Two Stochastic Variables		Schmit, T., Luo, J. and J.M. Conrad
2010-09	Protecting the Poor against the Next Crisis		Kanbur, R.
2010-08	Charitable Conservatism, Poverty Radicalism and Good Old Fashioned Inequality Aversion		Kanbur, R. and M. Tuomala

Paper copies are being replaced by electronic Portable Document Files (PDFs). To request PDFs of AEM publications, write to (be sure to include your e-mail address): Publications, Department of Applied Economics and Management, Warren Hall, Cornell University, Ithaca, NY 14853-7801. If a fee is indicated, please include a check or money order made payable to Cornell University for the amount of your purchase. Visit our Web site (*http://aem.cornell.edu/research/wp.htm)* for a more complete list of recent bulletins.