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Potential of Regional and Seasonal Requirements in US Regulation of Fresh Lemon Imports

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1. INTRODUCTION

SINCE the 1990s, Argentina has sought to export fresh lemons from its north-west region into the United States. The United States has expressed concerns about the risks from fruit flies, citrus canker, citrus black spot, sweet orange scab and, more recently, citrus variegated chlorosis (CVC) found in Argentine lemons. Although several of these concerns have declined over time, the risks from fruit flies and CVC associated with importing Argentine lemons remain a concern.

Discussions over lifting the import ban between the United States and Argentina have focused on two issues: conducting a pest risk assessment (PRA) that provides accurate estimates of probabilities of pest introduction and establishment in the United States if imports are permitted and the development of a system approach of risk mitigation measures that allows imports under specified conditions.[1] System approaches often involve regional restrictions on the source of the exported product as well as regional and/or seasonal restrictions on access within the importing country that limit the probability of its domestic production being adversely affected. A successful case of trade creation under a systems approach is the opening of the US market to avocados from Mexico. Initially limited to imports into Alaska in 1993, over a 15-year

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[1] A system approach includes multi-step, overlapping sanitary and phytosanitary (SPS) measures that reduce pest and disease risks. To the extent that this enables trade while meeting the importing country's risk aversion objectives, it is consistent with the World Trade Organization (WTO) Agreement on SPS measures.

period Mexico eventually gained access to the entire US market and developed an annual avocado export value exceeding $500 million.

In 1997, the Animal and Plant Health Inspection Services (APHIS) of the United States Department of Agriculture (USDA) published a PRA indicating that without mitigation measures there was high probability of fruit fly introduction into the United States (USDA/APHIS, 1997) from imports of Argentine lemons. However, with mitigation measures, the probabilities of fruit fly introduction were reduced significantly to almost zero. The 1997 PRA was the basis of a regulatory final rule that allowed entry of fresh Argentine citrus fruit in 2000 and 2001 under specific conditions (USDA/APHIS, 2000). Included in the conditions for entry were orchard design and management practices, post-harvest and packinghouse practices, certifications and a phase-in distribution plan wherein lemons were eligible initially only for entry into non-citrus-producing states during the US lemon production off-season, but after a certain period into all areas of the continental United States throughout the year.

Argentina's access to the US market was short lived because the 2000 rule was rescinded after a lawsuit filed against the USDA by California citrus growers and the US Citrus Science Council.[2] The lawsuit maintained that the rule was inconsistent with protection of domestic producers from imported pest risks under the Plant Quarantine Act of 1912. The complainants argued that the risk assessment of APHIS was confusing and internally inconsistent; that the reliance on Servicio Nacional de Sanidad y Calidad Agroalimentaria (SENESA) to implement, verify and enforce part of the systems approach was misplaced; and that the economic impact analysis was inaccurate because it rested on unjustified risk assumptions (Thornsbury and Romano, 2007).

In 2007, APHIS published another PRA (USDA/APHIS, 2007). The 2007 PRA went through a peer review process, including a supplemental 2009 peer review that examined the assumptions on pest risks associated with CVC. However, no rule that allowed entry was drafted based on the 2007 PRA.

Were any future negotiations on entry of Argentine lemons to occur, the designed system approach would almost certainly include conditions similar to the mitigating measures in the 1997 and 2007 PRAs, including initial limits on the distribution of lemons geographically and seasonally in the United States. This paper utilises a simulation model to analyse the possible economic effects of entry of Argentine lemons under full market access and under specific geographical and seasonal restrictions.

One challenge to assessing the economic effect of entry by Argentine lemons is determining the postentry quantity that would be demanded in the US market.

[2] Harlan Land Co., Limoneira Company, Pecht Ranch, R7 Enterprises and US Citrus Science Council versus US Department of Agriculture, United States District Court, Eastern District of California, Case No. CIV F00-6106 REC LIO.

Often simulation models rely on constant–elasticity-of-substitution (CES) utility functions to represent consumers' preferences for differentiated products. A drawback of demand functions from CES utility functions is that they require exogenous changes in the specification of consumer preferences when a new commodity becomes available and do not allow for consumers' choice of zero consumption of the new product. We utilise a different approach to the specification of demand for varieties that are initially unavailable. Based on Bergin and Feenstra (2009), a homothetic trans-log expenditure function represents consumer preferences for lemons from different sources. Because the derived demand functions are linear in price, a reservation price for all varieties that are not initially available (e.g. Argentine lemons) can be computed given the observed prices and quantities of varieties that are consumed initially. By comparing the computed reservation price for Argentine lemons to an estimated entry price, the model determines whether entry will occur and the equilibrium level of postentry exports. Yue and Beghin (2009) and Beghin and Melatos (2012) in the special issue, also use an approach that allows for zero demand for a newly available product.

2. LEMON PRODUCTION AND TRADE

The world production of lemons is about seven million tonnes per year. Argentina is the largest lemon producer, and the second largest exporter (Table 1). Its export ratio (exports/production) rose from 17 per cent in the late 1990s to 25 per cent in 2006–08 as Argentine producers pursued an aggressive export promotion. The main markets for Argentine lemons are the EU-27 (two-thirds) and Russia (18 per cent).

In the United States, the growth in fresh lemon consumption has outpaced the growth in lemon production. Although the United States remains the sixth largest exporter of lemons, its export ratio fell from 38 per cent in the late

TABLE 1
World Production and Trade of Lemons, 2006–08

Production		*Exports*		*Imports*	
Country	*Share (%)*	*Country*	*Share (%)*	*Country*	*Share (%)*
Argentina	22.1	Spain	22.8	EU-27	65.1
India	13.3	Argentina	18.8	Russia	12.8
Mexico	12.6	Turkey	14.7	Japan	4.2
Spain	10.3	Mexico	8.4	Canada	3.7
Brazil	8.4	South Africa	7.6	United States	3.4
Italy	8.2	United States	7.1	Hong Kong	1.5
United States	6.5	Brazil	3.0	Switzerland	1.1
All others	18.7	All others	17.5	All others	8.0

Sources: Food and Agriculture Organization, Global Trade Atlas, and US Department of Agriculture.

1980s to 28 per cent in 2006–08, while US lemon imports rose from 2 per cent to 15 per cent of consumption. Approximately 80 per cent of US lemon imports are supplied by Mexico and Chile and 15 per cent by Spain.

The EU is one of the largest markets for lemons, with an average of 1.8 million tonnes of lemons consumed each year. Annual lemon production during 2006–08 in the EU (primarily from Spain and Italy) averaged only 1.3 million tonnes, leaving the EU by far the world's largest market for lemon imports. Spain's exports are largely to other EU countries.

3. MODEL STRUCTURE AND BASE DATA

Because Argentina is a large lemon exporter, a multi-region model of lemon trade is used to analyse the effects of the entry of Argentine lemons into the US market. The base period for prices and quantities is an average over the three marketing years 2005/06–2007/08. Cororaton and Peterson (2011) provide a complete description of the data and model structure.

The United States, EU and an aggregate importing rest of world (ROW) are the three demand regions in the model. There are eight supply regions: the United States, EU, ROW and five other supply regions. The US demand region initially imports from Mexico, Chile, the EU (Spain), and an aggregate of other suppliers (other United States). The EU demand region imports from the United States, Argentina, Mexico, Chile and two aggregates of other suppliers, other EU (which does not export to the United States) and other United States (where there is possible trade diversion between the United States and EU).[3] The five additional suppliers are treated more parsimoniously (only exports modelled) than the three major markets (consumption, production and trade modelled) because the former are large lemon exporters with minimal imports, while the latter are major lemon importers with significant domestic fresh lemon demand.

To account for potential geographic restrictions were imports allowed, the US demand region is further divided into two regions: the citrus-producing states of Arizona, California, Florida, Louisiana and Texas (region 1), and the rest of the United States (region 2). To allow for possible seasonal restrictions on Argentine exports to the United States, two seasons are identified: November to May (season 1), which is the main US lemon production period and the off-season of June to October (season 2). In the model, producer and wholesale prices are linked by a fixed margin that differs with markets (including regions in the United States) and seasons for each lemon supplier. Prices in the model

[3] Other EU includes South Africa, Turkey, Brazil, Morocco. Uruguay, Egypt, Syria, Israel, Tunisia and Venezuela. Other-United States includes Dominican Republic, New Zealand, Guatemala, El Salvador, Ecuador, Colombia and Peru.

adjust to equilibrate the quantity of lemons demanded in each market and season to the quantity of lemons supplied to that market.

a. Lemon Consumption

Consumer preferences for lemons in each demand region are represented by a two-level structure. At the lower level, consumer preferences in demand region j for lemon varieties, distinguished by supply regions (i, k), are represented by a trans-log unit expenditure function:

$$\ln e_j(p) = \alpha_{0j} + \sum_{i=1}^{N_T} \alpha_{ij} \ln wp_{ij} + 1/2 \cdot \sum_{i=1}^{N_T} \sum_{k=1}^{N_T} \gamma_{ijk} \cdot \ln wp_{ij} \ln wp_{kj}, \tag{1}$$

where N_T is the number of possible lemon varieties, some of which may not be available in a demand region and have zero demand, wp_{ij} is the wholesale price of lemon variety i in demand region j and the α_{0j}, α_{ij} and γ_{ikj} are parameters. For the expenditure function to be homogeneous of degree one in prices requires:

$$\sum_{i=1}^{N_T} \alpha_{ij} = 1; \text{ and} \sum_{i=1}^{N_T} \gamma_{ikj} = 0; \ \forall k = 1, ..., N_T.$$

Also, because of symmetry, $\gamma_{ikj} = \gamma_{kij}$. The budget share for each variety (s_{ij}) is derived from equation (1) using Shephard's lemma.

If the demand for a commodity is zero, its price must equal or exceed its reservation price. As shown by Bergin and Feenstra (2009), it is possible to solve for the reservation prices of the ($N_T - N_A$) varieties that are not available, where N_A is the number of available varieties, in terms of the parameters in equation (1) and the observed prices of the N_A varieties. In the case of Argentine lemons, the computed reservation price can then be compared with the projected entry price. If the reservation price exceeds the entry price, then Argentine lemons will be sold in the US market.

The budget shares derived from the trans-log expenditure function in equation (1) determine the demand for each lemon variety given the amount of total expenditure on lemons by consumers. Lemon expenditure is defined as the product of a lemon wholesale price index (PL) times a lemon quantity index (QL). Assuming a CES preference structure between lemons and all other goods, QL for demand region j is as follows:

$$QL_j = \frac{\beta_j PL_j^{1-\sigma_j} I_j}{\beta_j PL_j^{1-\sigma_j} + \left(1 - \beta_j\right)}, \tag{2}$$

where I_j is income in demand region j, β_j is the share parameter of lemons in the CES utility function and σ_j is the elasticity of substitution between lemons and all other goods. The quantity demand for each lemon variety (x_{ij}) is equal to the budget share times the quantity index times the price index divided by the wholesale price.

b. Lemon Supply

Because lemon suppliers sell to multiple markets in multiple seasons, we assume that the suppliers maximise revenue subject to a constant-elasticity-of-transformation (CET) production possibility frontier. This specification allows producers to shift sales between market destination and seasons as relative prices change. Two parameters (σ_{ij} and σ_{is}) represent the elasticities of transformation between demand regions and seasons. The location of the production possibilities frontier is determined by the amount of inputs used in lemon production whose supply is a linear function of the composite producer price across all seasons and destinations.

4. CALIBRATION

One drawback of using the trans-log functional form in an empirical simulation model is the large number of parameters that must be chosen or calibrated. To reduce the number of unknown parameters, we follow Bergin and Feenstra (2009) and assume that the cross-price effects are the same for all goods, implying that $\gamma_{ikj} = \gamma_j$ for all $i \neq k$. The value of γ_j can be chosen to replicate the own-price demand elasticity (ε_{ii}) of one good in each region using the definition of the own-price elasticity from the trans-log expenditure. In all demand regions, ε_{ii} is assumed to equal -1.5. This yields γ of 0.514, 0.344 and 0.414 for the United States, EU and ROW, respectively.

Because the reservation prices for the unavailable goods are not observable, it is not possible to calibrate the values of the parameters α_{0j} and α_{ij} directly. To determine their values, note that the observed budget share for each unavailable good is equal to zero. Assuming there is a single unavailable good, the reservation price (wp_{ij}^*) can be expressed as follows:

$$\ln wp_{ij}^* = -\left(\alpha_i + \sum_{k=1}^{N_A} \gamma_{ik} \ln wp_{ik}\right) \Big/ \gamma_{ii}. \tag{3}$$

Substituting equation (3) into equation (1), it is possible to derive a ‘reduced-form’ expenditure function that is valid for the N_A available goods. As shown by Peterson (2011), the parameters in the ‘reduced-form’ expenditure function can be calibrated using the observed budget shares and prices. Once their values are known, the reduced-form parameters can be used to calibrate the parameters α_{0j} and α_{ij}, which in turn can be used to compute the reservation prices for Argentine lemons.

a. Calibrated US Reservation Prices for Argentine Lemons

Because the expenditure function is linear homogeneous, it is not possible to identify unique values for all α_{ij}s and the reservation price. To overcome this indeterminacy, given the proximity and seasonal production patterns of Chile and Argentine, we assume that consumers have similar preferences for lemons from these two countries. This implies that consumers' reservation price for Argentine lemons should be similar to their reservation price for Chilean lemons. The reservation price for Chilean lemons in a given demand region is determined by setting the share of Chilean lemons equal to zero in the demand equation from the reduced-form expenditure function and solving for the price of Chilean lemons. The estimated reservation prices for each US demand region and each season using this procedure are shown in the first column of Table 2.

Our initial estimates of the postentry wholesale prices of Argentine lemons are shown in the second column of Table 2. These are the producer (free on board) price of Argentine lemons plus a marketing margin set equal to the margin for Chilean lemons in a given US demand region and season. Because the reservation price exceeds the initial wholesale price estimate in each US demand region and season, Argentina would export lemons to both US demand regions in both seasons if it were permitted to do so. The largest difference between the estimate reservation price and initial wholesale price occurs in season 2 for both US demand regions. Intuitively, one would expect the US consumers would be willing to pay a higher price for imported fresh lemons during the period of low domestic availability.

b. Aggregate Lemon Demand and Lemon Supply

The demand for aggregate lemons in equation (2) depends on σ_j, the elasticity of substitution between lemons and all other goods. Because lemon con-

TABLE 2
Reservation and Initial Wholesale Prices of Argentine Lemons

	Prices (\$/kg)		*Percentage difference*
	Reservation	*Estimated Postentry*	
Region 1, season 1	1.65	1.53	7.2
Region 1, season 2	2.33	1.75	33.1
Region 2, season 1	1.55	1.45	6.4
Region 2, season 2	2.13	1.66	28.5

sumption constitutes a very small share of total consumption in all regions, σ_j is equal (approximately) to the negative of the aggregate demand elasticity for a CES utility function. We use an estimated aggregate lemon demand elasticity of -0.5 from Jetter et al. (2003) for all demand regions. Then, the value of β_j can be determining using equation (2), noting that PL is equal to the exponential of the calibrated trans-log expenditure function in equation (1), with QL determined from the identity that the price index times the quantity index must equal total expenditure.

For the supply-side of the model, the elasticity of transformation between destinations (σ_{ij}) is determined from the observed ratio between US domestic supply and US exports and between US domestic producer price and US export price. This value is used for all other supply regions. Because fresh lemons are perishable, we assume limited transformation possibilities between seasons and set σ_{is} equal to -0.5. Once the values of σ_{ij} and σ_{is} have been determined, the shift parameters in the CET revenue function are then chosen to ensure that conditional quantities supplied equal the observed quantities supplied. As Argentina does not initially ship lemons to the United States, this procedure would yield a shift parameter between Argentina and the United States equal to zero initially. Rather than make an arbitrary choice for post-entry value of this shift parameter, we assume a constant postentry wholesale price for Argentine lemons in the United States and let the shift parameter be endogenously determined in the model. Because of biological lags in lemon production, we assume that the aggregate supply elasticity is 0.5.

5. SIMULATION RESULTS

Three scenarios that allow entry of Argentine lemons into the United States under alternative geographic and seasonal restrictions are examined. In the scenario ‘full market access’, entry of Argentine lemons is allowed to both US demand regions in both seasons. In the scenario ‘regional restricted access’, entry is allowed to the noncitrus-producing states (region 2) in both seasons. In the scenario ‘limited access’, entry is allowed only in noncitrus-producing states (region 2) during the lemon production off-season (season 2). We highlight key results.[4]

a. Full Market Access

Initially, the ban on fresh lemon imports from Argentina is equivalent to the US wholesale prices of Argentine lemons equalling the reservation prices in Table 2. Removing the import ban is equivalent to these prices dropping from

[4] A full set of results is available on request.

the reservation price to the estimated post-entry price. At constant prices for other lemon varieties, US consumers will substitute Argentine lemons for all other lemons. Because the difference between the reservation price and post-entry wholesale price is much larger in season 2 than in season 1, the substitution effect is much larger in season 2. Moving from reservation prices to post-entry prices for Argentine lemons also leads to a reduction in the lemon wholesale price index (*PL*). It decreases by 1.2 per cent and 1.1 per cent in demand regions 1 and 2 in season 1 and 4.9 per cent and 4.4 per cent in season 2 (Table 3). The decrease in *PL* makes lemons relatively less expensive than all other consumption goods, leading US consumers to increase aggregate lemon consumption (*QL*). With an assumed aggregate demand elasticity of −0.5, the percentage increase in *QL* is roughly half the percentage decrease in *PL*. As both the substitution and expansion effects are positive for Argentine lemons, US consumption summed for regions 1 and 2 increases from zero to 4,600 tonnes in season 1 and 10,300 tonnes in season 2. However, for all other lemon varieties, the substitution effect dominates the expansion effect and US consumption decreases.[5] Across regions and seasons, the consumption of domestically produced lemons in the United States decreases by 4,700 tonnes or by 1.3 per cent. Consumption of lemons imported from all regions except Argentina decreases by 6,100 tonnes or by 11.5 per cent.

The increase in US demand for Argentine lemons leads to higher Argentine producer prices. With most of the increase in US demand occurring in season 2, Argentine producer prices increase by 2.1 per cent in season 2 compared with 0.9 per cent in season 1. Overall, the composite producer price for Argentine lemons increases by 1.7 per cent (Table 4). This increase in producer prices leads to increases in the wholesale prices of Argentine lemons in both the EU and the ROW demand regions (not shown in the tables). With the consequent reduction in exports to the EU and ROW, total exports of Argentine lemons increase by 3,400 tonnes (Table 4).

US lemon producers are able to increase exports by 1,600 tonnes kg, as consumers in the EU and ROW substitute away from the more expensive Argentine lemons. This increase in exports offsets about one-quarter of the reduction in US consumption. Because of the larger reduction in consumption in season 2, the US producer price decreases by 1.0 per cent in season 1 and 3.7 per cent in season 2. These seasonal price changes yield a 1.7 per cent reduction in the composite US producer price. For EU lemon producers, the increase in the EU wholesale price of Argentine lemons causes EU consumers to substitute EU lemons for Argentine lemons. The 1,500 tonnes increase in EU consumption of EU lemons more than offsets the 1,000 tonnes reduction in exports to

[5] Even when the aggregate demand is elastic, the substitution effect still dominates the expansion effect for the non-Argentine lemon varieties.

TABLE 3
Changes in US Lemon Consumption and Wholesale Prices

Lemon Consumption	*Base*	*Full Access*	*Regional Restricted*	*Limited Access*
Region 1/season 1	(Thousand *tonnes*)			
United States	75.6	75.0	74.9	75.6
Argentina	0.0	1.4	0.0	0.0
Others	4.6	4.2	5.9	4.6
Quantity index	80.1	80.6	80.5	80.1
Region 2/season 1				
United States	179.8	178.4	178.8	179.8
Argentina	0.0	3.2	4.0	0.0
Others	10.8	10.5	9.0	10.8
Quantity index	190.6	191.7	191.6	190.7
Region 1/season 2				
United States	28.4	27.6	27.8	27.8
Argentina	0.0	3.2	0.0	0.0
Others	11.2	9.2	12.6	12.6
Quantity index	39.6	40.6	40.3	40.3
Region 2/season 2				
United States	67.6	65.6	65.9	65.9
Argentina	0.0	7.1	8.0	8.0
Others	26.6	23.2	21.2	21.2
Quantity index	94.2	96.3	96.0	96.0
Wholesale price	*$/kg*	*Percentage Change from Base*		
Region 1/season 1				
Composite price	1.61	−1.2	−1.0	0.0
United States	1.62	−1.1	−1.0	0.0
Others	1.36	−3.5	−2.0	0.0
Region 2/season 1				
Composite price	1.77	−1.1	−1.0	0.0
United States	1.79	−1.0	−0.9	0.0
Others	1.58	−2.7	−2.4	0.0
Region 1/season 2				
Composite price	1.76	−4.9	−3.4	−3.4
United States	1.83	−3.7	−3.1	−3.1
Others	1.36	−6.1	−4.1	−4.0
Region 2/season 2				
Composite price	1.89	−4.4	−3.7	−3.7
United States	2.03	−3.4	−2.8	−2.8
Others	1.51	−6.1	−4.5	−4.5

the United States. Overall, EU lemon production increases by 700 tonnes or 0.05 per cent and producer prices for EU lemon growers increase by 0.1 per cent.

Because the United States is the largest export market for both Mexico and Chile, they are negatively affected by entry of Argentine lemons in the US market. While Chilean exports to the United States decrease by 2,500 tonnes, their exports to the EU and ROW demand regions increase by 1,200 tonnes,

TABLE 4
Changes in Lemon Production or Exports and Composite Producer Prices

	Lemon Production or Exports (thousand tonnes)			
	Base	*Full Access*	*Regional Restricted*	*Limited Access*
Production				
United States	474.9	471.8	472.3	473.4
EU	1,306.8	1,307.5	1,307.4	1,306.9
Rest of world	2,237.3	2,238.7	2,238.4	2,237.8
Exports				
Argentine	360.0	363.4	362.6	362.2
Chile	39.6	38.1	38.5	38.6
Mexico	23.6	21.5	22.1	22.2
	Composite Producer Price			
	$/kg	*Percentage Change from Base*		
United States	1.34	−1.7	−1.5	−0.8
EU	0.87	0.1	0.1	0.0
Rest of world	0.71	0.1	0.1	0.1
Argentine	0.58	1.7	1.4	1.1
Chile	0.58	−6.6	−4.9	−4.1
Mexico	0.36	−16.9	−12.3	−10.5

resulting in a 3.8 per cent decrease in total exports. While Mexican exports to the United States decrease by a similar amount, 2,400 tonnes, because the United States is the main export destination for Mexican lemons, total Mexico exports decrease by 2,100 tonnes or 8.9 per cent. The reduction in exports leads to the composite producer price decreasing by 6.6 per cent for Chilean lemons and 16.9 per cent for Mexican lemons.

b. Regional Restricted Access

In this simulation, Argentine lemons are not allowed entry into the US citrus-producing region 1. However, entry is allowed into region 2 in both seasons. Argentine lemon exports to the United States are 2,900 tonnes lower than in the full access scenario. With reduced competition from Argentine lemons, the demand for United States and non-Argentine lemons is higher than in the full access scenario, resulting in smaller reductions in US wholesale prices for those lemon varieties. Thus, the substitution effect for Argentine lemons is larger in region 2, leading to a 1,700 tonne increase in the consumption of Argentine lemons in region 2 compared with the full access scenario.

Even though Argentine exports to region 2 are larger than in the full access scenario, the consumption of US lemons in region 2 is also 700 tonnes higher.

This occurs because of differences in the changes in relative prices between US and Mexican and Chilean lemons in the two scenarios. This can be seen by comparing the change in US wholesale price for US lemons to the average change for 'other' lemons in Table 3. Because the total US consumption of 'other' lemon varieties (mainly Mexican and Chilean) is higher than in the full access scenario, there is a much smaller decrease in producer prices. The decrease in the composite producer price for Chile and Mexico are 1.7 and 4.6 percentage points smaller, respectively, compared with the full access scenario, thus there are smaller decreases in US wholesale prices for these varieties. While the substitution effect between US and imported lemons is smaller in both seasons and regions, compared with the full access case, so is the expansion effect owing to smaller decrease in the lemon composite price. For region 2, the smaller substitution effect offsets the smaller expansion effect for US lemons, leading to an increase in consumption compared with the full access scenario.

With a smaller increase in US demand for Argentine lemons in this scenario, the Argentine producer price only increases by 1.4 per cent, 0.3 percentage points less than the full access scenario. This leads to smaller substitution away from Argentine lemons by consumers in the EU and ROW demand regions. The increase in US lemon exports is 300 tonnes smaller compared with the full access scenario while EU lemon production is 200 tonnes kg smaller. Overall, US lemon production declines by 2,600 tonnes compared with 3,100 tonnes in the full access scenario.

c. Limited Access

In this scenario, entry is allowed only in the noncitrus-producing region during the lemon production off-season (region 2/season 2). With no substitution in consumption between seasons and limited supply-side substitution, the effects on US consumption are essentially confined to season 2. US lemon consumption is virtually unchanged in season 1 for both regions compared with base values. In season 2, the changes in consumption in both regions are indistinguishable from the regional restricted access scenario. With these results, the composite producer prices fall less for the US, Chile and Mexico than in the regional restriction scenario. While the impact on US lemon producers is relatively small across all three scenarios, the impact (decline in production of 1,500 tonnes) is 50 per cent smaller with seasonal and geographic restrictions compared with full access. The impacts on international markets are also much smaller than in the previous two scenarios.

d. Welfare Effects

The reduction in US wholesale prices from granting access to Argentine lemons increases US consumer welfare, measured by equivalent variation, from

TABLE 5
Welfare Changes

	Full Access	Regional Restricted	Limited Access
	$ million		
US total	5.9	4.4	3.8
Equivalent variation	16.8	13.7	9.1
Producer surplus	−10.9	−9.3	−5.3
EU total	−3.9	−3.1	−2.5
Equivalent variation	−5.2	−4.2	−2.7
Producer surplus	1.3	1.1	0.2
Rest of world total	−1.8	−1.4	−1.1
Equivalent variation	−3.8	−3.1	−1.9
Producer surplus	2.0	1.7	0.8
Excess suppliers' producer surplus			
Argentina	3.6	2.9	2.4
Mexico	−1.5	−1.1	−0.9
Chile	−1.4	−1.0	−0.9

$9.1 million for limited access to $16.8 million for full access (Table 5). With losses in producer surplus for US lemon producers of $5.3 million for limited access to $10.9 million loss for full access, net US welfare increases between $3.8 million to $5.9 million. Because of increases in wholesale prices in the EU and ROW, equivalent variation decreases, while increases in producer prices in those regions lead to an increase in producer surplus. Overall, the losses in equivalent variation are larger than the gains in producer surplus.

e. Pest Risk

The three scenarios mentioned previously do not take into consideration any production losses that may result if there is non-zero pest risk from importing lemons from Argentina. Without specific mitigation measures, the pest risk for both the South American (*Anastepha fraterculus*) and Mediterranean (*Ceratitis capitata*) fruit flies were rated as high in the 2007 PRA. If estimates of the probabilities of infestation, the pest-related yield losses and the costs of pest control measures were available for all pests of concern, the effects of pest risk could be incorporated into the model, as in Peterson and Orden (2008) for avocados. However, the 2007 PRA only provides a qualitative assessment of the pest risks (e.g. low, medium or high), and information is not available on the yield losses or costs of control for US lemon producers if a pest outbreak occurs.

An alternative approach to assessing the importance of pest risk is to determine the reduction in US lemon production that on a certainty basis would offset the welfare gains to the US from allowing fresh lemon imports from

Argentine with zero risk. Because the pest risk potential is the highest for the full access scenario, we focus on this scenario to determine its potential importance. A reduction in yield owing to a pest infestation or increased producer pest control costs will cause the production possibilities frontier for US lemon producers to shift inward. In this simulation, the shift becomes an endogenous variable and the change in equivalent variation is constrained to offset the change in producer surplus in the United States.

With a reduction in US lemon production of 5,000 tonnes or 1.1 per cent (from 471,800 tonnes in the full access scenario with no pest risk, to 466,800 tonnes), consumer welfare in the US increases by only $11.1 billion because the reduction in the availability of US lemons leads to smaller reductions in the wholesale prices of US lemons across all demand regions and seasons. The loss of producer surplus increases by $0.2 million compared with the full access scenario, as the effects on US lemon producers of yield losses and costs of pest control are mitigated owing to increased producer prices caused by the supply reduction. The composite producer price of US lemons decreases by 0.8 per cent compared with a 1.7 per cent reduction in the no risk case. Of course, imports of lemons from Argentina would not be allowed if pest-related losses were certain to occur. On an expectations basis, for US production losses to offset the expected welfare gains, the effects on production occurring with some non-zero but positive probability would have to be equivalent to the certainty losses illustrated here.

6. CONCLUSION

The United States bans imports of Argentine lemons because of citrus pest and disease concerns, particularly fruit flies and CVC found in Argentina. One approach to minimise pest and disease risks while allowing imports is the use of geographic destination and seasonal restrictions. We incorporate an innovative approach of Bergin and Feenstra (2009) to the specification of demand for varieties that are initially unavailable into a simulation model of the international lemon market to trace the effects of three options for replacing the US ban on Argentine lemons.

The results presented for the scenarios of full access, regional restricted access and limited access are illustrative of the effects of the assumed changes in US regulatory policies towards imports of lemons from Argentina. Implementing any changes to the existing ban would require a formal rule making process. One might anticipate that any future negotiations between the United States and Argentina over a systems approach to pest risk mitigation will likely include discussion of limited regional and seasonal distribution of lemons in the US along the lines modelled. This limited distribution could be permanent, or the regional and seasonal restrictions could be relaxed in phases.

Comparison of the Argentine lemon case to Mexico's experience gaining access to the US avocado market provides an informative juxtaposition. The broad policy lesson from this comparison is that while a systems approach to easing trade bans is an attractive concept when there are pest or disease risks, this concept by no means provides a mechanical answer to the difficult question of how to regulate trade when these issues are involved. Specific outcomes have to rest on science-based regulatory decisions for which reaching agreement can be difficult. A heavy burden remains on the exporting countries to make the case for the system approach as meeting the risk-reducing requirements of the importers. In meeting this challenge, there may be room for increased use of regional and/or seasonal destination restrictions as an alternative to complete import bans.

REFERENCES

Beghin, J. and M. Melatos (2012), 'The Trade and Welfare Impact of Australian Quarantine Polcies: The Case of Pigmeat', *The World Economy*.

Bergin, P.R. and R.C. Feenstra (2009), 'Pass-Through of Exchange Rates and Competition between Floaters and Fixers', *Journal of Money, Credit and Banking*, **41**, 1, 35–70.

Cororaton, C.B. and E. Peterson (2011), 'The Potential of Regional and Seasonal Access Requirements in Sanitary and Phytosanitary Regulation of Trade: The Case of US Fresh Lemon Imports', GII Working Paper 2011–4 (Arlington, VA: Global Issues Initiative, Institute for Society, Culture and Environment, Virginia Tech).

Jetter, K.M., D.A. Sumner and E.L. Civerolo (2003), 'Ex-ante Economics of Exotic Disease Policy: Citrus Canker in California', in D. A. Sumner (ed.), *Exotic Pests and Diseases* (Iowa: Iowa State Press), 121–47.

Peterson, E. (2011), 'Using the Trans-log Expenditure Function to Endogenize New Market Access in Partial Equilibrium Models,' GII Working Paper No. 2011-2. Available at: http://www.gii.ncr.vt.edu/docs/GII_WP2011-2.pdf (accessed 20 September 2011).

Peterson, E. and D. Orden (2008), 'Avocado Pests and Avocado Trade', *American Journal of Agricultural Economics*, **90**, 2, 321–35.

Thornsbury, S. and E. Romano (2007), 'Linking Risk and Economic Assessments in the Analysis of Plant Pest Regulations: The Case of U.S. Imports of Argentine Lemons', A report for USDA, Economics Research Service, GII Working Paper No. 2007-1. (December), Available at: http://www.gii.ncr.vt.edu/docs/GII_WP2007-1.pdf (accessed 16 June 2010).

USDA, Animal and Plant Health Inspection Service (1997), 'Importation of Fresh Citrus Fruit (Sweet Orange, *Citrus sinensis*, Lemon, *C.limon*, and Grapefruit, *C. paradisi*) from Argentina into the Continental United States', Supplemental Plant Pest Risk Assessment, (Washington DC: USDA/APHIS).

USDA, Animal and Plant Health Inspection Service (2000), 'Importation of Grapefruit, Lemons, and Oranges from Argentina. Final Rule', *Federal Register*, **65**, 116, 37608–669.

USDA, Animal and Plant Health Inspection Service (2007), *Risk Assessment for the Importation of Fresh Lemon (Citruslimon* (L.) Burm. F.) Fruit from Northwest Argentina into the Continental United States (Raleigh, NC: USDA/APHIS).

Yue, C. and J. Beghin (2009), 'The Tariff Equivalent and Forgone Trade Effects of Prohibitive Technical Barriers to Trade', *American Journal of Agricultural Economics*, **91**, 4, 930–41.