Economic Impact of Potential U.S. Regulatory Decisions Concerning Imports of Argentine Lemons [*]

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Caesar B. Cororaton, David Orden and Everett Peterson
Virginia Tech

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Executive Summary

Argentina has become a major lemon producer and exporter. It has increased lemon production using modern technology especially in the northwest region of the country. It has aggressively pursued its drive to sell its lemons to the world market, with the growth of its lemon exports averaging 10 percent annually over the past 10 years. At present, the European Union and Russia are the major international markets for Argentine lemons. The U.S. prohibits entry of Argentine lemons because of citrus pest and disease concerns.

The trade ban on Argentine lemons is currently based on the concern in the U.S. about the risks from the destructive effects of Mediterranean fruit flies and citrus variegated chlorosis (CVC) found in Argentina. Since the 1990s the government of Argentina has negotiated with the government of the U.S. for possible market access for Argentine lemons. The ongoing discussions between Argentina and the U.S. have focused on two critical concerns: (a) whether or not the estimates of the risk of introduction and establishment associated with pests and diseases through lemon imports are accurate and reliable; and (b) whether or not a systems approach to risk management can be defined that would prevent these pests and diseases from entering the U.S. if imports were allowed under specified conditions. Thus far, there are no agreed answers to these questions.

If the U.S. modifies the ban on Argentine lemons, consumption and production of lemons in the U.S. will be affected. The entry of these lemons will also affect the demand for lemon imports from the other suppliers to the U.S. market. The objective of this paper is to analyze these effects using a partial equilibrium simulation model.

The paper adopts the modeling framework of Peterson and Orden (2008) in their research regarding the opening of the U.S. market to imports of fresh avocados from Mexico. There are observed market price differentials in lemons of different origins, and they are treated in the lemon model as imperfect substitutes through multi-level CES functions in consumption and CET in production. The model has seasonal and regional disaggregation in order to analyze seasonal and geographic restrictions in the systems approach to pest risk management. However, unlike the Peterson and Orden model, the lemon model does not incorporate pest risks and related mitigation and damage costs because of the absence of known estimates, particularly for the pest risks associated with imports.

The lemon model was calibrated to a three-year base period (2006-2008). The paper analyzes the potential economic effects of the entry of Argentine lemons under three scenarios: (a) year-around access in non citrus-producing states under SIM 1, assuming the lemon import shares of Chile and Argentina are similar; (b) year-around access in non citrus-producing states under SIM 2, assuming the lemon import shares of Mexico, Chile, Spain and others are reduced proportionately in order to accommodate entry of Argentine lemons; and (c) entry restricted to

only the U.S. lemon production off-season and non citrus-producing states in SIM 3, assuming again that lemon import shares of Mexico, Chile, Spain and others are reduced proportionately.

A total of 7.2 million kg of Argentine lemons are imported under SIM1, 8.9 million kg in SIM 2 and 6.1 million kg in SIM 3. The entry of Argentine lemons in all three scenarios decreases the price of lemons in the U.S. and increases lemon consumption. This increases consumer welfare. However, the entry displaces lemon production in the U.S. and lemon imports from Mexico, Chile, Spain, and others. The reduction in demand for lemons from these sources decreases their supply to the U.S. market and increases their exports to the rest of the world. The producer prices of these lemons fall and both aggregate lemon production in the U.S. and total lemon exports of these suppliers decline. The reduction in the producer price and the output of U.S. produced lemons generate losses in producer surplus. The consumer welfare gain exceeds the producer surplus loss in all three scenarios.

The regional and seasonal restrictions generate indirect as well as direct effects in the U.S. In SIM 1and SIM 2, where Argentine lemons are allowed entry in non citrus-producing states year-around, consumers in that region benefit from lower prices. Consumers in citrus-producing states benefit as well through the indirect effects. Some of the lemons displaced by Argentine lemons in non citrus-producing states move to citrus-producing states and to the rest of the world. The increased supply of lemons in citrus-producing states results in lowers lemon prices.

Indirect effects of seasonal restrictions are illustrated in SIM 3 where both regional and seasonal restrictions are imposed. The seasonal restriction prohibits imports of Argentine lemons during the main lemon production season in the U.S. The effects will depend on how easily lemon suppliers are able to shift supply between seasons. If the elasticity of transformation between seasons is low, the displacement effects of Argentine lemons on the aggregate supply will dominate compared to substitution effects. In this case, lemon prices increase and demand falls in both regions in the season when Argentine lemons are prohibited. If the elasticity is high, and suppliers can more easily switch supplies between seasons, the opposite effects are generated in the lemon production season. In the model, the elasticity of transformation is low (-0.1) to reflect seasonal constraints in lemon production and storage.

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1. Introduction

Argentina has become a major lemon producer and exporter. It has increased lemon production using modern technology especially in the northwest region of the country. It has been aggressive in its drive to sell its lemons to the world market, with the growth of its lemon exports averaging 10 percent annually over the past 10 years. At present, the European Union and Russia are the major international markets for Argentine lemons. The U.S. prohibits Argentine lemons because citrus pest and disease concerns.

Since the 1990s the government of Argentina has negotiated with the government of the United States for possible markets for Argentine lemons into the U.S. The concerns of the U.S. have been about the risks from Mediterranean fruit fly, citrus canker, citrus black spot, sweet orange scab, and, more recently, citrus variegated chlorosis (CVC) found in Argentine lemons. Although the concerns on citrus canker, citrus black spot, and sweet orange scab have declined over the years, the risks from the destructive effects of Mediterranean fruit flies associated with importing Argentine lemons remain a concern and provides the main rational for the current import ban. The ongoing dialogue between Argentina and the U.S. focuses on two critical concerns: (a) whether or not the estimates of the risk of introduction and establishment associated with pests and diseases through lemon imports are accurate and reliable; and (b) whether or not a systems approach to risk management can be defined that would prevent these pests and diseases from entering the U.S. if imports were allowed under specified conditions[1]. At the moment there no agreed answers to these questions.

If the U.S. modifies the import ban on Argentine lemons, it will have an impact on consumption and production of lemons in the U.S. It will also affect imports of lemons from other suppliers to the U.S. market. The objective of this paper is to analyze these effects using a partial equilibrium simulation model. The paper adopts the modeling framework of Peterson and Orden (2008) in their research regarding the opening of the U.S. market to imports of fresh avocados from Mexico.

[1] A systems approach is "a defined set of phytosanitary procedures, at least two of which have independent effect in mitigating pest risk associated with movement of commodities." Plant Protection Act (7 USC 7702, Section 403, Number 18).

There are observed market price differentials in lemons of different origins. Following Peterson and Orden, in the lemon model, lemons of different origins are treated as imperfect substitutes through multi-level CES functions in consumption and CET in production. Peterson and Orden evaluated the effects of opening the U.S. market with different seasonal and geographic restrictions as components of the system approach to pest risk management. A similar approach is followed in this paper. Peterson and Orden also were able to incorporate pest risks and related mitigation and damage costs into their economic analysis for avocados. However, in the present specification of the lemon model, compliance costs for Argentine producers, pest risks from imports, and costs of potential trade-related pest infestations in the U.S. are not incorporated because of the absence of known estimates, particularly for the pest risks associated with imports.

The paper consists of six sections. After the introduction, the second section gives an overview of lemon production, consumption, and trade of the U.S., a brief review of U.S. regulations on Argentine lemons, and a brief overview of the lemon market in Argentina. The third section outlines the framework and the specification of the model. The fourth section outlines the assumptions in each of three scenarios analyzed in the paper regarding the possible entry of Argentine lemons into the U.S. The fifth section traces the economic effects of the possible entry of Argentine lemons into the U.S. under each of the three scenarios. The last section gives a brief summary and conclusions.

In addition, the paper has three appendices. Appendix A discusses the very substantial efforts required to construct the benchmark data. Appendix B presents the calibration of the model and Appendix C presents the derivation of the welfare measures.

2. The Lemon Markets of the U.S. and Argentina

This section presents an overview of the production, consumption and trade of fresh lemons between the U.S. and Argentina. The U.S. regulatory decision-making about Argentine lemon imports is also described.

2.1. The U.S. Market

Over the past 20 years, fresh lemon production in the U.S. has generally been stable (Table 1). From 1989/90 to 2008/09, the average growth in lemon production was about 0.78 percent per year. The average production was about 400 and 500 million kg, with a peak in 2005/06 then a minimum in 2007/08 when production dropped to 360 million kg because of the effects of an unusual freeze. Over the years, there has been an increasing trend in the lemon per capita consumption from about 1.1 kg per capita in the second half of the 1980s to about 1.4 to 1.9 kg in the 2000s. The lemon per capita consumption peaked at 1.88 kg in 2005/06, but dropped in the following years with smaller domestic production. The increase in lemon imports during these years was not enough to offset the domestic production decline. Overall, the total consumption of fresh lemons in the U.S. has grown at an average of 2.2 percent per year, outpacing the growth of lemon production. Lemon hectarage in the U.S. declined from 26.6 thousand hectares in the early 2000s to 23.9 thousand hectares by 2008.

Because of the increased domestic demand for lemons in the U.S., lemon imports have been increasing, while lemon exports have declined. The import/production ratio of lemons increased from less than 3 percent in the second half of the 1980s to 12.5 percent in 2006/07 and 18.6 percent in 2007/08. In 2008/09 the import ratio declined to 8.5 percent. The variation in the import ratio during these three years is explained by the increase in lemon imports due to the freeze in 2007/08 when produced dropped. Imports declined to closer to the 2000s average in the following year when lemon production recovered.

The export/production ratio has declined from about 38 percent in the second half of the 1980s to about 20-25 percent in the 2000s. However, the export ratio increased to 42.9 percent in 2007/08 because of increased U.S. lemon exports to Japan, Canada, Australia and South Korea to take advantage of higher international prices and demand in these countries. These exports further widened the deficit in the supply of lemons in the U.S. domestic market as a result of lower production during 2007/08.

Table 1: U.S. fresh lemons production, consumption and trade, 1989/90 to 2008/09

Year	Production	Consumption	Exports	Imports	Import/ production, %	Export/ production, %	Per capita consumption, kg	Hectarage 1000 hectares /b/
	million kg /a/							
1989/90	422.8	293.3	140.0	10.5	2.5	33.1	1.18	25.6
1990/91	406.8	296.7	121.7	11.6	2.8	29.9	1.18	25.1
1991/92	415.3	292.3	132.2	9.2	2.2	31.8	1.15	25.1
1992/93	431.4	309.0	129.6	7.3	1.7	30.1	1.20	25.1
1993/94	429.2	315.2	121.6	7.6	1.8	28.3	1.21	24.7
1994/95	458.9	340.7	129.0	10.8	2.4	28.1	1.29	24.7
1995/96	467.7	347.6	130.9	10.8	2.3	28.0	1.30	24.8
1996/97	418.1	328.9	113.2	24.0	5.7	27.1	1.18	25.1
1997/98	469.7	311.1	175.4	16.9	3.6	37.3	1.10	25.4
1998/99	418.1	328.9	113.2	24.0	5.7	27.1	1.18	25.5
1999/00	469.7	311.1	175.4	16.9	3.6	37.3	1.11	25.8
2000/01	462.2	381.7	113.4	32.9	7.1	24.5	1.34	26.4
2001/02	497.2	433.9	101.8	38.5	7.7	20.5	1.51	26.6
2002/03	504.9	436.9	98.2	30.2	6.0	19.4	1.51	26.2
2003/04	489.8	414.0	101.9	26.0	5.3	20.8	1.42	25.1
2004/05	452.6	394.1	96.8	38.3	8.5	21.4	1.34	24.9
2005/06	622.4	559.9	100.0	37.5	6.0	16.1	1.88	24.7
2006/07	444.5	382.8	117.3	55.5	12.5	26.4	1.27	24.5
2007/08	357.9	270.8	153.5	66.4	18.6	42.9	0.89	23.9
2008/09	490.0	441.0	90.7	41.7	8.5	18.5	1.44	23.9

/a/ Original data in million pounds, converted into million kg

/b/ Original data in bearing acreage, converted into bearing hectarage

Sources: USDA, National Agricultural Statistics Service, *Citrus Fruits Summary*, various issues; and USDA, Economic Research Service.

The main suppliers of lemons to the U.S. are Mexico and Chile (Table 2). In 2007, Mexico exported 17.4 million kg of lemons to the U.S. In 2008, Mexico's lemon exports surged to 42.9 million kg. Over the past few years, Chile exported about 20 million kg of lemons to the U.S[2]. Spain is another supplier to the U.S. market, with the level of lemon exports erratic over different years. During 2003 to 2008, peak years were 2003 (10.5 million kg) and 2007 (15.9 million kg) but in the other years Spain's lemon exports to the U.S. dropped to less than 6 million kg.

[2]Lemon imports from Mexico declined from 42.9 million kg in 2008 to 13.8 million kg in 2009, while imports from Chile increased from 20.5 million kg to 24 million kg. Thus in 2009, the share of Chile in total U.S. lemon imports improved to 57.7 percent from 30.9 percent in 2008, while the share of Mexico declined to 33.1 percent from 64.6 in 2008.

Table 2: Suppliers of imported lemons to the United States, 2003 to 2008

Import Suppliers	2003	2004	2005	2006	2007	2008
	million kg /a/					
World	30.2	26.0	38.3	37.5	55.5	66.4
Mexico	1.1	3.2	13.8	11.6	17.4	42.9
Chile	14.6	15.3	19.8	19.3	20.6	20.5
Spain	10.5	3.5	1.9	5.3	15.2	1.1
Others	4.0	4.1	2.9	1.3	2.2	1.9
	% share					
Mexico	3.5	12.2	35.9	31.0	31.4	64.6
Chile	48.4	58.8	51.6	51.5	37.1	30.9
Spain	34.8	13.3	5.0	14.1	27.5	1.7
Others	13.2	15.6	7.4	3.5	4.0	2.8

/a/ Original data in metric ton, converted into million kg
Source: USDA/Foreign Agricultural Service/Global Agricultural Trade System
http://www.fas.usda.gov/gats/ExpressQuery1.aspx

The U.S. lemon production is seasonal. In the absence of having monthly production or shipment data, a seasonality index for lemon production in the U.S. was developed based on monthly variations in lemons exports and imports (see Appendix A). U.S. lemon exports peak from November/December until May of the following year (Appendix A, Figure 2A). Since the share of lemon exports is about one-quarter of production, these are also the months when lemon harvest in the U.S. is assumed to reach its peak. During the peak months for exports and production in the U.S., lemon imports are at their lowest level. However, when lemon exports are at their lowest level from June to October, lemon imports reach their peak level. These monthly variations provide strong evidence of counter-cyclicality between lemon exports/production and imports. Based on these monthly variations, Season 1 is defined in the paper as the main lemon production season covering the months from November/December to May of the following year, and a Season 2 (the lemon production off season) as the months between June and October.

2.2. U.S. Regulation on Argentine Lemons

Thornsbury and Romano (2007) provide a detailed historical analysis of the U.S. regulatory policies on Argentine lemons. As indicated above, concerns over citrus canker, citrus black spot, and sweet orange scab have declined over the years, but possible destructive effects from Mediterranean fruit flies in Argentine lemons remain a concern in the U.S. The negotiations

between Argentina and the U.S. over citrus trade are ongoing. The key points in the discussion included the conducting of a pest risk assessment (PRA) that can provide accurate estimates of probabilities of pest introduction and establishment in the U.S. associated with imports from Argentina and the development of a systems approach of risk mitigation measures that would allow for imports under specified conditions. A systems approach would include multi-step, overlapping sanitary and phytosanitary measures to reduce pest risks. Furthermore, to minimize the introduction of pest risk, Argentine lemons may be allowed entry only during the lemon production off season in the U.S. (i.e. season 2) and may be restricted to non citrus-producing states. The citrus-producing states are Arizona, California, Florida, Louisiana and Texas. In the simulation analysis, a Region 1 is defined to consist of these five citrus-producing states, while Region 2 consists of the rest of the U.S.

In 1997, the Animal and Plant Health Inspection Services (APHIS) of the U.S. Department of Agriculture (USDA) provided a PRA which indicated that the median probability estimate of citrus canker becoming established in the U.S. as a result of citrus imports from Argentina's northwest was very low. However, without mitigation measures there was high probability for the introduction into the U.S. of fruit flies and sweet orange scab, and medium probabilities for the introduction of citrus black spot. If mitigation measures were implemented, the probabilities of pest introduction into the U.S. were reduced significantly to almost zero.

In August 1998, APHIS drafted and published a proposed rule that allowed entry of Argentine citrus (grapefruit, lemons or oranges) into the U.S. (USDA, APHIS 1998a). To keep citrus fruits with black spot and sweet orange scab from entering the U.S. border, the proposed rule contained a systems approach whose key elements included:

a. Origin requirements which specified that citrus fruits must have come from groves located in regions that are citrus canker-free which included the provinces of Catamarca, Jujuy, Salta and Tucuman.

b. Grove requirements which specified that citrus fruits must have come from groves which are: (i) registered in SENASA's citrus fruit export program; (ii) surrounded by a 150-meter-wide buffer area, and citrus planted within the buffer area cannot be exported to the U.S.; (iii) planted with citrus planting stock that come from Catamarca, Jujuy, Salta

and Tucuman; and obtained through SENASA's approved citrus stock propagation center; (iv) maintained by removing fallen fruit, leaves and branches within the grove and the buffer area, and inspected by SENASA before grove blossom; (v) treated during the growing season by oil-copper oxychloride spray under the supervision of SENASA; and (iv) surveyed for possible citrus black spot and sweet orange scab by SENASA 20 days before harvest.

c. Postharvest requirements which specified that citrus fruits must be: (i) identifiable by putting the fruit in a box or container marked with SENASA's registration number that indicates the grove where the fruit comes from; (ii) not be mixed in the packing houses with fruits coming from other locations that do not meet the requirements of the rule; (iii) placed in packing house with room temperature in four days to allow fruit damages to become apparent; (iv) damaged fruits must be removed and the fruits must be inspected by SENASA for possible citrus black spot and sweet orange scab; and (v) treated chemically through immersion for two minutes with sodium hypochloride at a concentration of 2000 parts per million, immersion in orthophenilphenate of sodium, spraying with imidazole, and application of 2-4 thiazailil benzimdazole and wax.

d. Phytosanitary certificate which specified that the citrus fruits exported to the U.S. are SENASA-certified that the fruits were produced and handled according with the requirements of the rule and are free of citrus black spot and sweet orange scab.

e. Cold treatment which specified that the citrus fruits must be treated in an authorized cold treatment listed in the Plant Protection and Quarantine and Treatment Manual for possible Medfly and other fruit flies.

f. Disease detection which specified that if citrus black spot and sweet orange scab are detected after all of the processing requirements were done, both APHIS and SENASA are notified and the grove where the fruit originated must be delisted in SENASA's citrus export program for the remainder of the growing and harvest season, and no citrus fruit from the grove are allowed entry into the U.S. during the remainder of the shipping season.

g. Distribution which specified that the citrus fruits have limited distribution in the continental U.S: (i) cannot be distributed during 2000 and 2001 shipping season in

Alabama, Arizona, Arkansas, California, Colorado, Florida, Louisiana, Mississippi, Nevada, New Mexico, Oklahoma, Oregon, Texas, and Utah; (ii) cannot be distributed during 2002 and 2003 shipping season in Arizona, California, Florida, Louisiana and Texas,; (iii) can be distributed in all continental U.S. in 2004 shipping season.

h. Port of entry which specified that citrus fruits may enter the U.S. only through ports located in a State where distributed is allowed.

i. Repackaging which specified that the original stickers will not be removed if repackaged and the new boxes must be marked with all the required information.

APHIS published a final rule on June 15, 2000 that allowed citrus imports from Argentina using a systems approach to guard against citrus black spot, sweet orange scab, fruit flies and other plant pests (USDA APHIS, 2000). In the Federal Rules and Regulations implementing the 1997 PRA, Argentine citrus fruits (oranges, grapefruits and lemons) from regions free of citrus canker were to be allowed initially-limited but increasing entry to the U.S.[3] During the 2000 and 2001 shipping seasons, citrus fruits from Argentina were to be distributed in all areas of the continental U.S., except Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Louisiana, Mississippi, Nevada, New Mexico, Oklahoma, Oregon, Texas, and Utah[4]. During the 2002 and 2003 shipping seasons, the fruits were to be distributed in all areas of the continental U.S., except Arizona, California, Florida, Louisiana, and Texas. For the 2004 shipping season and beyond, the fruit was to be distributed in all areas of the continental U.S.

But the access to the U.S. market lasted only briefly because the rule was challenged in the U.S. courts where a lawsuit was filed against the U.S. Department of Agriculture by four California citrus growers and the U.S. Citrus Science Council. The position of the complainants was that the final rule was unlawful because of inconsistency with the Plant Quarantine Act of 1912, which was intended "to exclude plants or plant products which may convey fruits diseases or insect pests new to or not therefore widely prevalent or distributed within and throughout the

[3] http://www.gpo.gov/fdsys/pkg/FR-2000-06-15/pdf/00-14851.pdf

[4] In the Federal Rules and Regulations implementing the 1997 Final Rule on importation of citrus imports from Argentina, shipping season refers to the months when Argentine starts shipping lemons in May or June (http://www.gpo.gov/fdsys/pkg/FR-2000-06-15/pdf/00-14851.pdf). This generally coincides with season 2 in the present paper which is defined as the period June to October.

U.S." (Harland Land Co. versus USDA, 2001)[5].The complainants prevailed in their suit against USDA which resulted in re-imposition of a ban on importation of any citrus fruit from Argentina.

In 2007, APHIS released another PRA which focused only on imports of fresh lemons from the northwest region of Argentina. The PRA identified seven quarantine pests that are likely to follow identified pathways for introduction to the U.S. Table 3 summarizes the overall risk ranking of the seven identified pests. Arthropod pests have the highest total potential risk.

Table 3: Summary of pest risks

Pest	Consequences of introduction	Likelihood of introduction	Total potential pest risk
Arthropod			
Anastepha fraterculus	High /14/	High /16/	High /30/
Ceratitis capitata	High /14/	High /16/	High /30/
Parlatoria cinereae	High /13/	Medium /13/	Medium /26/
Parlatoria ziziphi	High /13/	Medium /13/	Medium /26/
Bacteria			
Zanthomonas axonopodis pv citri	Medium /11/	Low /9/	Medium /20/
Fungi			
Elsinoe australis	Low /6/	Medium /13/	Medium /19/
Guignardia citricarpa	Medium /9/	Medium /13/	Medium /22/

Source: USDA AHPIS, 2007, p58
Note: numbers in // are ranking

No revised import rule has been proposed based on the 2007 PRA. It also did not recommend specific mitigation measures. However, Thornsbury and Romano (2007) compared the 1997 PRA with the 2007 PRA based on the latter's discussion on the likelihood and consequences of pest introduction and mitigating steps. The results of their analysis are presented in Table 4.

[5] Harlan Land Co., Limoneira Company, Pecht Ranch, R7 Enterprises and U.S. Citrus Science Council versus U.S. Department of Agriculture, Daniel R. Glickman, Secretary of Agriculture, and Craig A. Reed, Administrator, Animal and Plant Health Inspection Service, United States District Court, Eastern District of California, Case No.CIV F00-6106 REC LIO.

Table 4: Comparison of systems approach measures presented in the U.S. 1997 and 2007 PRAs for lemon imports from Argentina

Measures	1997 PRA	2007 PRA/a/
Orchard design	150 meter buffer zone around grove Nursery stock must originate from the canker-free zone	Buffer zone around export approved groves Windbreaks
Orchard practices	Two, or more, treatments with a copper-oil spray per year. Fallen leaves and fruit must be removed from the grove floor Inspection prior to fungicide spray applications. Fruit with any visible symptions to be sent for laboratory analysis. Survey for disease symptoms 20 days before harvest. Sampled fruit to be held for 20 days and examined for disease symptoms. Blemished fruit culled during harvest.	Copper spray Chemical control of scale insects Pruning diseased shoots and remove leaf litter from orchard floor Remove any old fruit left on the tree and cull any symptomatic fruit. Harvest prior to maturity
Post-harvest or packinghouse practices	Packing houses in the program will be used for export to the US only. Harvest fruit held at room temperature for 4-5 days in the packinghouse to check for development of citrus black spot symptoms. Fruit dipped in the packinghouse to control fungal and bacterial growth. Fruit inspected and culled again after treatment and before packing Cold treatment required for fruit flies (oranges and grapefruit only, lemons are exempt)	Cull symptomatic fruit SOPP or chlorine wash and mechanical brushing of fruit Treat with TBZ Wax fruit Storage temperature requirements
Certifications	Identity and origin of fruit maintained throughout the process Export groves must be registered with SENASA Certificate from SENASA that fruit originated in a canker-free area and that it is apparently free from citrus back spot	Export groves must be registered with SENASA

/a/ The 2007 PRA does not recommend any specific mitigation measures, these measures represent only those mentioned in the discussion of likelihood and consequences of introduction.

Source: Thornsbury and Romano (2007)

There were peer reviews conducted on the 2007 PRA. The first[6], which was completed in September 4, 2007, focused on the pest risk associated with the importation of fresh commercially grown and packed lemon fruit from Northwest Argentina, while the second[7], which was completed in May 27, 2008, focused on the risk management strategy to control the pests. In addition, a supplemental peer review was conducted in 2009 that examined the assumption in the 2007 PRA regarding the pest risk associated with citrus variegated chlorosis (CVC)[8]. APHIS has required Argentine to monitor all citrus plants that show symptoms of CVC.

There was no preliminary or final rule drafted based on the 2007 PRA. The ongoing negotiations between the U.S. and Argentina may result in a number of agreed mitigating steps

[6] http://www.aphis.usda.gov/peer_review/downloads/Argentina-lemonPeerReviewPlan110807.pdf

[7] http://www.aphis.usda.gov/peer_review/downloads/ArgentinalemonRMAPeerReviewPlan120908.pdf

[8] http://www.aphis.usda.gov/peer_review/content/printable_version/peer_review_plan_suppl_cvc_rev_of_rma_for_arg_lemon_041409.pdf

which likely will incorporate measures included in the 2007 and 1997 PRAs. If so, a rule could be draft based on these sets of measures. There would be another set of Federal Rules and Regulations to implement the final rule. Similar to the earlier ones, they would almost certainly include a limited distribution, phase-in plan for monitoring purposes, or possibly permanent geographic and/or seasonal restrictions on imports.

2.3. The Argentine Market

In the eleven-year period 1998-2008, lemon production in Argentine averaged 1,400 million kg (Table 5). About 75 percent of lemons produced in the country are processed or consumed domestically and 25 percent are sold as fresh fruit in world markets. Lemon production in Argentina grew by 2.9 percent per year during the decade. While processing and domestic consumption of lemons increased by only 1.1 percent per year, exports grew by 9.8 percent per year.

Table 5: Argentine lemon production, consumption/processing and exports, 1998 to 2008

	Production	Consumption/ Processing	Exports
Year	million kg		
1998	1,025	869	156
1999	1,043	845	198
2000	1,163	958	206
2001	1,217	979	238
2002	1,313	1,045	268
2003	1,236	900	336
2004	1,340	1,021	319
2005	1,498	1,119	379
2006	1,504	1,179	326
2007	1,517	1,158	359
2008	1,362	966	396
Growth /a/	2.9	1.1	9.8
Ave 2006-08	1,461	1,101	360

/a/ Geometric growth 1998-2008

Source: La Actividad Citricola Argentina,The Argentine Citrus Industry (2009)

In 2008 lemon production in Argentina was 1,362 million kg. The bulk of lemon production (87 percent) came from the province of Tucuman, which is located in the northwest of Argentina (Table 6). The remaining 13 percent of lemon production occurred mainly in five other provinces: Salta, 6 percent; Jujuy and Corrientes, 2.5 percent each; and Entre Rios, 1 percent.

Table 6: Lemon production in Argentina by Province, 2008

Provinces	Production million kg	%, share
Tucuman	1,181.4	86.73
Salta	85.5	6.28
Jujuy	35.4	2.60
Corrientes	35.0	2.57
Entre Rios	16.3	1.19
Misiones	7.2	0.53
Catamarca	0.5	0.04
Buenos Aires	0.5	0.03
Chaco	0.4	0.03
Formosa	0.1	0.01
Total	1,362.2	100.0

Source: La Actividad Citricola Argentina,The Argentine Citrus Industry (2009)

There was a significant shift in Argentina's lemon market in the 1980s. Local businessmen bought and converted sugar farm lands in the northwest region of Argentina (Catamarca, Jujuy, Salta and Tucuman) to citrus production. The goal was to apply modern citrus production technology to produce citrus fruit free of citrus canker in preparation for the opening up of foreign markets anticipated from international negotiations, including the Uruguay Round of GATT negotiations that created the World Trade Organization (WTO). Argentina was particularly eyeing the markets in the EU and U.S., although entry to the U.S. would require new regulatory measures, not just market-access tariff reductions.

Since the 1980s Argentina has been aggressive in its lemon export drive. The largest single-country buyer of Argentine lemons in 2008 was Russia, absorbing 18.2 percent of the total (Table 7). The EU countries as a whole are major consumers of Argentine lemons. In 2008, 67 percent of Argentina's lemon exports ended up in the EU market. Within the EU, the Netherlands absorbed 17 percent. Spain (14.8 percent) and Italy (14.4 percent) are also major destinations, despite their domestic citrus production and possible pest-risk concerns.

Table 7: Destination of Argentine lemon exports, 2008

Export Markets	Exports metric tons	% share
Total	395,791	100.000
Russia	71,982	18.187
EU Countries	265,325	67.037
Netherlands	67,710	17.108
Spain	58,717	14.835
Italy	57,110	14.429
Greece	22,486	5.681
Belgium	18,284	4.620
Poland	10,833	2.737
United Kingdom	7,845	1.982
Romania	5,385	1.361
France	4,303	1.087
Germany	3,666	0.926
Slovenia	2,725	0.688
Portugal	1,666	0.421
Cyprus	1,435	0.363
Lithuana	947	0.239
Sweden	939	0.237
Denmark	689	0.174
Ireland	301	0.076
Bulgaria	165	0.042
Finland	48	0.012
Czech Republic	48	0.012
Hungary	24	0.006
All Others	58,485	14.777

Source: La Actividad Citricola Argentina,The Argentine Citrus Industry (2009)

3. The Lemon Simulation Model

This section provides the specification of the simulation model developed to examine the economic impact of U.S. regulation decisions concerning imports of Argentine lemons. The model has two basic blocs: (i) the demand for lemons in the U.S., and (ii) the supply of lemons in the U.S., which includes domestically produced lemons and the excess supply (exports) from other countries supplying the U.S. Appendix A presents the data sources and full approach taken to specifying the benchmark values for the model and Appendix B discusses the approach taken in the calibration of the model.

The demand for lemons in the U.S is modeled based on a nested CES consumption preference structure of a representative consumer. In the first nest, the consumer has the choice between lemons and all other goods. In the second nest, the consumer has the choice between

U.S. produced lemons and imported lemons. In the third nest, the consumer has the choice among lemons imported from Mexico, Chile, Spain, and others. The choice of imported lemons from Argentina is added in the simulation.

As indicated above, any systems approach adopted to allow entry of lemons from Argentina into the U.S. is likely to include geographic and possibly seasonal restrictions. In the model, U.S. demand regions are indexed as r {*r1* = citrus-producing states, *r2* = non-citrus producing states}, and seasons as s {*s1* = lemon season, *s2* = lemon off-season}.

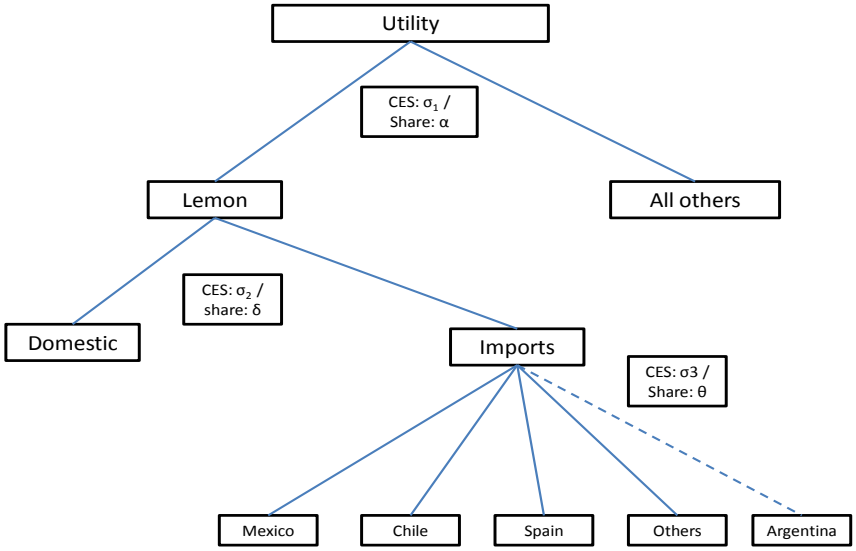
In the U.S., the supply of lemons is based on a two-level CET production possibility frontier of a representative producer. In the first level, U.S. producers decide between selling in season 1 and season 2. In the second level, U.S. producers decide between selling to the U.S. or to the rest of the world. Similarly, in the excess supplier countries that sell lemons to the U.S., the exporters decide between selling in season 1 and season 2. In the second level, they decide between selling to the U.S. and the rest of the world.

In the model, there are five lemon suppliers which are indexed as j {*U.S.*, *Mex* = Mexico, *Chl* = Chile, *Spn* = Spain, and *others*}. In the simulation, Argentina (*Arg*) is added in the list of suppliers.

3.1. Demand for lemons

In the model, the preference structure of a representative consumer has three nests (Figure 1). The first nest is a CES utility function of lemons and all other goods. The second nest is another CES function that aggregates the demand for domestically produced and imported lemons, while third nest is a CES function that aggregates imported lemons from various sources.

Figure 1: Consumption preference structure



The utility function of the representative consumer is

$$(1) \qquad Max \quad U_{r,s} = \left(\alpha_{r,s}^{\frac{1}{\sigma_1}} \cdot QL_{r,s}^{\frac{\sigma_1 - 1}{\sigma_1}} + \left(1 - \alpha_{r,s}\right)^{\frac{1}{\sigma_1}} \cdot QO_{r,s}^{\frac{\sigma_1 - 1}{\sigma_1}} \right)^{\frac{\sigma_1}{\sigma_1 - 1}}$$

where $U_{r,s}$ is utility of the consumer in region r during season s, $QL_{r,s}$ quantity of lemons, $QO_{r,s}$ quantity of all other goods, $\alpha_{r,s}$ the share parameter in the CES utility function, and σ_1 the elasticity of substitution in the first nest. The income constraint is

$$(2) \qquad I_{r,s} = PL_{r,s} \cdot QL_{r,s} + PO_{r,s} \cdot QO_{r,s}$$

where $I_{r,s}$ is income, $PL_{r,s}$ the wholesale price of lemons, and $PO_{r,s}$ the wholesale price of all other goods.

The first order condition of utility maximization generates the following uncompensated demand for lemons

(3) $$QL_{r,s} = \frac{\alpha_{r,s} \cdot PL_{r,s}^{-\sigma_1} \cdot I_{r,s}}{\alpha_{r,s} \cdot PL_{r,s}^{1-\sigma_1} + \left(1-\alpha_{r,s}\right)}$$

In the second nest, the consumer has the choice between U.S. produced lemons and imported lemons. The expenditure function at this nest is

(4) $$PL_{r,s} \cdot QL_{r,s} = wp_{r,s,US} \cdot x_{r,s,US} + PM_{r,s} \cdot QM_{r,s}$$

where $wp_{r,s,US}$ the wholesale price of U.S. produced lemons in region r and season s, $x_{r,s,US}$ is the demand for U.S. produced lemons, $PM_{r,s}$ the composite wholesale price of imported lemons, and $QM_{r,s}$ the composite demand for imported lemons. The CES demand for U.S. produced lemons in the U.S. is

(5) $$x_{r,s,US} = \frac{\delta_{r,s} \cdot wp_{r,s,US}^{-\sigma_2} \cdot PL_{r,s} \cdot QL_{r,s}}{\delta_{r,s} \cdot wp_{r,s,US}^{(1-\sigma_2)} + \left(1-\delta_{r,s}\right) \cdot PM_{r,s}^{(1-\sigma_2)}}$$

where $\delta_{r,s}$ is the share parameter in the CES function in the second nest; and σ_2 is the elasticity of substitution in the second nest.

In the third nest, the consumer has the choice of buying imported lemons from four sources (Argentina is added in the simulations). The expenditure function in the third branch is

(6) $$PM_{r,s} \cdot QM_{r,s} = \sum_{j \neq US} wp_{r,s,j} \cdot x_{r,s,j}$$

where $wp_{r,s,j}$ is the wholesale price of lemons from exporter j; and $x_{r,s,j}$ is the corresponding demand which is specified as

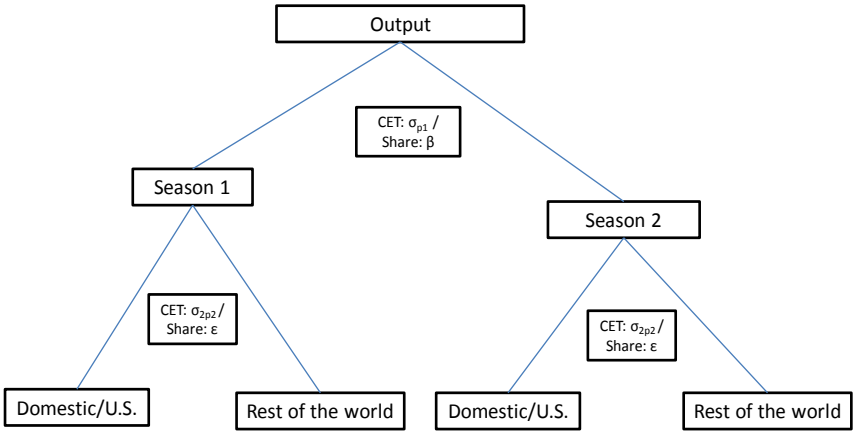
(7) $$x_{r,s,j} = \frac{\theta_{r,s,j} \cdot wp_{r,s,j}^{-\sigma_3} \cdot PM_{r,s} \cdot QM_{r,s}}{\sum_{j \neq US} \theta_{r,s,j} \cdot wp_{r,s,j}^{(1-\sigma_3)}} \qquad j = Mexico; Chile; Europe; Others - U.S.$$

where $\theta_{r,s,j}$ is the import share parameters in the CES function in the third nest which sum up to one; and σ_3 is the elasticity of substitution in the third nest. The values of the elasticity of substitution are $\sigma_3 \geq \sigma_2 \geq \sigma_1 \geq 0$ and $\sigma_3 > 1$[9].

3.2. Supply of Lemons

There are two nests in the generic production structure of lemon suppliers (Figure 2). For suppliers in the U.S, the choice in the first nest is to sell lemons either in season 1 or season 2. In the second nest, the suppliers have the choice of selling lemons to the U.S. or to the rest of the world. In the specification below, these markets are indexed as m {*US*, *ROW*}. The production structure is modeled similarly for the excess suppliers selling to the U.S.

Figure 2: Generic model of suppliers



[9]Appendix B discusses the calculation of these parameters and presents the conditions regarding the values of these parameters.

The producers of lemons in the U.S. and the excess suppliers to the U.S. maximize revenue subject to a CET production possibility frontier. The maximization yields the CET revenue function

$$(8) \qquad R_j = \left(\sum_s \beta_{j,s} \cdot PPS_{j,s}^{(1-\sigma_{p1})} \right)^{\frac{1}{(1-\sigma_{p1})}} \cdot V_j$$

where R_j is revenue of j, $PPS_{j,s}$ the producer price in season s; V_j the aggregate factor input used by supplier j; $\beta_{j,s}$ the share parameters in the CET function which sum up to one; and σ_{p1} the elasticity of transformation in the first nest of the production structure.

In the first nest, the conditional lemon supplies are derived by taking the first derivative of the CET revenue function with respect to prices. They are given by

$$(9) \qquad QY_{j,s} = \beta_{j,s} \cdot PPS_{j,s}^{-\sigma_{p1}} \cdot \left(\sum_s \beta_{j,s} \cdot PPS_{j,s}^{(1-\sigma_{p1})} \right)^{\frac{\sigma_{p1}}{(1-\sigma_{p1})}} \cdot V_j$$

where $QY_{j,s}$ is lemon supply of j in season s.

In the second nest, the revenue function is

$$(10) \qquad PPS_{j,s} \cdot QY_{j,s} = \sum_m pp_{m,j,s} \cdot y_{m,j,s}$$

where $pp_{m,j,s}$ is the lemon producer price of j sold in market m in season s; and $y_{m,j,s}$ the corresponding lemon supply. The conditional supply of lemons by the *jth* supplier in market m and season s is

$$(11) \qquad y_{m,j,s} = \frac{\varepsilon_{m,j,s} \cdot pp_{m,j,s}^{-\sigma_{p2}} \cdot PPS_{j,s} \cdot QY_{j,s}}{\sum_m \varepsilon_{m,j,s} \cdot pp_{m,j,s}^{(1-\sigma_{p2})}}$$

where $\varepsilon_{m,j,s}$ are the share parameters in the CET function which sum up to one; and σ_{p2} the elasticity of transformation in the second branch.

The aggregate factor input of supplier j is affected by the level of the producer price through a linear function which is given by

(12) $V_j = \tau_j + \eta_j \cdot PPL_j$

where PPL_j is the composite producer price lemons of supplier j and τ_j and η_j are parameters are parameters chosen to fit the simulation model to benchmark data. The composite producer price is given by

(13) $PPL_j \cdot \sum_{s=1}^{2} QY_{j,s} = \sum_{s=1}^{2} PPS_{j,s} \cdot QY_{j,s}$

The values of the elasticity of transformation satisfy the conditions $\sigma_{p2} \leq \sigma_{p1} \leq 0$.

3.3. Market Equilibrium

The market equilibrium is determined by the equality of the sum of the demand for lemons over the two regions in each season and the supply available in that season (i.e., for each j = U.S., Mexico, Chile, Spain, Others).

(14) $\sum_{r} x_{r,s,j} = y_{d,j,s}$

Marketing margins between wholesale and producer prices are assumed fixed for each supplier. To solve the model, the producer prices ($pp_{m,j,s}$) are determined at which equation (14) clears simultaneously. The producer prices of supplier j in the rest of the world ($pp_{w,j,s}$) are assumed fixed. Thus, this is essentially a "small country model" in which price and quantity developments in the U.S. market affect the quantities in other markets but not prices[10].

4. Definition of Scenarios

Three scenarios are analyzed to assess the economic impact on the U.S. lemon markets of the potential U.S. regulatory decisions concerning the removal of the import ban on Argentine lemons. In all three scenarios, imports into the U.S. are restricted to region 2, the non citrus-producing states. Imports are allowed year-around in the first two scenarios, but are further

[10] See Cororaton, Orden and Peterson (2011 forthcoming) for an extension of the model with endogenous prices and quantities in the EU and an aggregate rest of world importing region.

restricted to the U.S. lemon production off season (season 2) in the third scenario. The scenarios are:

4.1. SIM 1 – Chile and Argentina have equal import shares

Chile and Argentina have similar geographic location. Their distance to the U.S. is almost the same. Given these factors, Chile and Argentina may produce lemons of similar qualities in consumer perceptions and therefore be closer substitutes than the other imported lemons in the U.S. Thus, this scenario assumes that once Argentine lemons are allowed entry into the U.S., they compete directly with lemons imported from Chile in changing consumer preferences and will reduce the import shares of Chile by half. The other half is assigned as the import share of lemons from Argentina. Under this initial assumption, the model then solves with competition among lemons from different sources as specified in the CES demand system.

To introduce Argentine lemons in the model, Argentina is added in the list of import suppliers by expanding the vector of share parameters, $\theta_{r2,s,j}$, in equation (7) to include the share for Argentina in region 2 for both seasons. Table 3B in Appendix B shows that the import share of lemons from Chile in region 2 is $\theta_{r2,s1,Chl} = 0.4392$ in season 1 and $\theta_{r2,s2,Chl} = 0.4782$ in season 2, where *Chl* denotes Chile. Thus, under this scenario, in region 2 the import share of lemons from Argentina is $\theta_{r2,s1,Arg} = 0.4392/2 = 0.2196$ in season 1 and $\theta_{r2,s2,Arg} = 0.4782/2 = 0.2391$ in season 1, where *Arg* denotes Argentina. In region 1, the import shares of lemons from Chile are unchanged in both seasons. The import shares of lemons from Mexico, Spain, and others also unchanged in region 1 and region 2 for both seasons.

4.2. SIM 2 – Argentine lemons compete equally with all other imports

Argentine lemons are also allowed entry in non citrus-producing states year-around in SIM 2. However, in this scenario Argentine lemons compete directly in terms of consumer preferences not only with lemons from Chile, but with all imported lemons. Similar to SIM 1, the vector of share parameters $\theta_{r2,s,j}$, in equation (7) is expanded to include the share for Argentina in region 2 for both seasons. A share value of $\theta_{r2,s,Arg} = 0.4$ is assumed in region 2 for both seasons. This value is approximately equal to the average shares of Mexico and Chile in 2006-08 (see Table 2; for the three years Mexico's share was 42.3 percent and Chile's 39.8 percent). If the share parameter of Argentina is introduced in the demand function, the quantity demand for

all other imported lemons is reduced proportionately. The implied values of the share parameters including the new share for Argentina, computed using the new equilibrium values of quantities and prices, are also reduced proportionately so that the sum of the share parameters is equal to one.

4.3. SIM 3 – Argentine lemons are allowed entry with regional and seasonal restrictions

To further reduce the possibility of pest introduction and establishment, SIM 3includes two items in the systems approach: Argentine lemons are not allowed entry in citrus-producing states and can only be shipped into the non citrus-producing states during the lemon production off-season (season 2 in the model) which consists of the months from June to October. The vector of share parameters $\theta_{r2,s2,j}$, in equation (7) is expanded to include the share for Argentine in region 2–season 2.The value of the share parameter for Argentina is also $\theta_{r2,s2,Arg} = 0.4$ where s2 is season 2.

5. Simulation Results

The effects on the producer and wholesale prices, the production, consumption and trade of lemons in the U.S. are discussed for each scenario. The effects on the producer prices and lemon exports of the excess suppliers are analyzed. The effects under each scenario are computed relative to the base values, as shown in Tables 8-13.

5.1. SIM 1 – Chile and Argentina have equal import shares

A total of 7.2 million kg of Argentine lemons are imported into the U.S. (Table 8) under SIM 1. Of these imports, 2.2 million kg will be shipped in season 1 and 5 million kg in season 2[11]. The entry of Argentine lemons decreases the composite price of lemons in the U.S. by 0.65 percent (Table 9) and increases the overall demand for lemons by 0.3 percent.

There is essentially a negligible effect on the total lemon exports of Argentina (Table 10). Argentina decreases its lemon export supply to rest of the world by almost the same amount of

[11] As discussed in Appendix A, and apparent in Table 8, the bulk of lemon imports in the U.S. are shipped in season 2. Thus, even without seasonal restrictions in SIM 1, imports of Argentine lemons are higher in season 2 compared to season 1.

lemons as it sells to the U.S.[12] In the benchmark, Chile sells half of its lemons to the U.S. The assumed consumer substitution from Chile to Argentina in region 2 in SIM 1 leads to a sharp drop in Chile's lemon exports to the U.S. by 23 percent. While Chile's lemon exports to the rest of the world increase by15.7 percent, its overall lemon exports decline by 5 percent.

In region 2 the entry of Argentine lemons, with the assumed reduction in the share of lemons from Chile, changes the structure of lemon demand in the U.S., the production of U.S. produced lemons, and the lemon exports of Mexico, Spain and others. For lemons from Chile, the demand falls sharply by almost 40 percent in both seasons (Table 8). The wholesale prices of lemons from Chile fall by 13.6 percent in season 1 and 9.3 percent in season 2.

The drop in wholesale prices of lemons from Chile is the key factor behind the fall in the composite import price in region 2, by 3.3 percent in season 1 and 2.7 percent in season 2 (Table 9). With the decline in the composite import prices, the overall lemon imports in region 2 increase by 3.9 percent in season 1 and 2.8 percent in season 2 (Table 8). The wholesale prices of U.S. produced lemons decline in region 2, by only about 0.05 percent. This price decline is small relative to the fall in the composite import prices. Thus, consumers in region 2 substitute imported lemons for U.S. produced lemons in both seasons. The demand for U.S. produced lemons in region 2 declines (0.1 percent in season 1 and 0.28 percent in season 2), while the aggregate demand for imported lemons increases. The import demand for lemons from Mexico, Spain, and others each decline, but the decreases are marginal relative to the fall in lemon imports from Chile. The decline in the wholesale prices of these lemons in region 2 is marginal as well.

Region 1 is affected indirectly by the changes that take place in region 2. In region 1 Argentine lemons remain prohibited and consumer preferences are unchanged as no new variety is available. As prices of lemons imported from Chile fall, their wholesale prices fall in region 1 and demand increases. The demand for lemons from Chile in region 1 increases by 18 percent in season 1 and 16.4 percent in season 2 (Table 8). The wholesale import prices of lemons from

[12] In an expanded model in which the reduced supply of lemons from Argentina raises prices in world markets, there is a stronger net effect on Argentina's total supply, which expands when access is allowed into the U.S. market. One consequence of increased aggregate supply from Argentina is that imports into the U.S. also increase more than in SIM 1. For full results and discussion see Cororaton, Orden and Peterson (2011, forthcoming).

Mexico, Spain and others also decline in season 1 and season 2, but the decline is small relative to the fall in the wholesale prices of lemons from Chile. Thus, consumers in region 1 substitute lemons imported from Chile for those imported from Mexico, Spain and others. The composite import price falls in region 1 by 5.5 percent in season 1 and 4.2 percent in season 2. In region 1 the demand for lemons from Chile increases in both seasons, while the demand for lemons from Mexico, Spain and others decline as the substitution effect dominates the effect of own-price declines.

In region 1, the wholesale price of U.S. produced lemons also declines in both seasons. The decline is small relative to the fall of the composite import prices. Thus, consumers in region 1 also substitute imported lemons for U.S. produced in both seasons. Thus, the demand for U.S. produced lemons in region 1 declines (0.17 percent in season 1 and 0.52 percent in season 2), while the demand for imported lemons increases.

As the demand for U.S. produced lemons in the U.S. decline, U.S. producers decrease their lemon supply to the U.S. market by 0.18 percent and increase their exports to the rest of the world by 0.09 percent (Table 10). The composite producer price of U.S. produced lemons falls by 0.2 percent because of the decline in demand in the U.S. market (Table 12). Thus, total U.S. lemon production decreases by 0.11 percent. Similarly, as the demand in the U.S. for lemons imported from Mexico, Spain, and others declines, producers in these countries reduce their supply to the U.S. market and increase their exports to the rest of the world. The composite producer prices of lemons from Mexico, Spain, and others decline because of the decrease in the demand for these lemons in the U.S. market. Thus, their total lemon exports decline.

5.2. SIM 1 – Welfare effects

In SIM 1, the decrease of the composite wholesale price of lemons by 0.65 percent and increases in total U.S. consumption of lemons by 0.3 percent increases consumer welfare by $4.65 million (Table 13). However, there are displacement effects on U.S. lemon production which decreases as the composite producer price of U.S. produced lemons falls by 0.2 percent and production by 0.11 percent. This reduces the producer surplus of U.S. producers by $1.9 million. The net welfare gain in the U.S. economy is $2.7 million.

Table 8: Quantity of lemons consumed in the U.S. by region and season

	Base quantities	Simulated quantities (mil. kg)			% change from base		
Lemons	(mil. kg)	SIM 1	SIM 2	SIM 3	SIM 1	SIM 2	SIM 3
Region 1/Season 1 - Total	80.115	80.279	80.382	80.039	0.204	0.333	-0.095
U.S. produced	75.563	75.436	75.358	75.546	-0.168	-0.271	-0.022
Lemon imports	4.553	4.843	5.024	4.493	6.380	10.355	-1.305
Mexico	1.927	1.900	2.183	1.878	-1.397	13.286	-2.547
Chile	1.814	2.141	1.963	1.803	18.051	8.209	-0.606
Spain	0.655	0.647	0.705	0.657	-1.246	7.624	0.192
Others	0.156	0.154	0.173	0.156	-1.210	10.558	-0.370
Argentina							
Region 1/Season 2 - Total	39.569	39.897	40.060	40.109	0.828	1.241	1.364
U.S. produced	28.400	28.251	28.139	28.136	-0.523	-0.917	-0.930
Lemon imports	11.169	11.645	11.921	11.973	4.262	6.728	7.196
Mexico	4.728	4.560	5.175	5.231	-3.558	9.460	10.645
Chile	4.450	5.181	4.647	4.649	16.418	4.414	4.470
Spain	1.608	1.536	1.685	1.679	-4.433	4.827	4.446
Others	0.384	0.369	0.414	0.414	-3.950	7.881	7.842
Argentina							
Region 2/Season 1 - Total	190.648	190.902	191.023	190.480	0.133	0.196	-0.088
U.S. produced	179.814	179.641	179.583	179.788	-0.097	-0.129	-0.015
Lemon imports	10.834	11.261	11.439	10.692	3.944	5.590	-1.309
Mexico	4.586	4.565	3.716	4.475	-0.449	-18.963	-2.418
Chile	4.317	2.599	3.396	4.285	-39.789	-21.327	-0.724
Spain	1.559	1.555	1.210	1.561	-0.293	-22.417	0.124
Others	0.372	0.371	0.297	0.371	-0.250	-20.191	-0.432
Argentina		2.171	2.820				
Region 2/Season 2 - Total	94.162	94.719	94.828	94.927	0.592	0.707	0.813
U.S. produced	67.582	67.396	67.403	67.397	-0.275	-0.265	-0.273
Lemon imports	26.580	27.323	27.424	27.530	2.797	3.178	3.574
Mexico	11.251	11.183	9.200	9.309	-0.600	-18.225	-17.256
Chile	10.590	6.377	8.323	8.341	-39.786	-21.408	-21.235
Spain	3.826	3.776	3.036	3.030	-1.287	-20.650	-20.802
Others	0.913	0.905	0.742	0.743	-0.867	-18.740	-18.634
Argentina		5.082	6.123	6.106			
Total U.S. - Annual	404.495	405.797	406.293	405.555	0.322	0.444	0.262
U.S. produced	351.359	350.724	350.484	350.867	-0.181	-0.249	-0.140
Total imports	53.136	55.073	55.809	54.688	3.646	5.031	2.921
Mexico	22.492	22.208	20.275	20.893	-1.259	-9.856	-7.106
Chile	21.171	16.298	18.329	19.079	-23.017	-13.426	-9.882
Spain	7.648	7.514	6.636	6.927	-1.742	-13.232	-9.429
Others	1.825	1.799	1.626	1.683	-1.419	-10.929	-7.792
Argentina		7.252	8.944	6.106			

Table 9: Wholesale price of lemons in the U.S. by region and season

Lemons	Base prices ($/kg)	Simulated prices ($/ kg)			% change from base		
		SIM 1	SIM 2	SIM 3	SIM 1	SIM 2	SIM 3
	Region 1 - Season 1						
Composite price	1.609	1.602	1.598	1.612	-0.407	-0.663	0.190
U.S. produced	1.624	1.623	1.622	1.626	-0.070	-0.117	0.124
Composite import price	1.356	1.281	1.239	1.374	-5.539	-8.686	1.276
Mexico	1.089	1.087	0.976	1.113	-0.173	-10.378	2.201
Chile	1.555	1.355	1.442	1.565	-12.822	-7.232	0.695
Spain	1.583	1.579	1.475	1.585	-0.288	-6.852	0.091
Others	1.409	1.404	1.286	1.416	-0.315	-8.719	0.516
Argentina							
	Region 1 - Season 2						
Composite price	1.758	1.729	1.715	1.711	-1.635	-2.436	-2.673
U.S. produced	1.827	1.817	1.814	1.811	-0.556	-0.718	-0.851
Composite import price	1.583	1.517	1.483	1.475	-4.157	-6.346	-6.801
Mexico	1.347	1.330	1.251	1.242	-1.295	-7.173	-7.829
Chile	1.744	1.590	1.651	1.646	-8.787	-5.318	-5.583
Spain	1.818	1.802	1.719	1.717	-0.917	-5.475	-5.574
Others	1.637	1.618	1.528	1.525	-1.126	-6.606	-6.832
Argentina							
	Region 2 - Season 1						
Composite price	1.769	1.765	1.762	1.772	-0.265	-0.392	0.177
U.S. produced	1.794	1.793	1.792	1.796	-0.064	-0.106	0.113
Composite import price	1.364	1.318	1.300	1.380	-3.344	-4.680	1.217
Mexico	1.167	1.165	1.054	1.191	-0.161	-9.684	2.054
Chile	1.472	1.272	1.359	1.483	-13.544	-7.639	0.735
Spain	1.629	1.624	1.520	1.630	-0.280	-6.659	0.089
Others	1.422	1.418	1.300	1.430	-0.312	-8.635	0.511
Argentina		1.458	1.457				
	Region 2 - Season 2						
Composite price	1.887	1.865	1.860	1.860	-1.174	-1.399	-1.399
U.S. produced	2.034	2.023	2.020	2.018	-0.499	-0.645	-0.764
Composite import price	1.513	1.473	1.467	1.461	-2.681	-3.079	-3.471
Mexico	1.333	1.316	1.237	1.228	-1.308	-7.249	-7.911
Chile	1.651	1.497	1.558	1.553	-9.282	-5.618	-5.897
Spain	1.655	1.638	1.556	1.554	-1.007	-6.015	-6.123
Others	1.546	1.528	1.438	1.435	-1.192	-6.991	-7.230
Argentina		1.654	1.648	1.647			
	All U.S. - Annual						
Composite price	1.764	1.752	1.748	1.754	-0.646	-0.888	-0.534
U.S. produced	1.806	1.802	1.801	1.803	-0.202	-0.276	-0.160
Composite import price	1.484	1.434	1.415	1.441	-3.392	-4.626	-2.893
Mexico	1.281	1.268	1.179	1.213	-1.033	-8.017	-5.331
Chile	1.625	1.472	1.532	1.561	-9.416	-5.733	-3.954
Spain	1.678	1.664	1.582	1.614	-0.844	-5.715	-3.838
Others	1.528	1.513	1.420	1.454	-0.991	-7.105	-4.863
Argentina		1.596	1.588	1.647			

Table 10: Annual quantities of lemon consumption (all markets)

Producers/Markets	Base quantities (mil. kg)	Simulated quantities (mil. kg)			% change from base		
		SIM 1	SIM 2	SIM 3	SIM 1	SIM 2	SIM 3
United States	474.940	474.417	474.219	474.538	-0.110	-0.152	-0.085
Domestic market	351.359	350.724	350.484	350.867	-0.181	-0.249	-0.140
Season 1	255.377	255.076	254.941	255.334	-0.118	-0.171	-0.017
Season 2	95.982	95.648	95.542	95.533	-0.348	-0.458	-0.468
Exports	123.580	123.693	123.736	123.671	0.091	0.125	0.073
Mexican exports	23.621	23.379	21.786	22.356	-1.025	-7.771	-5.358
U.S. market	22.492	22.208	20.275	20.893	-1.259	-9.856	-7.106
Season 1	6.513	6.465	5.899	6.353	-0.730	-9.421	-2.457
Season 2	15.979	15.743	14.376	14.541	-1.475	-10.033	-9.001
Non-U.S. market	1.130	1.171	1.511	1.462	3.646	33.741	29.436
Chilean exports	39.579	37.595	38.283	38.717	-5.012	-3.273	-2.177
U.S. market	21.171	16.298	18.329	19.079	-23.017	-13.426	-9.882
Season 1	6.130	4.740	5.359	6.088	-22.675	-12.588	-0.689
Season 2	15.041	11.558	12.970	12.991	-23.156	-13.767	-13.629
Non-U.S. market	18.408	21.297	19.955	19.638	15.695	8.405	6.685
Spanish exports	437.114	437.071	436.815	436.906	-0.010	-0.068	-0.048
U.S. market	7.648	7.514	6.636	6.927	-1.742	-13.232	-9.429
Season 1	2.215	2.202	1.915	2.218	-0.575	-13.528	0.144
Season 2	5.433	5.313	4.721	4.709	-2.218	-13.112	-13.331
Non-U.S. market	429.467	429.556	430.179	429.979	0.021	0.166	0.119
Others	4.407	4.395	4.324	4.350	-0.261	-1.879	-1.282
U.S. market	1.825	1.799	1.626	1.683	-1.419	-10.929	-7.792
Season 1	0.529	0.526	0.470	0.526	-0.534	-11.093	-0.414
Season 2	1.297	1.274	1.156	1.157	-1.779	-10.863	-10.800
Non-U.S. market	2.582	2.596	2.698	2.667	0.558	4.520	3.321
Argentine exports	359.983	359.983	359.983	359.983	0.000	0.000	0.000
U.S. market		7.252	8.944	6.106			
Season 1		2.171	2.820				
Season 2		5.081	6.123	6.106			
Non-U.S. market	359.983	352.723	351.039	353.877	-2.015	-2.485	-1.696

Table 11: Producer price of lemons by season

Prices	Base prices (FOB, $/kg)	Simulated prices (FOB, $/ kg)			% change from base		
		SIM 1	SIM 2	SIM 3	SIM 1	SIM 2	SIM 3
	Season 1						
United States	1.467	1.466	1.465	1.469	-0.078	-0.130	0.138
Mexico	0.417	0.415	0.304	0.441	-0.451	-27.102	5.749
Chile	0.638	0.439	0.525	0.649	-31.248	-17.624	1.695
Spain	0.838	0.833	0.729	0.839	-0.544	-12.950	0.172
Others	0.868	0.863	0.745	0.875	-0.511	-14.158	0.838
Argentina		0.624	0.624				
	Season 2						
United States	1.529	1.519	1.516	1.514	-0.664	-0.857	-1.016
Mexico	0.343	0.326	0.246	0.238	-5.084	-28.168	-30.743
Chile	0.551	0.398	0.458	0.454	-27.805	-16.829	-17.666
Spain	0.935	0.918	0.835	0.834	-1.783	-10.648	-10.840
Others	0.913	0.895	0.805	0.801	-2.018	-11.841	-12.246
Argentina		0.555	0.549	0.547			

Table 12: Composite producer price of lemons

	Base prices (FOB, $/kg)	Simulated prices (FOB, $/ kg)			% change from base		
		SIM 1	SIM 2	SIM 3	SIM 1	SIM 2	SIM 3
United States	1.339	1.336	1.335	1.337	-0.221	-0.305	-0.171
Mexico	0.364	0.352	0.270	0.303	-3.346	-25.887	-16.793
Chile	0.576	0.504	0.529	0.545	-12.543	-8.185	-5.344
Spain	0.907	0.907	0.905	0.906	-0.025	-0.171	-0.120
Others	0.900	0.894	0.858	0.871	-0.653	-4.694	-3.211
Argentina	0.577	0.576	0.576	0.576	-0.006	-0.025	-0.036

Table 13: Welfare change

Welfare	SIM 1	SIM 2	SIM 3
Total welfare change ($ mil.)	2.739	3.742	2.416
Equivalent variation	4.654	6.378	3.894
Producer surplus	-1.914	-2.636	-1.478

5.3. SIM 2 – Argentina lemons allowed entry with regional restriction

Under this scenario Argentine lemons are allowed entry in non citrus-producing states year-round similar to SIM 1. However, the entry of Argentine lemons is assumed to reduce proportionately the import shares of Mexico, Chile, Spain, and others. The scenario generates relatively bigger effects compared to SIM 1 because of the proportionate reduction in the shares of lemons from all import suppliers.

A total of 8.9 million kg of Argentine lemons are imported in the U.S. under SIM 2. The total lemon exports of Argentina are again almost unchanged relative to the base. The import demand in the U.S. for lemons from Mexico, Chile, Spain and others drop. Thus lemon exports to the U.S. from these suppliers declines. They increase their exports to the rest of the world but their total exports decline. Under SIM 2 the composite import price of lemons declines by 4.6 percent and lemon imports increase by 5 percent. The decline in composite wholesale price of U.S. produced lemons is 0.3 percent, which is small relative to the fall in the composite import price of lemons. Thus, U.S. lemon consumers substitute imported lemons for U.S. produced lemons, which reduces the demand for U.S. produced lemon by 0.2 percent and increases the demand for imported lemons. With the entry of Argentine lemons, the overall composite price of lemons falls by 0.9 percent which increases the total lemon demand by 0.4 percent.

One major difference between SIM 1 and SIM 2 can be observed in the relatively similar percentage reductions in the demand for lemons from Mexico, Chile, Spain and others in region 2 under SIM 2 compared to SIM 1 where the fall in demand is largely for lemons from Chile. The reduction in the wholesale prices of imported lemons is also relatively similar across the import suppliers in region 2 in SIM 2. AS in SIM 1, demand for U.S. produced lemons and their wholesale prices fall in region 2.

The regional restrictions in SIM 2 generate similar aggregate effects to SIM 1. However, in this case, wholesale prices fall in region 1 relatively similarly among imports and demand expands for lemons from each import source. In region 1, the composite import price declines by 8.9 percent in season 1 and 6.3 percent in season 2. The wholesale price of U.S. produced lemons also decline, but by relatively less than the composite import price. Thus, similar to region 2, consumers in region 1 substitute imported lemons for U.S. produced lemons. In region 1, the demand for U.S. produced lemons declines by 0.27 percent in season 1 and 0.92 percent in season 2. These indirect effects in region 1 taken together reduce the composite wholesale price and the consumption of lemons in region 1 increases by 0.3 percent in season 1 and 1.2 percent in season 2.

Because of the decline in the price and the increase in total consumption of lemons as a result of the entry of Argentine lemons into the U.S., consumer welfare improves by $6.3

million, an increase slightly higher compared to SIM 1 (Table 13). But there are also slightly higher displacement effects on U.S. lemon production that generate losses of $2.6 million in producer surplus. The total net gain in the U.S. is $3.7 million.

5.4. SIM 3 – Argentina lemons allowed entry with regional and seasonal restrictions

The difference between SIM 3 and SIM 2 is that Argentine lemons are allowed in non citrus-producing states during the lemon production off season only. The shares of lemons imported from all suppliers are reduced proportionately only in (region 2–season 2) to accommodate Argentine lemons.

Because of the additional seasonal restriction, the effects in SIM 3 are smaller compared to SIM 2. The effects are also relatively small under SIM 3 compared to the results in SIM 1. A total of 6 million kg of Argentine lemons are imported under SIM 3. The supply of Argentine lemons to the rest of the world again falls by almost the same amount as its exports increase to the U.S. The supplies of lemons from Mexico, Chile, Spain and others decline in the U.S. market and their export to the rest of the world increase. However, the entry of Argentine lemons in the U.S. again reduces the total lemon exports of these suppliers. In the U.S., while overall lemon consumption increases, the demand for U.S. produced lemons declines. The reduction in the composite price of imported lemons exceeds the decline in the wholesale price of U.S. produced lemons. Consumers in the U.S. therefore substitute imported lemons for U.S. produced lemons. As the demand for U.S. produced lemons in the U.S. declines, U.S. producers increase lemon exports to the rest of the world. However, overall lemon production in the U.S. declines.

In SIM 3, there are more differentiated seasonal as well as regional effects than in the other two scenarios. In (region 2–season 2), where Argentine lemons are allowed entry, the percentage reductions in the demand for lemons from Mexico, Chile, Spain and others are similar, as in SIM 2. The reduction in demand for these lemons reduces the wholesale prices in (region 2–season 2) and the producer prices of these lemons in season 2. This generates indirect effects in (region 1–season 2) as well as in both regions in season 1. Argentine lemons are prohibited in region 1, but as in the other scenarios as prices fall in region 2 import suppliers switch markets across regions and increase their supply in region 1. The increased supply of

imported lemons in (region 1– season 2), reduces the wholesale prices, and increases the demand for these lemons.

Within region 2, the reduction in the producer prices in season 2 also generates indirect effects in season 1. The traditional import suppliers reduce their supplies in season 2 because of the reduction in the producer prices in that season and increase supply in season 1. The shift in supply from season 2 to season 1 puts downward pressure on the wholesale prices in season 1. Likewise, consumers shift between seasons into consumption in season 2 in which prices fall as a result of the entry of Argentine lemons. Again, this substitution puts downward pressure on season 1 prices. However, in equation (13) the falling seasonal producer prices will also have an effect on the composite producer price of lemons, which in turn impact the aggregate levels of lemon exports. The results presented in Table 9 indicate higher wholesale prices. This indicates that with low elasticity of transformation in production between season 1 and season 2, the aggregate supply effect dominates the substitution effects in the equilibrium outcome in season 1[13]. A similar outcome occurs in (region1–season 1).

Consumer welfare increases under SIM 3 because of the decline in the composite price and the increased consumption of lemons in the U.S. as a result of the entry of Argentine lemons. The gain to consumers and loss to producers are smaller than in SIM 2 because of the additional season restriction in SIM 3.

6. Summary and Conclusions

Except for a brief period in 2000 and 2001, the U.S. has prohibited entry of Argentine lemons because of citrus pest and disease concerns. Initially, the U.S. was concerned with three citrus diseases (citrus canker, citrus black spot, and sweet orange scab) found in Argentine lemons. At present, the U.S. is concerned with fruit flies and more recently CVC in Argentina. However, there are ongoing negotiations between Argentina and the U.S. to develop a systems

[13] These seasonal substitution effects in production will depend upon the elasticity of transformation in equation (9). The higher the value of this elasticity, the larger is the shift in lemon supply from season 2 to season 1. In the model the seasonal elasticity of transformation assumed was low (-0.1, see Table 5B in Appendix B) to reflect seasonal constraints in lemon production and storage. However, sensitivity analysis conducted with higher values of the elasticity of transformation indicates that with more substitutability the shift in supply from season 2 to season 1 results in lower wholesale prices in season 1, and therefore higher demand in season 1.

approach with several non-tariff measures that can minimize pest risks and allow imports of Argentine lemons under specified conditions. The 1997 and the 2007 PRAs were outcomes of these negotiations. The 1997 PRA included some specific mitigating measures. The 2007 PRA did not recommend specific measures, but it hinted at several conditions for entry that were similar to the 1997 PRA. Regional and seasonal restrictions are likely to be part of any system approach that would allow imports of lemons from Argentina.

If the ban on Argentine lemons is modified, it will affect lemon consumption and production in the U.S. as well as lemon exports of excess supply countries. Using a simulation model calibrated to a three-year base period (2006-2008), this paper analyzes these effects under three scenarios: (a) year-around access in non citrus-producing states under SIM 1, assuming the lemon import shares of Chile and Argentina are similar; (b) year-around access in non citrus-producing states under SIM 2, assuming the lemon import shares of Mexico, Chile, Spain and others are reduced proportionately in order to accommodate entry of Argentine lemons; and (c) entry restricted to only the U.S. lemon production off-season and non citrus-producing states in SIM 3, assuming again that lemon import shares of Mexico, Chile, Spain and others are reduced proportionately.

A total of 7.2 million kg of Argentine lemons are imported under SIM1, 8.9 million kg in SIM 2 and 6.1 million kg in SIM 3. In all three scenarios, the entry of Argentine lemons decreases the composite price of lemons in the U.S. and increases lemon consumption. However, the entry displaces lemon production in the U.S. and lemon imports from Mexico, Chile, Spain, and others. The reduction in demand for these lemons decreases their supply to the U.S. market and increases their exports to the rest of the world. The producer prices of these lemons, aggregate lemon production in the U.S., and the total lemon exports of the excess suppliers decline.

In all three scenarios, consumer welfare in the U.S. improves. The displacement effects on U.S. lemon production generate losses in producer surplus. The improvement in the consumer welfare exceeds the loss in the producer surplus. Thus, there is net benefit to the U.S. overall. The net benefit is highest under SIM 2 where the lemon import shares of all import suppliers are assumed to be reduced proportionately in non citrus-producing states as a result of entry of

lemons from Argentina into the market. The lowest benefit is under SIM 3 where the additional restriction is imposed that prohibits entry of Argentine lemons during the lemon production season in the U.S.

There are differential regional and seasonal effects in each of the scenarios. The consumers in non citrus-producing states benefit directly from the entry of Argentine lemons through the reduction in lemon prices and the increase in lemon consumption. There are indirect effects that benefit the consumers in citrus-producing states where Argentine lemons are prohibited. The effects arise through the shift in lemon supply (particularly import supply) from non citrus-producing states to citrus-producing states. This decreases the prices of lemons in citrus-producing states, which increases lemon consumption.

If seasonal restrictions are imposed together with regional restrictions, the seasonal effects depend in part upon how suppliers are able to shift supplies between seasons, which is reflected in the level of the seasonal elasticity of transformation. If the U.S. and import suppliers are not sufficiently able to shift lemon supply to the season when entry is prohibited (which is the production lemon season), then the supply of lemons during that season declines. This increases prices and decreases lemon consumption in that season.

These various results are illustrative of the effects arising from U.S. regulatory policy toward imports of lemons from Argentina. Citrus pests and diseases found in Argentine lemons are a major concern in the U.S. Any systems approach that comes out of the ongoing negotiations between the U.S. and Argentina will likely contain several measures similar to the 1997 and 2007 PRAs, including the limited regional and seasonal distribution of lemons in the U.S. This limited distribution could be permanent or the regional and seasonal restrictions could be relaxed in phases, similar to the final rule which was enacted in 2000. If phases occur, the first one could be similar to the restrictions under SIM 3. A second phase could be similar in scope as SIM 2 or SIM 1. The price and quantity effects and welfare gains in the U.S. differ between these scenarios. Even if access is initially determined to be permanently restricted by regions and seasons, increased access for lemons from Argentina might eventually occur if an initial access can be achieved, just as the experience of Mexico was to gain increased access for avocados in the U.S. market over time. For sure, if any market access opening for lemons from Argentina

occurs there will be constant monitoring which will determine the exact length of the time involved in each of the phases.

References

Argentina. 2009. "La Actividad Citricola Argentina, The Argentine Citrus Industry".

Conner, C. 2006. Letter to Charles H. Bronson, Florida's Commissioner of Agriculture. Available at: http://www.doacs.state.fl.us/pdf/Canker%20-%20Bronson.pdf.

Cororaton, C., D. Orden, and E. Peterson. 2011 forthcoming. "Economic Impact on the EU Fresh Lemon Market of Potential U.S. Regulatory Decisions Concerning Imports from Argentina". A paper being prepared for the project "Analyzing the Effects from Non-Tariff Measures (NTM) in Global Agri-Food Trade," European Commission 7th Framework Program grant no. 227202.

Dixit, Avinash K. and Stiglitz, Joseph E. 1977. "Monopolistic Competition and Optimum Product Diversity". *American Economic Review* 67(3): 297-308.

Foltyn, R. 2009. "Results from the Dixit/Stiglitz Monopolistic Competition Model." Available at http://www.foltyn.net/wp-content/uploads/2009/12/dixitstiglitz.pdf

Global Agricultural Trade System Online. Available at: http://www.gtis.com/gta/

Green, R. 1999. "Demand for California Agricultural Commodities", *Update*, Department of Agricultural and Resource Economics, Vol. 2, No. 2

Harland Land Co. v. USDA (2001). Court Ruling. Eastern District Of California. Factual Background. Available at: http://www.thecre.com/pdf/Citrus_vs_usda.pdf.

Jetter, K.M. , D. A. Sumner and E. L. Civerolo.2003. "Ex-ante Economics of Exotic Disease Policy: Citrus Canker in California" in Exotic Pests and Diseases (Daniel A. Sumner, editor). Iowa: Iowa State Press.

Keller, Wouter J. "A Nested CES-Type Utility Function and Its Demand and Price-Index Functions." *European Economic Review* 7(1976): 175-186.

McLean, M. 2004. "The Impact of International Phytosanitary Requirements on the Lemon Industry in Tucuman," Report prepared for the World Bank, Annex IX. Available at:http://siteresources.worldbank.org/INTARGENTINAINSPANISH/Resources/Lemon_case_study_2.pdf.

Nuckton, C., 1978. "Demand Relationship for California Tree Fruits, Grapes, and Nuts: A Review of Past Studies." Giannini Foundation.

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

Plant Protection Act (7 USC 7702, Section 403, Number 18). http://www.aphis.usda.gov/brs/pdf/PlantProtAct2000.pdf

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

United States. 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 D.C. September.

United States. USDA, Animal and Plant Health Inspection Service (APHIS). 2007. "Risk Assessment for the Importation of Fresh Lemon (*Citruslimon* (L.) Burm. F.) Fruit from Northwest Argentina into theContinental United States". Raleigh, North Carolina: USDA/APHIS. Available at: http://docs.google.com/viewer?a=v&q=cache:gCObLvO9ZfEJ:www.regulations.gov/search/Regs/contentStreamer%3FobjectId%3D090000648027316b%26disposition%3Dattachment%26contentType%3Dpdf+Risk+assessment+for+the+important+of+fresh+leomns&hl=en&gl=us&pid=bl&srcid=ADGEESh2TPZfWe1ZxI_vG8YveGNVK38XGvL6zQ1aMJW04Ks5ygMCF0-j1BUPCEz4dW9G8BOw0IvaWCYWA5L-CSzCoM4Bf353-1DZBr9ou5fuuK0Nz5dF3EKVZfcRU-kb8uk_ae4ZCMS3&sig=AHIEtbRjrfB8B_tIKtW3BepsNxLJ7ET7mg

United States. USDA, Agriculture Marketing Service. Available at: http://marketnews.usda.gov/portal/fv?paf_dm=full&paf_gear_id=1200002&startIndex=1&dr=1&rowDisplayMax=25&class=FRUITS&repType=termPriceDaily&dr=1&locName=&commAbr=LEM&commName=LEMONS

United States. Bureau of Economic Analysis. Available at: http://www.bea.gov/regional/index.htm#gsp

United States. USDA, Economic Research Service. Available at: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377

United States. USDA Foreign Agriculture Service, GAIN Report, Global Agricultural Information Network. Available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Citrus%20Semi-annual_Buenos%20Aires_Argentina_6-15-2010.pdf

United States. USDA/Foreign Agricultural Service/Global Agricultural Trade System. Available at: http://www.fas.usda.gov/gats/ExpressQuery1.aspx

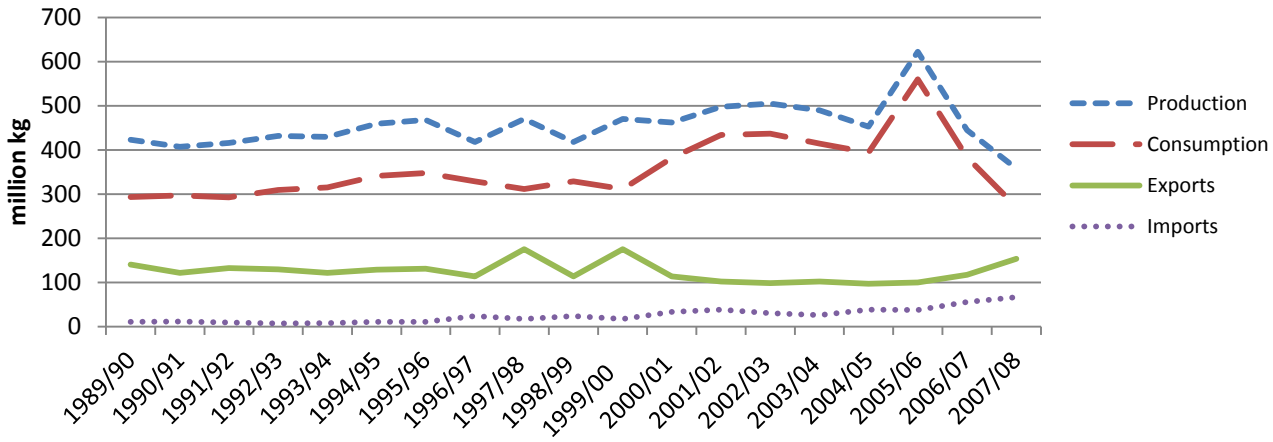
United States. USDA, National Agricultural Statistics Service. Available at: http://www.nass.usda.gov/Statistics_by_Subject/result.php?E2CE8F81-D54B-3186-B66F-EB7E71E5AFE7&sector=CROPS&group=FRUIT%20%26%20TREE%20NUTS&comm=LEMONS

United States. USDA, National Agricultural Statistics Service, *Citrus Fruits Summary*, various issues.

Appendix A: Benchmark Data

This appendix discusses the benchmark data. Figure 1A presents the historical data on fresh lemons in the U.S. Production and consumption are generally stable except for the period 2004/05-2007/08. In the last three years lemon production and consumption have declined while exports and imports have increased. The benchmark is the average of the years 2005/06-2007/08. The choice of these years was based on the fact although lemon production and consumption have declined, the three-year averages are still within the historical values. Also exports and imports of fresh lemons are increasing.

Figure 1A: Production, consumption and trade of fresh lemons in the U.S., 1989/90 to 2007/08



The initial starting point in terms of U.S. data for the construction of the full benchmark data for the model with its regional and seasonal breakdowns and differentiation among excess suppliers and between the U.S. and rest of world markets is presented in Table 1A. At the aggregate level, the period average for U.S. fresh lemon production is 474.94 million kg, U.S. consumption 404.49 million kg, U.S. exports, 123.58 million kg and U.S. imports 53.14 million kg.

Table 1A: Fresh lemon production, consumption exports and imports in the U.S., 2005/06–2007/08

Year	Production	Consumption	Exports	Imports
	million kg /a/			
2005/06 /b/	622.38	559.92	99.95	37.50
2006/07	444.53	382.79	117.25	55.51
2007/08	357.90	270.77	153.54	66.40
Average 2005/06 - 2007/08	474.94	404.49	123.58	53.14

/a/ Original data in million pounds, converted into million kg
/b/ These annual numbers cover the period from August of the year to July of the following year
Source: USDA, Economic Research Service
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377

As noted in the paper, any systems approach adopted to allow entry of lemons from Argentina into the U.S. is likely to include geographical and possibly seasonal restrictions in order to minimize any resulting introduction and establishment of pests. The geographical restriction may prohibit entry into the citrus-producing states which include five states: Arizona, California, Florida, Louisiana, and Texas. The seasonal restriction may allow entry only during lemon production off-season in the U.S. To incorporate these issues, the benchmark data has seasonal and regional disaggregation.

To our knowledge, there are no monthly fresh lemon production data available to allow us to establish and incorporate seasonality[14]. Instead, the monthly variations in exports and imports which are available were used to define the peak and off-peak seasons for lemon production. This may be justified because: (a) exports are a significant component of production, accounting for 28 percent; and (b) imports smooth out seasonal variations in supply. Table 2A presents the monthly data on lemon exports and imports.

[14] We have inquired from various people/offices to check the availability of monthly fresh lemon production data in the U.S., and so far the feedback we gathered was that the monthly lemon production data may not be available. We have asked: (a) Richard De Moura of the University of California-Davis Extension Office; (b) Kelly Krug of the USDA-NASS, California Field Office; (c) Susan Pollack of the USDA Economic Research Service; and (d) the California Citrus Quality Council. We will continue our search for monthly lemon production data, and if these data prove available we can replace our derived seasonal production data in the paper with actual numbers.

Table 2A: Monthly variations in exports and imports of fresh lemons in the U.S., 2005–2008

Exports (mil. kg) /a/	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season1 /b/	Season2 /c/	Total /d/
2005								3.30	4.96	6.70	10.02	11.91			
2006	10.62	8.83	12.18	11.81	9.65	6.00	3.97	3.61	2.15	7.79	14.86	10.08			
2007	11.62	12.05	14.75	14.44	16.75	5.78	3.36	2.52	1.85	15.84	18.32	16.63			
2008	12.83	12.30	15.55	18.04	18.89	13.55	7.23								
Average /b/	11.69	11.06	14.16	14.77	15.10	8.44	4.85	3.14	2.99	10.11	14.40	12.88	94.05	29.53	123.58
Imports (mil. kg)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season1	Season2	Total
2005								12.15	4.92	2.26	2.46	0.72			
2006	0.33	0.43	0.37	0.80	0.69	4.54	7.83	9.02	5.80	4.83	2.90	1.25			
2007	0.54	5.22	6.48	1.23	2.16	4.73	11.37	14.05	10.91	13.50	10.22	5.88			
2008	2.29	1.17	0.32	0.35	0.36	0.87	6.49								
Average	1.05	2.27	2.39	0.79	1.07	3.38	8.56	11.74	7.21	6.86	5.19	2.62	15.39	37.75	53.14

/a/ Original data in metric tons, converted into million kg

/b/ Consistent with Table 1A, the averages for January to July were computed over 2006-08, while for August to December 2005-07

/b/ Season 1 is defined as the sum of row 'Average' over the months November-December/January-May

/c/ Season 2 is defined as the sum of row 'Average' over the months June-October

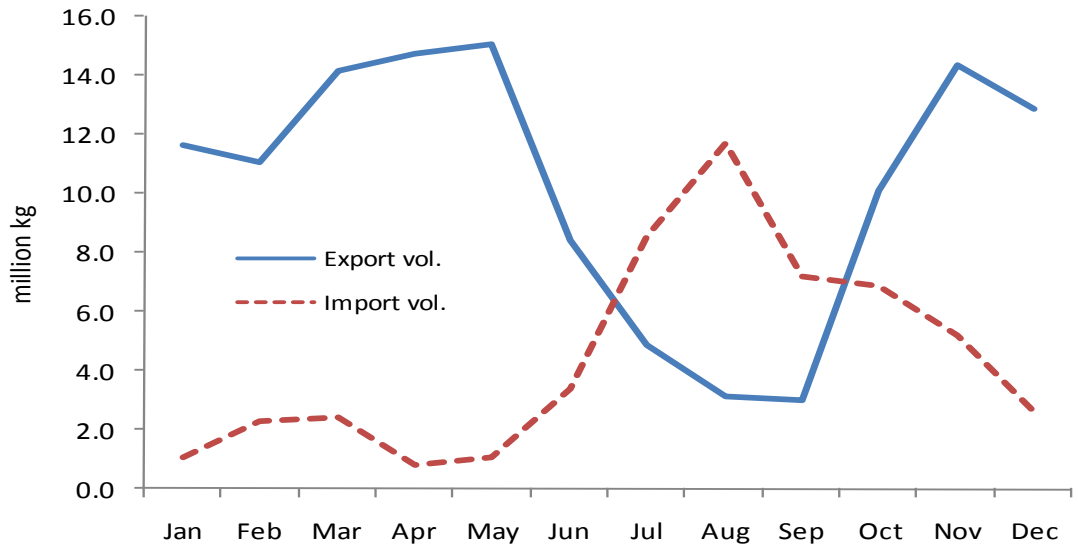
/d/ The sum of row 'Average' over the months January-December, consistent with the annual exports and imports in Table 1A

Source: USDA, Foreign Agricultural Service, Global Agricultural Trade System Online

http://www.fas.usda.gov/gats/ExpressQuery1.aspx

Figure 2A shows the 2006-08 average monthly variations in exports and imports. Lemon exports of the U.S. peak from November/December until May of the following year. Since the share of lemon exports is about one-quarter of production, these are also the months when lemon harvest in the U.S. is assumed to reach its peak. During the peak months for exports and production in the U.S., lemon imports are at their lowest level. However, when lemon exports are at their lowest level from June to October, lemon imports reach their peak level. These monthly variations provide strong evidence of counter-cyclicality between lemon exports/production and imports.

Figure 2A: Monthly variations in fresh lemon exports and imports in the U.S., average 2005/06–2007/08



Based on these monthly variations, season 1 is defined as the main lemon production season covering the months from November/December to May of the following year, and a Season 2 (the lemon production off season) as the months between June and October. Adopting this seasonal breakdown, the benchmark data uses the following index which combines the variations in lemon exports and imports:

$$Season_1 = average\left(\frac{\sum_{Nov/Dec}^{Jan/May} exportvolume = 94.05}{\sum_{Jan}^{Dec} exportvolume = 123.58} \; and \; \frac{\sum_{Jun}^{Oct} importvolume = 37.75}{\sum_{Jan}^{Dec} importvolume = 53.14} \right)$$

$$Season_1 = \frac{(0.7610 + 0.7104)}{2} = 0.7357$$

$$Season_2 = 1 - Season_1 = 0.2643$$

This seasonal index was applied to the annual production data to derive seasonal production, i.e., the production data for season 1 is computed as 474.94 x 0.7357= 349.42. For season 2, production is computed as 474.94 – 349.42 = 125.52. Actual data were used for the seasonal exports and imports. To maintain consistency, seasonal lemon consumption is computed as: consumption = production – exports + imports. The results are presented in Table 3A.

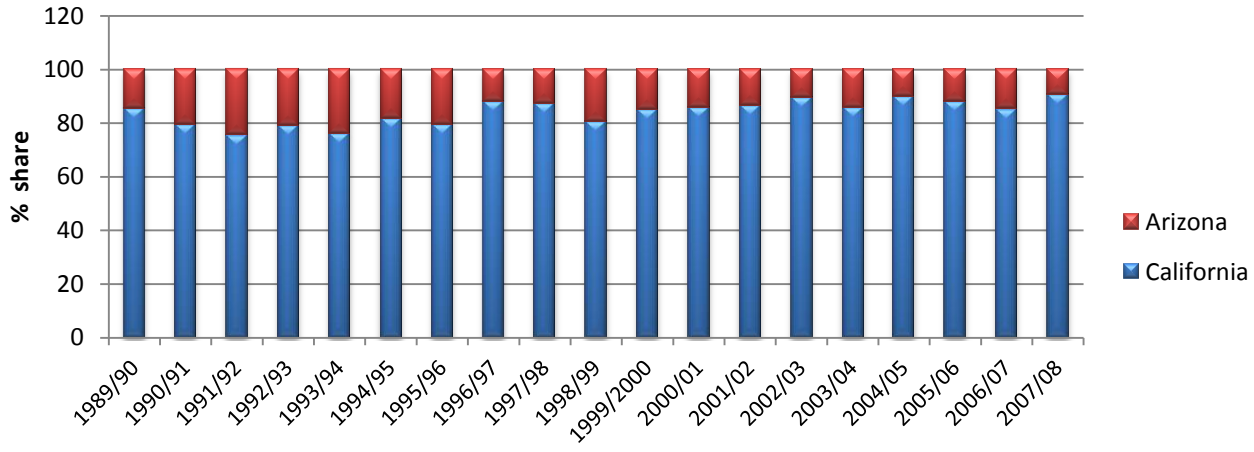
Table 3A: Seasonal lemon production, consumption, exports and imports in the U.S., average 2005/06–2007/08

	Production /d/	Consumption /e/	Exports /f/	Imports /f/
Season	million kg			
Average 2005/06 - 2007/08 /a/	474.94	404.49	123.58	53.14
Season 1 /b/	349.42	270.76	94.05	15.39
Season 2 /c/	125.52	133.73	29.53	37.75
Seasonality ratios /g/				
Season 1	0.7357	0.6694	0.7610	0.2896
Season 2	0.2643	0.3306	0.2390	0.7104
Average per month				
Season 1 /h/	49.92	38.68	13.44	2.20
Season 2 /i/	25.10	26.75	5.91	7.55

/a/ From Table 1A
/b/ November/December and January/May
/c/ June to October
/d/ Seasonal production values derived using seasonal exports and imports in Table 2A, i.e. production for season1 is computed as 474.94*0.7357 = 349.42
/e/ Derived as production less exports plus imports
/f/ From Table 2A
/g/ Season/Annual
/h/ Seasonal volume divided by 7
/i/ Seasonal volume divided by 5
Source: Table 1A and Table 2A

There are two series on lemon producer prices that are available, California and Arizona. However, the producer price series for Arizona is not complete. The producer price in California was used in the benchmark because California's lemon production captures about 90 percent of total lemon production in the U.S. (Figure 3A). Also, the California prices series is complete.

Figure 3A: Sources of fresh lemon production in the U.S., 1989/90–2007/08



In California, there are two lemon producer price series: the Freight-On-Board (FOB) which is the price at the shipping point; and the price equivalent at the packinghouse–door (Table 4A). The packinghouse price is consistently lower than the FOB price (Figure 4A). In the benchmark the FOB price was used as the producer prices of U.S. produced lemons. The FOB the average producer price is $1.32/kg in season1 and $1.40/kg in season 2. The average annual producer price is $1.35/kg.

Table 4A: California lemon price, 2005–2008

FOB ($/kg) /b/	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season1 /e/	Season2 /f/	Average /g/
2005								0.94	0.84	0.78	0.85	0.80			
2006	0.75	0.76	0.80	0.97	1.12	1.12	1.18	1.23	1.35	1.44	1.20	1.00			
2007	0.92	1.55	1.54	1.51	1.50	1.56	1.64	1.72	1.80	1.84	1.85	1.71			
2008	1.78	1.82	1.79	1.71	1.75	1.79	1.71								
Average /c/	1.15	1.38	1.38	1.40	1.45	1.49	1.51	1.30	1.33	1.35	1.30	1.17	1.32	1.40	1.35
Packinghouse ($/kg)/d/	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season1	Season2	Average
2005								0.47	0.43	0.34	0.47	0.37			
2006	0.44	0.45	0.50	0.67	0.81	0.82	0.87	0.94	1.06	1.14	0.91	0.71			
2007	0.63	1.26	1.25	1.22	1.20	1.27	1.34	1.42	1.50	1.54	1.55	1.41			
2008	1.49	1.53	1.49	1.41	1.45	1.49	1.41								
Average	0.85	1.08	1.08	1.10	1.16	1.19	1.21	0.94	1.00	1.01	0.98	0.83	1.01	1.07	1.04

/a/ Original data in $ per box (where 1 box contains 76 pounds), converted into $/kg

/b/ Shipping point

/c/ Consistent with Table 1A, the averages for January to July were computed over 2006-08, while for August to December 2005-07

/d/ Equivalent packinghouse - door

/e/ November/December and January/May

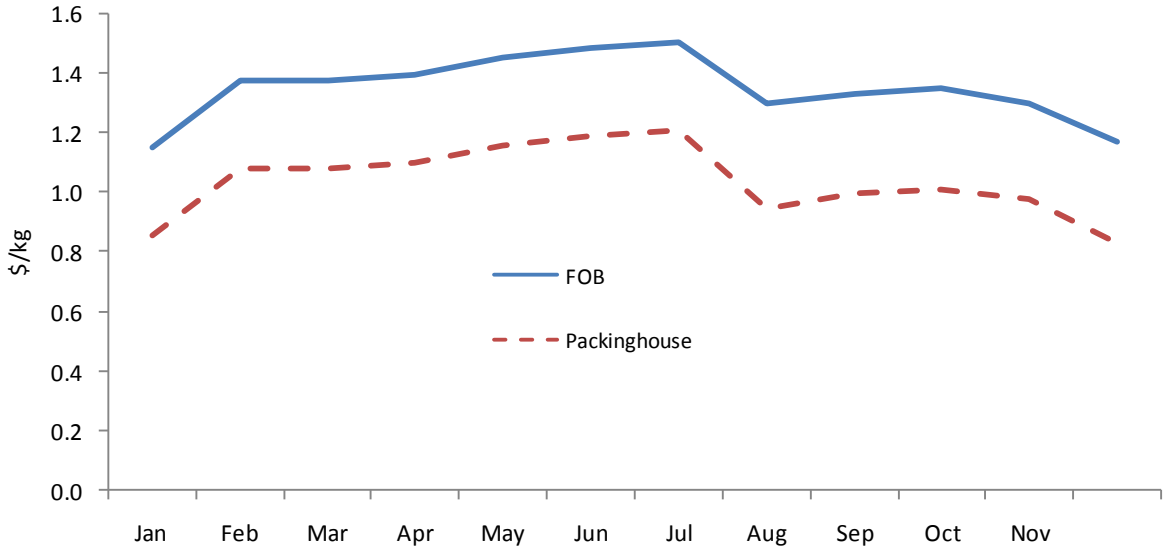
/f/ June to October

/g/ Average of row 'Average' over the months January-December

Source: USDA, National Agricultural Statistics Service

http://www.nass.usda.gov/Statistics_by_Subject/result.php?E2CE8F81-D54B-3186-B66F-EB7E71E5AFE7&sector=CROPS&group=FRUIT%20%26%20TREE%20NUTS&comm=LEMONS

Figure 4A: Average California lemon producer price, average 2006–2008



The export price of lemons is the FOB export unit price derived by dividing the monthly FOB value of fresh lemon exports of the U.S. with corresponding volume (Table 5A). In Figure 5A the export price reaches a peak in July. It lowest level is in November and December. The average export price is $0.92/kg in season 1 and $0.96/kg season 2. The average annual export price is $0.93/kg.

Table 5A: U.S. export unit price of fresh lemons, 2005–2008

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season1 /b/	Season2 /c/	Average /d/
	FOB, $/kg /a/														
2005								0.76	0.76	0.87	0.81	0.80			
2006	0.76	0.73	0.74	0.77	0.80	0.77	0.83	0.80	0.96	0.95	0.90	0.89			
2007	0.99	0.96	1.06	1.15	1.01	1.07	1.23	1.25	1.15	0.95	0.92	0.94			
2008	1.00	1.00	0.98	1.00	1.01	1.02	1.01								
Average /e/	0.92	0.90	0.92	0.98	0.94	0.95	1.03	0.94	0.95	0.92	0.88	0.88	0.92	0.96	0.93

/a/ Derived as value/volume and converted into $/kg

/b/ Average of row 'Average' for November/December and January/May

/c/ Average for June to October

/d/ Average of row 'Average' over the months January-December

/e/ Consistent with Table 1A, the averages for January to July were computed over 2006-08, while for August to December 2005-07

Source: USDA, Foreign Agricultural Service, Global Agricultural Trade System Online

http://www.fas.usda.gov/gats/ExpressQuery1.aspx

Figure 5A: Monthly export fresh lemon price variation in the U.S., average 2005/06–2007/08

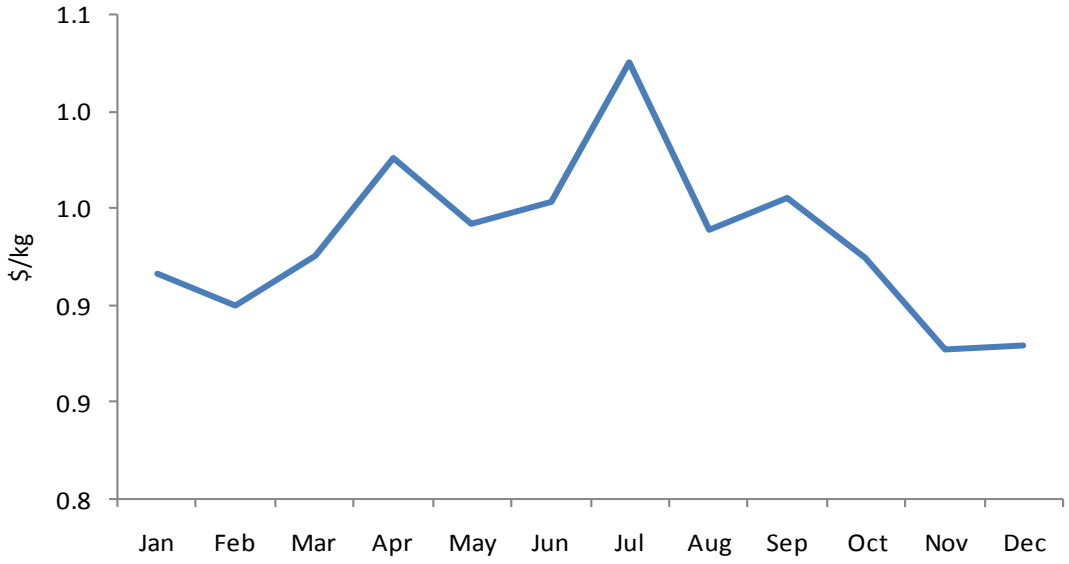


Table 6A presents the seasonal volume, prices and value of lemon production and exports. The value data was derived by multiplying volume with the corresponding price. The data on lemons sold to the U.S. domestic market was derived in the following way. The export volume was subtracted from the production volume to derive the volume sold to the domestic market. Similarly, the export value was subtracted from the production value to get the domestic value. The domestic price was derived by dividing the domestic value with the domestic volume.

The annual values and volumes are the sums over the two seasons. The annual price was derived by dividing the annual value with the annual volume. The derived annual price is $1.34/kg. However, the average annual price in Table 4A was $1.35/kg. There is a very small difference[15]. In the benchmark data the annual producer price of $1.34/kg was used.

[15] The very small difference may be due to the use of production data for the entire U.S. and the use of the California producer price as the approximate producer price.

Table 6A: Price and quantity of fresh lemons in the U.S, average 2006–2008

Season	Production		
	Price	Volume	Value
	$/kg /b/	million kg	million $
Season 1	1.32	349.42	460.81
Season 2	1.40	125.52	175.11
Annual /a/	1.34	474.94	635.92
	Exports		
	Price	Volume	Value
	$/kg /c/	million kg	million $
Season 1	0.92	94.05	86.14
Season 2	0.96	29.53	28.33
Annual /a/	0.93	123.58	114.47
	Domestic		
	Price	Volume	Value
	$/kg /d/	million kg /e/	million $
Season 1	1.47	255.38	374.67
Season 2	1.53	95.98	146.78
Annual /a/	1.48	351.36	521.45

/a/ The annual price is value divided by volume
/b/ F.O.B. price in Table 4A
/c/ Export unit price in Table 5A
/d/ Derived as value/volume
/e/ Both value and volume are derived as: production less exports
Source: Table 4A and Table 5A

In the benchmark, region 1 consists of the five citrus-producing states: Arizona, California, Florida, Louisiana, and Texas. Region 2 is the rest of the United States. There are no data available on lemon consumption and prices according to this regional disaggregation. The U.S. population data was used to disaggregate total lemon consumption into regional consumption, i.e., regional population ratios were used to estimate regional lemon consumption. The population data together with the other relevant economic indicators are presented in Table 7A. The real gross domestic product (GDP) was used as the regional income in the benchmark data. The derived regional lemon consumption is presented in Table 8A.

Table 7A: Key indicators in region1 and region 2, 2006–2008

Regions	Indicators	2006	2007	2008	Average 2006-08
Region 1 /a/	Nominal GDP, $ million	3,953,274	4,145,513	4,285,494	4,128,094
	Real GDP 2000 prices, $ million	3,298,691	3,362,419	3,361,442	3,340,851
	GDP deflator	1.20	1.23	1.27	1.24
	Per capita GDP real, $	37,515	37,718	37,216	37,482
	Population, million	88	89	90	89
Region 2 /b/	Nominal GDP, $ million	9,137,502	9,570,228	9,880,071	9,529,267
	Real GDP 2000 prices, $ million	7,923,595	8,080,710	8,168,947	8,057,751
	GDP deflator	1.15	1.18	1.21	1.18
	Per capita GDP real, $	37,653	38,090	38,219	37,989
	Population, million	210	212	214	212

/a/ California, Arizona, Texas, Florida, and Loiusiana
/b/ U.S. excluding California, Arizona, Texas, Florida, and Loiusiana
Source: U.S. Bureau of Economic Analysis
http://www.bea.gov/regional/index.htm#gsp

Table 8A: Seasonal and regional demand for lemons in the U.S., average 2006–2008

	Region 1 /a/	Region 2	Total
Seasons	million kg		
Season 1	80.12	190.65	270.76
Season 2	39.57	94.16	133.73
Total	119.68	284.81	404.49

/a/ Seasonal consumption in Table 3A was disaggregated into regions
using regional population ratios in Table 7A, i.e., 282.78*(89.1/301.2) = 83.67
where 301.2 is total U.S. population.
Source: Table 3A and Table 7A

There are no regional consumption prices of lemons available consistent with the regional breakdown in the benchmark. Instead, the wholesale prices of lemons in major cities in the U.S. from the USDA/Agricultural Marketing Service (USDA/AMS) were used. The wholesale prices available were weekly and prices of various lemon sizes. The prices of the various sizes were averaged to derive the average weekly price of lemons. The weekly price of lemons was averaged to derive the monthly price. This process was applied to all 12 major cities for 2006 to 2008.

The wholesale price of lemons for region 1 was calculated as the average price in the following cities: Dallas, Los Angeles, San Francisco and Miami. The average wholesale price for region 2 was the average of the price in the following cities: Atlanta, Baltimore, Chicago, New

York, Philadelphia, Pittsburg, Seattle and St. Louis. The results are presented in Table 9A. The monthly wholesale price variations in region 1 and region 2 in Figure 6A indicate that the price in region 1 is consistently lower than the price in region 2.

Table 9A: Average wholesale price of lemons, 2006–2008

Regions/year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Season1 /e/	Season2 /f/	Average /g/
Region 1 /a/	$/kg /c/ & /d/														
2006	1.06	0.90	0.95	1.16	1.37	1.45	1.60	1.78	1.85	1.89	1.70	1.48			
2007	1.52	1.78	1.75	1.68	1.70	1.79	1.79	1.82	1.94	2.07	2.05	2.05			
2008	2.08	2.08	2.09	2.09	2.14	2.22	2.21	1.90	1.61	1.47	1.28	1.23			
Average	1.55	1.59	1.60	1.64	1.74	1.82	1.87	1.84	1.80	1.81	1.67	1.58	1.62	1.83	1.71
Region 2 /b/															
2006	1.14	1.12	1.11	1.26	1.48	1.62	1.72	1.80	1.94	2.10	1.92	1.66			
2007	1.64	1.87	1.83	1.74	1.75	1.90	2.00	2.01	2.11	2.30	2.30	2.32			
2008	2.32	2.29	2.35	2.30	2.39	2.53	2.51	2.35	1.97	1.63	1.49	1.38			
Average	1.70	1.76	1.76	1.77	1.87	2.02	2.08	2.06	2.01	2.01	1.90	1.79	1.79	2.03	1.89

/a/ Average wholesale prices in Dallas, Los Angeles, San Francisco, and Miami

/b/ Average wholesale price in Atlanta, Baltimore, Chicago, New York, Philadelphia, Pittsburg, Seattle and St Lious

/c/ Average of weekly wholesale prices of lemons in various sizes: 75s, 95s, 115s, 140s, 165s, 200s and 235s. Lemons come from California and Arizona

/d/ Converted into $/kg from various original units:$ per 4/5 bushel carton; $ per 7/10 bushel carton; $ per 15-kg container; $ per 17-kg container; $ per 18-kg container

/e/ Average of row 'Average' for November/December and January/May

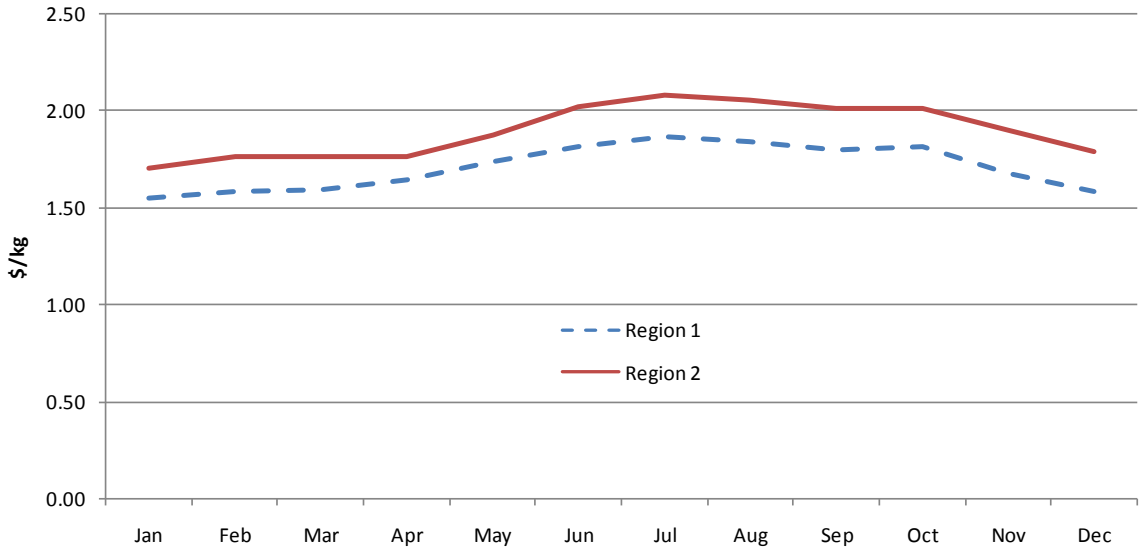
/f/ Average of row 'Average' for June to October

/g/ Average of row 'Average' for January to December

Source: USDA, Agriculture Marketing Service

http://marketnews.usda.gov/portal/fv?paf_dm=full&paf_gear_id=1200002&startIndex=1&dr=1&rowDisplayMax=25&class=FRUITS&repType=termPriceDaily&dr=1&locName=&commAbr=LEM&commName=LEMONS

Figure 6A: Monthly variation in wholesale prices of lemons in region 1 and 2, average 2006–2008



Lemon imports in the U.S. come from four sources: Mexico, Chile, Spain and others. The 2006–2008 average share of lemons imported from Mexico was 42.3 percent, from Chile 39.8 percent, Spain 14.4 percent, and from others 3.4 percent (Table 10A).

Table 10A: Import suppliers of fresh lemons in the U.S., 2003–2008

	2003	2004	2005	2006	2007	2008
Sources	million kg /a/					
World	30.2	26.0	38.3	37.5	55.5	66.4
Mexico	1.1	3.2	13.8	11.6	17.4	42.9
Chile	14.6	15.3	19.8	19.3	20.6	20.5
Spain	10.5	3.5	1.9	5.3	15.2	1.1
Others	4.0	4.1	2.9	1.3	2.2	1.9
			% share			
Mexico	3.5	12.2	35.9	31.0	31.4	64.6
Chile	48.4	58.8	51.6	51.5	37.1	30.9
Spain	34.8	13.3	5.0	14.1	27.5	1.7
Others	13.2	15.6	7.4	3.5	4.0	2.8

/a/ Original data in metric ton, converted into million kg
Source: USDA/Foreign Agricultural Service/Global Agricultural Trade System
http://www.fas.usda.gov/gats/ExpressQuery1.aspx

Seasonal imports in Table 3A were disaggregated by regions using the regional population shares in Table 7A. Regional and seasonal imports were disaggregated by source using the shares in Table 10A. The regional and seasonal imports by source are presented in Table 11A.

Table 11A: Sources of lemon imports, average 2006–2008

		Imports,	Sources of imports, mil. kg /c/			
Seasons	Regions	mil. kg /b/	Mexico	Chile	Spain	Others
Season 1	Region 1	4.55	1.93	1.81	0.66	0.16
	Region 2	10.83	4.59	4.32	1.56	0.37
Season 2	Region 1	11.17	4.73	4.45	1.61	0.38
	Region 2	26.58	11.25	10.59	3.83	0.91
Total		53.14	22.49	21.17	7.65	1.83
Import average share: 2006-08, % /b/			42.3	39.8	14.4	3.4

/a/ Seasonal consumption in Table 3A is disaggregated into regions
using regional population ratios in Table 7A, i.e., 15.39*(89.1/301.2) = 4.55
where 301.2 is total U.S. population.
/b/ Based on Table 10A
/c/ Country import sources are derived as 'Imports' x 'Import supplier average share'
e.g., for Mexico in region1-season 1 volume is computed as 4.55*0.423 = 1.93
Source: Table 3A, Table 7A, and Table 10A

The USDA/Agricultural Marketing Service (USDA/AMS) publishes wholesale prices of lemons from California and Arizona as well as from various import sources particularly from Mexico, Chile, Spain and others. Similar process used to derive the wholesale prices in Table 9A was applied to calculate the wholesale prices of lemon imports from Mexico, Chile, Spain and others. The results are presented in Table 12A. The regional and seasonal consumption and sources of lemon supply in the U.S. is present in Table 13A.

Table 12A: Wholesale prices, volumes, values of lemon imports by source, average 2006–2008

		Total imports			Mexico			Chile			Spain			Others		
		Price /a/	Volume /b/	Value /c/	Price /d/	Volume /e/	Value /f/	Price /g/	Volume /h/	Value /i/	Price /j/	Volume /k/	Value /l/	Price /m/	Volume /n/	Value /o/
Seasons	Regions	prices-$/kg; volume-mil. kg; value-$ mil.														
Season 1	Region 1	1.356	4.55	6.18	1.089	1.93	2.10	1.555	1.81	2.82	1.583	0.66	1.04	1.409	0.16	0.22
	Region 2	1.364	10.83	14.77	1.167	4.59	5.35	1.472	4.32	6.35	1.629	1.56	2.54	1.422	0.37	0.53
Season 2	Region 1	1.583	11.17	17.68	1.347	4.73	6.37	1.744	4.45	7.76	1.818	1.61	2.92	1.637	0.38	0.63
	Region 2	1.513	26.58	40.23	1.333	11.25	15.00	1.651	10.59	17.48	1.655	3.83	6.33	1.546	0.91	1.41

/a/ Value/volume
/b/ Based on Table 11A
/c/ Sum of import value of lemons from Mexico, Chile, Spain and others
/d/ Average wholesale price of Mexican lemons, derived using the method in Table 9A but applied to Mexican lemons only
/e/ Based on Table 11A
/f/ Price x volume
/g/ Average wholesale price of Chilean lemons, derived using method in Table 9A but applied to Chilean lemons only
/h/ Based on Table 11A
/i/ Price x volume
/j/ Average wholesale price of Chilean lemons, derived using method in Table 9A but applied to Spanish lemons only
/k/ Based on Table 11A
/l/ Price x volume
/m/ Average of wholesale price of Mexico, Chile, and Spain
/n/ Based on Table 11A
/o/ Price x volume
Source: USDA, Agriculture Marketing Service, Table 9A and Table 11A
http://marketnews.usda.gov/portal/fv?paf_dm=full&paf_gear_id=1200002&startIndex=1&dr=1&rowDisplayMax=25&class=FRUITS&repType=termPriceDaily&dr=1&locName=&commAbr=LEM&commName=LEMONS

Table 13A: Wholesale prices and lemon consumption in the U.S. by source, average 2006–2008

		Consumption			Domestic			Imports		
		Price /a/	Volume /b/	Value /c/	Price /d/	Volume /e/	Value /f/	Price /g/	Volume /h/	Value /i/
Seasons	Regions	price - $/kg; volume - mil. kg; & value - $ mil.								
Season 1	Region 1	1.609	80.12	128.89	1.624	75.56	122.71	1.356	4.55	6.18
	Region 2	1.769	190.65	337.31	1.794	179.81	322.54	1.364	10.83	14.77
Season 2	Region 1	1.758	39.57	69.57	1.827	28.40	51.89	1.583	11.17	17.68
	Region 2	1.887	94.16	177.66	2.034	67.58	137.43	1.513	26.58	40.23
	Annual/Total	1.764	404.49	713.43	1.806	351.36	634.57	1.484	53.14	78.86

/a/ Value/volume

/b/ Based on seasonal and regional lemon consumption in Table 8A

/c/ Sum of value of domestic production and imports

/d/ Based on seasonal and regional wholesale price in Table 9A

/e/ Seasonal domestic demand in Table 6A is disaggregated into regions using regional population ratios in Table 7A, i.e., 267.39*(89.1/301.2) = 79.12, where 301.2 is total U.S. population.

/f/ Price x volume

/g/ Based on the average wholesale price of imported lemons in Table 12A

/h/ Based on seasonal and regional import demand in Table 12A

/i/ Price x volume

Source: Table 6A, Table 7A, Table 9A, and Table 12A

Table 14A presents the FOB and CIF prices of lemon imports by source. In the benchmark the FOB prices were used as the producer prices of lemons Mexico, Chile, Spain and others exported to the U.S. and the rest of the world.

Table 14A: Imports of fresh lemons in the U.S., average 2006–2008

Sources	Volume and price	Season 1	Season 2	Annual
World	Volume /a/	15.386	37.749	53.136
	$/kg, FOB /b/	0.613	0.506	0.569
	$/kg, CIF /c/	0.733	0.660	0.703
Mexico	Volume	6.513	15.979	22.492
	$/kg, FOB	0.417	0.343	0.386
	$/kg, CIF	0.469	0.400	0.440
Chile	Volume	6.130	15.041	21.171
	$/kg, FOB	0.638	0.551	0.594
	$/kg, CIF	0.887	0.788	0.837
Spain	Volume	2.215	5.433	7.648
	$/kg, FOB	0.838	0.935	0.877
	$/kg, CIF	1.033	1.098	1.059
Others	Volume	0.529	1.297	1.825
	$/kg, FOB	0.868	0.755	0.821
	$/kg, CIF	1.034	0.887	0.973

/a/ From Table 12A, sum of region 1 and region 2
/b/ Data from Foreign Agricultural Service: Value/volume
/c/ Data from Foreign Agricultural Service: CIF Value/volume
Source: USDA/Foreign Agricultural Service
http://www.fas.usda.gov/gats/ExpressQuery1.aspx

In the benchmark, the import volume data in Table 14A, which is at 10-digit HS, corresponds to lemon exports of Mexico, Chile, Spain and others to the U.S. Both the Global Trade Atlas (GTA) and the United Nations COMTRADE (UNCOMTRADE) publish trade data of these countries, including breakdown of market destination. However, the amount of exports to the U.S. from Mexico, Chile and others reported in these two sources are significantly larger than the level of lemon imports from these countries reported in the U.S. This is because the data in the GTA and UNCOMTRADE is both at 6-digit HS level which includes lemons and limes. To calculate the total lemon exports from these countries consistent with the 10-digit HS import data available in the U.S., the GTA data in Table 15A was used together with the import data in the U.S. in Table 14A. In particular, the ratio (exports to the U.S./World exports) was derived

from the GTA data. This ratio was applied to the U.S. data to get the total lemon exports of these countries. This process was done for Mexico and Chile. However, in the benchmark, the data for Spain was taken from UNCOMTRADE because the data on exports to the U.S. is similar to those available in U.S. sources. The results are presented in Table 16A.

Table 15A: Export destination of lemons and limes from Mexico and Chile, 2006–2008

	Export destination of lemons and limes from Mexico								
	World			U.S.			Non-U.S		
Year	Value $million	Volume million kg	Unit price $/kg	Value $million	Volume million kg	Unit price $/kg	Value $million	Volume million kg	Unit price $/kg
2006	192.75	428.13	0.45	186.10	409.97	0.45	6.65	18.16	0.37
2007	222.79	462.87	0.48	211.86	439.92	0.48	10.93	22.95	0.48
2008	295.45	489.39	0.60	263.82	464.47	0.57	31.64	24.91	1.27
Average	237.00	460.13	0.51	220.59	438.12	0.50	16.41	22.01	0.70
	Export destination of lemons and limes from Chile								
	World			U.S.			Non-U.S		
	Value $million	Volume million kg	Unit price $/kg	Value $million	Volume million kg	Unit price $/kg	Value $million	Volume million kg	Unit price $/kg
2006	21.19	33.18	0.64	8.56	15.93	0.54	12.64	17.25	0.73
2007	36.05	46.90	0.77	17.19	27.48	0.63	18.86	19.43	0.97
2008	33.72	41.25	0.82	15.05	21.49	0.70	18.67	19.76	0.95
Average	30.32	40.45	0.74	13.60	21.63	0.62	16.72	18.81	0.88

Source: Global Trade Atlas (http://www.gtis.com/gta/)

Table 16A: Lemon exports of Mexico, Chile, and Spain, average 2006–2008

		Volume (million kg)			Price, FOB ($/kg) /c/		
Exporter	Export to:	Season 1	Season 2	Annual	Season 1	Season 2	Annual
Mexico	U.S. /a/	6.513	15.979	22.492	0.417	0.343	0.386
	Non-U.S. /b/	0.327	0.803	1.130	0.417	0.343	0.386
Chile	U.S. /a/	6.130	15.041	21.171	0.638	0.551	0.594
	Non-U.S. /b/	5.330	13.077	18.408	0.638	0.551	0.594
Spain	U.S.	2.215	5.433	7.648	0.838	0.935	0.877
	Non-U.S.	124.360	305.106	429.467	0.838	0.935	0.877

/a/ From Table 12A, sum of region 1 and region 2

/b/ This may be explained by an illustration in the case of Mexico

b1. From Table 15A take the ratio: Average 2006-08 Mexico's exports of lemons and lines to U.S. (430.12)/ Average 2006-08 Mexico's exports of lemons and lines to the World (460.13) = 0.9522

b2. From Table 14A, take Mexico's annual lemon exports to U.S. (22.492), and divide by the result in b1, i,.e., 22.492/0.9522 = 23.621

b3. Subtract Mexico's annual lemon exports to U.S. (22.492) from the result in b2, i.e., 23.621 - 22.492 = 1.130

b4. The result for season 1 is derived as 1.130*[Mexico's export to the U.S. in the first season (6.513) divide by annual export (22.492)] = 0.327

b5. The results for season 2 is derived as residual, i.e. 1.130 - 0.327 = 0.803

/c/ The FOB prices derived in Table 14A are assumed to hold in the U.S. and non-U.S.

The process that was applied to Mexico and Chile was applied to others which include Dominican Republic, New Zealand, Guatemala, Ecuador, El Salvador, Columbian, and Peru. The results are presented in Table 17A.

Table 17A: Fresh lemon exports of others, average 2006–2008

	Exports, mil. Kg		
Countries	Season 1	Season 2	Annual
Others /a/	1.276	3.131	4.407
U.S.	0.529	1.297	1.825
Non-U.S.	0.748	1.834	2.582

/a/ Includes Dominican Republic, New Zealand, Guatemala, El Salvador, Ecuador, Colombia, and Peru
Source: Global Trade Atlas and Table 14A

The data on lemon production, consumption/processing, and exports in Argentina is presented in Table 18A. From 1998 to 2008, lemon production in Argentina grew by 2.9 percent per year. Although a large part of production is processed domestically, Argentina has been aggressive in its drive to exports its lemon produce. In 1998 to 2008, its exports grew by 9.8 percent per year while its domestic consumption and processing expanded only by 1.07 percent per year. In the period 2006-08, the total lemon exports of Argentina was 360 million kg.

Table 18A: Argentine lemon production, consumption/processing, and exports, average 2006–2008

		Consumption/	
	Production	Processing	Exports
Year	mil. kg		
1998	1,025	869	156
1999	1,043	845	198
2000	1,163	958	206
2001	1,217	979	238
2002	1,313	1,045	268
2003	1,236	900	336
2004	1,340	1,021	319
2005	1,498	1,119	379
2006	1,504	1,179	326
2007	1,517	1,158	359
2008	1,362	966	396
Geometric growth 1998-08	2.89	1.07	9.76
Average: 2006-08	1461	1101	360

Source: La Actividad Citricola Argentina,The Argentine Citrus Industry (2009)

Monthly FOB producer prices of lemons in Argentina are also available (Table 19A). In season 1 the average producer price is $0.618/kg and in season 2 $0.56/kg. Season 1 is relatively higher than season 2 because the price producer reaches its highest level in November at $0.721/kg and in February at $0.685/kg.

The summary of the benchmark data is presented in Table 20A.

Table 19A: Lemon producer prices in Argentina, 2006–2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	season 1	season 2	Annual
Year	FOB, $/kg														
2006	0.360	0.550	0.410	0.380	0.380	0.380	0.380	0.380	0.390	0.400	1.000				
2007		0.482	0.477	0.473	0.469	0.464	0.469	0.466	0.483	0.367	0.318	0.519			
2008	0.583	1.022	0.870	1.016	1.074	1.076	0.976	0.758	0.710	0.694	0.844	0.683			
Average	0.472	0.685	0.586	0.623	0.641	0.640	0.608	0.535	0.528	0.487	0.721	0.601	0.618	0.560	0.594

Source: USDA Foreign Agriculture Service, GAIN Report, Global Agricultureal Information Network
http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Citrus%20Semi-annual_Buenos%20Aires_Argentina_6-15-2010.pdf

Table 20A: Summary of lemon model dataset, average 2006–2008

	Region 1				Region 2			
	Season 1		Season 2		Season 1		Season 2	
Lemon demand	Volume million kg	Wholesale prices ($/kg)	Volume million kg	Wholesale prices ($/kg)	Volume million kg	Wholesale prices ($/kg)	Volume million kg	Wholesale prices ($/kg)
U.S.	75.56272	1.62401	28.39981	1.82697	179.81446	1.79373	67.58222	2.03353
Imports								
Northern Hemisphere								
Mexico	1.92708	1.08863	4.72791	1.34742	4.58581	1.16669	11.25087	1.33339
Spain	0.65525	1.58307	1.60761	1.81844	1.55929	1.62891	3.82558	1.65514
Others	0.15638	1.40877	0.38367	1.63651	0.37214	1.42244	0.91301	1.54640
Southern Hemisphere								
Chile	1.81393	1.55462	4.45030	1.74368	4.31655	1.47173	10.59025	1.65065
Argentina	-	-	-	-	-	-	-	-

	Volume (milllion kg)		Producer prices, FOB ($/kg)	
Lemon Supply	Season 1	Season 2	Season 1	Season 2
U.S.				
Domestic	255.37718	95.98202	1.46711	1.52927
Exports	94.04630	29.53417	0.91594	0.95907
Mexico				
U.S.	6.51289	15.97878	0.41687	0.34313
Rest of the world	0.32713	0.80257	0.41687	0.34313
Spain				
U.S.	2.21455	5.43319	0.83765	0.93498
Rest of the world	124.36019	305.10631	0.83765	0.93498
Chile				
U.S.	6.13047	15.04055	0.63790	0.55102
Rest of the world	5.33030	13.07741	0.63790	0.55102
Others				
U.S.	0.52852	1.29668	0.86757	0.91301
Rest of the world	0.74757	1.83409	0.86757	0.91301
Argentina				
U.S.	-	-	0.61821	0.55953
Rest of the world	104.23992	255.74308	0.61821	0.55953

	Region 1		Region 2	
	Season 1	Season 2	Season 1	Season 2
Real income ($million)	1,948,830	1,392,021	4,700,354	3,357,396

Appendix B: Model Calibration

This appendix discusses the calibration of the simulation model. The calibration uses the benchmark data in Appendix A.

B.1. Consumption Preference Structure

There are three nests in the consumption preference structure (Figure 1). The CES function in each nest requires estimates of the share parameters and the elasticity of substitution. In estimating these parameters the paper adopts the approach of Keller (1980) and Peterson and Orden (2008).

The formulas for the own-price Allen partial elasticity of substitution (AEOS) are:

(1B) $$\sigma_{AA} = -\sigma_1 \cdot \left(sh_A^{-1} - 1 \right)$$

(2B) $$\sigma_{D,D} = -\left[\sigma_2 \cdot \left(sh_D^{-1} - sh_A^{-1} \right) + \sigma_1 \cdot \left(sh_A^{-1} - 1 \right) \right]$$

where σ_{AA} is the aggregate lemon demand own-price AEOS, σ_1 the elasticity of substitution in the first nest, sh_A the budget share of aggregate lemons, σ_{DD} the own-price AEOS for U.S. produced lemons, sh_D the budget share of U.S. produced lemons, σ_2 the elasticity of substitution in the second nest, subscript *A* represents the aggregate lemon demand, and *D* the demand for U.S. produced lemons.

The value of the elasticity of substitution in the first nest, σ_1, can be estimated using equation (1B), the elasticity form of the Slutsky decomposition, and the homotheticity of the CES utility function. That is,

(3B) $$\varepsilon_A = sh_A \cdot \left(\sigma_A - \eta_A \right) = sh_A \cdot \left[-\sigma_1 \cdot \left(sh_A^{-1} - 1 \right) - 1 \right] = -\sigma_1 + sh_A \cdot \left(\sigma_1 - 1 \right)$$

where η_A is income elasticity which equal to 1 and ε_A the aggregate own-price demand elasticity.

Equation (3B) can be simplified as

(4B) $$\sigma_1 = \frac{\varepsilon_A + sh_A}{sh_A - 1}$$

Once the value if σ_1 is determined, it can be substituted into (2B) and use the Slutsky decomposition similar to (3B) to get

$$\text{(5B)} \qquad \varepsilon_D = sh_D \cdot \left\{ -\left[\sigma_2 \cdot \left(sh_D^{-1} - sh_A^{-1} \right) + \sigma_1 \cdot \left(sh_A^{-1} - 1 \right) - 1 \right] \right\}$$

where ε_D is the U.S. produced lemons own-price demand elasticity. Equation (5B) can be solved for σ_2

$$\text{(6B)} \qquad \sigma_2 = \frac{sh_A \cdot \left\{ \varepsilon_D + sh_D \cdot \left[1 + \sigma_1 \cdot \left(sh_A^{-1} - 1 \right) \right] \right\}}{sh_D - sh_A}$$

The third nest in the consumption structure entails substitution among lemons from imported from Mexico, Chile, Spain and others. Once σ_2 is calculated, its value is substituted into (5B). Apply the Slutsky decomposition to get

$$\text{(7B)} \qquad \varepsilon_M = sh_M \cdot \left\{ -\left[\sigma_3 \cdot \left(sh_M^{-1} - sh_D^{-1} \right) + \sigma_2 \cdot \left(sh_D^{-1} - sh_A^{-1} \right) + \sigma_1 \cdot \left(sh_A^{-1} - 1 \right) - 1 \right] \right\}$$

where ε_M is the Mexican produced lemons own-price demand elasticity, and sh_M the budget share of lemons imported from Mexico. Equation (7B) can be solved for σ_3

$$\text{(8B)} \qquad \sigma_3 = \frac{sh_M \cdot \left\{ \varepsilon_M + sh_M \cdot \left[1 + \sigma_2 \cdot \left(sh_D^{-1} - sh_A^{-1} \right) + \sigma_1 \cdot \left(sh_A^{-1} - 1 \right) \right] \right\}}{sh_M - sh_D}$$

The own-price demand elasticities (ε_A, ε_D, and ε_M) are related because the aggregate demand is the horizontal sum of the individual demand curves. At a constant price, the aggregate own-price demand elasticity is smaller in absolute terms than the individual own-price demand elasticities. Assuming the slopes of the three demand curves are equal, the own-price demand elasticities are

$$\text{(9B)} \qquad \varepsilon_A = \varepsilon_D \frac{Q_D}{Q_A} \quad \text{and} \quad \varepsilon_D = \varepsilon_M \frac{Q_M}{Q_D}$$

where Q_D is the demand for U.S. produced lemons, Q_A the total lemon demand, and Q_M the demand for lemons from Mexico.

The benchmark data was used calculate the budget shares at each level (sh_A, sh_D, and sh_M). The benchmark also provided the quantity demand (Q_A, Q_D and Q_M). The remaining parameter that is unknown is ε_A, the aggregate own-price demand elasticity. Based on a literature search, three estimates of lemon own-price demand elasticities are available for the U.S.: (a) -0.5 (Jetter, Sumner and Civerolo, 2003); (b) -0.34 (Green, 1999) and (c) -0.21 (Nuckton, 1978).

The estimates of the share parameters and the elasticity of substitution in Table 1B were calculated using ε_A = -0.34.

Table 1B: Consumption parameters using -0.34 own-price demand elasticity

Parameters	1/Season 1	Region 2/Season 1	Region 1/Season 2	Region 2/Season 2
ε_A	-0.3400	-0.3400	-0.3400	-0.3400
ε_D	-0.3605	-0.3605	-0.4737	-0.4737
ε_M	-0.8516	-0.8516	-1.1191	-1.1191
σ_1	0.3400	0.3400	0.3400	0.3400
σ_2	0.7675	0.8078	0.8661	0.9306
σ_3	0.9035	0.8993	1.6216	1.5490

In all region/season the conditions $\sigma_3 \geq \sigma_2 \geq \sigma_1 \geq 0$ are satisfied. However, σ_3 is less than 1 in Region1/Season 1 and Region 2/Season 1. This does not satisfy the 'variety-loving' assumption which is discussed below.

The parameter estimates using ε_A = -0.50 are presented in Table 2B.

Table 2B: Consumption parameters using -0.5 own-price demand elasticity

Parameters	1/Season 1	Region 2/Season 1	Region 1/Season 2	Region 2/Season 2
ε_A	-0.5000	-0.5000	-0.5000	-0.5000
ε_D	-0.5301	-0.5301	-0.6966	-0.6966
ε_M	-1.2524	-1.2524	-1.6458	-1.6458
σ_1	0.5000	0.5000	0.5000	0.5000
σ_2	1.1287	1.1879	1.2737	1.3685
σ_3	1.3286	1.3225	2.3848	2.2779

The conditions $\sigma_3 \geq \sigma_2 \geq \sigma_1 \geq 0$ are satisfied. The values for σ_3 are all greater than 1. Thus, the simulation model uses the parameter estimates in Table 2B.

The condition $\sigma_3 > 1$ ensures that the entry of Argentine lemons into the U.S. as another lemon variety leads to higher demand for lemons. This is the "variety-loving" condition (Dixit and Stiglitz, 1977, and Foltyn, 2009). To see this consider the following utility function

$$(10B) \quad U = \left\{ \sum_{j=1}^{n} x_j^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}$$

where U is utility, x_j the differentiated product, σ the constant elasticity of substitution among all differentiated products, and n the number of differentiated products or varieties. The uncompensated demand for the jth variety is

$$(11B) \quad x_j = \frac{p_j^{-\sigma} I}{\sum_{j=1}^{n} p_j^{1-\sigma}}$$

where p_j is the price of x_j, and I income. The composite price index (PI) is

$$(12B) \quad PI = \left\{ \sum_{j=1}^{n} p_j^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}$$

If prices of all varieties are equal, then $p_i = \bar{p}$, then $q_i = \bar{q}$, where $\bar{p}$ and $\bar{q}$ are averages. Thus, the expenditure will be equally divided over all varieties. In this case the composite price (PI) and quantity (QI) indices are

$$(13B) \quad PI = \left\{ n\bar{p}^{(1-\sigma)} \right\}^{\frac{1}{(1-\sigma)}} = n^{\frac{1}{1-\sigma}} \bar{p}$$

$$(14B) \quad QI = \left\{ n\bar{x}^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}} = n^{\frac{\sigma}{\sigma-1}} \bar{x}$$

Differentiate equations (13B) and (14B) with respect to n to get

$$(15B) \quad \frac{\partial PI}{\partial n} = \frac{1}{1-\sigma} n^{\frac{\sigma}{1-\sigma}} \bar{p} \quad and \quad \frac{\partial QI}{\partial n} = \frac{\sigma}{\sigma-1} n^{\frac{1}{\sigma-1}} \bar{x}$$

If $\sigma > 1$ higher n decreases the price index and increases the quantity index. The opposite effect is generated when $\sigma < 1$. Thus, to ensure "variety loving" outcome, $\sigma > 1$ is necessary in the CES sub-utility function where the entry of a new variety occurs, which is the third nest in the consumption preference structure.

Given the estimates of the elasticity of substitution, the share parameters in each nest are calculated and given in Table 3B.

Table 3B: Share parameters in the consumption preference structure

Lemons	Parameters	Region 1/Season 1	Region 2/Season 1	Region 1/Season 2	Region 2/Season 2
Third nest					
Mexico	$\theta_{r,Mex,s}$	0.3140	0.3432	0.2805	0.3124
Chile	$\theta_{r,Chl,s}$	0.4745	0.4392	0.4883	0.4782
Spain	$\theta_{r,Spn,s}$	0.1756	0.1814	0.1950	0.1738
Others	$\theta_{r,oth,s}$	0.0359	0.0362	0.0362	0.0355
Second nest					
United States	$\delta_{r,s}$	0.9531	0.9583	0.7532	0.7921
Imports	$(1 - \delta_{r,s})$	0.0469	0.0417	0.2468	0.2079
First nest					
Lemons	$\alpha_{r,s}$	0.000052	0.000054	0.000038	0.000039
All others	$(1 - \alpha_{r,s})$	0.999948	0.999946	0.999962	0.999961

B.2. Production Structure

There are two nests in the production structure (Figure 2). In the first nest supplier *j* has the option of selling lemons either in season 1 or season 2. In the second nest, the supplier has the choice of selling lemons to the U.S. or to the rest of the world.

The supply function that needs to be calibrated is equation (11) in section 3. The calibration of this equation would require either the share parameter $\varepsilon_{j,1}$, or the elasticity of transformation σ_{p2}. The literature search that was conducted did not find estimates of these parameters. Thus, in the paper the benchmark data was used to get estimates of these parameters.

Table 4B presents the quantity supply of lemons and prices. It also presents the simple quantity shares, which indicate that the share of U.S. produced lemons sold in the U.S. domestic is more than 70 percent.

Table 4B: Lemon supply, prices, and quantity shares in the U.S.

	Volume (milllion kg)		Producer prices, FOB ($/kg)	
Lemon supplies and parameters	Season 1	Season 2	Season 1	Season 2
Lemon Supply				
U.S.				
Domestic	255.377	95.982	1.467	1.529
Exports	94.046	29.534	0.916	0.959
Simple quantity shares				
Domestic	0.731	0.765		
Exports	0.269	0.235		

Equation (11) can also be written as

$$(16B) \quad y_{w,j,s} = y_{d,j,s} \cdot \frac{\left(1-\varepsilon_{j,s}\right)}{\varepsilon_{j,s}} \cdot \left(\frac{pp_{d,j,s}}{pp_{w,j,s}} \right)^{\sigma_{p2}}$$

The formula for the share parameters can be derived from (16B) as

$$(17B) \quad \varepsilon_{j,s} = \frac{k}{1+k} \qquad \text{where} \quad k = \left(\frac{y_{d,j,s}}{y_{w,j,s}} \right) \cdot \left(\frac{pp_{d,j,s}}{pp_{w,j,s}} \right)^{\sigma_{p2}}$$

Using (17B), the implied elasticity of transformation of the simple quantity shares in Table 4B is zero.

The formula for the elasticity of transformation is

$$(18B) \quad \sigma_{p2} = -\frac{\ln\left(\frac{y_{d,j,1}}{y_{w,j,1}} \right)}{\ln\left(\frac{pp_{d,j,1}}{pp_{w,j,1}} \right)}$$

Substituting the data on quantity supply and prices from Table 4B into (18B), the implied the values of the elasticity of transformation are -2.120 for season 1 and -2.526 for season 2.

Thus, values of the elasticity of transformation range from zero to -2.120 for season 1 and -2.526 for season 2. The mid-point was used in the model, that is, –2.120/2 = –1.060 for season1 and –2.526/2= –1.263 for season 2. Furthermore, these parameters were assumed for all lemon suppliers. The estimates of the share parameters and the elasticity of transformation are given in Table 5B.

Table 5B: Parameters in the second branch of the production structure

Parameters	Season 1	Season 2
Elasticity of transformation:	-1.0602	-1.2630
Share parameters:		
U.S.		
Domestic	0.6223	0.6432
Exports	0.3777	0.3568
Mexico		
U.S.	0.9522	0.9522
Rest of the world	0.0478	0.0478
Spain		
U.S.	0.0175	0.0175
Rest of the world	0.9825	0.9825
Chile		
U.S.	0.5349	0.5349
Rest of the world	0.4651	0.4651
Others		
U.S.	0.4142	0.4142
Rest of the world	0.5858	0.5858

There are no available estimates found in the literature on the elasticity of transformation between season 1 and season 2 at the first nest, i.e., σ_{p1} in equation (9) in section 3. A small value of σ_{p1}= – 0.1 was used instead in the model to reflect the seasonality constraint in lemon production. This value was assumed for all suppliers. Given the value of σ_{p1} and the benchmark data, equation (9) can be used to solve the share parameters in the first nest of the production structure, β_j. These parameters estimates can be substituted into equation (9) to compute the aggregate factor input V_j. The results are presented in Table 6B.

Table 6B: Parameters in the first branch of the production structure

Parameters	U.S.	Mexico	Chile	Spain	Others	Argentina
Elasticity of transformation (σ_{p1}):	-0.1000	-0.1000	-0.1000	-0.1000	-0.1000	-0.1000
Share parameters (β_j):						
Season 1	0.736814	0.285581	0.286566	0.291836	0.29062	0.287522
Season 2	0.263186	0.714419	0.713434	0.708164	0.70938	0.712478
Aggregate factor input (V_j)	474.954	23.631	39.588	437.168	4.407	360.020
Conditional supply elasticity	0.500	0.300	0.400	0.400	0.400	0.400
Parameters of equation (37)						
η_j	177.362	19.450	27.483	192.841	1.959	249.786
τ_j	237.477	16.542	23.753	262.301	2.644	216.012

The estimates of the elasticity of transformation in the two nests of the production structure satisfy the conditions that $\sigma_{p2} \leq \sigma_{p1} \leq 0$.

The last set of parameters required to calibrate the simulation model are estimates of τ_j and η_j in equation (12). However, estimates of these parameters require conditional supply elasticity estimates for each lemon supplier. Jetter, et al (2003) used a supply elasticity of 0.5 in their analysis of the welfare effects of containing citrus canker in California. This estimate was adopted in the model for U.S. lemon suppliers. For Mexican suppliers the elasticity used was 0.30 because Mexico is highly dependent on the U.S. lemon market. For the rest of the suppliers the value of the elasticity applied was 0.40.

These elasticities are related to the slope of equation 12, i.e.

$$\text{(19B)} \quad \text{supply\_elas}_j = \frac{\partial V_j}{\partial PPL_j} \cdot \frac{PPL_j}{V_j} = \eta_j \cdot \frac{PPL_j}{V_j}$$

Given the estimates of the supply elasticity and the values of PPL_j and V_j, the slope and intercept of equation 12 can be computed. The results are presented in Table 6B.

Appendix C: Measure of Welfare

This appendix presents the measure of welfare used in the analysis. In consumption, equivalent variation was used to measure changes in consumer welfare. In production, producer surplus was used to measure producer loss or gain.

C.1. Consumer Welfare – Equivalent Variation

The corresponding indirect utility function of (1) is

$$(1C) \qquad IU_{r,s} = \left\{\alpha_{r,s} \cdot PL_{r,s}^{1-\sigma_1} + \left(1-\alpha_{r,s}\right)\right\}^{\frac{1}{1-\sigma_1}} \cdot I_{r,s}$$

where *IU* is indirect utility. Solve for $I_{r,s}$ to derive money metric indirect utility function

$$(2C) \qquad mm_{r,s}\left(PL_{r,s}, I_{r,s}\right) = \left\{\alpha_{r,s} \cdot PL_{r,s}^{1-\sigma_1} + \left(1-\alpha_{r,s}\right)\right\}^{\frac{1}{\sigma_1-1}} \cdot IU_{r,s}$$

The equivalent variation is

$$(3C) \qquad \begin{aligned} EV_{r,s} &= mm_{r,s}\left(\overset{Base}{PL}_{r,s}, IU_{r,s}\left(\overset{SIM}{PL}_{r,s}, \overset{SIM}{I}_{r,s}\right)\right) - mm_{r,s}\left(\overset{Base}{PL}_{r,s}, IU_{r,s}\left(\overset{Base}{PL}_{r,s}, \overset{Base}{I}_{r,s}\right)\right) \\ EV_{r,s} &= mm_{r,s}\left(\overset{Base}{PL}_{r,s}, IU_{r,s}\left(\overset{SIM}{PL}_{r,s}, \overset{SIM}{I}_{r,s}\right)\right) - \overset{Base}{I}_{r,s} \end{aligned}$$

where $\overset{Base}{PL}_{r,s}$ and $\overset{Base}{I}_{r,s}$ are the base prices and income, while $\overset{SIM}{PL}_{r,s}$ and $\overset{SIM}{I}_{r,s}$ the simulated prices and income. Since income is exogenous $\overset{SIM}{I}_{r,s} = \overset{Base}{I}_{r,s}$, the formula of the equivalent variation is

$$(4C) \qquad EV_{r,s} = \left[\left(\frac{\left\{\alpha_{r,s} \cdot \overset{Base}{PL}_{r,s}^{1-\sigma_1} + \left(1-\alpha_{r,s}\right)\right\}}{\left\{\alpha_{r,s} \cdot \overset{SIM}{PL}_{r,s}^{1-\sigma_1} + \left(1-\alpha_{r,s}\right)\right\}}\right)^{\frac{1}{\sigma_1-1}} - 1\right] \cdot \overset{Base}{I}_{r,s}$$

The wholesale price of lemons $PL_{r,s}$ is a composite of the individual wholesale prices $wp_{r,j,s}$ of lemon type *j* = U.S., Mexico, Chile, Spain, Others. The index *j* includes Argentina if Argentine lemons are allowed entry into the U.S. Equation (4C) depends not only on the value of

σ_1 but also on σ_2 and σ_3. The value of $EV_{r,s}$ is positive if $\overset{SIM}{PL}_{r,s} < \overset{Base}{PL}_{r,s}$. The equivalent variation for the whole U.S. is

(5C) $$TotalEV = \sum_s \sum_r EV_{r,s}$$

C.2. Producer Surplus

The reduced form supply equations can be derived as

(6C) $$y_{d,j,s1} = \varepsilon_{j,s1} \cdot \beta_j \cdot pp_{d,j,s1}^{-\sigma_{p2}} \cdot PPS_{j,s1}^{(\sigma_{p2}-\sigma_{p1})} \cdot PPL_j^{\sigma_{p1}} \cdot V_j$$

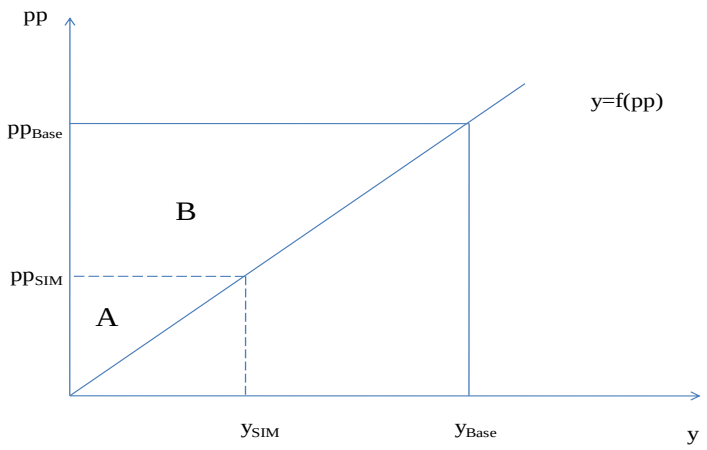
(7C) $$y_{w,j,s1} = \left(1-\varepsilon_{j,s1}\right) \cdot \beta_j \cdot pp_{w,j,s1}^{-\sigma_{p2}} \cdot PPS_{j,s1}^{(\sigma_{p2}-\sigma_{p1})} \cdot PPL_j^{\sigma_{p1}} \cdot V_j$$

(8C) $$y_{d,j,s2} = \varepsilon_{j,s2} \cdot \left(1-\beta_j\right) \cdot pp_{d,j,s2}^{-\sigma_{p2}} \cdot PPS_{j,s2}^{(\sigma_{p2}-\sigma_{p1})} \cdot PPL_j^{\sigma_{p1}} \cdot V_j$$

(9C) $$y_{w,j,s2} = \left(1-\varepsilon_{j,s2}\right) \cdot \left(1-\beta_j\right) \cdot pp_{w,j,s2}^{-\sigma_{p2}} \cdot PPS_{j,s2}^{(\sigma_{p2}-\sigma_{p1})} \cdot PPL_j^{\sigma_{p1}} \cdot V_j$$

The supply equations are affected by the parameters in the two nests of the production structure, as well as the level of the producer prices ($pp_{m,j,s}$) , the composite prices ($PPS_{j,s}$ and PPL_j) and the level of the aggregate factor input (V_j). However, $pp_{m,j,s}$ affects $PPS_{j,s}$ (equation 10) and $PPS_{j,s}$ affects PPL_j (equation 13). Since V_j is related to PPL_j (equation 12) , the supply equations functions of $pp_{m,j,s}$. Since the producer prices in the rest of the world ($pp_{w,j,s}$) are fixed, the supply equations are affected by the producer price ($pp_{d,j,s}$) in the U.S. market only. This means that a policy shock will only involve movements along the supply functions. Therefore, the producer surplus may be illustrated in Figure 1C. If the producer price declines from pp_{Base} to pp_{SIM} because of a policy shock, supply decreases from y_{Base} to y_{SIM}. The reduction in the producer surplus may be indicated by area B.

Figure 1C: Producer surplus



Thus the producer surplus can be computed as

$$(10C)\quad Surp_{m,j,s} = \left[pp^{SIM}_{m,j,s} \cdot y^{SIM}_{m,j,s} - \int_0^{y^{SIM}_{m,j,s}} f_{m,j,s}\left(y_{m,j,s}\right) dy_{m,j,s} \right] - \left[pp^{Base}_{m,j,s} \cdot y^{Base}_{m,j,s} - \int_0^{y^{Base}_{m,j,s}} f_{m,j,s}\left(y_{m,j,s}\right) dy_{m,j,s} \right]$$

where $f_{m,j,s}(y_{m,j,s})$ are the inverted functions of (6C) to (9C). To calculate the overall producer surplus in the U.S. (10C) is summed over $m = d,w$ and $s = s1,s2$ for j=U.S.