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The Free Trade Area of the Americas and the Market for Processed Orange Products

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The proposed Free Trade Area of the Americas would join the world's two largest processed orange producing regions: Brazil and the United States. Because the United States currently imposes a sizeable tariff on imported processed orange products, there is concern by U.S. orange growers over possible adverse effects resulting from tariff elimination. A model of the world processed orange market is developed as a spatial equilibrium model with implicit supply functions based on the dynamic behavior of orange production. The model is used to estimate the impact of U.S. tariff elimination on U.S. production, grower and processor prices, and imports. The results suggest a sizeable price impact on U.S. producers if the tariff is eliminated.

Key Words: orange juice, spatial equilibrium, tariffs, trade

JEL Classifications: C61, F13

The Free Trade Area of the Americas (FTAA) is a proposal that would create a free trade zone that encompasses nearly all of the countries of the western hemisphere. This region encompasses a population of 825 million with an aggregate gross domestic product (GDP) of US$10 trillion.[1] It would be the largest free trade zone in the world. The countries included in the FTAA account for most of the world's production of orange juice. The states of Sao Paulo, Brazil, and Florida in the United States together produce ~85% of the world's orange juice. Mexico and Cuba in the western hemisphere and Italy, Spain, and Greece in Europe also produce orange juice for export. World production of orange juice by country is shown in Table 1.

The United States is the largest processed orange–consuming country in the world. Canada is also a large market, despite its relatively small population; Canada's per capita consumption rivals that found in the United States.[2] The other countries of the western hemisphere, however, do not have significant consumption of orange juice. Consumers in these countries still buy oranges in fresh form

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[1] As reported by WEFA, the GDP of the NAFTA countries in 1999 was US$8.7 trillion in 1990 US$, and the GDP of the other western hemisphere countries in 1999 was US$1.4 trillion in 1990 US$.

[2] Canada imports frozen concentrated orange juice at no tariff. All of its imports from NAFTA partners are tariff free; it does, however, levy a 2% ad valorem on single-strength orange juice imports from non-NAFTA countries such as Brazil.

Table 1. Processed Orange Production by Country, 2000[a]

Country	Production (million 90-lb. boxes)
Brazil	314.3
United States	238.3
Italy	21.5
Spain	12.2
Mexico	10.0
Greece	9.6
Cuba	8.1
Australia	7.3
South Africa	6.8
Costa Rica	6.6
Argentina	3.4
Others	27.7
Total	662.4

Source: FAO.
[a] Figures presented are in fresh fruit equivalent.

Table 2. Processed Orange Consumption by Country, 2000[a]

Country	Consumption (million 90-lb. boxes)	Per capita (lbs.)
United States	269.7	85.69
European Union	265.1	61.58
Canada	31.8	94.44
Australia	9.4	44.26
Mexico	7.8	7.12
Brazil	6.0	3.15
Japan	6.3	4.47
Others	36.7	N/A[b]
Total	632.7	9.39

Source: FAO.
[a] Figures presented are fresh fruit equivalent.
[b] N/A is not applicable.

and produce orange juice at home. As a result, nearly all of Brazil's orange juice production is exported. Outside of the western hemisphere, the European Union (EU) is the other major orange juice–consuming region. Consumption of orange juice in the major consuming regions of the world is shown in Table 2.

The purpose of the present article is to examine the world market for orange juice, document the existing tariff structure for orange juice, and project the possible impact of the FTAA on world orange juice trade. The analysis is conducted using a mathematical model of the world orange juice market developed at the University of Florida (McClain; Brewster and Spreen).

The Impact of Not-From-Concentrate Orange Juice

The introduction of not-from-concentrate orange juice (NFC) into the orange juice markets of the United States and Canada has been one of the most important phenomena of the 1990s. Consumption of NFC in the United States has increased from <200 million single strength equivalent (SSE) gallons in 1988–1989 to >500 million SSE gallons in the 2000–2001 season (Table 3). Much of this growth has occurred despite the fact the retail prices of NFC have remained relatively stable over that period. Widespread acceptance of NFC by North American consumers has been unexpected and requires a change in the understanding of the world orange juice market.

The growth of NFC consumption in the

Table 3. U.S. Consumption of Orange Juice by Product Form, 1988–1989 through 2000–2001

Season	Million SSE Gallons		
	FCOJ[a]	NFC[b]	Total[c]
1988–1989	1,078	190	1,268
1989–1990	890	213	1,103
1990–1991	871	229	1,100
1991–1992	893	233	1,126
1992–1993	1,006	280	1,286
1993–1994	1,080	301	1,381
1994–1995	1,065	317	1,382
1995–1996	1,028	347	1,374
1996–1997	1,064	371	1,435
1997–1998	1,142	455	1,597
1998–1999	1,077	472	1,548
1999–2000	1,119	481	1,600
2000–2001	966	535	1,501

[a] Estimated as a residual. Includes FCOJ, reconstituted OJ, and shelf-stable OJ.
[b] Estimated as Florida NFC production + estimated other U.S. NFC production + NFC imports − NFC exports + Florida NFC inventory adjustment.
[c] Based on estimates from the Florida Department of Citrus.

Table 4. FCOJ Tariff Schedule for Major Orange Juice Importing Countries under GATT

Year	United States (Cents/SSE gallons)	Ad Valorem	
		Europe	Japan
1994	35.01	19.00	30.00
1995	34.13	18.37	29.25
1996	33.24	17.74	28.50
1997	32.36	17.10	27.75
1998	31.48	16.47	27.00
1999	30.59	15.84	26.25
2000 & beyond	29.71	15.20	25.50

Source: Spreen and Mondragon.

United States and Canada affects world trade in orange juice in that nearly all of the NFC consumed in North America is produced in Florida. Mexico has exported small quantities of NFC to the United States (<4 million SSE gallons annually), but, to date, very little NFC has been shipped from Brazil to the United States. As such, an increasing share of Florida's orange crop has been allocated to NFC. In the past three seasons, >40% of Florida's orange crop has been sent to the NFC market (Florida Citrus Processors Association).

Nearly all of the frozen concentrated orange juice (FCOJ) traded in the world is first concentrated to 65° or 66° Brix. At this level of concentration, six parts water must be added to reconstitute the juice to SSE. NFC, on the other hand, is never concentrated. Therefore, to ship an equivalent volume of NFC compared with FCOJ, seven times the volume must be shipped. As a result, transportation costs become an increasingly important component of the cost of NFC delivered to its final destination.

An important implication of the establishment of a large-scale NFC market in the United States is that, for the present, the Florida processed orange industry has been able to differentiate its product from that produced elsewhere and thereby partially insulate itself from import competition. In the analysis of the proposed FTAA, the markets for NFC and reconstituted FCOJ in the United States have been separated, because the latter market is more vulnerable to reduction or elimination of the U.S. orange juice tariff.

Consumption of NFC has begun in both Canada and the EU. Given Canada's proximity to the United States, it is not surprising that Canadian consumers have begun drinking NFC. Canadian import data can be used to infer the composition of consumption. Although data are available on imports of orange juice into the EU, the composition of imports is not known. U.S. export data indicate that ~70 million SSE gallons of NFC were exported from the United States in both the 1998–1999 and 1999–2000 seasons. Of this total, >90% of U.S. exports were sent to Canada and the EU.[3]

Tariffs and the World Orange Juice Market

Three of the largest orange consuming regions levy tariffs on imported orange juice. In this section, those tariffs are reviewed. Recently, these tariffs have been reduced as negotiated in the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The most favored nation (MFN) FCOJ tariff schedules for the United States, the EU, and Japan are shown in Table 4. Prior to the GATT agreement of 1994, Canada imposed an ad valorem tariff of 3% on imports of FCOJ. Canadian import tariffs imposed on orange juice from the United States and Mexico have been phased out under the North American Free Trade Agreement (NAFTA).

The United States allows the importation of orange juice duty-free to those countries identified under the Caribbean Basin Economic Recovery Agreement (CBERA), also known as the Caribbean Basin Initiative. CBERA countries that currently export orange juice to the United States include Costa Rica, Belize, Honduras, and the Dominican Repub-

[3] Data were recently published in a USDA publication regarding imports of NFC into Europe. That report, however, contained no information on domestic production of NFC in the EU. Both Spain and Italy have become significant producers of NFC, but their exact production figures are not known. For further discussion, see Goodrich and Brown.

lic. In 2000, imports from CBERA countries totaled 65.7 million SSE gallons, which was 20.6% of total U.S. imports and ~4% of total U.S. orange juice consumption.

Under NAFTA, both the United States and Mexico agreed to phase out their tariffs on orange juice imports over a 15-year period, beginning in 1994. At the time the agreement was signed, Mexico levied a 20% ad valorem duty on imports of orange juice, even though very little was imported. Before NAFTA, Mexico's exports to the United States were subject to the MFN tariff, which at the time the agreement was implemented was US$.35 per SSE gallon for FCOJ and US$.175 per SSE gallon for NFC.

Imports of orange juice from Mexico had been increasing before NAFTA was implemented, which raised fears in Florida that reductions in the U.S. orange juice tariff would result in massive increases in Mexican juice exports. To allay these fears, a rather complicated arrangement was negotiated under which Mexican exporters were granted a tariff rate quota of 40 million SSE gallons at one-half the prevailing MFN tariff or US$.175 per SSE gallon. Exports above 40 million SSE gallons are charged a higher tariff that declines over a 15-year period, reaching zero in 2008. A snapback provision was built into the agreement that was intended to protect against "surges" of orange juice imports from Mexico. In the snapback provision, if both price and quantity triggers were crossed, then overquota imports would be charged the MFN tariff rate.

NAFTA was implemented on January 1, 1994. The Uruguay Round of GATT was completed in mid-1994, with its provisions put into effect beginning January 1, 1995. Because the GATT agreement was to reduce the MFN orange juice tariff by ~15% over 6 years, the NAFTA tariff schedule was revised to conform to GATT. The revised NAFTA tariff schedule can be found in Spreen and Mondragon or Spreen.

The European Union also offers trade preferences to selected orange juice exporters. Through the Lome Convention, the EU grants to countries identified as members of the African, Caribbean, and Pacific (ACP) countries[4] preferential access for a wide range of agricultural commodities. Among the orange juice exporting countries, only Belize is an ACP country. As such, Belize is granted duty-free access to the EU. Under a special arrangement, Costa Rica is also granted duty-free access to the EU.

The countries of Argentina, Brazil, Uruguay, and Paraguay formed a customs union known as MERCOSUR in 1994. Although Chile is not a member of MERCOSUR, it does grant certain trade concessions to MERCOSUR members. With little consumption of orange juice in these countries, MERCOSUR has not resulted in large-scale expansion of orange juice exports from Brazil to the other MERCOSUR countries.

Japan currently imposes an ad valorem tariff of 25.5% on imports of FCOJ. No country is given preferential access to Japan according to our review of Japan's trade regime.

A Model of the World Orange Juice Market

A model of the world orange juice market has been developed at the University of Florida. This model was originally developed in 1989 (McClain) and has been updated and modified since then (Brewster and Spreen). In the model, there are four production areas for orange juice: Sao Paulo, Mexico, and Florida and California in the United States. Production in Sao Paulo and Florida is modeled explicitly, whereas production from Mexico and California is assumed to be fixed over the forecast horizon. The existing tree inventory in Sao Paulo and Florida is used to forecast orange production in each region. Historical processed utilization rates and juice yields are combined with the orange production forecast to predict orange juice production in each region. After a spatial price equilibrium is established, lagged grower (on-tree) prices are used to predict future tree plantings. Historical

[4] Most of the ACP countries are former colonies of France and the United Kingdom, although former overseas territories of other EU members are also included.

tree loss rates are used to adjust the tree inventory. The updated inventory is then used to predict next year's crop. The model is solved in a forward recursive fashion over a specified time horizon.

The four consumption regions included in the model are the United States, Canada, the EU, and Japan. The tariffs imposed by these countries are included in the pricing structure of the model. Demand equations have been estimated for each of these countries, which also account for growth in demand over time. For the purposes of this analysis, the annual demand growth rates are assumed to be 1% in the United States, 0.5% in Canada, 2% in the EU, and 2.5% for Japan.[5]

The model allocates the available supply of orange juice across the four consumption regions so as to establish a spatial price equilibrium. It is assumed that in each year, production equals consumption—i.e., changes in inventory are not taken into account. In the most recent version of the model, the orange juice markets in the both the United States and Canada are disaggregated into consumption of NFC and FCOJ. Because most of the FCOJ produced is ultimately consumed as reconstituted chilled orange juice, this level of disaggregation was deemed appropriate. Separate demand equations have been estimated for NFC and FCOJ at the processor level—i.e., the prices in the model reflect the prices charged by processors for NFC and bulk FCOJ. Each demand equation also includes a cross-price effect. This term accounts for the fact that NFC and bulk FCOJ are close substitutes. The quantity of FCOJ in the market affects the price of NFC and vice versa. It is also important to note that, in this analysis, the existing tariff structure is assumed to remain unchanged over the forecast period.

[5] A demand growth rate of 1% means that a 1% increase in the quantity consumed can be accomplished with no increase in price. Demand growth in the United States and Canada is mainly driven by population growth. Demand growth in Europe and Asia is primarily the result of increased per capita consumption. These estimates are based on work by the Florida Department of Citrus.

Mathematical Representation of the Model

The world orange juice model is a multiyear spatial equilibrium model. The supply side of the model is implicit in that a relationship between current price and quantity is not specified. Rather, orange production in Florida and Sao Paulo is based on the orange tree inventories in those respective regions. The linkage of price and production is accomplished through a new planting function. It specifies that new plantings react to price changes. Orange trees take several years to reach full production, generating a substantial lag between a price signal and increased production. Furthermore, given the high initial cost of orange grove development, there is also a substantial lag between depressed prices and contraction of production.

In the current specification of the model, the demands for FCOJ and NFC vary across the four consumption regions. In the EU and Japan the main processed orange product consumed is FCOJ. In the United States and Canada, however, NFC now accounts for ~35% and 30%, respectively, of orange juice consumption.

To account for the presence of NFC, a two-equation inverse demand system is estimated for the United States and Canada. The linear form of this system is

$$P_{FCOJ} = \alpha_1 - \beta_1 Q_{FCOJ} + \gamma_1 Q_{NFC} \tag{1}$$

$$P_{NFC} = \alpha_2 - \beta_2 Q_{NFC} + \gamma_2 Q_{FCOJ}, \tag{2}$$

where P_{FCOJ} is the processor price of FCOJ, P_{NFC} is the processor price of NFC, Q_{FCOJ} is the quantity of FCOJ,[6] and Q_{NFC} is the quantity of NFC consumed.

The parameters γ_1 and γ_2 are the "cross-price" effects—i.e., the impact of a change in the quantity of one product on the price of another product. To formulate the quadratic programming model that will determine the optimal allocation of orange juice across product forms and spatially separated markets, it must be assumed that $\gamma_1 = \gamma_2$. For further dis-

[6] This includes that purchased as FCOJ and chilled reconstituted juice from FCOJ.

cussion, see McCarl and Spreen. The demand system denoted by Equations (1) and (2) is estimated individually for the United States and Canada.

For the other consumption regions, let the inverse demand equation be given by

$$(3) \quad P_j = a_j - b_j Q_j,$$

where P_j is the price of FCOJ in region j (j = EU or Japan) and Q_j is the quantity of FCOJ consumed in region j.

To develop the supply side of the model, remember the existence of the lag between production decisions and output. In Florida, there are excellent data available on the number of orange trees disaggregated by variety, age, and location. In Sao Paulo, Brazil, the quality of the tree data is less, although the distribution of tree numbers across age categories can be estimated on the basis of data published by the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture (USDA).

Let n_{ia} be the number of trees in age category a in region i where i can equal Florida or Sao Paulo, and let Y_{ia} be the yield of oranges per tree associated with a tree of age a located in production region i. Then

$$(4) \quad \sum_a n_{ia} Y_{ia} = TP_i$$

is the total production of oranges in region I—i.e., TP_i denotes total fresh orange production in region i.

In Florida, processed orange utilization is high and has remained relatively constant, at 94% over recent years. In Sao Paulo, a larger proportion of orange production is utilized in its internal market as fresh oranges (which often are juiced at home). Processed utilization in Sao Paulo ranges from 70% to 75%. In this model, assume that processed orange utilization is a fixed proportion of the crop and is given by U_i

$$(5) \quad OJ_i = TP_i \times U_i \times JU_i,$$

where OJ_i is orange juice production in region i and JU_i is a conversion factor between fresh oranges and the volume of orange juice.[7]

The presence of two products in Florida, NFC and FCOJ, however, complicates the conversion of fresh oranges to orange juice. A separate submodel must be developed to model the allocation of oranges to NFC and FCOJ.

The quality of oranges used for processing can be characterized by three main factors: Brix, ratio, and color score. Brix is a measure of the orange solids content of the juice. Single-strength juice such as NFC typically has a Brix level near 12°. On the other hand, a high Brix level is desired for oranges used for FCOJ. In the FCOJ process, water is removed to attain a level of concentration of 65° Brix.[8] The ratio represents the solids/acid ratio. A high ratio is associated with very sweet juice, whereas low-ratio juice may be sour. The desired level of ratio in the United States market is 15.5–17.5.

Color score is a concept that has its origin in the grading system used by the USDA. The USDA grading system for FCOJ sold in the United States is based on three factors: color, defects, and flavor. Most processors, which market in the United States and the EU, achieve low levels of defects. Flavor is related to Brix and ratio, but there are other less quantifiable factors that also affect flavor. Color is based on a 40-point scale in which darker juice is awarded a higher value. Juice from Valencia oranges typically is darker in color (resulting in a higher color score) compared with juice from earlier maturing varieties such as Hamlin. The Pera variety grown extensively in Brazil also produces juice of good color.

Given these observations, a blending model is developed for FCOJ and NFC for the U.S. market. It assumes that each of these products can be made from the following ingredients: Hamlins from Florida and Valencias from Florida, California, Mexico, and Brazil.

The quality requirements are minimum and

[7] This term is commonly referred to as "juice yield." In Florida, it is measured as pound solids per box.

[8] Many processors in Sao Paulo now produce 66° Brix FCOJ.

maximum Brix for NFC, minimum color score for both FCOJ and NFC, and minimum and maximum ratio for FCOJ and NFC. Estimates of average Brix, ratio, and color score for each of the ingredients were provided by industry sources.

To mathematically formulate the blending model, let Z_{ivp} be the pound solids of juice type p made from variety v from production region i and i is Florida, California, Mexico, or Brazil, v is Hamlin or Valencia, and p is FCOJ or NFC.

Next define a_{ivpc} as the level of quality attribute c per unit of Z_{ivp} and c is Brix, ratio, or color. The desired level of quality attribute c is achieved by imposing a set of constraints of the form

$$(6) \quad \sum_{v} a_{ivpc} Z_{ivp} \leq QU_{ipc}$$

$$(7) \quad \sum_{v} a_{ivpc} Z_{ivp} \geq QL_{ipc},$$

where QU_{ipc} is the upper limit imposed on quality attribute c in product p produced in region i and QL_{ipc} is the lower limit imposed on quality attribute c in product p produced in region i.

To complete the model, two more issues must be considered. First consider the tariffs imposed on imported orange juice. The United States applies a per unit tariff on imports from Brazil. In the framework of a spatial equilibrium model, per unit tariffs are added to transportation costs so that the transfer cost from region i to region j is $T_{ij} = t_{ij} + tar_j$ where t_{ij} is the per unit transportation cost and tar_j is the tariff imposed by region j. The EU and Japan, however, use ad valorem tariffs. Ad valorem tariffs are percentage tariffs. In a standard spatial equilibrium model, integrating the demand function and summing across regions forms the objective function. To simplify the exposition, if all demand equations are of the form $P_j = a_j - b_jQ_j$ and there are J demand regions, then the objective function looks like

$$\sum_{j-1}^{J} \int_{O}^{Q_j} (a_j - b_jQ_j)\, dQ_j \quad \text{or}$$

$$\sum_{j-1}^{J} \left(a_jQ_j - \frac{1}{2}b_jQ_j^2\right).$$

The ad valorem tariff is imposed by dividing the integral by one plus the tariff (AD) expressed as a decimal, or

$$(8) \quad \sum_{j-1}^{J} \frac{1}{1 + AD_j}\left(a_jQ_j - \frac{1}{2}b_jQ_j^2\right).$$

The other issue relates to new plantings. Based upon previous work of McClain and Kalaitzandonakes and Shonkwiler, new plantings react to current and lagged on-tree prices; i.e., $NP_{t+1} = f(ON_t, ON_{t-1}, \ldots, ON_{t-k})$ where NP_t is new plantings in year t, ON_t is the on-tree (or grower) price in year t, k is the number of years in the lag structure.

In the present study, separate planting relationships for early and midseason oranges and Valencia oranges were estimated. Planting levels were related to expected on-tree price variables for oranges and grapefruit.[9] Data on planting levels and on-tree prices were obtained from publications by the Florida Agricultural Statistics Service. Annual data from 1965 through 1999 (35 observations) were studied.

A double-log model was used to model tree planting levels. Formally, this model can be written as

$$(9) \quad LNP_{vt} = \delta_{v0} + \delta_{v1}LON^*_{1,t+1} + \delta_{v2}LON^*_{2,t+1} + \delta_{v3}LON^*_{3,t+1}, \quad v = 1, 2,$$

where LNP_{vt} is the log of the number of trees planted of variety v in year t and LON^*_{vt} is the log of the expected on-tree price of variety v ($v = 1$ for early and midseason oranges, $v = 2$ for Valencia oranges, and $v = 3$ for grapefruit) in year t.

An adaptive expectations specification was used to model prices. The log of the expected on-tree price for each variety of citrus in the upcoming period is specified as a weighted average of the log of the current (actual) on-tree

[9] The prime interest rate and the interest rate for long-term U.S. government securities, proxies for alternative noncitrus investment opportunities, were also considered as explanatory variable but were found to be statistically insignificant.

price and the log of current expected on-tree price. The weight for the log of the current price is λ ($0 < \lambda < 1$) and the weight for the log of the current expected price is $1 - \lambda$. Formally, the expected price variables can be written as

$$(10) \quad LON^*_{v,t+1} = \lambda LON_{vt} + (1 - \lambda)LON^*_{vt},$$

or, by recursively substituting for LON^*_{vt} in Equation (10),

$$(11) \quad LON^*_{v,t+1} = \sum_{j=0 \text{ to } t-1} \lambda(1 - \lambda)^j LON_{v,t-j} + (1 - \lambda)^t LON^*_{v1}, \quad v = 1, \ldots, 3,$$

where LON_{vt} is the log of the on-tree price of citrus variety v in year t and LON^*_{v1} is the log of the expected price for the first sample observation (1965). That is, the log of the expected price $LON^*_{v,t+1}$ is composed of (a) the log of the expected price at the beginning of the sample LON^*_{v1} times the factor $(1 - \lambda)^t$ that decreases geometrically with time and (b) a sum of weighted prices, $\Sigma_{j=0;\text{ to } t-1}\ \lambda(1 - \lambda)^j LON_{v,t-j}$, in which the weights $\lambda(1 - \lambda)^j$ decline geometrically over time. The weight λ was selected so as to minimize the sum of squared errors.

Substituting Equation (11) into Equation (9) results in

$$(12) \quad LNP_{vt} = \delta_{v0} + \sum_{k=1 \text{ to } 3} \delta_{vk}\left(\sum_{j=0 \text{ to } t-1} \lambda(1 - \lambda)^j LON_{k,t-j}\right) + \delta_{v4}(1 - \lambda)^t,$$

where $\delta_{v4} = \delta_{v1}LON^*_{11} + \delta_{v2}LON^*_{21} + \delta_{v3}LON^*_{31}$.

Preliminary analysis revealed a multicollinearity problem among the price variables for early and midseason oranges, Valencia oranges, and grapefruit. The simple correlation coefficients between the expected price variables defined by $\Sigma_{j=0 \text{ to } t-1}\ \lambda(1 - \lambda)^j LON_{v,t-j}$ ranged from 0.91 to 0.99. Given this situation, only the own-price variables were included in model (12). A grid search revealed that the best values for λ were 0.37 for early and midseason oranges and 0.26 for Valencia oranges. Ordinary least-squares estimates of model (12) based on these values for λ are shown in Table 5. All the parameter estimates are significantly different from zero at the $\alpha = 0.10$ level. At the end of the sample ($t = 35$), the term $\delta_4(1 - \lambda)^t$ is approaching zero and can be ignored for predicting future expected prices.

Table 5. Ordinary Least-Squares Estimates of New Planting Equations for Early–Mid-Season and Valencia Oranges in Florida

	Early and Midseason		Valencia	
Parameter	Est. Parameter	Est. Std. Error	Est. Parameter	Est. Std. Error
δ0	5.293	0.159	4.760	0.216
δ1 or δ2	1.493	0.128	1.725	0.153
δ4	4.005	0.558	3.659	0.532
R^2	0.813		0.800	

In Sao Paulo, citrus must compete with sugarcane for land and capital. The new planting equation for Sao Paulo takes the form

$$(13) \quad NP^{SP}_{t+1} = \eta_{SP} + \theta_{SP}\left[\frac{ON^{SP}_t}{SC_t}\right],$$

where the superscript SP refers to Sao Paulo and SC_t is the price of sugarcane paid to growers in year t.

To write the complete model, note that it has two main components: the production submodels for Sao Paulo and Florida and the pricing model. The production model for year t uses the price equilibrium from year $t - 1$ to compute on-tree prices in Sao Paulo and Florida. These prices are used in Equations (12) and (13) to predict new plantings in each region. Trees of age $a - 1$ in year $t - 1$ are moved to age a in year t, adjusted for death loss—i.e.,

$$(14) \quad n_{ia,t} = n_{i,a-1,t-1}(1 - DL_{i,\ a-1}),$$

where $DL_{i,a-1}$ is the death loss associated with trees of age $a - 1$ in region i.

Once the new tree age distribution is known, Equations (4) and (5) are used to project orange juice production in both regions. After $OJ_{iv,t}$ is calculated, it is used as input into the spatial equilibrium model. Omitting the time subscript for simplicity, the spatial model is

$$\max \sum_{j=\mathrm{EU,Japan}} \frac{1}{1+AD_j}\left(a_j Q_j - \frac{1}{2} b_j Q_j^2\right)$$
$$+ \sum_{j=\mathrm{US,Canada}} \left[\int (\alpha_{1j} - \beta_{1j} Q_{j,\mathrm{FCOJ}} + \gamma_{1j} Q_{j,\mathrm{NFC}})\, dQ_{j,\mathrm{FCOJ}} + \int (\alpha_{2j} - \beta_{2j} Q_{j,\mathrm{NFC}} + \gamma_{2j} Q_{j,\mathrm{FCOJ}})\, dQ_{j,\mathrm{NFC}} \right]$$
$$- \sum_i \sum_j \sum_p T_{ijp} X_{ijp}$$

s.t.

$$-\sum_i X_{ijp} + Q_{jp} \le 0$$
$$-Y_{ip} + \sum_j X_{ijp} \le 0$$
$$-\sum_v Z_{ivp} + Y_{ip} \le 0$$
$$\sum_p JU_{iv} Z_{ivp} \le OJ_{iv}$$
$$\sum_v a_{ivpc} Z_{ivp} \le QU_{ipc}$$
$$\sum_v a_{ivpc} Z_{ivp} \ge QL_{ipc}$$

all variables are nonnegative where X_{ijp}, Q_{jp}, OJ_{iv}, and Z_{ivp} are defined as before. Y_{ip} is the quantity product p produced in supply region i.

The two submodels (production and spatial pricing) are solved in a forward recursive fashion over a specified time horizon. A program written in GAMS is used to solve the combined models on a desktop personal computer.

Empirical Specification-Baseline Model

U.S. and Canadian inverse demand parameters were based on regressions of log prices for NFC, other OJ (predominately FCOJ), and grapefruit juice on associated log quantities and real income (disposable income divided by the CPI). Quantities and real income were deflated by population, and prices were deflated by the CPI. The equations were estimated in differential form with symmetry imposed. A.C. Nielsen data for period August 10, 1996 through July 7, 2001 were used. Each observation is for a 4-week period, and, to account for seasonality in demand, the variables were 13th differenced (13 4-week periods per year). Symmetry was imposed on the basis of the condition that the compensated inverse demand elasticities (flexibilities) multiplied by their respective budget shares are symmetrical; in each equation, the log change in the CPI deflated price was multiplied by the budget share of the good in question to impose this condition. The resulting inverse demand equations are an approximation of the compensated inverse demand system proposed by Laitinen and Theil (see Barten and Bettendorf or Brown, Lee, and Seale for additional discussion).

After incorporating the demand and new planting equations into the model, the model was validated using the 2000–2001 marketing year. This involved confirming the model's ability to properly allocate Florida orange production between FCOJ and NFC production and the generation of both FOB and on-tree prices consistent with the level observed in that season.

Empirical Results-Baseline Model

Projected orange and orange juice production in Sao Paulo and Florida are shown in Table 6. Orange production in Sao Paulo is projected to decline from the 395 million 90-pound-box crop produced in 1999–2000 to 332.7 million boxes in the 2004–2005 season. Production is projected to recover to nearly 360 million boxes by the 2009–2010 season and continue to expand to 484 million boxes by 2020. The near-term decline in Sao Paulo orange production is a result of citrus variegated chlorosis (CVC), a viral disease that has killed millions of young trees in Sao Paulo over the past 5 years. The latest data on tree numbers in Sao Paulo indicate that there are currently 12 million nonbearing orange trees in the state. The

Table 6. Projected Production of Oranges and Orange Juice in Sao Paulo and Florida, 2005, 2010, and 2020

	Projected Orange Production (million 90-lb. boxes)		Projected Orange Juice Production (million SSE gallons)	
Season	Sao Paulo	Florida	Sao Paulo	Florida
2004–2005	332.7	254.7	1,435	1,536
2009–2010	359.8	264.7	1,552	1,599
2019–2020	484.3	278.3	2,089	1,684

Table 7. Projected Orange Juice Consumption in Major Consuming Regions, 2005, 2010, and 2020

	Consumption Region (million SSE gallons)			
Season	United States[a]	Canada	European Union[b]	Japan
2004–2005	1,615	131	1,214	128
2009–2010	1,689	134	1,303	141
2019–2020	1,867	143	1,689	189

[a] Includes both NFC and FCOJ consumption.
[b] Does not include production from other areas.

normal annual death loss in Sao Paulo is ~6%. At present, there are an estimated 154 million bearing trees in Sao Paulo (FAS, USDA), so that nearly 9 million trees are needed to enter the bearing tree population each year. With a total of 12 million nonbearing trees (ages <1, 1–2, and 2–3 years), bearing tree numbers should decline over the next few seasons.

Orange production in Florida is estimated to increase modestly to 255 million 90-pound boxes[10] (229 million boxes were produced in 2001–2002) by the 2004–2005 season. Orange production is projected to grow slowly over the next 15 years, reaching 278 million boxes by the 2019–2020 season. This forecast is based on the reality that orange producers face constraints to significantly expand citrus production. These constraints include competition from urban growth for land and water and the problem of finding harvest labor. Research is under way in Florida on mechanical harvesting of citrus, but it is not yet widely adopted.

Orange juice production in Sao Paulo is projected to decline to 1,435 million SSE gallons (1.03 million MT ~65° Brix) in the 2004–2005 season. Production will then recover to 1,552 million SSE gallons in 2009–2010 and continue to grow to 2,089 million SSE gallons by 2020. Orange juice production in Florida is projected to range from 1,500 to 1,700 million SSE gallons over the next 20 years (Table 6).

Even though total orange production in Sao Paulo is considerably larger compared with Florida, in recent years, Florida's production of orange juice rivals that in Sao Paulo. This occurs because processed utilization is much higher in Florida (94% vs. 74%) and juice yields are higher in Florida, although Sao Paulo has been closing the gap in recent years.

With this production forecast, consumption levels in the four major consuming regions are expected to expand modestly over the next 20 years, as shown in Table 7. With per capita consumption in the EU continuing to expand, EU consumption is expected to be 1,689 million SSE gallons 2020. With underlying demand growth in all four markets, increased production can be accommodated with relatively stable grower prices (Tables 8 and 9). Processor prices in Florida for FCOJ are projected to be nearly flat, averaging approximately US$1.10 per SSE gallon for FCOJ (Table 10). NFC prices are also expected to show a similar pattern over the forecast period. Prices in the other consumption markets are expected to decline modestly (Tables 11–13).

Prices at these levels mean that grower prices should remain in a profitable range over the forecast period. Grower prices in Sao Paulo should range from US$1.88 to $US2.20 per box, whereas prices in Florida will range from US$4.39 to US$4.82 per box. These on-tree prices are above the cost of production in both Sao Paulo and Florida as recently reported by Muraro et al. and could be sufficiently high to

[10] This projection does not account for the likely effect of a disease called tristeza, which began to kill orange trees in Florida in 2000.

encourage expansion of the world's citrus industry in countries other than the United States and Brazil.

On-tree prices that exceed cost of production in Sao Paulo have proved, in the past, to stimulate new tree plantings. The main competitor to orange production for land and labor in Sao Paulo is sugarcane. Brazil has recently modified its ethanol program so as to divert more cane to sugar production. The recent increase in the world price of oil has caused the government of Brazil to reconsider its recent policy changes toward ethanol. This change will likely stimulate the domestic sugarcane industry and provide a viable alternative to citrus in Sao Paulo.

The Projected Impact of FTAA on the World Orange Juice Market

The FTAA proposal is intended to create a free trade zone extending from Canada to Chile and Argentina. If it is similar in scope to other free trade agreements, it is likely that tariffs and quotas will be eliminated on nearly all products traded within the region. Clearly, the U.S. tariff on orange juice imports is one of those import tariffs that could be affected by the passage of FTAA.

In the present analysis, the impact of elimination of the U.S. tariff on orange juice imports is conducted using two scenarios. Scenario 1 assumes that the tariff on both FCOJ and NFC will be phased out over a 15-year period beginning in 2002. A 15-year phase out is considered because this is the same timetable used in NAFTA. Scenario 2 is based on the assumption that the tariff would be reduced to zero beginning with the 2002–2003 season. The results of this analysis are summarized in Tables 8–19.

The impact of phased and immediate elimination of the U.S. orange juice tariff on Sao Paulo is shown in Table 8. The results indicate that tariff elimination would have little effect on orange production in Sao Paulo. At the end of the forecast horizon, orange production in Sao Paulo is projected to be 494 million boxes under immediate elimination, a level 10 million boxes greater than is forecast if the tariff remains in place. Phased elimination of the tariff is projected to gradually increase on-tree prices in Sao Paulo with the advantage reaching US$.12 per box by 2015–2016. Immediate tariff elimination results in an immediate gain of US$.32 per box in 2002–2003 expanding to US$.55 per box in 2019–2020.

The impact of tariff elimination on Florida orange producers is shown in Table 9. As is the case with Sao Paulo, the impact of the tariff removal on Florida orange production is not large over the 19-year forecast horizon. At the end of the forecast horizon, Florida orange production under phased elimination is projected to be 272 million boxes, compared with 278 million boxes in the baseline. Under immediate elimination, the impact is greater, with projected production being 251 million boxes in 2019–2020, a decline of nearly 10%. The impact on on-tree prices, however, is greater. Phased elimination of the tariff is projected to reduce on-tree prices in Florida by US$.30 per box in 2014–2015, a decline of 6%. Immediate elimination would cause grower prices in Florida to decline by more than US$1.14 per box early in the forecast period. By the end of the forecast period, grower prices are projected at US$3.91 per box, still well below the $4.51 per box forecasted under phased elimination. These results suggest that if the tariff is removed, Florida growers would fare much better under a phased reduction compared with immediate elimination.

One way to measure the impact of immediate elimination of the tariff on Florida orange producers is to examine its impact on producer revenue. If the tariff were eliminated immediately, producer revenue in Florida would decline by US$291 million in the 2004–2005 season and US$343 million in both the 2009–2010 and 2019–2020 seasons. These declines represent a 25% decline in 2004–2005 and 26% in 2019–2020. Another effect is illustrated in that future orange production is expected to rise modestly with the tariff intact but follows a more cyclical pattern under immediate elimination, with projected production in 2019–2020 nearly equal to that projected for 2002–2003.

One of the by-products of the model's formulation is that separate prices for early- and

Table 8. Projected Orange Production and On-Tree Prices in Sao Paulo, with Phased Reduction of and Immediate Elimination of the U.S. Orange Juice Tariff

	With U.S. Tariff		Phased Reduction		Immediate Elimination	
Season	Production (mil. 90-lb. boxes)	On-Tree Price (US$/box)	Production (mil. 90-lb. boxes)	On-Tree Price (US$/box)	Production (mil. 90-lb. boxes)	On-Tree Price (US$/box)
2002–2003	337.4	1.88	337.4	1.91	337.4	2.20
2003–2004	333.9	1.99	333.9	2.03	333.9	2.31
2004–2005	332.7	2.07	332.7	2.14	332.7	2.39
2005–2006	333.6	2.14	333.6	2.23	333.7	2.46
2006–2007	337.2	2.18	337.6	2.27	337.8	2.49
2007–2008	342.6	2.20	342.7	2.27	343.3	2.52
2008–2009	349.9	2.20	350.0	2.27	351.1	2.53
2009–2010	359.8	2.17	360.1	2.24	361.6	2.52
2010–2011	372.1	2.11	372.6	2.21	374.6	2.50
2011–2012	386.9	2.06	387.5	2.16	390.1	2.46
2012–2013	402.0	2.00	402.8	2.10	405.9	2.42
2013–2014	415.8	1.96	416.8	2.07	420.5	2.40
2014–2015	429.6	1.92	430.8	2.03	435.1	2.39
2015–2016	442.5	1.90	443.9	2.01	448.8	2.38
2016–2017	455.0	1.88	456.7	2.00	462.2	2.39
2017–2018	466.6	1.87	468.5	2.00	474.6	2.40
2018–2019	476.1	1.89	478.3	2.02	485.0	2.43
2019–2020	484.3	1.92	486.7	2.06	494.0	2.48

Table 9. Projected Orange Production and On-Tree Price in Florida, with Phased Reduction of and Immediate Elimination of U.S. Orange Juice Tariff, 2002–2003 through 2019–2020

	With U.S. Tariff		Phased Reduction		Immediate Elimination	
Season	Production (mil. 90-lb. boxes)	On-Tree Price (US$/box)	Production (mil. 90-lb. boxes)	On-Tree Price (US$/box)	Production (mil. 90-lb. boxes)	On-Tree Price (US$/box)
2002–2003	251.2	4.39	251.2	4.35	251.2	3.25
2003–2004	253.2	4.52	253.2	4.38	253.2	3.37
2004–2005	254.7	4.62	254.7	4.39	254.7	3.47
2005–2006	256.0	4.71	256.0	4.39	256.0	3.56
2006–2007	257.7	4.76	257.7	4.44	257.7	3.61
2007–2008	259.9	4.80	259.8	4.54	259.1	3.66
2008–2009	262.1	4.82	262.0	4.59	260.2	3.69
2009–2010	264.6	4.80	264.2	4.54	261.0	3.69
2010–2011	266.4	4.87	265.6	4.54	260.8	3.69
2011–2012	268.1	4.82	266.9	4.50	260.3	3.67
2012–2013	269.8	4.77	268.0	4.45	259.6	3.66
2013–2014	271.4	4.73	269.1	4.43	258.6	3.66
2014–2015	272.8	4.71	269.9	4.41	257.5	3.67
2015–2016	274.1	4.69	270.5	4.40	256.3	3.70
2016–2017	275.2	4.68	271.0	4.40	255.0	3.73
2017–2018	276.3	4.69	271.4	4.42	253.6	3.77
2018–2019	277.3	4.72	271.8	4.46	252.4	3.83
2019–2020	278.3	4.76	272.1	4.51	251.2	3.91

Table 10. Orange Juice Consumption and Price in the United States, with Phased Reduction of and Immediate Elimination of the U.S. Orange Juice Tariff, 2002–2003 through 2019–2020

	Consumption (million SSE gallons)			With Tariff		Prices Phased Reduction		Immediate Elimination	
Season	With Tariff	Phased Reduction	Immediate Elimination	NFC[a]	FCOJ[a]	NFC[a]	FCOJ[a]	NFC[a]	FCOJ[a]
2002–2003	1,597.2	1,605.6	1,714.2	1.55	1.08	1.53	1.06	1.34	0.86
2003–2004	1,607.0	1,623.7	1,725.3	1.57	1.09	1.54	1.06	1.35	0.88
2004–2005	1,615.3	1,640.4	1,736.5	1.58	1.11	1.54	1.06	1.37	0.89
2005–2006	1,625.1	1,659.9	1,749.0	1.59	1.12	1.53	1.06	1.38	0.91
2006–2007	1,639.0	1,673.8	1,765.7	1.60	1.13	1.54	1.07	1.39	0.91
2007–2008	1,654.3	1,683.6	1,782.4	1.61	1.13	1.55	1.08	1.39	0.92
2008–2009	1,671.0	1,698.9	1,800.5	1.61	1.13	1.56	1.09	1.39	0.92
2009–2010	1,689.1	1,717.0	1,818.6	1.60	1.13	1.56	1.09	1.39	0.92
2010–2011	1,700.3	1,736.5	1,838.1	1.59	1.14	1.55	1.08	1.38	0.91
2011–2012	1,721.2	1,757.4	1,860.4	1.58	1.13	1.54	1.07	1.38	0.90
2012–2013	1,743.4	1,779.6	1,881.3	1.58	1.12	1.53	1.06	1.37	0.90
2013–2014	1,762.9	1,799.1	1,902.2	1.57	1.11	1.52	1.05	1.37	0.89
2014–2015	1,782.4	1,820.0	1,921.7	1.57	1.11	1.52	1.05	1.37	0.89
2015–2016	1,801.9	1,839.5	1,941.2	1.57	1.10	1.51	1.04	1.37	0.89
2016–2017	1,820.0	1,857.6	1,959.3	1.57	1.10	1.51	1.04	1.37	0.89
2017–2018	1,838.1	1,874.3	1,977.4	1.57	1.10	1.51	1.04	1.37	0.90
2018–2019	1,853.4	1,891.0	1,992.7	1.57	1.10	1.52	1.05	1.38	0.90
2019–2020	1,867.4	1,905.0	2,008.0	1.58	1.11	1.52	1.05	1.38	0.91

[a] U.S.$ per SSE gallon, processor price.

late-maturing oranges in Florida are estimated. Hamlin is the main early-maturing orange variety found in Florida. Although Hamlins produce a high yield per unit of land area, the juice from Hamlins is generally not of good color. Historically, Florida based processors have needed to import juice of better color for blending purposes. Valencia is a late-maturing variety found in Florida, Sao Paulo, and Mexico. Valencias generally produce fewer boxes per unit of land area, but the juice from Valencia oranges is of better color. In the baseline run of the model, a substantial premium is estimated for Valencia oranges compared with early-maturing oranges in Florida. In the 2009–2010 season, this premium is estimated to be nearly US$.30 per pound solid. When the tariff is eliminated, however, this premium is reduced to US$.12 per pound solid. This result occurs because under tariff elimination, juice from Sao Paulo, which is assumed to be Valencia, is now less expensive to import into the United States.

The impact of tariff removal on orange juice consumption and prices in the United States is shown in Table 10. Under immediate tariff elimination, U.S. orange juice consumption is projected to increase by 117 million SSE gallons in 2002–2003 (equivalent to ~84,000 MT at 65° Brix). Almost all of the consumption increase would be FCOJ. By 2015–2016, the projected increase in U.S. consumption is 139 million SSE gallons, or 8%. To support higher consumption, FCOJ processor prices in the United States would decline by approximately US$.22 per SSE gallon (~$300 MT at 65° Brix) in the 2002–2003 season, or 20%. NFC prices in the United States would also decline, although the percentage decline is smaller than that projected for FCOJ. NFC prices changes are due to the cross-price effect between NFC and FCOJ and that the model chooses to increase NFC production in Florida.

The impact of phased reduction and immediate elimination of the U.S. orange juice

Table 11. Orange Juice Consumption and Price in Canada, with Phased Reduction of and Immediate Elimination of the U.S. Orange Juice Tariff, 2002–2003 through 2019–2020

	Consumption (million SSE gallons)			Prices (U.S.$ per SSE gallon)		
Season	With Tariff	Phased Reduction	Immediate Elimination	With Tariff	Phased Reduction	Immediate Elimination
2002–2003	130.9	130.9	132.3	0.84	0.85	0.90
2003–2004	130.9	130.9	132.3	0.86	0.87	0.92
2004–2005	130.9	130.9	132.3	0.88	0.89	0.94
2005–2006	130.9	130.9	132.3	0.89	0.91	0.95
2006–2007	130.9	130.9	132.3	0.90	0.91	0.95
2007–2008	132.3	132.3	132.3	0.90	0.91	0.96
2008–2009	132.3	133.7	133.7	0.90	0.91	0.96
2009–2010	132.3	133.7	135.1	0.90	0.91	0.96
2010–2011	133.7	135.1	135.1	0.88	0.90	0.96
2011–2012	135.1	136.5	136.5	0.87	0.89	0.95
2012–2013	136.5	137.9	137.9	0.86	0.88	0.94
2013–2014	137.9	137.9	137.9	0.86	0.88	0.94
2014–2015	139.3	139.3	139.3	0.85	0.87	0.93
2015–2016	140.6	140.6	140.6	0.85	0.87	0.93
2016–2017	140.6	140.6	140.6	0.84	0.87	0.93
2017–2018	142.0	142.0	142.0	0.84	0.87	0.94
2018–2019	143.4	142.0	142.0	0.84	0.87	0.94
2019–2020	143.4	143.4	143.4	0.85	0.88	0.95

tariff on orange juice prices and consumption in Canada is shown in Table 11. Immediate elimination would cause virtually no change in orange juice consumption and a small increase in price. Phased reduction would also result in virtually no change in orange juice consumption over the forecast horizon.

Elimination of the U.S. orange juice tariff on Brazilian imports would cause prices in the EU to increase and consumption to decrease. This result occurs because the U.S. market has become more attractive to Brazilian exporters vis à vis the EU market. The impact of phased reduction and immediate elimination of the U.S. tariff on orange juice prices and consumption in the EU is shown in Table 12. Under immediate U.S. tariff elimination, the impact in the EU would be modest, with EU consumption projected to decline ~107 million SSE gallons (76,000 MT at 65° Brix) in 2002–2003, a decline of nearly 9%. By the 2019–2020 season, projected consumption in the EU is expected to decrease by nearly 241 million SSE gallons. Prices are projected to increase by US$.06 per SSE gallon in 2002–2003 and by US$.12 per SSE gallon in 2019–2020, the latter figure representing a price increase of nearly 13% (Table 12). Phased elimination of the U.S tariff has a smaller impact on EU orange juice consumption and prices, although consumption declines by 58.5 million SSE gallons, and prices are projected to increase by US$.03 per SSE gallon in 2019–2020.

The impact of FTAA on orange juice consumption and prices in Japan is shown in Table 13. In percentage terms, the impact on Japan is comparable to that in the EU. Under immediate U.S. tariff elimination, Japanese consumption declines by 8%–12%, with comparable increases in prices.

The impact of U.S. tariff reductions on world trade in orange juice is shown in Tables 14–19. In Table 14, projected exports under the present tariff regime by country of destination from Sao Paulo are shown. Although the figures underestimate recent levels of exports to the United States, they do confirm that

Table 12. Orange Juice Consumption and Price in the European Union, with Phased Reduction of and Immediate Elimination of the U.S. Orange Juice Tariff, 2002–2003 through 2019–2020

	Consumption (million SSE gallons)			Prices (U.S.$ per SSE gallon)		
Season	With Tariff	Phased Reduction	Immediate Elimination	With Tariff	Phased Reduction	Immediate Elimination
2002–2003	1,229.6	1,221.2	1,122.4	0.94	0.94	1.00
2003–2004	1,218.5	1,203.1	1,108.4	0.96	0.97	1.02
2004–2005	1,214.3	1,190.6	1,101.5	0.98	0.99	1.04
2005–2006	1,215.7	1,183.6	1,101.5	0.99	1.01	1.06
2006–2007	1,226.8	1,194.8	1,111.2	1.00	1.02	1.06
2007–2008	1,243.5	1,215.7	1,123.8	1.00	1.02	1.07
2008–2009	1,268.6	1,242.1	1,143.3	1.00	1.02	1.07
2009–2010	1,303.4	1,276.9	1,171.1	1.00	1.01	1.07
2010–2011	1,350.7	1,314.5	1,201.7	0.98	1.00	1.06
2011–2012	1,396.7	1,359.5	1,237.9	0.97	0.99	1.06
2012–2013	1,444.0	1,403.7	1,275.5	0.96	0.98	1.05
2013–2014	1,487.2	1,444.0	1,307.6	0.95	0.97	1.04
2014–2015	1,529.0	1,484.4	1,338.2	0.94	0.97	1.04
2015–2016	1,568.0	1,520.6	1,367.5	0.94	0.96	1.04
2016–2017	1,605.6	1,554.0	1,393.9	0.94	0.96	1.04
2017–2018	1,639.0	1,586.1	1,417.6	0.93	0.96	1.04
2018–2019	1,666.8	1,609.7	1,434.3	0.94	0.97	1.05
2019–2020	1,689.1	1,630.6	1,448.2	0.94	0.97	1.06

Table 13. Orange Juice Consumption and Price in Japan, with Phased Reduction of and Immediate Elimination of the U.S. Orange Juice Tariff, 2002–2003 through 2019–2020

	Consumption (million SSE gallons)			Prices (U.S.$ per SSE gallon)		
Season	With Tariff	Phased Reduction	Immediate Elimination	With Tariff	Phased Reduction	Immediate Elimination
2002–2003	126.7	126.7	117.0	1.14	1.14	1.21
2003–2004	126.7	125.3	117.0	1.16	1.17	1.23
2004–2005	128.1	125.3	117.0	1.18	1.19	1.25
2005–2006	129.5	125.3	118.4	1.19	1.22	1.27
2006–2007	130.9	128.1	121.1	1.20	1.22	1.27
2007–2008	133.7	130.9	122.5	1.21	1.23	1.28
2008–2009	136.5	135.1	125.3	1.21	1.22	1.28
2009–2010	140.6	139.3	129.5	1.20	1.22	1.28
2010–2011	146.2	143.4	132.3	1.19	1.21	1.27
2011–2012	151.8	149.0	137.9	1.17	1.20	1.27
2012–2013	157.4	153.2	142.0	1.16	1.19	1.26
2013–2014	162.9	158.7	146.2	1.15	1.18	1.25
2014–2015	167.1	162.9	150.4	1.14	1.17	1.25
2015–2016	172.7	168.5	154.6	1.14	1.17	1.25
2016–2017	176.8	172.7	157.4	1.13	1.16	1.25
2017–2018	182.4	176.8	161.5	1.13	1.16	1.25
2018–2019	186.6	181.0	164.3	1.14	1.17	1.26
2019–2020	189.4	183.8	167.1	1.15	1.18	1.27

Table 14. Projected Exports of FCOJ from Sao Paulo, Brazil by Destination under Existing Tariff Schedule, 2002–2003 through 2019–2020

	Destination (million SSE gallons)			
Season	United States	Canada	European Union	Japan
2002–2003	10	89	1,230	127
2003–2004	6	89	1,218	127
2004–2005	6	89	1,214	128
2005–2006	8	88	1,216	130
2006–2007	11	88	1,227	131
2007–2008	13	88	1,244	134
2008–2009	17	88	1,269	136
2009–2010	19	88	1,303	141
2010–2011	19	89	1,351	146
2011–2012	32	89	1,397	152
2012–2013	43	89	1,444	157
2013–2014	54	91	1,487	163
2014–2015	65	91	1,529	167
2015–2016	78	91	1,568	173
2016–2017	89	91	1,606	177
2017–2018	102	91	1,639	182
2018–2019	111	91	1,667	187
2019–2020	120	91	1,689	189

Table 15. Projected Export of FCOJ from Sao Paulo under Phased Elimination of the U.S. Tariff, by Destination, 2002–2003 through 2019–2020

	Destination (million SSE gallons)			
Season	United States	Canada	European Union	Japan
2002–2003	19	89	1,221	127
2003–2004	25	89	1,203	125
2004–2005	32	89	1,191	125
2005–2006	45	88	1,184	125
2006–2007	47	88	1,195	128
2007–2008	45	88	1,216	131
2008–2009	47	88	1,242	135
2009–2010	52	88	1,277	139
2010–2011	64	89	1,315	143
2011–2012	78	89	1,359	149
2012–2013	93	89	1,404	153
2013–2014	107	91	1,444	159
2014–2015	123	91	1,484	163
2015–2016	139	91	1,521	168
2016–2017	155	91	1,554	173
2017–2018	171	91	1,586	177
2018–2019	185	91	1,610	181
2019–2020	198	91	1,631	184

the EU has become the most important market for Brazilian orange juice.[11] In Table 15, projected exports from Sao Paulo under phased elimination of the U.S. tariff are shown, whereas Table 16 presents results for Sao Paulo if the tariff were eliminated immediately in the 2001–2002 season.

The clear conclusion drawn from the figures presented in Tables 14–16 is that U.S. imports of FCOJ from Brazil would increase substantially if the U.S. orange juice tariff were eliminated. Under immediate elimination, U.S. imports would increase by 124 million SSE gallons (89,000 MT at 65° Brix) in the 2002–2003 season. Under phased elimination, there is a gradual increase in U.S. FCOJ imports, which reach 198 million SSE gallons in the 2019–2020 season, compared with 120 million SSE gallons in the baseline model.

Increased imports by the United States would come at the expense of exports to the EU and Japan. Canada would be only marginally affected. Because both the EU and Japan are assumed to maintain their FCOJ tariff in the scenario presented herein, it is not surprising that consumption in these two regions would be adversely affected by phased reduction or immediate elimination of the U.S. tariff.

The figures presented in Table 16 also help explain why the supply response in Sao Paulo is relatively small if the U.S. orange juice tariff is removed. Under immediate tariff elimination, the United States is projected to account for <10% of Sao Paulo's market. Therefore, the price impact on Brazilian growers and processors is diluted by the fact that the majority of its exports will still be sent to other markets.

[11] For example, U.S. imports of Brazilian orange juice were nearly 200 million SSE gallons in 2000–2001 season, and the model indicates that ~74 million SSE gallons were exported in 2001–2002. It is difficult to completely validate a model of this type and trade flows are particularly difficult to track.

Table 16. Projected exports of FCOJ from Sao Paulo under Immediate Elimination of the U.S. Tariff, by Destination, 2002–2003 through 2019–2020

Season	Destination (million SSE gallons)			
	United States	Canada	European Union	Japan
2002–2003	134	84	1,122	117
2003–2004	132	82	1,108	117
2004–2005	134	82	1,101	117
2005–2006	139	82	1,101	118
2006–2007	145	81	1,111	121
2007–2008	153	81	1,124	123
2008–2009	166	81	1,143	125
2009–2010	180	81	1,171	130
2010–2011	201	81	1,202	132
2011–2012	227	81	1,238	138
2012–2013	253	82	1,276	142
2013–2014	280	82	1,308	146
2014–2015	306	82	1,338	150
2015–2016	334	82	1,367	155
2016–2017	362	82	1,394	157
2017–2018	389	81	1,418	162
2018–2019	414	81	1,434	164
2019–2020	436	81	1,448	167

Table 17. Projected Utilization of U.S. Orange Juice Production under Existing U.S. Tariff, by Product Form and Destination, 2002–2003 through 2019–2020

Season	United States (million SSE gallons)		Canada
	FCOJ	NFC	NFC
2002–2003	1,032	529	19
2003–2004	1,036	533	23
2004–2005	1,040	536	26
2005–2006	1,042	540	29
2006–2007	1,043	547	33
2007–2008	1,044	554	36
2008–2009	1,046	564	40
2009–2010	1,050	572	44
2010–2011	1,054	575	46
2011–2012	1,054	586	47
2012–2013	1,053	596	48
2013–2014	1,053	606	48
2014–2015	1,051	616	49
2015–2016	1,050	624	50
2016–2017	1,047	633	51
2017–2018	1,046	641	51
2018–2019	1,044	647	52
2019–2020	1,046	652	53

Another factor that limits supply response in Sao Paulo is that the industry is already undergoing a major recovery from the trees lost to CVC. There are physical limits on how quickly orange groves can be developed. The main lesson learned in Sao Paulo from its last major expansion is that the use of noncertified planting material can lead to serious disease problems.

Utilization of orange juice production in the United States under the three scenarios is shown in Tables 17–19.[12] Under the current tariff regime, United States consumption of NFC is expected to grow modestly from current levels, reaching nearly 652 million SSE gallons by the 2019–2020 season.[13] U.S. consumption of FCOJ (including reconstituted chilled orange juice and retail pack FCOJ) is expected to grow modestly, with Florida production of FCOJ reaching 1,046 million SSE gallons (751,000 MT at 65°) Brix by 2019–2020. The model suggests that all of the FCOJ supplied to Canada will come from Brazil. Currently, a large proportion of FCOJ consumption in Canada originates from Florida.[14]

Under phased tariff elimination (Table 18), production of FCOJ by U.S. producers declines, whereas NFC production increases compared to the with tariff scenario. This result is consistent with the notion that Florida has a comparative advantage in the supply of NFC to the North American market and, with declining tariff protection, it would choose to

[12] The figures presented in Tables 17–19 include orange juice production from California, Arizona, and Texas.

[13] Some would argue that this forecast is conservative. In the model, growth of NFC consumption is expected to moderate from the high levels that occurred over the past decade.

[14] Given the duty drawback option available to Florida processors, it is possible that the model accurately reflects the present situation in Canada even though the model does not choose to "pass through" Brazilian concentrate, which is ultimately destined for Canada.

Table 18. Projected Utilization of U.S. Orange Juice Production under Phased Elimination of the U.S. Tariff, by Product Form and Destination, 2002–2003 through 2019–2020

Season	United States (million SSE gallons)		Canada
	FCOJ	NFC	NFC
2002–2003	1,001	536	42
2003–2004	1,003	547	43
2004–2005	1,003	556	44
2005–2006	1,000	566	45
2006–2007	1,003	573	45
2007–2008	1,011	578	46
2008–2009	1,017	586	47
2009–2010	1,021	594	47
2010–2011	1,019	604	48
2011–2012	1,015	615	49
2012–2013	1,011	626	50
2013–2014	1,007	636	51
2014–2015	1,001	646	51
2015–2016	996	655	52
2016–2017	989	664	53
2017–2018	983	672	54
2018–2019	978	678	55
2019–2020	973	684	55

Table 19. Projected Utilization of U.S. Orange Juice Production under Immediate Elimination of the U.S. Tariff, by Product Form and Destination, 2002–2003 through 2019–2020

Season	United States (million SSE gallons)		Canada
	FCOJ	NFC	NFC
2002–2003	915	616	49
2003–2004	920	623	49
2004–2005	925	629	50
2005–2006	925	635	50
2006–2007	926	645	51
2007–2008	925	655	52
2008–2009	919	666	52
2009–2010	913	676	53
2010–2011	902	686	54
2011–2012	886	697	55
2012–2013	869	709	56
2013–2014	852	720	57
2014–2015	834	730	58
2015–2016	816	740	59
2016–2017	798	750	60
2017–2018	780	759	60
2018–2019	763	767	61
2019–2020	748	774	62

allocate an ever-increasing share of its production to NFC.

In Table 19, utilization of U.S. orange juice under immediate tariff elimination is shown. The trend discerned from these figures is similar to that observed in Table 18 except that the impact occurs much sooner. Utilization of U.S. orange production in the U.S. FCOJ market decreases and increased utilization occurs in NFC produced for both the U.S. and Canadian market for all years of the forecast horizon.

Although not explicitly included in the quantitative model of the world orange juice market, phased reduction or complete elimination of the U.S. orange juice tariff would have adverse effects on those countries that currently have preferential access to the U.S. orange juice market. These countries include Belize, Costa Rica, Honduras, and Mexico. Given that all of these countries currently export most of their orange juice production to the United States, reduced tariffs for Brazilian exporters would result in lower prices received for exports from third countries, along with a possible loss of market share. These countries might choose to send more of their production to the EU. Given Mexico's proximity to the United States, orange juice processors in that country could possibly insulate themselves from competition from Brazil by focusing on NFC production.

Concluding Remarks

World orange juice consumption and trade has shown remarkable growth over the past two decades. After major freezes destroyed many orange trees in Florida in the 1980s, the high prices that followed have spurred a major expansion in orange production in both Florida and Sao Paulo, Brazil. These two regions continue to dominate the world market for orange juice, collectively accounting for ~85% of world production.

Using a mathematical model of the world orange juice market, production and price projections are made through the 2019–2020 season under varying assumptions regarding the U.S. orange juice tariff. The model explicitly accounts for the dynamic nature of orange production through its linkage of a supply model that is based on the existing tree inventory. The model is long run, however, as inventory adjustments are not incorporated.

These projections indicate that, in the near term, world orange juice production will decline somewhat as Brazil recovers from the effects of CVC, a viral disease that has killed millions of young trees. Production should recover by 2010 and continue to expand to 2020, with Brazilian orange juice output projected to exceed 2 billion SSE gallons. Orange juice production in Florida is expected to remain relatively flat at ~1.6 billion SSE gallons. It is anticipated that other citrus-producing regions will not significantly expand their production of orange juice over the next 20 years. The possible exception to this observation is Mexico, which will gain tariff free access to the United States in 2008.

The main impact of FTAA would be duty-free access for Brazil to the United States. In recent years, Brazil's orange juice exports to the United States have stabilized at ~240 million SSE gallons. Because nearly all of Brazil's exports are FCOJ, the potential impact of elimination of the U.S. tariff has been muted somewhat with the increase in NFC consumption in the United States.

The quantitative effects of complete elimination of the U.S. orange juice tariff on Brazilian imports suggest that the benefit to Brazilian orange producers would not be large. Production would increase slightly, and on-tree prices would also increase. The impact on Florida producers is somewhat larger. Production in Florida would contract, and on-tree prices would likely decline substantially. Immediate elimination of the tariff is projected to result in a decrease of US$.22 per SSE gallon in the U.S. price of FCOJ and a US$.21 decrease in NFC prices. Expanded consumption in the United States would come at the expense of reduced consumption in the EU and Japan. Florida producers would fare somewhat better if the tariff is phased out over a 15-year period, although Florida production and prices would still decline.

There are several issues that could affect the empirical results presented in the present article. This most important is the response of growers in both Sao Paulo and Florida to a new price regime under tariff elimination. If tariff elimination itself serves to cause Florida growers to substantially lower their expectation of future orange prices, then the negative impact on Florida production presented herein is underestimated. The analysis has excluded the response of other processed orange regions especially Mexico and Central America. If those regions are unable to compete with Brazil in the U.S. market without the preferential access they currently have, then the price impact on Florida is likely overestimated. These questions remain for future research.

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