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Location of Vertically Linked Industries under Free Trade: Case Studies of Orange Juice and Tomato Paste in the Western Hemisphere

by

Darcy Hartman, Ian Sheldon, and Luther Tweeten*

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*Darcy Hartman is a former Research Associate, Ian Sheldon is a Professor and Luther Tweeten is an Anderson Professor, all in the Department of Agricultural, Environmental, and Development Economics at the Ohio State University in Columbus, Ohio.

Correspondence regarding this paper should be addressed to:

Luther Tweeten
Department of Agricultural, Environmental, and Development Economics
The Ohio State University
2120 Fyffe Road
Columbus, OH 43210-1067

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Abstract

The objective of this study was to determine the economic impact on the United States of removing tariff barriers on imports of concentrated orange juice and tomato paste from South America. The study highlighted an agglomeration model of industry location recognizing imperfect competition and increasing returns. The results were contrasted with those from a competitive model with conventional estimates of supply and demand elasticities. Because the assumptions of the models differed, the results also differed. The agglomeration model indicated that the United States would gain market share of production and processing with the removal of tariffs. In contrast, the competitive model indicated that the United States would lose market share in production and processing. According to the competitive model, US consumers would gain, producers would lose, and the government would lose from less tariff revenue, but the gains to consumers would offset losses elsewhere so that national income would rise. In South America, consumers would lose, producers would gain, and national incomes would rise. In the long run, countries would individually and collectively gain from freer trade in fruits and vegetables. Both models indicated that American production and processing of oranges and tomatoes would not be displaced by removing barriers to international trade.

Keywords: oranges, tomatoes, juice, paste, model, agglomeration, competitive, comparative advantage.

*Respectively, former Research Associate, Professor, and Anderson Professor, Department of Agricultural, Environmental, and Development Economics, The Ohio State University, Columbus. The Economic Research Service of the US Department of Agriculture, Ohio Agricultural Research and Development Center, and the Anderson Chair provided financial support for this analysis. The authors are solely responsible for content, including any errors or omissions.

BACKGROUND

In June 1990, President Bush announced the Enterprise for the Americas Initiative (EAI) which envisions the economic integration of the Western Hemisphere into a Free Trade Agreement of the Americas (FTAA). A 1994 summit meeting of the Americas in Miami called for FTAA by the year 2005. Progress has been delayed for numerous reasons including failure to grant the President fast-track authority.

Although FTAA may be a long way off, preparations for negotiations warrant examining the implications of freer regional trade. The Economic Research Service (ERS) of the USDA along with the Anderson Chair and the Ohio Agricultural Research and Development Center of The Ohio State University have supported this initiative to analyze the economic impact of freer trade in the fruit and vegetable fresh and processing sectors.

The US fruit and vegetable industry is sizable. The value of production for fresh market and processing vegetables in 1995 was $14.8 billion (ERS, November 1996); in 1993, the value of fruit and nut production was $9.84 billion (ERS, September 1994).

US producers face major competition from the countries in the southern half of this hemisphere. While a large portion of production in Latin America occurs during the off-season of US production, overlap of seasons is extensive, particularly given improvements in harvesting and storage techniques. Additionally, a large portion of fruit and vegetable production ends up being traded as processed goods for which seasonality is less important. Given expectations that developing countries have lower costs, US industries might be adversely affected by freer trade.

OBJECTIVES

The general objective of this study is to determine the effect of freer trade on fruit and vegetable production and processing location in the Western Hemisphere. Specifically, the objectives of this study are as follows:

(1) To examine the differences among locations in costs of production and processing for tomato paste and orange juice, and use these cost comparisons for insights into where production would occur under free trade;
(2) To adapt an agglomeration model of industry location for empirical analysis of expected outcomes in the orange juice concentrate and tomato paste industries;
(3) To utilize this model to determine future locations of these processing industries;
(4) To compare the outcomes from an agglomeration model of location highlighted in this study with the outcomes from simple cost comparisons and a competitive model of trade;

This study emphasizes relatively new theory focusing on agglomeration economies, imperfect competition, and increasing returns to size. An agglomeration model is supplemented by crop budgets and a competitive model, which offer the reader a considerably different set of assumptions, analyses, and projections regarding the future of the US fruit and vegetable industry with expanded free trade in the Western Hemisphere.

Agglomeration theory, predominantly advanced by Krugman and Venables(1993) and Fujita, Krugman, and Venables (1999) has strong theoretical ties to previous work in trade theory. Little empirical analysis exists in the literature, and no previous empirical applications of the model used for this study have been found in literature searches. We present conceptual models before presenting empirical results of location advantage in orange juice concentrate and tomato paste for the US versus Argentina, Brazil, and Chile.

CONCEPTUAL FRAMEWORK

Two models to predict the production-processing of orange juice concentrate and tomato paste are presented. One is a competitive model and the other is an agglomeration model.

Competitive Model

Comparative advantage played a role in the initial development of the locations being studied. Before delving into location theory, it is useful to review the effects of trade barriers under neoclassical assumptions of competitive trade with a tariff by the US on imports from South America (SA) as portrayed in Figure 1.

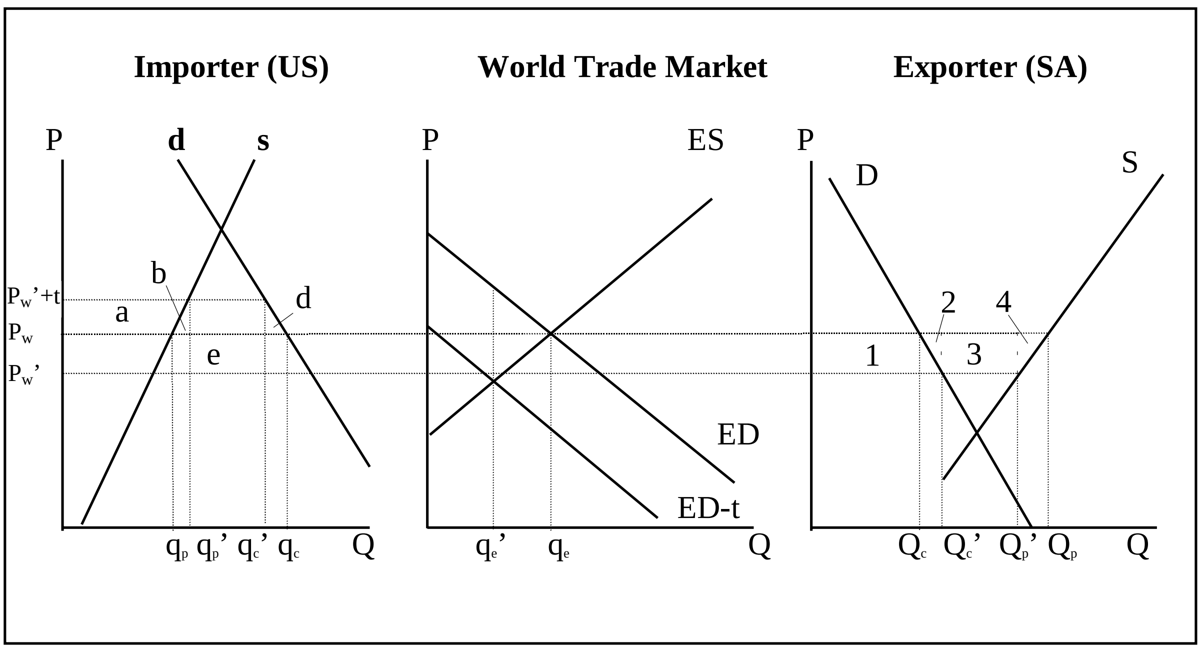

Figure 1: Effects of an import tariff under neoclassical assumptions (Tweeten, 1992, p.80).

If the importer imposes a specific tariff t on the good, excess demand drops from ED to ED-t, world price from P_w to P_w', and imports from q_e to q_e'. The importer produces more (q_p' rather than q_p) and consumes less (q_c' rather than q_c). The exporter produces less (Q_p' rather than $Q_{p)}$ and consumes more (Q_c' rather than Q_c) than it would under a free trade scenario. The tariff results in a gain to producers in the importing country at the expense of its own consumers and the exporter's producers. Removal of the tariff would increase production and price for the exporter. The price in the importing country would be lower and consumers in the importing country would be better off. The magnitude of gains and losses and of price and quantity impacts for tomato paste and orange juice depends on supply and demand parameters and tariffs as well as on initial prices and quantities.

Economic impacts in Figure 1 are summarized as follows from terminating the tariff on imports.

Gain to:

	Importer (US)	Exporter (South America)
Consumer	a+b+c+d	-1
Producers	-a	1+2+3+4
Taxpayers	-c-e	--
National Income	b+d-e	2+3+4
Combined Country Income (e=3)	b+d+2+4	

US consumers gain while producers and taxpayers lose from an end to the tariff. South American producers gain and consumers lose. Net benefits to South America are positive and to the US are positive if area b+d is greater than area e. The combined country benefits are positive.

Agglomeration Model

As alternatives to the competitive model in Figure 1, economists have proposed agglomeration location models recognizing imperfect competition among firms and internal and external economies of size. Krugman (1995) describes several approaches to the explanation of agglomeration. In discussing central place theory, which examines the location of manufacturing centers given an evenly distributed agricultural population, he states, "(t)he idea is simple enough: each firm faces a trade-off between economies of scale, which push toward a limited number of production sites, and transport costs, which can be reduced by multiplying the number of sites.

To represent imperfect competition and increasing returns to size, we utilize a model by Venables (1993;1996) providing demand and cost linkages, along with selected intermediate linkages. Venables details a general equilibrium version of the agglomeration model, but the version presented here is only a partial equilibrium. This version seems appropriate given that the industries are small relative to factor markets and total income, hence wages and relative demand for the consumption good can be treated as exogenous.

The industry model is characterized by the Dixit-Stiglitz (1978) form of monopolistic competition. Firms are assumed to produce differentiated goods with increasing returns to size, suggesting that, depending on the average cost curve, the most efficient number of firms might be one – a monopoly. Consumers, however, desire a wide variety of differentiated goods; this will serve to limit firm size thereby maintaining enough firms so as to remain competitive, at least monopolistically. To model agglomeration economies, increasing returns are a necessary condition. This eliminates perfect competition for modeling purposes. The easiest way to model increasing returns while maintaining a competitive environment is with monopolistic competition, utilizing a technology of fixed costs and constant marginal costs.

Two vertically linked industries exist in this model along with two locations where both industries may locate; regardless of where an individual firm is located, it may provide the good for either location. Subscripts in the following equations refer to location, i.e., 1 or 2;

superscripts refer to industry, i.e., a or b. A constant elasticity of substitution utility function is used to aggregate over varieties. If e refers to expenditure and p to price, demand for a particular variety is:

$$x_{ii}^k = (p_i^k)^{-\varepsilon^k} (P_i^k)^{\varepsilon^k - 1} e_i^k ,$$
$$x_{ij}^k = (p_i^k t^k)^{-\varepsilon^k} (P_j^k)^{\varepsilon^k - 1} e_j^k \qquad (1)$$
$$i \neq j \qquad \varepsilon^k > 1 \qquad t^k \geq 1$$

where the first subscript on x indicates where the good was produced and the second subscript indicates where it is sold and consumed.

The elasticity of demand for a particular product is represented by ε ; all goods are required to be normal. While theoretically demand elasticities are negative, it is common to refer to the absolute value of the elasticity. The elasticity of demand must be larger than one "in order to make sense of monopolistic competition (if the elasticity of demand with respect to price is smaller than one, marginal revenue is negative)" (Helpman and Krugman, 1993, p.117). As is customary with such models, t is used to represent "iceberg" transport costs, which rise proportional to distance.

The P's are price indices for each location. Using n to indicate the number of firms, the price indices are defined as:

$$(P_1^k)^{1-\varepsilon^k} = (p_1^k)^{1-\varepsilon^k} n_1^k + (p_2^k t^k)^{1-\varepsilon^k} n_2^k ,$$
$$(P_2^k)^{1-\varepsilon^k} = (p_1^k t^k)^{1-\varepsilon^k} n_1^k + (p_2^k)^{1-\varepsilon^k} n_2^k . \qquad (2)$$

With positive trade costs, the relocation of a firm results in a decrease in the price index for the location to which that firm has moved due to a savings from the elimination of t for that firm's good.

Profits, represented by π, are as follows:

$$\pi_i^k = (p_i^k - c_i^k)(x_{ii}^k + x_{ij}^k) - c_i^k f^k \qquad (3)$$

with marginal costs represented by c and fixed costs represented by the last term. This equation is merely revenue less marginal and fixed costs. Note the appearance of increasing returns. Assuming a profit of zero and price equal to average cost, standard assumptions for monopolistic competition, maximizing π with respect to price and marginal cost results in:

$$c_i^k = p_i^k (1 - \frac{1}{\varepsilon^k}) . \qquad (4)$$

The following is also derived from profit maximization:

$$x_{ii}^k + x_{ij}^k = f^k (\varepsilon^k - 1) = \phi^k . \qquad (5)$$

Equations (4) and (5) are equivalent statements. Solving each one out for ε^k, the following equation is obtained:

$$\frac{c_i^k}{p_i^k - c_i^k} = \frac{x_{ii}^k + x_{ij}^k}{f^k}. \qquad (6)$$

The term f^k is calculated as the per unit fixed cost multiplied by production and divided by marginal cost, so that both sides of equation (6) result in the marginal portion of the price divided by the fixed portion of the price with price equal to average cost. The demand elasticity is determined by price and ability to substitute. This ability, of course, depends upon the number of varieties from which to choose, which gets us back to increasing returns. Using fixed and variable costs to calculate the demand elasticities for a particular variety of a good is equivalent to using prices and substitutability, as demonstrated in equation (6).

As explained in Helpman and Krugman (1993), the demand elasticity for a CES subutility function is actually considered to be the same as its elasticity of substitution. The subutility function has the form:

$$u_i(D_{i1}, D_{i2}, \ldots) \equiv \left(\sum_{\omega} D_{i\omega}^{\beta_i}\right)^{1/\beta_i}, \beta_i = \left(1 - \frac{1}{\sigma_i}\right), \sigma_i > 1$$

with σ_i representing the elasticity of substitution. Of course, this elasticity must be greater than one; otherwise, marginal revenue is negative. The demand function for a particular variety is:

$$D_{i\omega} = \frac{p_{i\omega}^{-\sigma_i}}{\sum_{\omega' \in \Omega_i} p_{i\omega'}^{1-\sigma_i}} E_i, \omega \in \Omega_i,$$

where $p_{i\omega}$ is the price of variety ω and Ω_i is the set of available varieties. This results in the following demand elasticity:

$$\sigma_i + \frac{p_{i\omega}^{1-\sigma_i}}{\sum_{\omega' \in \Omega_i} p_{i\omega'}^{1-\sigma_i}} (1 - \sigma_i).$$

With sufficient variety, the second term can be ignored so that the demand elasticity is essentially equivalent to the elasticity of substitution with this particular utility function.

For algebraic simplicity, demand in Venables' model for a single variety at its home location per unit of expenditure is represented by $1/z_i^k$ where $z_i^k \equiv (p_i^k)^{\varepsilon^k} (P_i^k)^{1-\varepsilon^k}$. Relative costs and prices of two firms in the same location are represented by ρ^k which is defined as $\rho^k \equiv c_2^k / c_1^k \equiv p_2^k / p_1^k$. The break-even production level for a firm can be expressed as ϕ^k where:

$$\frac{e_1^k}{z_1^k} + \frac{e_2^k}{z_2^k}\left(\frac{t^k}{\rho^k}\right)^{-\varepsilon^k} = \phi^k,$$
$$\frac{e_1^k}{z_1^k}(t^k \rho^k)^{-\varepsilon^k} + \frac{e_2^k}{z_2^k} = \phi^k. \qquad (7)$$

As one last step in the simplification process, we define relative expenditure to be $\sigma \equiv e_2 / e_1$.

Now to consider the case of vertically linked industries, let *a* represent the upstream industry that supplies *b*, the downstream industry that supplies consumption goods. The demand for industry *a* is assumed to come solely through the downstream industry, i.e., consumers do not directly consume the goods of industry *a*. The linkages of these two industries must now be clarified.

Assuming relative prices for the downstream industry are endogenous to the system, the division of industry *b* between locations 1 and 2 can be expressed as a function of relative expenditure at both locations, transport costs, and relative production costs:

$$\frac{n_2^b p_2^b}{n_1^b p_1^b} = \frac{\sigma^b (t^b)^{\varepsilon^b} + (t^b)^{1-\varepsilon^b} - (\rho^b)^{\varepsilon^b} (\sigma^b + t^b)}{(t^b)^{\varepsilon^b} + \sigma^b (t^b)^{1-\varepsilon^b} - (\rho^b)^{-\varepsilon^b} (1 + \sigma^b t^b)}. \qquad (8)$$

Note again that the firm ratio is dependent not just upon relative production costs and transport costs, but also upon relative expenditure. If relative expenditure is eliminated from the equation by setting $\sigma^b = 1$, the following equation is obtained:

$$\frac{n_2^b p_2^b}{n_1^b p_1^b} = \frac{(t^b)^{\varepsilon^b} + (t^b)^{1-\varepsilon^b} - (\rho^b)^{\varepsilon^b} (1 + t^b)}{(t^b)^{\varepsilon^b} + (t^b)^{1-\varepsilon^b} - (\rho^b)^{-\varepsilon^b} (1 + t^b)}.$$

The numerator and denominator are identical except for the opposite signs on ρ^b's exponent.

As stated previously, this model is a partial equilibrium where relative wages are considered to be exogenous. Labor is assumed to be the only factor of production; however, industry *b* uses industry *a*'s output as an input. Labor is also considered to be immobile; this assumption is useful for examining agglomeration possibilities on an international level.

The use of the wage ratio to measure relative production costs is incomplete because relative productivity and other input costs are omitted. For consistency in the model, the processed product price ratio is used to estimate the raw product price ratio for more reasonable results under current trade conditions.

Since industry *a* only uses labor, the model shows relative costs and prices to be:

$$\rho^a = \omega. \qquad (9)$$

Industry *b* must incorporate the inputs from *a* into its relative costs. Labor share in industry *b*'s output is represented by μ. Assuming a Cobb-Douglas production function, and utilizing the CES aggregator, industry *b* can be characterized as follows:

$$c_i^b = w_i^\mu (P_i^a)^{1-\mu},$$
$$\rho^b = \omega^\mu \left(\frac{P_2^a}{P_1^a} \right)^{1-\mu}. \qquad (10)$$

Performing some algebraic manipulations, relative costs for industry *b* can be transformed further to the following:

$$\rho^b = \omega^{\frac{\mu-\varepsilon^a}{1-\varepsilon^a}} \left(\frac{e_2^a}{e_1^a} \frac{\left[1-(t^a/\omega)^{-\varepsilon^a}\right]}{\left[1-(t^a\omega)^{-\varepsilon^a}\right]} \right)^{\frac{1-\mu}{1-\varepsilon^a}}. \qquad (11)$$

Assuming that the expenditure ratio for industry a and wage ratio are known, and using the zero profit condition, we can determine the firm allocation and the price indices for industry a. Once these are calculated, we can determine the relative costs/prices for industry b. Relying on the partial equilibrium nature of this model and assuming that the expenditure ratio for industry b is exogenous, we can determine expenditures for industry a. Implicit in this is that industry b is the only source of demand for industry a's output.

$$e_i^a = (1-\mu) n_i^b c_i^b (x_{ii}^b + x_{ij}^b + f^b) = (1-\mu) n_i^b p_i^b \phi^b,$$
$$\left(\frac{e_2^a}{e_1^a} \right) = \frac{n_2^b p_2^b}{n_1^b p_1^b}. \qquad (12)$$

The expenditure for industry a at a particular location is proportional to the production in the downstream industry at that location. Thus, the above two equations are the demand linkage equations for the intermediate linkage. The previous equation is the cost linkage.

Using equation (12), the following transformation can be made to facilitate understanding of μ:

$$\mu = 1 - \frac{e_i^a}{n_i^b p_i^b (x_{ii}^b + x_{ij}^b)}$$
$$\mu = 1 - \frac{n_i^a p_i^a x_{ii}^a + n_j^a p_j^a t^a x_{ji}^a}{n_i^b p_i^b (x_{ii}^b + x_{ij}^b)} \qquad (13)$$

$$\Rightarrow \mu = 1 - \frac{\text{total value of tomatoes consumed in country } i}{\text{total value of tomato paste produced in country } i}.$$

Note that units are canceled out in this equation, so the units used in the upstream industry do not necessarily have to match those of the downstream industry.

Utilizing the cost and demand linkages, we arrive at the following equilibrium condition:

$$\frac{\left[1-(t^a\omega)^{-\varepsilon^a}\right]}{\left[1-(t^a/\omega)^{-\varepsilon^a}\right]} (\rho^b)^{\frac{1-\varepsilon^a}{1-\mu}} \omega^{\frac{\varepsilon^a-\mu}{1-\mu}} = \frac{\sigma^b (t^b)^{\varepsilon^b} + (t^b)^{1-\varepsilon^b} - (\rho^b)^{\varepsilon^b} (\sigma^b + t^b)}{(t^b)^{\varepsilon^b} + \sigma^b (t^b)^{1-\varepsilon^b} - (\rho^b)^{-\varepsilon^b} (1+\sigma^b t^b)}. \qquad (14)$$

With σ^b and ω treated as parameters, along with all the others, ρ^b is now a function only of parameters. These parameters include not only relative prices or costs and trade costs, but also relative expenditure. Once this is calculated, all other variables can be identified.

Given ρ^b and using equation (8), the ratio of n_2^b/n_1^b can be determined. With equation (12), the expenditure ratio for industry a is calculated. This is substituted into:

$$\left(\frac{z_2^a}{z_1^a}\right) = \left(\frac{e_2^a}{e_1^a}\right) \frac{\left[1-(t^a/\omega)^{-\varepsilon^a}\right]}{\left[1-(t^a\omega)^{-\varepsilon^a}\right]} \quad . \tag{15}$$

The price ratio for industry *a* remains the same. Ultimately, various permutations of *z* ratios are equalized to obtain the ratio of firms in industry *a* as follows:

$$\sigma^a \frac{\left[1-(t^a/\rho^a)^{-\varepsilon^a}\right]}{\left[1-(t^a\rho^a)^{-\varepsilon^a}\right]} = \frac{p_1^a n_1^a (\rho^a)^{\varepsilon^a} (t^a)^{1-\varepsilon^a} + p_2^a n_2^a}{p_1^a n_1^a + p_2^a n_2^a (\rho^a)^{\varepsilon^a} (t^a)^{1-\varepsilon^a}} \,. \tag{16}$$

One caveat to the above is that the number of firms must be non-negative. This is met with the conditions:

$$\left(\frac{\sigma^b (t^b)^{\varepsilon^b} + (t^b)^{1-\varepsilon^b}}{\sigma^b + t^b}\right)^{\frac{1}{\varepsilon^b}} > \rho^b > \left(\frac{(t^b)^{\varepsilon^b} + \sigma^b (t^b)^{1-\varepsilon^b}}{1+\sigma^b t^b}\right)^{-\frac{1}{\varepsilon^b}}, \tag{17}$$
$$(t^a)^{1-\mu}\omega^\mu > \rho^b > (t^a)^{\mu-1}\omega^\mu .$$

Venables goes on to provide numerical examples by choosing multiple parameter values. While these results will not be discussed here, the general outcome can be summarized. Three general outcomes are possible. First, at a high level of trade cost, production in both the upstream and downstream industries is diversified; extremely high trade costs simulate autarky. As trade costs decrease, diversification remains stable, but two other stable equilibria emerge wherein production in industry *a* is located at only one site while industry *b* is still diversified. Production in industry *b* would be skewed towards the location of industry *a*. This outcome, that fruit and vegetable production would take place just in the US or South America, is implausible due to perishability of the unprocessed products and subsequent high transport costs. Some production will occur at each location and the high cost of transporting raw product dictates that the commodities be processed where they are produced. As *t* continues to decrease and approach unity, the diversified equilibria become unstable; specialization in both *a* and *b* becomes the equilibrium. "With high trade costs firms become tied to markets and their location decisions are much less sensitive to differences in production costs. When production is subject to increasing returns to scale, then at intermediate levels of trade costs location becomes skewed towards (although not completely concentrated in) locations with easy market access. Such locations can therefore support higher real wages better than can less well placed locations" (Venables, 1993, p.1).

The general findings of the above model provides an interesting contrast with previous work in intra-industry trade (IIT). IIT theory typically states that countries with similar economic status would engage in two-way trade in differentiated products. These models typically use models of imperfect competition (see Helpman and Krugman, 1993). Agglomeration theory states that with the right combination of increasing returns, imperfect competition, and transportation costs, countries that are very similar in terms of resource endowments might eventually specialize in completely different goods.

The Solution Procedure

Given the complexity of the equations in Venables' model, it seems obvious that a straightforward solution is unlikely. The partial equilibrium condition (16) is a nonlinear equation with respect to the unknown variable ρ^b. Solving for this variable is the key to solving for all the other variables; in particular, the relative number of firms in each location can be determined once this equation is solved.

The first step to solving this and the remaining equations is to establish parameter values for all the exogenous variables including relative consumer demands, σ^b, and wage rates, ω. These parameter values are calculated based on primary and secondary data sources.

The next issue is to solve the model given the data. As stated previously, the first equation to be solved is highly nonlinear. With Fortran programming, Newton's method is utilized to solve for ρ^b (Miranda, 1994, pp.29-30). The complete model and samples of the programs used to solve it are found in Hartman (1998, Appendices).

Relevance to Horticultural Products

Obviously, any location under consideration must have the production capability for the first-stage product because transport costs for the raw products are prohibitively expensive. The locations being studied have world prominence in the production of the particular good. One can immediately identify production and processing locations for horticultural products in the US: tomato processing in California, orange juice production in Florida. Likewise, processing locations can be identified in regions of South America: tomato processing in Chile, Argentina, and Brazil; orange juice production in the state of São Paulo in Brazil.

The primary authors of agglomeration theory do not include agricultural goods in their models, but recent work in agricultural economics indicates that agriculture is characterized increasingly by industrialization and processed, differentiated final goods (see Drabenstott (1994) and Sheldon (1996) among others). The processing industries for horticultural goods can generally be considered to be imperfectly competitive. While the total number of firms in existence might seem high, the market is generally controlled by fewer players. A quick glance at the grocery store shelves provides a strong indication that differentiation is occurring to some extent in tomato paste and orange juice. Whether the differences are real (such as different tastes or consistencies) or perceived (such as brand name alone), the high numbers of different varieties correspond to an assumption of differentiation. However, tomato paste and orange juice concentrates are more nearly competitively marketed bulk commodities than the differentiated processed products sold at retail.

A combination of varieties of the raw product provides processors with the vital components for manufacturing a good with the desired characteristics. With the investments typically required for machinery and storage for the goods in question, increasing returns may exist in the upstream and downstream industries. Although technically all costs are variable in the long run, the model does not contain a time element. Another shortcoming of the agglomeration model is that limits on the size of a firm due to the assumption of consumer demand for variety are not known. Thus, we do not know whether an individual firm can grow to the most efficient size given the constraints of the model.

A concern might exist, at least in regard to tomato and orange production, regarding the shape of the supply curve. In the Venables model, a supply curve is not part of the mechanics.

Agricultural products typically have an upward-sloping supply curve measured ex post by econometric models (see Henneberry and Tweeten, 1991). In a monopolistically competitive system, however, price and supply quantity will have an inverse relationship. In such a system, an increase in supply quantity is associated with a decrease in price because firms are producing at a lower point on their average cost curves – price equals average cost.

Because of the above and other questions regarding the validity of underlying assumptions of each model, we estimate the competitive model and agglomeration model. The reader can select results based on his/her appraisal of the validity of the assumptions and logic of each model.

Tomato Paste Analysis and Results

The Venables' model performs quite nicely when carefully selected numbers are inserted into the equations, as demonstrated in his article. When using real numbers, however, it becomes obvious that the partial equilibrium equation is highly sensitive to the values of the wage ratio and the processed product expenditure ratio. The following empirical analysis includes production costs and competitive model analysis to more fully inform and to give insights into what drives the results.

Cost Comparisons for Tomato Paste

The first product under consideration for this study is tomatoes. According to Gould (1992, p. 3):

> Tomatoes rank second to potatoes in dollar value among all vegetables produced in the US and in other parts of the world where they are grown. In terms of per capita consumption tomatoes are the leader of processed vegetables. The average American now consumes over 25 lbs. of processed tomatoes exclusive of catsup and sauces per year compared with a total of 60 lbs. for all commercially processed vegetables.

The primary tomato product of interest for this study is tomato paste. While paste represents less than 20% of processed tomato utilization, it is a very important commodity in world trade.

In the US, California is the leading state in processing tomato production. In fact, California produces approximately one-fourth of all processing tomatoes in the world. In 1989, California had 480 growers and 30 processing firms (Sims, 1992). Processed tomato products are primarily intended for domestic consumption.

In South America, Chile and Brazil are major producers with some production occurring in Argentina. Chile is the seventh largest tomato paste producer in the world. Its tomato processing industry is largely geared toward the export market with tomato paste accounting for over half of all canned fruit and vegetable exports. According to Roberts (1995), Chile has 14 processing plants. Chile is an important paste supplier to the US market, but canned tomatoes play a larger role in US imports from Chile.

In Argentina, the Mendoza region is a prominent producer of processing tomatoes. While it is not a major player in the world, the proximity of the Mendoza region to Chile's production regions makes Argentina important in light of agglomeration economies modeled later in this study. According to Cuevas and Davila (1992), 70% of Argentine processed tomato products were produced in Mendoza by 32 firms.

Brazil is cited as the sixth largest tomato producer in the world. Tomato production takes place in three distinct regions: the Northeast, predominantly the submiddle São Francisco River Valley; the Southeast, predominantly São Paulo and Minas Gerais; and Central Brazil, predominantly Goias state and Brasilia. Tomato paste is the most important product. Four firms control most of the market (90%) (Tavares de Melo, 1992).

A basic comparison of costs in the four countries can provide useful information for appraising the future location of processing tomato and tomato paste production given free trade between the three South American countries and the US. Because distance and spoilage preclude sizable fresh tomato trade between South America and the US, emphasis herein is on tomato paste costs.

Costs for producing tomatoes in Argentina on average are higher than for the US (MEPWS, 1996). A detailed summary of production costs can be found in Hartman (1998), and are apparent in the following data for paste production costs as the "raw product" component.

Both high cost and low cost estimates for tomato paste processing were available for California production (Moulton and Garoyan, 1991). The low cost estimates that follow are based on an assumption of a plant specialized in production of tomato paste. The high cost estimates per metric ton assume a variety of products are being produced in one location:

High Cost Estimate for California	
Raw Product	**$454.02**
Aseptic Drum	**98.19**
Fuel	**9.5**
Electricity	**8.45**
Direct Labor	**190.05**
Indirect Labor	**88.69**
Depreciation	**40.12**
Plant Interest	**40.12**
Working Interest	**44.35**
TOTAL COSTS/MT	**$973.50**

Low Cost Estimate for California	
Raw Product	**$454.02**
Tank Car Fill	**36.95**
Ingredients	**1.06**
Fuel and Electricity	**17.95**

Maintenance and Repair	**11.61**
Disposal	**4.22**
Direct Labor	**88.69**
Fees, Labor, Taxes, Etc.	**88.69**
Depreciation	**33.79**
Plant Interest	**33.79**
Working Interest	**36.95**
TOTAL COSTS/MT	**$807.70.**

For Argentina, two cost estimates were available, as well. The Argentine costs are comparable in total to the California costs. The two sets of estimates are as follows (MEPWS, 1996; Moulton and Garoyan, 1991):

Estimate for Argentina	
Raw Product	**$518.00**
Labor	**45.45**
Electricity	**77.27**
Packaging	**109.09**
Others	**4.55**
Depreciation	**65.64**
Administrative	**27.27**
Interest	**13.64**
TOTAL COSTS/MT	**$859.10**

Estimate for Argentina	
Tomatoes	**$484.08**
Freight in	**69.26**
Aseptic Drum	**183.32**
Natural Gas	**27.16**
Electricity	**10.86**
Direct Labor	**43.45**
Indirect Labor	**19.01**
Depreciation	**32.59**
Overhead Cost	**66.54**
TOTAL COSTS/MT	**$936.27.**

One set of estimates was available for Brazilian production of tomato paste. This estimate fell within the low and high estimates for both California and Argentina. The estimates are as follows (Moulton and Garoyan, 1991):

Brazilian Paste Production Cost	
Tomatoes	**$468.21**
Manufacturing	**156.07**
Packaging	**72.83**
Indirect Cost	**218.50**

TOTAL COSTS/MT	**$915.65.**

Finally, one set of estimates is available for Chilean production. The total costs for Chile are the lowest of all four countries under study. The costs are estimated to be as follows (Moulton and Garoyan, 1991):

Chilean Paste Production Cost	
Raw Product	**$311.07**
Container	**91.63**
Energy	**33.76**
Labor (direct and indirect)	**18.09**
Interest Charges	**150.71**
Depreciation	**84.40**
Other Overhead	**30.14**
TOTAL COSTS/MT	**$719.77.**

Of the South American countries, Chile has the most advanced tomato paste production operation, has low costs, and is the only one of the three South American countries that produces primarily for the export market. Argentina and Brazil produce mostly for internal markets, and have only recently been exposed to much competition. If investment took place in these two countries to bring their efficiency to that of the Chilean industry, the entire bloc could be a strong international competitor in the production of paste.

With this in mind, the following trade cost information from Moulton and Garoyan (1991) focuses on the cost to ship paste from South America to the US:

Argentina trade costs are estimated to be:	
Freight to Port	**$83.86**
Freight to US	**159.34**
Duty	**172.74**
TOTAL TRADE COSTS/MT	**$415.94**

Brazilian trade costs are estimated to be:	
Freight to Port	**$33.99**
Freight to US	**107.41**
Duty	**139.88**
TOTAL TRADE COSTS/MT	**$281.28**

Chilean trade costs are estimated to be:	
Freight to Port	**$69.81**
Freight to US	**161.39**
Duty	**113.36**
TOTAL TRADE COSTS/MT	**$344.56.**

Shipping costs to the US are much cheaper from Brazil than from Argentina or Chile. Improvements in infrastructure, including planned transcontinental links, could decrease these costs substantially.

For all three countries, the duty paid on paste definitely hinders the competitiveness of their products. If Chilean producers had no duty to pay, they could have landed their product in the US at a total cost of $950 – a price that falls within the range for California production, but much higher than California's lower cost estimate. If Brazilian production efficiencies were the same as those of Chile, Brazilian paste could, theoretically, have landed in the US at a total cost of $861, still within the range for California. The following summarizes landed costs for tomato paste in the US with and without duties:

	US II	**Argentina II**	**Brazil**	**Chile**
Production Cost	**$807.70**	**$859.10**	**$915.65**	**$719.77**
Landed Cost w/Duty	**807.70**	**1275.04**	**1196.93**	**1064.33**
Landed Cost w/o Duty	**807.70**	**1102.30**	**1057.05**	**950.97.**

With the costs presented here, an obvious winner under free trade does not emerge based on absolute advantage. California and Chile are operating at similar levels in terms of efficiency. While Chile could not competitively land paste in the US based on the second set of cost estimates, neither could California competitively land paste in South America. The ratio of marginal costs to average costs is the measure of economies of size. The US tends to have higher fixed cost proportions, suggesting larger returns from size are possible; however, the fixed versus variable cost breakdowns were difficult to establish, and, hence, not very reliable.

The best evidence whether tomato paste processors face increasing costs is contained in Moulton, Garoyan, and Hetland (1994). In a study looking at installed processing capacity, the authors found that overcapacity existed in the industry. "(W)e cannot escape the reality that since 1989, processing capacity in California has expanded more rapidly than paste production, even with recent closures. This creates the potential for expanding production of raw product in the state by 1.3 million tons beyond the level expected in 1993 without a significant increase in investment"(p.11). In fact, for the world as a whole, the authors predicted an overcapacity in 1993 equal to 30% of operating capacity. With this in mind, average costs of producing tomato paste could decline with an increase in production. Of course if the industry is competitive and marginal costs are rising, a real possibility when tomato production costs are included with paste costs, prices will tend to rise with additional output.

Agglomeration Model – Parameter Values

We now turn to the agglomeration model presented earlier and more fully in Hartman (1998) to predict where tomato paste production will take place with free trade in the Western Hemisphere. The cost comparisons presented earlier provide much information for calculating the necessary parameters to operationalize Venables' model . To calculate parameter values for ω and σ^p, where the *p* stands for paste, the following values are necessary: n_u^p, n_s^p, p_u^p, p_s^p, ρ^p, t^t, t^p, ε, ε^p, and μ. The superscript *t* stands for tomatoes, and the *u* and *s* represent the US (California, in particular) and South America, respectively. Within South America, the ABC countries Argentina, Brazil, and Chile are examined.

Selecting parameters for firm numbers is difficult because the available numbers on paste processing firms are somewhat misleading. In 1993, California had 32 processing firms. While this does not account for all US production, California produces the vast majority of paste; hence, this is the number used for the US. Argentina had 41 plants at this time. Most of these processors were very small and/or produced several other products. Brazil had 12 processors, while Chile had 10. The South American total for this time period was 63 in 1993 (Moulton *et al.*, 1994). The remaining data for this study are reported for 1994, the representative year chosen for the analyses that follow.

Price data come from several sources. The simple average of the two California prices in 1994 dollars is $882.50/MT (ERS, 1996; MEPWS, 1996). The price for tomato paste in Argentina was $986/MT (MEPWS, 1996), in Brazil was $1041/MT (Moulton and Garoyan, 1991), and in Chile was $804/MT. For South America, a weighted average of prices was $889.68/MT, just slightly higher than the average used for the US. The price ratio, with South America on the top, is 1.008. Because Chile is the biggest competitor of California, it is useful to know that the price ratio for these two locations is 0.9110.

To calculate initial values for the trade costs factors, the *t*'s, the trade costs were added to the originating country's price; this total was then divided by the price. Trade cost factors were calculated for the three South American countries individually. The trade cost factor *t* for Argentina for tomato paste was 1.422, for Brazil was 1.532, and for Chile was 1.427. The weighted average of the three is 1.465.

Specific information on trade costs for tomatoes proved extremely difficult to obtain since virtually no fresh processing tomatoes were shipped between the US and these three South American countries. Given information on shipping costs including spoilage for similar products, a trade cost factor of 1.9 seems reasonable for tomatoes; that is, trade costs almost double the price of a tomato that arrives in the US from South America, and vice versa.

Demand elasticities can be calculated in several different ways, but each method resolves to a ratio of the variable portion of the cost to the fixed portion of the cost, based on price equal to average cost. Comparing elasticities for the agglomeration model with positivistic estimates from other studies is not very useful because other studies treat these products as a whole. The agglomeration model assumes there are many horizontally differentiated varieties so that many imperfect substitutes exist within each product category.

For the US, two sources were available for cost data on processing tomatoes. One source gave variable costs of $28.96/MT and fixed costs of $12.41/MT (Le Strange *et al.*, 1992). Another source listed these costs as $42.12 and $18.05/MT (Cook *et al.*, 1991). These result in an average demand elasticity of 3.33 for the US. The breakdown of costs for Argentina was $57.72/MT for variable costs and $16.28 for fixed costs (MEPWS, 1996).

The demand elasticity calculated from the ratio of variable to fixed costs for Argentina was 4.55 (Moulton and Garoyan, 1991), for Brazil was 5.92 (Moulton and Garoyan, 1991; MEPWS, 1996), and for Chile was 8.15 (Moulton and Garoyan, 1991). The weighted average demand elasticity of the four countries was 5.58 for processing tomatoes.

For tomato paste, again a cost comparison is made. For California processing, the average demand elasticity resulting from high and low estimates of the ratios of variable to fixed costs was 4.37 (Moulton and Garoyan, 1991).

Two estimates are available for Argentina, as well. The simple average of the two elasticities was 8.125 (MEPWS, 1996; Moulton and Garoyan, 1991).

For Brazil, the demand elasticity is 4.18 (Moulton and Garoyan, 1991). For Chile, the processing industry had variable costs of $454.17/MT and fixed costs of $265.60/MT, giving an elasticity of only 2.71. The weighted elasticity for all four countries was 4.067.

Finally, a calculation of the labor share of production is required. First, an assessment was needed of production of tomatoes and paste. In this case, tomato production was estimated from paste production using the appropriate conversion ratios (see Moulton *et al.*, 1994). US production of tomato paste in 1994 was 1.112 million MT. Of that amount, only 1,043 MT was exported to South America. Processing tomato production devoted to tomato paste was estimated at 6.005 million MT (FAS and NTDB), virtually all used within the US.

In the South American countries, paste production totaled 141,064 MT for 1994. Of that 2,064 MT were produced in Argentina (*Condiciones de Rentabilidad*, 1996); Brazil produced 56,000 MT (FAS); Chile's share was 83,000 MT (FAS). Derived tomato production was as follows: Argentina – 14,448 MT, Brazil – 375,200 MT, Chile – 481,400 MT. These three countries sent a total of 6,386 MT of tomato paste to the US, the vast majority of that coming from Chile. Domestic consumption accounts for all production except that shipped from South America to the US, or vice versa.

Based on the verbal description of μ provided in the conceptual section, the labor share for US (California) tomato paste production was 0.6200. The shares for Argentina, Brazil, and Chile were 0.3468, 0.5618, and 0.6249, respectively. A weighted average for the four countries was 0.6149.

Comparison with per capita GDP ratios provides perspective. Using IMF data, the GDP per capita for the US is $26,608, for Argentina is $8,206, for Brazil's is $5,463, and for Chile is $3,732. Taking a weighted average of the three South American countries, based on paste production, the wage ratio, ω, is 0.1642.

For the agglomeration model, the wage ratio is used as the primary product's price ratio. Labor is assumed to be the only input for the primary product. In reality, many inputs besides labor go into the production of processing tomatoes. Given this, the weighted price ratio or weighted average cost ratio would be more useful for comparison with the parameter that is calculated by the model. (Recall the assumption that price is equal to average cost in this model.) The weighted price ratio using all three South American countries is 0.9300; the ratio of Chile to the US is 0.8352. Using the cost ratio results in a number greater than one. The ratio including Argentina, Brazil, and Chile versus the US is 1.7703, and using just Chile is 1.2796. The price ratios seem to be the most realistic for comparison purposes. Implicit in using these ratios is that the relative costs of the inputs for the raw product are exogenous. Tomatoes and oranges require a small portion of the respective nations' resources so input supply is quite elastic. If not used for tomatoes or oranges, inputs would be shifted to alternative uses offering similar returns.

Expenditure on tomato paste in the US totaled $988.2 million in 1994. In South America, expenditure was $121.2 million. The resulting expenditure ratio, with the South American figure in the numerator, is 0.1226. This is a very low expenditure ratio; South American consumption, including exports to countries other than the US, is only 12% of American consumption. Obviously, looking at Chile only, the expenditure ratio is even smaller. Remember that market potential, or the consumer base, along with the production base, plays an important role in Venables' model and in location models generally. Such small expenditure ratios will give California producers an advantage considering that they are competitive in price with the South

American producers. A strong price advantage in South America theoretically would be able to offset the consumer advantage.

Agglomeration Model – Analysis and Results

Using the parameter values from the previous section, several combinations of countries and values were analyzed in an effort to predict the location of tomato processing in the Western Hemisphere under free trade. Given the preceding observations, it was thought best to consider three combinations of countries and/or parameters. The first combination was an analysis of the three South American countries relative to the California industry. The number of South American firms was 63, while the number of Californian firms was 32. The initial trade cost factor for paste was 1.465 with a demand elasticity of 4.067. The initial trade cost factor for tomatoes was 1.9 with a demand elasticity of 5.5802. The labor share of production in paste processing was 0.6149.

For all results reported below, the table headings have the following meanings: t^p = trade cost factor for tomato paste, t^t = trade cost factor for tomatoes, ρ^p = price ratio for tomato paste, η^p = firm ratio for tomato paste, ρ^t = price ratio for tomatoes, η^t = firm ratio for tomatoes. In all cases, California is represented in the denominator.

The results are provided in Table 1. Using the actual paste price ratio, a tomato price ratio of 1.0609 was calculated along with a paste expenditure ratio of 1.4707. The tomato price ratio is not unreasonable compared to the average cost ratio reported in the preceding section, but the paste expenditure ratio is absurdly high.

t^p	t^t	ρ^p	η^p	ρ^t	η^t
1.465	1.9	1.0080	1.9708	1.0609	1.9090
1.4	1.8	1.1417	0.3984	1.0609	0.3363
1.3	1.7	1.0361	1.4801	1.0609	1.3283
1.2	1.6	1.0233	1.6784	1.0609	1.6012
1.1	1.5	1.0141	1.9364	1.0609	1.8918
1.05	1.4	1.0080	2.1855	1.0609	2.2231
1.04	1.4	1.0066	2.2248	1.0609	2.2828
1.035	1.4	1.0059	2.2458	1.0609	2.3150
1.03	1.4	1.0051	2.2677	1.0609	2.3488
1.025	1.4	1.0044	2.2906	1.0609	2.3845
1.02	1.4	1.0035	2.3146	1.0609	2.4222
1.015	1.4	1.0027	2.3397	1.0609	2.4620
1.01	1.4	1.0018	2.3661	1.0609	2.5041

$\sigma^p = 1.4707$

Table 1. Tomato paste results with Argentina, Brazil, and Chile.

The model assumes that all firms are the same size. Hence the change in η^p (firm ratio for paste production relative to that in California) as the trade cost factor for tomato paste t^p in South America relative to California declines with freer trade provides insight into the impact of trade liberalization on the location of the tomato paste industry. The general trend in the results is overall growth in the ratio of firms in Argentina, Brazil, and Chile.

For this combination and the combinations that follow, the model produced questionable results when using the actual wage and paste expenditure ratios reported in the preceding section. The scenario under current trade costs resulted in a negative number of paste-processing firms in California with the tomato grower ratio approaching zero with mixed signs.

The second case considered was a direct comparison of Chile and California. As mentioned previously, the Chilean industry is similar to that of California except for overall size. Chile had 10 paste processing firms compared to California's 32. The trade cost factor for paste was 1.4270, while the trade cost factor for tomatoes was 1.9, initially. The demand elasticities for paste and tomatoes were 3.54 and 5.74, respectively. The labor share of production was estimated to be 0.6225. The elasticities and labor share were calculated by taking the simple average of the Chilean and Californian figures.

The results for this scenario are presented in Table 2. The initial paste price ratio of 0.9113 yielded a tomato price ratio of 0.8399 and a paste expenditure ratio of 0.3775. The tomato price ratio is reasonable compared to actual data, although the paste expenditure ratio is very high relative to real figures. This expenditure ratio should work in Chile's favor. Additional support for these results lie in the initial figures for the firm ratios. The firm ratios indicate that the industry would agglomerate in California with minimal production occurring in Chile. Chile and California are quite competitive with each other in cost of production; therefore, once again the expenditure ratio plays a greater role in determining location outcome due to strong similarities in production. If greater disparity existed in the price ratio, the outcome could be quite different.

t^p	t^t	ρ^p	η^p	ρ^t	η^t
1.427	1.9	0.9113	0.3109	0.8399	0.3517
1.4	1.8	0.9204	0.2655	0.8399	0.3034
1.3	1.7	0.9315	0.2176	0.8399	0.2496
1.2	1.6	0.9441	0.1815	0.8399	0.2036
1.15	1.5	0.9535	0.1499	0.8399	0.1644
1.1	1.4	0.9656	0.0966	0.8399	0.0924
1.05	1.4	0.9803	0.0787	0.8399	0.0588
1.03	1.4	0.9875	0.0712	0.8399	0.0449

$\sigma^p = 0.3775$

Table 2. Tomato paste results with Chile only.

The third and final scenario considered was to incorporate all of the South American production capacity, but under the assumption that production technologies were like those of Chile. The industry in Brazil and Argentina has much room for improvement. With the cooperation that exists among these three countries and with their proximity to one another, it seems likely that great advancements could be made in Brazil and Argentina so that their efficiency in paste and tomato production could be brought more in line with that of Chile through investment and technology diffusion.

Tables 3 and 4 highlight the results for this third scenario with slightly different parameters. Table 3 uses 34 as the total number of paste firms in South America. Table 4 uses 20 as the total. These reductions from the total actual number (41 in Argentina alone) are meant to compensate for the unusually high number of firms in Argentina. For both tables, an initial paste price ratio of 0.9107 is used. For Table 3, this results in a tomato price ratio of 0.9169 and a paste expenditure ratio of 0.6460. For Table 4, this results in a tomato price ratio of 0.8826 and a paste expenditure ratio of 0.5093. These expenditure ratios are very high compared to the actual figure. The initial trade cost factor for paste was set at 1.465; otherwise, the parameters are the same as for the second case.

The results for both sets of figures in case three again show an overall decline in the tomato paste industry for South America. For Table 3 the industry declines to approximately one-fourth the size of the California industry. In Table 4, the industry declines to less than 20% of the size of the California industry. This occurs in spite of the artificially high paste expenditure ratios derived from the paste price ratio.

t^p	t^t	ρ^p	η^p	ρ^t	η^t
1.465	1.9	0.9107	1.0669	0.9169	1.1468
1.4	1.8	1.0037	0.2829	0.9169	0.2892
1.3	1.7	0.9805	0.3824	0.9169	0.3982
1.2	1.6	0.9789	0.3817	0.9169	0.3965
1.15	1.5	0.9814	0.3551	0.9169	0.3631
1.1	1.4	0.9854	0.3145	0.9169	0.3085
1.05	1.4	0.9911	0.2906	0.9169	0.2732
1.05	1.3	0.9913	0.2550	0.9169	0.2205

$\sigma^p = 0.6460$

Table 3. Tomato paste results based on Chile with an initial paste firm ratio of 1.0625.

t^p	t^t	ρ^p	η^p	ρ^t	η^t
1.465	1.9	0.9108	0.6266	0.8826	0.6868
1.4	1.8	0.9621	0.2937	0.8826	0.3164
1.3	1.7	0.9576	0.3057	0.8826	0.3316
1.2	1.6	0.9635	0.2714	0.8826	0.2917
1.15	1.5	0.9691	0.2365	0.8826	0.2485
1.1	1.4	0.9765	0.1923	0.8826	0.1882
1.05	1.4	0.9862	0.1681	0.8826	0.1496

$\sigma^p = 0.5093$

Table 4. Tomato paste results based on Chile with an initial paste firm ratio of 0.625

Competitive Market Analysis for Tomato Paste

The competitive market analysis employs a different set of assumptions than the forgoing agglomeration analysis and, not surprisingly, reaches different conclusions. A critical assumption of competitive analysis is that there are sufficient numbers of producers and processors so that no one can exercise market power – they are price takers. The market clears where excess demand equals excess supply as illustrated in the three-panel diagram in Figure 2.

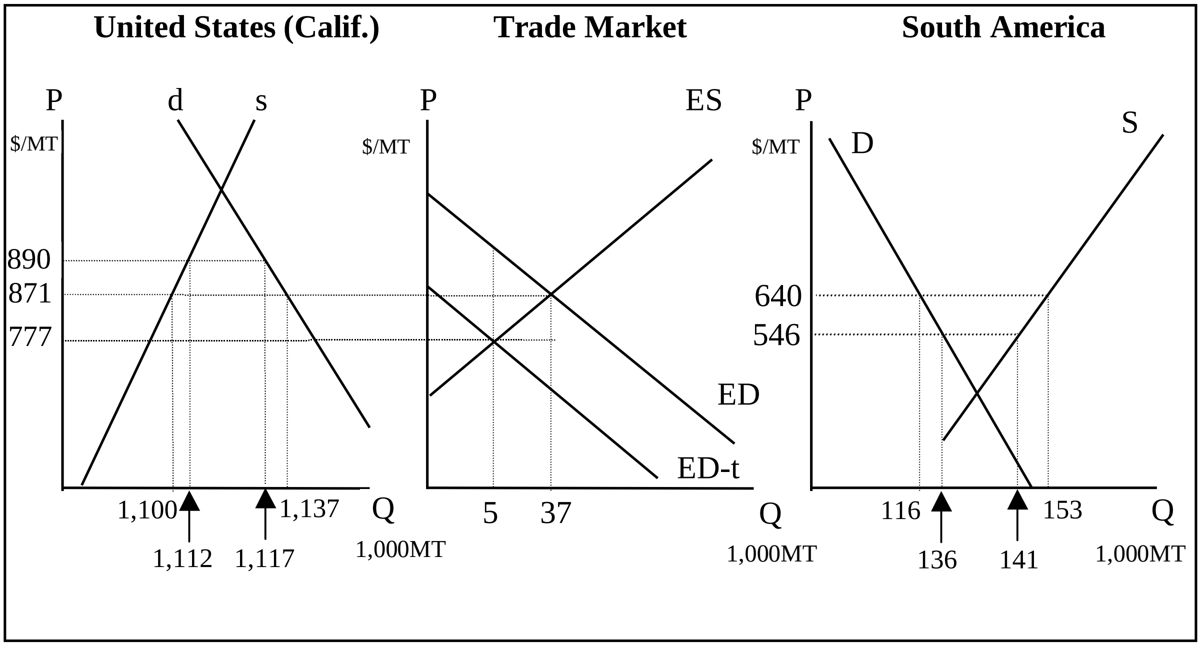

Figure 2: Effects of an import tariff under neoclassical assumptions as it pertains to tomato paste (see Figure 1 for framework). Not drawn to scale.

South American tomato paste production of 141,064 MT less net exports of 5,343 MT to the US leaves 135,721 MT to fill local and rest-of-world demand. US domestic demand of 1,117,343 MT less 1,112,000 MT of domestic supply leaves 5,343 MT to be imported from South America. US domestic tomato paste price of $890 per ton less $231 per ton shipping cost and $113 of import duty leave a South American price of $546 per MT. [1]

[1] That this South American price is less than the indicated average cost of production (see Hartman, 1998, p. 70 for sources) raises several issues:

- Production costs differ among producers. Some producers supply product at below the average cost of production. Net exports of 5,343 MT at a price of $546 per MT indicates some producers and processors find it advantageous to export at that price which covers their marginal cost.
- Shipping cost would decline with greater exports. Also processing and perhaps production costs in South America might fall with greater production and exports allowing opportunities to realize external economies of size. Hence, the above numbers may underestimate the gain in South American tomato paste exports to the US with an end to import duties.

The following elasticities are judgment estimates based on consultations with fruit and vegetable economists and on elasticities summarized for related crops (see for example Chern and Just, 1978, pp.78,80; Gardiner et al., 1989; Henneberry and Tweeten, 1991, pp. 69-95*):*

United States				**South America**			
Supply elasticity		Demand elasticity		Supply elasticity		Demand elasticity	
SR	LR	SR	LR	SR	LR	SR	LR
0.5	2.0	-0.8		0.5	2.0	-1.0	

Supply elasticities apply to short-run (SR) periods of up to 5 years and long-run (LR) to periods of 10 or more years. None of the sources indicated negative own-price supply elasticities.

The impact of removing the $113 per MT import duty is to increase Argentina, Brazil, and Chile (ABC) net exports to the US (US net imports of tomato paste from ABC) to 36,906 metric tons from 5,343 metric tons based on short-run supply elasticities of 0.5 and the demand elasticities of –0.8 in the US and –1.0 in ABC. The US price falls from $890 to $871 per MT, and the ABC price rises from $546 to $640 per MT.

In the long run with similar demand elasticities but with supply elasticities of 2.0 in the US and ABC, US net imports of tomato paste rise to 76,879 MT from 5,343 MT, for a gain of 71,536 MT. The US price falls from $890 per MT with the duty to $870 per MT without it. The ABC price rises from $546 per MT with the duty to $639 without the duty.

The distribution of gains from removal of the tariff is as follows :

	US		**ABC**	
Gain to:	SR	LR	SR	LR
		(Dollars per year)		
Consumers	21,530,763	23,078,192	-11,759,329	-11,601,626
Producers	-21,128,628	-22,236,397	13,799,529	15,390,875
Taxpayers	-603,757	-603,811	----	----
National Income	-201,622	237,984	2,040,200	3,789,249
Combined Country Income	1,838,578 (SR)		4,027,233(LR)	

US consumers gain about $22 million per year and ABC consumers lose $12 million per year. ABC producers gain $14 million per year while US producers lose. The US as a whole loses income in the short run but the US, ABC, and the four countries combined gain in the long run.

In summary, the competitive market solution predicts that removing the $113 per MT import duty will reduce the US price of tomato paste about $20 per MT and will increase the ABC price by approximately $94 per MT. In the US, the lower price and greater imports will benefit consumers and reduce net income of producers, but the nation as a whole is predicted to gain annually $237,984 in the long run from more open markets. US production falls only 1 percent and ABC production increases 8 percent. US consumption increases 2 percent while ABC consumption declines 15 percent. Thus, in contrast to the agglomeration model, the competitive model predicts that the US share of tomato production and processing will decline with free trade. The four countries gain an estimated $4 million per year with no tariff in the long-run.

Conclusions on Tomato Paste

Given the logic of Venables' model and location theory in general, the results reported for the agglomeration model are not surprising. While basic cost comparisons were not able to provide a clear-cut winner, Venables' model strongly favors the Californian industry. The industry in California dwarfs the South American industry and its share would grow. Certainly, attempts could be made to expand production and increase efficiency particularly in Argentina and Brazil. In fact, one study cited in this research was financed by a Japanese agency exploring ways to increase tomato paste supplies in Argentina for export to Japan (MEPSA). The results from the Venables model imply that increasing the industry in South America would be uneconomic given the low demand within the region and lack of a cost advantage over California.

In contrast to the agglomeration model, the competitive model of tomato paste production indicates that the US share of production and processing would decline with freer trade. US consumers and ABC producers would be better off but US producers and ABC consumers would be worse off with freer trade. Annual gains to the US and ABC individually and collectively would be positive, however, in the long run.

One important point to consider in the preceding analyses is the role of exchange rates. While the model is taking a static view of the industry, fluctuations in exchange rates could drastically affect cost differences in the real world. In and around 1994, exchange rates for the countries of concern were behaving in a relatively stable fashion, so the cost ratios provided herein should be reasonably realistic. But exchange rates will change in the future, perhaps increasing the competitive position of South America.

Summing up, under either model, the California tomato paste industry under free trade in the Western Hemisphere would not be displaced. ABC-US trade barriers could be removed for tomatoes and tomato paste without severely harming US producers while benefiting consumers from freer trade not only in tomatoes but in other products as well.

Orange Juice Analysis and Results

Analysis next turns to orange juice. Oranges are the third largest fruit crop in the world in production with approximately 30 million MT (Nagy *et al.*, 1993). Florida production of oranges in 1994-95 was 10,641,000 MT. Production in Brazil was 15,710,000 MT for the same time period (Spreen, 1996). Juice production in Florida was 1,257.2 million SSE gallons (FAS). In Brazil, production was 1,525.4 million single strength equivalent (SSE) gallons (FAS). Total production was assumed to be used for domestic consumption or export in both countries. Exports were considered to be anything shipped from Florida to Brazil, or vice versa. Domestic consumption was assumed to be the remainder, thus, including exports to any other country. This was particularly important in the case of Brazil, where domestic consumption is quite low. Brazil exports predominantly to Europe. Including European consumption within Brazilian consumption seemed most appropriate given the limitations of the model. Floridian exports to Brazil were 15,685 SSE gallons; Brazilian exports to Florida were 120,705,573 SSE gallons; this amounts to approximately 8% of Brazil's total production of orange juice.

While California dominated in the production of oranges for many years in the US, World War II initiated the search for improved juice technology. Upon its development, the citrus industry began to be dominated by Florida because its climate is especially suitable for juice oranges.

According to Kimball (1991, pp. 1,2):

> One Florida venture was to initiate a citrus industry in Brazil in order to avoid the economic damage of freezes in Florida. This budding industry was later sold to the Brazilians, who have, in recent times, emerged as a major contender in the international citrus juice market. With a few devastating freezes in Florida, it did not take long for the Brazilian citrus empire to establish markets in the US and usurp Florida's previous position as king in the citrus industry. Brazil has the largest juice processing plants in the world and is a leader in citrus technology in many areas.

Brazilian orange and orange juice production is centered on the state of São Paulo. Almost all orange production is utilized for juice. In 1989/90, there were 10 companies in the São Paulo state producing orange juice (Goncalves, 1991).

While the US is the second largest producer of oranges (second to Brazil), it is a net importer of juice (Spreen *et al.*, 1991). More than 90% of US imports are supplied by Brazil. Due to the political influence of Florida agriculture, as witnessed in NAFTA and other negotiations, the orange juice market is highly protected.

In the preceding analysis of tomato paste, cost comparisons were done initially to determine if a final outcome could be predicted based on absolute advantage. No clear winner emerged from these cost comparisons. With orange juice, this is not the case. A basic comparison of costs in the two countries provides useful information. Economic theory has costs and prices endogenous to the system, so current prices and costs are a snapshot of short-term economic equilibrium at a point in time; nonetheless, it is helpful to see the differences between these two producing nations.

For orange production in Florida, two sources yielded information on costs. First looking at the Farm Bureau report on NAFTA (AFBF, 1991; Cook *et al.*, 1991), the following Florida orange production cost per box was obtained:

Cultural Costs	**$2.0822**
Picking	**0.7457**
Roadsiding	**0.7138**
TOTAL VARIABLE COSTS/BOX	**$3.5417.**

For total costs, the following were added: general administrative and overhead costs, management costs, property taxes, and interest. This created a total of $4.321/box. Variable expenses were 81.96%, and fixed costs were 18.04% of the total.

A second estimate of Florida orange production costs was taken from Muraro (1995):

Cultural Costs and Other Costs	**$2.274**
Picking/Collecting	**0.755**
Load Oranges	**0.728**
Administrative	**-----------**

TOTAL COSTS/BOX	**$3.757.**

Assuming that fixed costs were included in "other costs," and assuming the same percentage as that from the Farm Bureau report, fixed costs were calculated to be $0.678/box, with variable costs at $3.079/box.

For Brazil, the percentage breakdown of costs was based on a representative grower in São Paulo state: 33.8% of total costs were fixed, with 66.2% variable. Using data from Muraro (1995) the following breakdown was obtained:

Cultural Costs and Other Costs	**$1.396**
Picking/Collecting	**0.432**
Loading	**0.058**
Administrative	**0.190**
TOTAL COSTS/BOX	**$2.076.**

With this information, it was estimated that fixed costs in Brazil were $0.702/box and variable costs were $1.374/box.

Comparing Florida and Brazil costs, Brazilian producers have lower costs in oranges across the board. In fact, Florida oranges are produced at almost twice the expense of Brazilian oranges. The disparity in costs is less when costs per pound solid are compared. The quantity of oranges needed for a single strength equivalent gallon of orange juice is dependent upon the pounds solid in the oranges. Florida's costs per pound solid are approximately 1.5 times larger than Brazil's costs. A more detailed cost breakdown in Muraro (1995) shows Florida with an advantage in chemical and fertilizer costs, and Brazil with a major advantage in labor and operating costs. Including trade costs raises the overall cost of Brazilian oranges in the US or of US oranges in Brazil to levels that do not justify trade – whole fresh oranges are practically nontraded goods. The US has a one-cent per pound tariff on fresh oranges, which would add $0.90/box to the price of imported oranges.

One important issue in terms of the Venables model is whether there are increasing returns in the production of oranges and orange juice. Increasing returns may prevail within a considerable range of output in the processing end, but increasing costs may dominate the production of oranges. While definitive proof either way is not available with the data gathered for this research, some evidence in favor of increasing returns can be found.

First, the existence of fixed costs suggests that total average costs although not necessarily marginal costs would decrease with an increase in production. With available data, one cannot determine exactly how far down growers are on their average cost curves. Based on changes that have taken place in Florida, average costs could have decreased in the years following the year used for this study – 1994.

In the early 1980s, Florida suffered some devastating freezes. In response to this, orange production relocated from 1985 through 1994 to areas in the state less subject to freezing. In 1994, Florida had a record number of orange trees, a large portion of which were quite young. As these trees mature, and with the many advances made in orange production technology, Florida orange production is expected to increase dramatically. In addition to increasing yields as the trees age, expected annual losses should also be substantially lower due to the decreased likelihood of freezes (Spreen, 1996). New technological innovations should further reduce average costs; these innovations include better rootstocks, improved irrigation systems, and higher density plantings.

Calculation of orange juice costs begins with the price of oranges in each location. In Florida, the price of a box of oranges was $3.50 and each box contains 6.5 pounds of solids (ps) (Muraro, 1995); therefore oranges cost $0.534/ps. Based on Muraro (1997), 57.0% of costs are considered variable, and 43.0% are fixed. According to Muraro (1995), bulk processing costs are $0.171/ps, and other domestic costs are $0.030/ps. Combining the cost of the oranges with these costs results in a variable cost of $0.649/ps and a fixed cost of $0.086/ps. A pound solid is equivalent to 0.919 SSE gallons. Therefore, variable costs are $0.706/SSE gallon, and fixed costs are $0.094/SSE gallon.

Based on conversations with experts in the field, Hartman (1998) estimated that Brazilian labor costs were half of Florida's labor costs. Excluding oranges, the breakdown of costs was 51.2% variable and 48.8% fixed. The price of a box of oranges was $1.84/box with 6.00 ps/box; hence, the price of oranges was $0.307/ps. Industry experts in Brazil pointed out that the price per box of oranges received by growers was causing them to operate at a loss, so the cost of oranges for juice processing in Brazil may be higher than orange prices would indicate. The bulk processing cost was $0.153/ps, and the domestic costs were $0.086/ps (Muraro, 1995). This provides a total of $0.429/ps in variable costs and $0.117/ps in fixed costs. With a pound solid equivalent to 0.868 SSE gallons, variable costs are $0.494/SSE gallon and fixed costs are $0.135/SSE gallon. For orange juice production, Brazil has higher fixed costs, much lower variable costs, and lower total average costs than the US.

In Brazil, processors have to compete against the fresh market. According to interviews with processors, problems in vertical linkages cause processors to operate at less than full capacity when they are unable to compete with the fresh price. Exact estimates of installed capacity and operating capacity were not available.

Trade costs are for shipping orange juice from Brazil to the US. Specifically, the breakdown is as follows:

Freight to Santos, Storage, Insurance & Harbor Charges in Santos	**$0.0348**
ICM Tax (Brazilian tax)	**0.0399**
US FCOJ Custom Tax	**0.2952**
Florida Equalization Tax	**0.0260**
Ocean Freight and Insurance	**0.0746**
Harbor Charges in Florida	**0.0062**
Sales Charge, Cold Storage, & Florida Inland Freight	**0.0349**
USDA Inspection	**0.0022**
TOTAL TRADE COSTS/SSE GAL	**$ 0.5139.**

SOURCE: Muraro, 1995

If the US eliminated its tariffs against orange juice, trade costs theoretically could fall by $0.321/SSE gallon, which is roughly half the price of frozen concentrated orange juice (FCOJ) in Brazil. Total trade costs would then fall to $0.193/SSE gallon, making the price of Brazilian FCOJ in the US $0.890/SSE gallon compared to the Florida price of $0.962/SSE gallon. This results in a 7 cent difference, or a 7% difference in price. Brazil has an absolute advantage in the production of orange juice for the US market.

In terms of economies of size, Brazil's fixed to total cost percentage exceeds that of Florida. However, interviews with industry experts in both Brazil and Florida suggest that Brazil is operating closer to the low point on its average cost curve than is Florida. Brazil is producing more orange juice with fewer plants. This indicates that Florida has greater potential gains from an increase in firm size.

Agglomeration Model Parameters and Results

To calculate parameter values for ω and σ^j, where the *j* stands for juice, the following values are necessary: n_f^j, n_b^j, p_f^j, p_b^j, ρ^j, t^o, t^j, ε^o, ε^j, and μ. The *o* stands for oranges, and the *f* and *b* represent Florida and Brazil, respectively. Parameters and the model were defined earlier. Due to the availability of data, 1994 was chosen as the representative year for this study. FCOJ is the processed product analyzed in this study because it makes up the bulk of orange juice processing and trade, and has commodity-like qualities. The number of juice processing firms in Florida was 27 (Pollack, 1997); in Brazil the number was 20 (Amaro, 1996). The price of FCOJ in Florida was $0.962 per single strength equivalent (SSE) gallon (NASS, 1996). The price of FCOJ in Brazil was estimated to be $0.697/SSE gallon. This estimation was based on the 1990 price and was calculated relative to the percentage change in price for Florida. The numbers give a price ratio of 0.725. (Note that all ratios use Brazilian data in the numerator and Floridian data in the denominator.) Later, in this section, another price ratio will be calculated according to the ratio of average costs, assuming zero profits in the industry.

To calculate initial values for the trade cost factors, the *t*'s (the ratio of prices between the two countries) were used, based on the assumption of Dixit-Stiglitz style monopolistic competition of all firms in the study. As such, the following identity holds:

$$p_b^j t^j = p_f^j ;$$

therefore, t^j has a value of 1.409. For oranges, the price in Florida was $3.50/box, while the Brazilian price was $1.84/box (NASS, 1996). This results in a t^o of 1.902. One should expect a much higher *t* for oranges as the product is much bulkier, and in fact is rarely traded between Brazil and the US.

The demand elasticities can be calculated from a ratio of the variable cost to the fixed cost, based on price equal to average cost. Based on numbers presented earlier, the Florida-specific demand elasticity is 5.547 and the Brazil-specific demand elasticity is 2.959. The model calls for a single elasticity for oranges; taking a simple average of the two results in an elasticity of 4.253.

For juice in Florida, the variable cost of juice was estimated to be $0.706/SSE gallon, the fixed costs $0.094/SSE gallon, and hence the demand elasticity of Florida juice is 8.504. In Brazil, the variable cost was $0.494/SSE gallon, fixed costs $0.135/SSE gallon, and the elasticity is 4.673. Taking a simple average, the elasticity for the model is 6.585. Based on average costs, the price ratio is recalculated to be 0.786, the ratio used in the initial parameterization.

Finally, a calculation of the labor share of production is required. The labor share μ for Florida orange juice was 0.3945 while the share for Brazil was 0.5481. Taking a simple average results in a share of 0.4713.

The wage ratio, ω, was calculated using gross domestic product per capita. Using IMF data, the Brazilian figure is $5463.21 per capita. For the US, the figure is $26,608.23 per capita.

The resulting ratio is 0.2053. Basing the ratio on labor costs per box of oranges, the ratio is 0.184 (Muraro, 1995). As with tomato paste, oranges have many inputs besides labor, so the orange price ratio or cost ratio was better suited for comparison purposes. The price ratio for oranges is 0.526; the cost ratio is 0.553. Both of these ratios are much higher than the actual wage ratio, and would be higher still with pounds solid taken into account.

The juice expenditure ratio, based on the above-mentioned prices, trade costs, and production values, is 0.738. Recall that the juice expenditure ratio is the ratio of Brazilian expenditure (including its exports to countries other than the US) to US expenditure on orange juice.

Analysis required use of calculated parameters for the orange price ratio and the juice expenditure ratio. Attempts were made to use the actual wage and juice expenditure ratios, and also the actual orange price and cost ratios with the juice expenditure ratios. The model, however, is limited in what combinations of parameters will allow it to converge; thus, these attempts were unsuccessful.

As an alternative, the actual juice cost ratio was used to derive estimates of the orange price and juice expenditure ratios. Using the juice cost ratio of 0.786, the orange price ratio was calculated to be 0.774 and the juice expenditure ratio was calculated to be 0.216. The calculated orange price ratio is somewhat higher than the actual ratio. As stated previously, however, Brazilian orange growers appear to have been operating at a loss so that the actual price ratio should probably be higher than the ~0.55 reported. The juice expenditure ratio is much lower than the actual ratio. Nonetheless, these parameters yielded acceptable initial firm ratios for both oranges and juice.

Table 5 reports the price and firm ratios as trade costs decline. For Tables 5 and subsequent tables, symbol definitions are as follows: t^j = trade cost factor for juice, t^o = trade cost factor for oranges, ρ^j = price ratio for juice, η^j = firm ratio for juice, ρ^o = price ratio for oranges, η^o = firm ratio for oranges. Brazil is always represented in the numerator. Note that the price ratio remains constant for oranges because the model assumption is that the wage ratio is exogenous.

t^j	t^o	ρ^j	η^j	ρ^o	η^o
1.409	1.902	0.7860	0.7413	0.7743	1.1576
1.3	1.8	0.8894	0.2887	0.7743	0.4234
1.2	1.7	0.9238	0.2021	0.7743	0.3017
1.15	1.6	0.9378	0.1591	0.7743	0.2518
1.1	1.5	0.9531	0.1133	0.7743	0.1956
1.05	1.4	0.9727	0.0618	0.7743	0.1234
1.04	1.4	0.9774	0.0597	0.7743	0.1138
1.03	1.4	0.9824	0.0575	0.7743	0.1039
1.02	1.4	0.9879	0.0553	0.7743	0.0938
1.01	1.4	0.9938	0.0530	0.7743	0.0836

σ^j = 0.2160

Table 5. Orange juice results with juice price ratio = 0.7860.

The initial trade costs show Brazil with roughly three-fourths as many juice processors as Florida and with more orange growers than Florida; this is realistic given the actual values for these ratios. As the trade costs decline just slightly, due to lower tariffs or other reasons, to a trade cost factor of 1.3 for juice and 1.8 for oranges, a dramatic change takes place in firm ratios. The number of juice processors in Brazil falls to 30% that of Florida. The proportion for growers drops to 40% of Florida's. As trade costs continue to drop, these ratios continue their decline. The price ratio for juice steadily approaches one, as would be expected with freer trade.

Reducing the trade cost factor for the raw product might seem to be pointless considering that trade of the first-stage product is unlikely to occur for processing regardless of unnatural trade barriers. The primary reason for reducing this factor along with the processed good's trade cost factor is for ease in convergence. Doing so does not significantly influence the results. The last five rows of Table 5 show that holding the raw product trade cost factor at 1.4 while continuing to reduce the processed good's trade cost factor still results in a downward trend in firm ratios and hence in market shares for both the raw product and the finished good.

The juice price ratio was changed to determine its impact on expenditure ratio, the orange price ratio, and juice production shares. (See Hartman, 1998, Appendix C for insight as to how these numbers respond to changes in other data values.) Results indicate an unduly large reduction in juice production in Brazil relative to the US indicated by η^j with lower barrier to trade indicated by t^j.

Table 6 shows the results from arbitrarily setting the initial juice price ratio at 0.851 in an effort to raise the juice expenditure ratio. An orange price ratio of 0.907 and a juice expenditure ratio of 0.616 were derived from initial calculations. The initial firm ratios for juice and oranges show Brazil having more of both compared to Florida. As trade costs decrease, the general trend is a reduction in these ratios, leading to greater numbers of both in Florida. The industries do not decline as much as in the first analysis.

t^j	t^o	ρ^j	η^j	ρ^o	η^o
1.409	1.902	0.8505	1.4869	0.9066	1.8595
1.3	1.8	0.9944	0.4776	0.9066	0.5183
1.2	1.7	0.9823	0.5090	0.9066	0.5656
1.15	1.6	0.9834	0.4878	0.9066	0.5481
1.1	1.5	0.9861	0.4530	0.9066	0.5146
1.05	1.4	0.9911	0.3998	0.9066	0.4559
1.04	1.4	0.9925	0.3960	0.9066	0.4480
1.03	1.4	0.9940	0.3916	0.9066	0.4391
1.02	1.4	0.9958	0.3867	0.9066	0.4291
1.01	1.4	0.9978	0.3812	0.9066	0.4181

$\sigma^j = 0.6165$

Table 6. Orange juice results with juice price ratio = 0.8505.

Table 7 utilizes an even higher initial juice price ratio of 0.987. This ratio results in an orange price ratio of 0.951 and a juice expenditure ratio of 0.761. The juice expenditure ratio is more closely aligned with the actual juice expenditure ratio, treating Brazilian exports to countries other than the US as domestic consumption. The initial juice firm ratio is realistic. The initial orange firm ratio is low, but appropriate measures for this were hard to find. As in the preceding cases, the general trend for firm and hence output ratios in both the raw and processed sectors is a decrease for Brazil. The downward trend is not as dramatic as in the other cases, however. The Brazilian industry settles at approximately two-thirds the size of the Floridian industry. The juice price ratio again approaches one.

t^j	t^o	ρ^j	η^j	ρ^o	η^o
1.409	1.902	0.9875	0.7407	0.9509	0.7775
1.3	1.8	0.9841	0.7529	0.9509	0.7967
1.2	1.7	0.9873	0.7266	0.9509	0.7708
1.15	1.6	0.9893	0.7041	0.9509	0.7501
1.1	1.5	0.9916	0.6744	0.9509	0.7213
1.05	1.4	0.9948	0.6314	0.9509	0.6748
1.04	1.4	0.9956	0.6278	0.9509	0.6680
1.03	1.4	0.9965	0.6237	0.9509	0.6604
1.02	1.4	0.9976	0.6191	0.9509	0.6520
1.01	1.4	0.9987	0.6140	0.9509	0.6426

$\sigma^j = 0.7613$

Table 7. Orange juice results with juice price ratio = 0.9875.

Competitive Market Analysis for Orange Juice

A competitive neoclassical trade model provides predictions of production and consumption of orange juice under a very different set of assumptions than used for the agglomeration model.

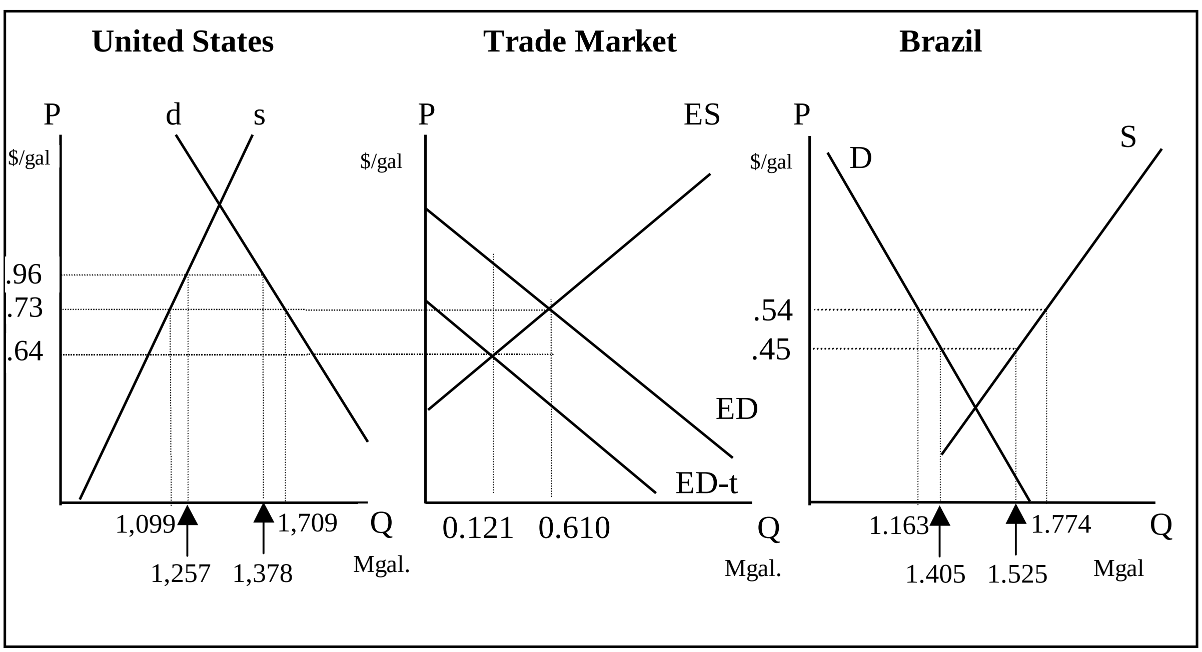

Figure 3: Effects of an import tariff under neoclassical assumptions as it pertains to orange juice (see Figure 1 for framework).

Figure 3 shows estimated outcomes under competitive market assumptions. The graphs are based on the following elasticities: US supply elasticity = 0.5, US demand elasticity = -0.8, Brazil supply elasticity = 0.8, Brazil demand elasticity = -1(see Gadiner et al.,1989; Henneberry and Tweeten 1991,pp 69-95; Powers,1993,pp.39-41). The Florida price for 1994 was $0.96/SSE gallon. Removing the US tariff of $0.32/SSE gallon results in an effective world price of $0.64/SSE gallon – Florida's price less the tariff. If the tariff were removed, the equilibrium US price would be $0.73/SSE gallon, Brazilian production would increase from 1.525 million SSE gallons to 1.774 million SSE gallons and Florida production would decrease from 1.257 million SSE gallons to 1.099 million SSE gallons under these short-run assumptions. Florida production is cut by 13 percent. This analysis ignores the rest of the world.

Long-run US and Brazil supply elasticities are assumed to be 2.0. The demand elasticities remain unchanged. In the long run, equilibrium prices in the US and Brazil are only slightly below $.73 per gallon and $.54 per gallon respectively. Long-run demand quantity is 1.720 million gallons and supply quantity is down to 0.722 million gallons compared to 1.099 million gallons in the short run. In Brazil as in the US, annual demand quantity changes very little at 1.176 million gallons in the long run, but the supply quantity expands to 2.177 million gallons from 1.774 million gallons per year or by 22 percent.

Economic impacts (see Figure 1) from an end to the tariff are summarized as follows for the US and Brazil in the short to intermediate run (SR) and the long run (LR):

	US		Brazil	
Gain to:	SR	LR	SR	LR
	(Dollars per year)			
Consumers	346,778	357,096	-199,164	-112,152
Producers	-267,364	-227,330	154,069	160,797
Taxpayers	-38,632	-38,632	---	---
National Income	40,782	91,134	34,905	48,645
Combined Country Income	75,687 (SR)		139,779 (LR)	

Termination of the tariff results in a moderate gain of $346,778 annually to the US consumers in the short run and $357,096 annually in the long run. Producers and taxpayers lose, but overall gain to the US averages $40,782 per year in the short run and $91,134 per year in the long run.

Gains and losses are less in Brazil. Brazilian producers gain $154,069 annually in the short run and $160,797 per year in the long run. These gains more then offset losses to consumers so Brazil's overall net annual gains average $34,905 in the short run and $48,645—all expressed in US dollars. Combined country gains average $75,687 in the short run and $139,779 in the long run. Thus the counties individually and collectively gain from freer trade. The modest gains shown above would be much greater if secondary impacts on each economy such as increased investment and capital formation in a general equilibrium context were considered.

Conclusions on Orange Juice

The agglomeration model results for the orange juice industry seem surprising given the cost advantage that exists for Brazil along with its relatively high juice expenditure ratio. While Brazil had a slight cost advantage under free trade, it was only 7% of the total cost. The US consumes large quantities of orange juice, and having an orange juice industry here appears to maximize the benefits of agglomeration.

The competitive model indicates that Florida's orange juice concentrate production would fall 3.7 percent and imports would double with removal of trade barriers. Florida's producers and the government would receive less income but gains to US consumers would more than offset so that real national income would rise. Brazil's producers would be better off and its consumers worse off, but the country as a whole would gain income according to the competitive model.

With free trade, Brazil's share of the US market would increase according to the competitive model but decrease according to the agglomeration model. The reader can examine assumptions and logic of each model in judging which gives more realistic results. Results of these two types of analyses suggest that the impact on Florida's orange juice industry would not be huge with the removal of tariffs.

Analyses by Spreen, Muraro, and Fairchild (1991) and Spreen (1996) also suggest that the removal of tariffs on orange juice in the US would have only modest effect on the Florida industry. These authors used a much different methodology with different assumptions – they were examining a gradual phaseout of tariffs. Taking into account expectations of dramatic increases in Florida orange production for the next several years, they concluded that by the time tariffs were eliminated, Florida would have reached the point of being a net exporter. The effects of tariff protection would already have been minimized as a result of its exposure to the world market.

We caution that the orange juice (and tomato paste) results have limitations. Strong policy conclusions are unwarranted without refinement of the models and data beyond the scope of this study. However, agglomeration economies will help the Florida orange juice industry to survive with free trade. The world probably benefits from having the insurance of at least two major producers of orange juice. Florida and São Paulo combined produced over 80 percent of the world orange juice supply in 1994-95 (Spreen, 1996). The relative variation in orange juice production is less for Brazil and Florida combined than for each county taken individually. That stability is likely to continue to benefit consumers.

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