Effects of Trade Barriers on U.S. Apple Exports

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Abstract

We build a spatial equilibrium trade model for apples using demand and supply relations for each importing and exporting country. The model maximizes welfare subject to demand and production constraints. A trade barrier (free trade) scenario which incorporates (removes) import quotas and tariffs is run. Comparison of the solutions of the two scenarios quantifies the impacts of trade barriers on US apple exports.

Key Words: apples, spatial equilibrium model, trade barriers.
JEL Classification: F10

I. Introduction

The United States is a major apple producing country. Owing to an oversupply in the domestic market, US apple growers have not been receiving remunerative prices. Exporting apples to other countries can solve this resulting market saturation. However, apple exports are far below the consumption potential in importing countries mainly due to high trade barriers. Tariffs range from a low of 15% in Venezuela to as high as 54% in Egypt and India. This implies that US apples cost about 1.5 times more in some countries even without accounting for transportation costs. Thus, US apple prices compare unfavorably with the locally grown apples. The dismantling or phasing out of these trade barriers will enable US apples to be competitive in foreign markets and thereby greatly increase US apple exports. In this paper we develop a trade model for the world apple market and quantify the impact of trade barriers on US apple exports.

II. World Apple Trade and the Impediments to free Trade

World apple trade has steadily grown over the years with total value of world exports being over US$ 2.3 billion in 2000. The United States is an important player in the world apple market accounting for over 15% of world exports in value. US domestic apple consumption has been relatively stagnant compared to its production therefore making exports very crucial to the apple industry. High levels of tariff prevalence in many countries have severely impeded the trade of apples. There is a huge market for apples in countries like India where imports have increased from practically nothing to around 17000 tones in 2000. The important importing regions worldwide are Mexico, Africa, Middle Eastern countries and the Far East. Countries like Egypt, Korea, Thailand, Vietnam and India, all potential markets for US apple exports, impose very high import tariffs thereby effectively limiting domestic apple consumption in these countries way below potential demand. The elimination of trade barriers results in increase in net social welfare. It brings down prices in importing countries thereby making the product more affordable. It will also increase export price for US apple growers relieving them of the present price slump. Therefore, tariff reduction in apples is very consequential to US apple growers.

III. Methodology

The method used in the paper is a spatial equilibrium trade model proposed by Takayama and Judge (1971). The model assumes perfect competition in all markets and involves maximizing the net social monetary gain function subject to a set of linear constraints. The net social monetary function is defined as the total social revenue minus the total social production cost minus total transportation cost. The model assumes the existence of linear regional demand and supply relations, which are used to construct the objective function. Under perfect competition and using the market equilibrium and arbitrage conditions, we derive the optimal solution to the quadratic programming problem.

We assume that there are two or more regions indexed i, j where $i, j = 1,....n.$ trading in a single product and separated by a positive transportation cost. The following form of demand and supply relations for each region is assumed:

Demand: $p_i = \lambda_i - \omega_i y_i$ for all i ,

Supply: $p^i = \upsilon_i + \eta_i x_i$ for all i ,

Where,

y_i = Quantity demanded in region i ,

x_i = Quantity supplied in region i ,

p_i = Demand price in region i ,

p^i = Supply price in region i ,

& λ_i , ω_i and $\eta_i \geq 0$

We define

$$\Omega = \begin{bmatrix} \omega_1 & & & & \\ & \omega_2 & & & \\ & & . & & \\ & & & . & \\ & & & & \omega_n \end{bmatrix} \qquad H = \begin{bmatrix} \eta_1 & & & & \\ & \eta_2 & & & \\ & & . & & \\ & & & . & \\ & & & & \eta_n \end{bmatrix}$$

$$\lambda = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ . \\ . \\ \lambda_n \end{bmatrix} \quad \text{and} \quad \upsilon = \begin{bmatrix} \upsilon_1 \\ \upsilon_2 \\ . \\ . \\ \upsilon_n \end{bmatrix}$$

Using these notations we have the set of demand and supply relations defined as

$$P_y = \lambda - \Omega y$$
$$P_x = \upsilon + Hx$$

Further we assume that the following two conditions are satisfied for each region:

1. The quantity demanded in each region is less than or equal to the quantity shipped into the region from all other regions I.e.

   $y_i \leq \sum_{j=1}^{n} x_{ji} \forall i$ Where x_{ji} represents a trade flow form j to i

2. The quantity supplied in each region is greater than or equal to the quantity Shipped from the region to all other regions

   $x_i \geq \sum_{j=1}^{n} x_{ij} \forall i$ Where x_{ij} represents a trade flow form i to j

These can be combined to be expressed as:

$$\begin{bmatrix} G_y \\ G_x \end{bmatrix} X \geq \begin{bmatrix} y \\ -x \end{bmatrix}$$

and

$$y \geq 0,\ x \geq 0,\ X \geq 0$$

where

$$y = \begin{bmatrix} y_1 \\ y_2 \\ . \\ . \\ y_n \end{bmatrix},\quad x = \begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ x_n \end{bmatrix} \qquad X = \begin{bmatrix} x_{11} \\ . \\ . \\ x_{1n} \\ . \\ x_{n1} \\ . \\ x_{nn} \end{bmatrix}$$ and

$$
\begin{bmatrix} G_y \\ G_x \end{bmatrix} =
\left[\begin{array}{cccccccccccccccc}
1 & & & & 1 & & & & 1 & & & & 1 & & & \\
 & 1 & & & & 1 & & & & 1 & & & & 1 & & \\
 & & . & & & & . & & & & . & & & & . & \\
 & & & 1 & & & & 1 & & & & 1 & & & & 1 \\
-1 & -1 & . & -1 & & & & & & & & & & & & \\
 & & & & -1 & -1 & . & -1 & & & & & & & & \\
 & & & & & & & & -1 & -1 & . & -1 & & & & \\
 & & & & & & & & & & & & -1 & -1 & . & -1
\end{array}\right] = G
$$

$$(2n \times n^2)$$

Given this notation we formulate the problem maximizing net social monetary gain as:

Find $(\overline{Y}, \overline{X}, \overline{\rho})$ that maximizes

$$
\left[\begin{bmatrix} C \\ -T \\ 0 \end{bmatrix} - \begin{bmatrix} Q & 0 & -E^T \\ 0 & 0 & -G_\delta^T \\ E & G & 0 \end{bmatrix} \begin{bmatrix} Y \\ X \\ \rho \end{bmatrix} \right]^T \begin{bmatrix} Y \\ X \\ \rho \end{bmatrix}
$$

subject to

$$
\begin{bmatrix} C \\ -T \\ 0 \end{bmatrix} - \begin{bmatrix} Q & 0 & -E^T \\ 0 & 0 & -G_\delta^T \\ E & G & 0 \end{bmatrix} \begin{bmatrix} Y \\ X \\ \rho \end{bmatrix} \le 0
$$

and $\quad (Y^T X^T \rho^T) \ge 0^T$

where

$C = \begin{bmatrix} \lambda \\ -\upsilon \end{bmatrix} \quad Y = \begin{bmatrix} y \\ x \end{bmatrix} \quad Q = \begin{bmatrix} \Omega & \\ & H \end{bmatrix}$ Constituting elements defined earlier and

$$\rho = \begin{bmatrix} \rho_y \\ \rho_x \end{bmatrix}, \quad \rho_y = \begin{bmatrix} \rho_1 \\ \rho_2 \\ . \\ \rho_n \end{bmatrix}, \quad \rho_x = \begin{bmatrix} \rho^1 \\ \rho^2 \\ . \\ \rho^n \end{bmatrix}, \text{ where}$$

ρ_i, ρ^i are respectively the shadow demand and supply prices in region i

$$T = \begin{bmatrix} t_{11} \\ . \\ t_{1n} \\ . \\ t_{n1} \\ . \\ t_{nn} \end{bmatrix}$$

where t_{ij} represents the unit transportation cost between region i and j

$E \equiv G$, and

$$G_\delta = \begin{bmatrix} 1/(1+\delta_{11}) & . & . & 1/(1+\delta_{n1}) & \\ . & . & . & . & \\ & . & . & . & . \\ & & . & . & . & 1/(1+\delta_{nn}) \\ -1 & . & . & . & \\ & . & . & . & . \\ & & . & . & . & . \\ & & & . & . & . & -1 \end{bmatrix}$$

$$(2n \times n^2)$$

Where δ_{ij} is the ad-valorem tariff imposed by region j for imports from region i.

The solution to this maximization problem satisfies the market equilibrium condition and the locational price equilibrium with ad valorem tariff condition. We use this problem formulation to solve for equilibrium prices and quantities. This specification enabled us to compute the competitive equilibrium prices, the quantities supplied and demanded, and the level of imports and exports for each country. We then conducted a free trade simulation by removing all the trade restrictions imposed by the importing countries. The comparison of the volume of trade and level of prices under the free trade scenario and the tariff regime allowed us to quantify the adverse impacts of trade barriers on the apple market.

IV.Empirical Results

Production, Demand and Price Data for 1971-2000 extracted from the *Food and Agricultural Organization Database* was used to estimate the linear demand and supply relations for 24 countries/regions. Countries with very little production/consumption were aggregated and demand and supply relations were derived for these aggregated regions. Prices in these regions were derived as a weighted average of the individual prices with the ratio of production/demand serving as the weights. All prices were converted to US$. Most data series showed strong autocorrelation and Weighted Least Squares Estimation was then carried out by transforming the data. Transportation prices were calculated by using the data from the *Ocean Freight Rate Bulletins*.

Total apple trade in the free trade model is significantly greater than the baseline model. Imports increase in India, Rest of Asia, Rest of North and Central America and in Rest of Africa. US exports increase by about 8%. In the case of free trade India, Rest of Asia, Rest of North and Central America and Rest of Africa would all import more. This is reasonable given that all these countries have high tariff regimes and have very low domestic production. India is a very big market for apples in the case of tariff reduction. There is a price drop of more than 15% in the free trade scenario resulting in a spurge in demand.

V. Concluding Remarks

We built a spatial equilibrium model to assess the effect of trade barriers on US apple exports. The model identifies 24 countries/regions and used data covering 1971-2000 to calculate equilibrium quantities and prices under the tariff regime and compare it with the results in a free trade scenario. The important findings were that apple trade increases significantly with the removal of tarrifs and resulted in an increase in US apple exports. A significant price drop in India identifies it as a potential market for US apples. The major importing countries/regions are Developing Africa, Mexico, Rest of North and Central America, India, and Rest of Asia. Removal of trade barriers increases net world welfare and is also very beneficial to US apple exporters.

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