Trade Policies in World Apple and Juice Markets

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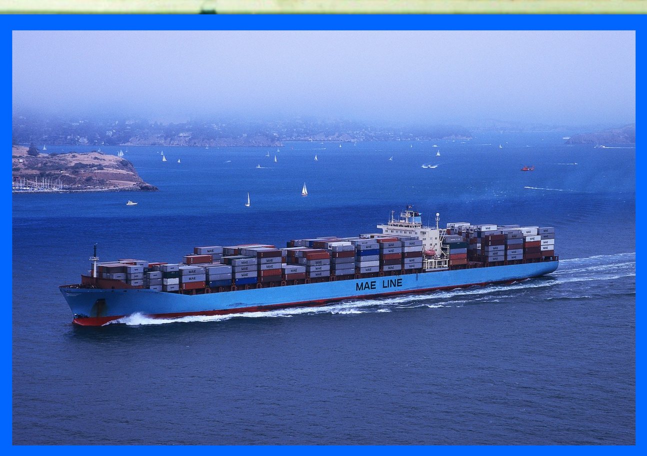
1. Introduction

Intermediate commodities are generally modeled as inputs in the production of final commodities but not as final products for consumption. This study allows for final consumption of the intermediate good.

The model can determine the optimal allocation of apples used in juice production in addition to the optimal production, consumption, prices, and trade flows of both commodities. It models apples both as a raw material along with other processing inputs in the production of apple juice and as a final consumption good.



2. Objectives

The objectives of this study are to

(1) develop a theoretical analysis to examine the effects of trade liberalization in an intermediate and final good framework, and

(2) construct a spatial equilibrium model of world apple and apple juice markets to quantify the effects of tariff removal on these markets.

3. Theoretical Model

The theoretical model consists of three countries i, j, and k (United States, China, and Rest of World respectively) and two commodities (apples and apple juice). Region i (United States) and j (China) produce and consume apples and juices. Region k (the rest of the world) produces only apples but consumes apple and juice. Regions i and j export apples to region k, and region j exports juice to regions i and k. Region k could be a tropical region which produces limited amount of apples, but does not produce juice, and imports apples from i and j and juice from j.

	Region i	Region j	Region k
Apple Supply	$S_i^I = S_i^I(P_i^I, \mathbf{Z_i^I})$	$S_j^I = S_j^I(P_j^I, \mathbf{Z_j^I})$	$S_k^I = S_k^I(P_k^I, \mathbf{Z_k^I})$
Apple Demand	$D_i^I = D_i^C(P_i^I, \mathbf{Y_i^C}) + D_i^R(P_i^I, P_i^F, \mathbf{Y_i^R})$	$D_j^I = D_j^C(P_j^I, \mathbf{Y_j^C}) + D_j^R(P_j^I, P_j^F, \mathbf{Y_j^R})$	$D_k^I = D_k^C(P_k^I, \mathbf{Y_k^C})$
Juice Supply	$S_i^F = S_i^F(P_i^I, P_i^F, \mathbf{Z_i^F})$	$S_j^F = S_j^F(P_j^I, P_j^F, \mathbf{Z_j^F})$	Not Applicable
Juice Demand	$D_i^F = D_i^F(P_i^F, \mathbf{Y_i^F})$	$D_j^F = D_j^F(P_j^F, \mathbf{Y_j^F})$	$D_k^F = D_k^F(P_k^F, \mathbf{Y_k^F})$
Apple Price Linkages	$P_i^I = P_k^I - t_{ik}^I$	$P_j^I = P_k^I - t_{jk}^I$	$P_k^I = P_i^I + t_{ik}^I$ and $P_k^I = P_j^I + t_{jk}^I$
Juice Price Linkages	$P_i^F = P_j^F + t_{ji}^F$	$P_j^F = P_i^F - t_{ji}^F$ and $P_j^F = P_k^F - t_{jk}^F$	$P_k^F = P_j^F + t_{jk}^F$

- Variable Definitions

The subscripts i, j, and k refer to the three regions, the superscripts I and F refer to apples (intermediate good) and juice (final good), S^I is apple supply, D^I is apple demand for consumption and juice production, D^C is apple demand for consumption, D^R is apple demand for juice production, P^I is apple price, $\mathbf{Z}^I$ is a vector of supply shifters, $\mathbf{Y}^C$ is a vector of consumption demand shifters, P^F is juice price, $\mathbf{Y}^R$ is a vector of input demand shifters, S^F is apple supply, $\mathbf{Z}^F$ is a vector of juice supply shifters, D^F is demand for juice, $\mathbf{Y}^F$ is a vector of juice demand shifters, t_{ij} is the tariff imposed by region i on imports coming from region j, and similar definitions apply to other tariffs.

4. Theoretical Analysis and Results

- Market Equilibrium Conditions

$$S_i^I\left(\left(P_k^I - t_{ik}^I\right), \mathbf{Z_i^I}\right) = D_i^C\left(\left(P_k^I - t_{ik}^I\right), \mathbf{Y_i^C}\right) + D_i^R\left(\left(P_k^I - t_{ik}^I\right), \left(P_j^F + t_{ji}^F\right), \mathbf{Y_i^R}\right) + X_{ik}^I$$

$$S_j^I\left(\left(P_k^I - t_{jk}^I\right), \mathbf{Z_j^I}\right) = D_j^C\left(\left(P_k^I - t_{jk}^I\right), \mathbf{Y_j^C}\right) + D_j^R\left(\left(P_k^I - t_{jk}^I\right), P_j^F, \mathbf{Y_j^R}\right) + X_{jk}^I$$

$$S_k^I\left(P_k^I, \mathbf{Z_k^I}\right) + X_{ik}^I + X_{jk}^I = D_k^C\left(P_k^I, \mathbf{Y_k^C}\right)$$

$$S_i^F\left(\left(P_k^I - t_{ik}^I\right), \left(P_j^F + t_{ji}^F\right), \mathbf{Z_i^F}\right) + X_{ji}^F = D_i^F\left(\left(P_j^F + t_{ji}^F\right), \mathbf{Y_i^F}\right)$$

$$S_j^F\left(\left(P_k^I - t_{jk}^I\right), P_j^F, \mathbf{Z_j^F}\right) = X_{ji}^F + D_j^F\left(P_j^F, \mathbf{Y_j^F}\right) + X_{jk}^F$$

$$X_{jk}^F = D_k^F\left(\left(P_j^F + t_{jk}^F\right), \mathbf{Y_k^F}\right)$$

- Theoretical Results

$$\frac{dP_i^I}{dt_{ji}^F} = \frac{\overbrace{-\left[\left(\frac{\partial S_j^F}{\partial P_j^F} - \frac{\partial D_j^F}{\partial P_j^F}\right) + \left(-\frac{\partial D_k^F}{\partial P_k^F}\right)\right]\frac{\partial D_i^R}{\partial P_i^F}}^{(-)} \overbrace{-\left[\left(\frac{\partial S_i^F}{\partial P_i^F} - \frac{\partial D_i^F}{\partial P_i^F}\right)\left(-\frac{\partial D_j^R}{\partial P_j^F}\right)\right]}^{(+)}}{\underbrace{|A|}_{(-)}}$$

The first effect is positive as the U.S. import tariff increases the U.S. juice price, leading to higher demand for apples in juice production and apple price. The second effect is negative as U.S. juice import tariff lowers the Chinese juice price, reducing apple use in juice production and more apples in the world market.

$$\frac{dX_{ik}^I}{dt_{ji}^F} = \frac{\overbrace{\left[\left(\left(\frac{\partial S_j^F}{\partial P_j^F} - \frac{\partial D_j^F}{\partial P_j^F}\right) + \left(-\frac{\partial D_k^F}{\partial P_k^F}\right)\right)\left(\left(\frac{\partial S_j^I}{\partial P_j^I} - \frac{\partial D_j^I}{\partial P_j^I} - \frac{\partial D_j^R}{\partial P_j^I}\right) + \left(\frac{\partial S_k^I}{\partial P_k^I} - \frac{\partial D_k^I}{\partial P_k^I}\right)\right)\right]\left(\frac{\partial D_i^R}{\partial P_i^F}\right)}^{(+)} \underbrace{+\left[\left(\frac{\partial S_i^I}{\partial P_i^I} - \frac{\partial D_i^I}{\partial P_i^I} - \frac{\partial D_i^R}{\partial P_i^I}\right)\left(\frac{\partial S_i^F}{\partial P_i^F} - \frac{\partial D_i^F}{\partial P_i^F}\right)\right]\left[\left(\frac{\partial D_j^R}{\partial P_j^F}\right)\right]}_{(+)} \underbrace{-\left(\frac{\partial S_i^F}{\partial P_i^I} + \frac{\partial S_j^F}{\partial P_j^I}\right)\left(-\frac{\partial D_j^R}{\partial P_j^F}\right)\left(\frac{\partial D_i^R}{\partial P_i^F}\right)}_{(-)}}{\underbrace{|A|}_{(-)}}$$

The first effect is negative as U.S. tariff on Chinese juice increases U.S. juice price, leading to higher demand for apples in juice production and reducing U.S. apple exports. The second effect is negative as U.S. tariff reduces Chinese juice price and demand for apples in juice production, leading to more Chinese apples in the world market, and lowering ROW import demand for U.S. apples. The third effect is positive as the higher U.S. juice price leads to more apple use in juice production, leading to more apple production and exports.

$$\frac{dP_i^F}{dt_{ik}^I} = \frac{\overbrace{-\left[\left(\frac{\partial S_C^I}{\partial P_C^I} - \frac{\partial D_C^I}{\partial P_C^I} - \frac{\partial D_C^R}{\partial P_C^I}\right) + \left(\frac{\partial S_R^I}{\partial P_R^I} - \frac{\partial D_R^I}{\partial P_R^I}\right)\right]\left(\frac{\partial S_U^F}{\partial P_U^I}\right)}^{(+)} + \overbrace{\left[\left(\frac{\partial S_U^I}{\partial P_U^I} - \frac{\partial D_U^I}{\partial P_U^I} - \frac{\partial D_U^R}{\partial P_U^I}\right)\left(\frac{\partial S_C^F}{\partial P_C^I}\right)\right]}^{(-)}}{\underbrace{|A|}_{(-)}}$$

The first effect is negative as this tariff leads to reduced U.S. apple exports and more apples in U.S. juice production, lowering U.S. juice prices. The second effect is positive because the reduced U.S. apple exports leads to larger Chinese apple exports, reducing Chinese juice production and exports to the United States, causing U.S. juice price to rise.

5. Empirical Model

- 31 Region Spatial Equilibrium Model

Though numerous studies have used the spatial equilibrium model (SEM) for trade modeling, only a few studies have modeled intermediate goods that are used both as raw commodities in the production of final goods and for consumption as final good.

Past SEM studies have analyzed trade policy impacts using specific tariffs, which is similar to incorporating transportation costs. Since the Uruguay Round all tariffs are presented in the form of ad valorem tariffs, therefore we include ad valorem tariffs imposed on apple and juice by importing countries.

The SEM is solved using a mixed complementarity problem. The Kuhn-Tucker conditions of the SEM problem obtained by nonlinear optimization yield the economic equilibrium conditions.

- Mixed Complementarity Problem and Economic Equilibrium Conditions

1) Total quantity of apples shipped into a region is greater than or equal to quantity of apples demanded for consumption and for juice production.
2) Total quantity of juice shipped into a region is greater than or equal to quantity of juice demanded for consumption
3) Total shipments of apples from a region are less than or equal to quantity of apples supplied in that region
4) Total shipments of juice from a region are less than or equal to quantity of juice supplied in that region
5) Willingness to pay for apples is less than or equal to market demand price for apples
6) Willingness to pay for juice is less than or equal to market demand price for juice
7) Marginal cost of production for apples is greater than or equal to market supply price for apples
8) Marginal cost of production for juice is greater than or equal to market supply price for juice
9) Apple supply price in region i plus transportation costs from i to j times ad valorem tariff is greater than or equal to apple market demand price
10) Juice supply price in region i plus transportation costs from i to j times ad valorem tariff is greater than or equal to juice market demand price

Data Sources

The data for the empirical analysis comes from various sources:

- Food and Agriculture Organization of the United Nations (FAO) for production, demand, prices, and trade data for apples and prices and trade data for juice.
- United States Department of Agriculture (USDA) World Apple Juice Situation Report for production and demand data for juice.
- USDA Ocean Freight Rate Bulletin for transportation costs.
- United Nations Commission for Trade and Development database for tariff rates.

Results

Baseline Apple Quantities Supplied Demanded and Prices and Impact of Free Trade for Selected Countries.

	Quantity Supplied (1,000 Tons)		Quantity Demanded (1,000 Tons)		Price ($/Ton)	
Regions	Baseline	Percentage Change	Baseline	Percentage Change	Baseline	Percentage Change
Brazil	1271	-0.97	1203	0.79	386	-1.59
Chile	1089	0.03	699	-0.02	336	0.04
China	20194	1.70	18119	-1.22	292	8.18
France	2167	-0.10	1853	0.45	478	-1.29
Germany	1376	-0.07	1582	0.19	508	-1.21
India	1544	-8.43	1777	3.67	592	-29.31
Poland	2666	-0.40	2253	0.14	494	-1.25
Russia	4366	0.01	4706	1.04	589	-16.64
Turkey	1940	-0.13	1872	0.36	491	-1.79
United States	2352	0.02	1967	-0.05	352	0.13

Chinese apple price and supply increase under free trade.

India and Russia import more apples, and consequently, their prices decrease and consumption increase under free trade.

Baseline Juice Quantities Supplied Demanded and Prices and Impact of Free Trade for Selected Countries.

	Quantity Supplied (1,000 Tons)		Quantity Demanded (1,000 Tons)		Price ($/Ton)	
Regions	Baseline	Percentage Change	Baseline	Percentage Change	Baseline	Percentage Change
Canada	21	-29.09	89	0.71	777	-5.94
Chile	28	1.36	3	-8.22	595	2.14
China	423	12.66	40	-58.20	537	2.74
France	37	1.30	37	-0.23	741	1.15
Germany	76	4.62	294	-0.59	767	1.66
India	67	3.45	33	-1.54	737	1.73
Poland	169	11.17	23	-27.19	753	1.69
Russia	32	-66.92	24	48.05	821	-6.49
Turkey	40	-6.60	40	2.73	847	-11.44
United States	134	1.62	301	-1.04	697	2.11

China and Poland augment their juice production under free trade. These countries export more juice and consume less.

Canada and Russia reduce their juice production. Russia imports and consumes more juice,

6. Conclusion

Apples and juice are highly traded commodities and free trade can impact both markets.

This study develops a theoretical model to analyze the apple and juice trade policies.

This study implements a spatial equilibrium trade model to quantify the effects of free trade in apple and juice world markets.

Results show that free trade has a more significant effect in apple trade than in juice trade.

Apple exporting countries such as China, Poland, and the United States and importing countries such as India and Russia gain from free trade.