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Tariff Equivalent of Japanese Sanitary and Phytosanitary: Econometric Estimation of Protocol for U.S.-Japanese Apple Trade

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Abstract
This paper econometrically estimates the tariff equivalent of sanitary and phytosanitary to U.S. apple imports in Japan. Many studies calculate the tariff equivalent of the Japanese SPS to imports of U.S. apple using the price differential between the domestic price and export prices, but this method is problematic when the SPS measures are prohibitive. This study uses a method that can econometrically estimate the tariff equivalent of the prohibitive technical barriers to trade suggested by Yue and Beghin (2009). This approach overcomes the lack of observed data on bilateral trade flows caused by prohibitive SPS measures and accounts for goods differentiated by the place of origin. Our estimated results show that the ad-valorem tariff equivalent of prohibitive Japanese SPS measures is extremely high, and its average effect on U.S. apples over the entire period is 118.9%. The Japanese SPS policy regarding overseas apples is stringent; hence, it is expected that Japan would benefit from the elimination of the SPS barriers.

Keywords
U.S.-Japanese apple trade, sanitary and phytosanitary, tariff equivalent, Kuhn-Tucker approach, corner solution

JEL Classification: F13, Q17, Q18.

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1. Introduction

This paper econometrically estimates the tariff equivalent of sanitary and phytosanitary (SPS) to U.S. apple imports in Japan. Many studies calculate the tariff equivalent of the Japanese SPS to the imports of U.S. apple using the price differential between the domestic price and export prices; this method is known as the price-wedge approach. This study uses an alternative method that can econometrically estimate the tariff equivalent of the prohibitive technical barriers to trade suggested by Yue and Beghin (2009). This approach overcomes the lack of observed data on bilateral trade flows caused by prohibitive SPS measures and accounts for goods differentiated by the place of origin.

Several studies have used the price-wedge approach to address the cost of the Japanese SPS regarding U.S. apples. Calvin and Krissoff (1998) first analyzed this case assuming perfect substitution between domestic and imported goods. They estimated the tariff equivalent at approximately 27.2% for four years from 1994 to 1998. Yue, Beghin, and Jensen (2006) generalized the basic price-wedge approach for cases wherein goods are an imperfect substitution. Their estimate is approximately 51.7% for 3 years from 2000 to 2002, but the estimated result is sensitive to the given parameters of substitution and preference. These two studies described above limited to a case in which all phytosanitary protocols were removed. Calvin, Krissoff, and Foster (2007) used a participation model to measure the economic costs of SPS measures and their approach enables an estimation of the costs of fire blight and codling moth protocols separately. They show that, during seven years from 1998 to 2004, the cost of fire blight was 3 cents per pound and the cost of methyl bromide fumigation and other costs were 8 cents per pound when a U.S. grower's price was 50 cents per pound, despite the existence of sensitivity to parameters. However, the price-wedge method used previous studies is problematic when SPS measures are prohibitive. This is because, in such cases, bilateral trade flows are not observed; hence, the results are underestimated.

This study attempts to econometrically estimate the tariff equivalent of Japanese SPS measures as prohibitive trade barriers. In the empirical analysis of international trade flow, one of the most important problems is the presence of zero trade flow. Yue and Beghin (2009) developed an approach to estimate the tariff equivalent of technical barriers to trade by applying Wales and Woodland's Kuhn-Tucker approach and evaluating the Australian SPS barriers to New Zealand apple imports. They calculated it at around 99%. The study uses this approach to econometrically estimate the tariff equivalent of Japanese SPS measures when zero trade flow is considered.

2. Model for the Econometric Estimation of SPS Measures

This study uses the approach suggested by Yue and Beghin (2009). They derived a method to econometrically estimate the tariff equivalent and forgone trade effects of a prohibitive TBT, on the basis of the Kuhn-Tucker approach of Wales and Woodland (1983), to corner solutions in consumer choice.

In this model, assume that the representative global consumer maximizes the utility of consuming three types of apples (U.S. apples, Japanese apples, and aggregated other apples) and other goods subject to a budget constraint:

$$\max_{\mathbf{x},AOG} U = \sum_j \exp\left(\eta_j GDP + \delta_j + \varepsilon_j\right) \ln\left(x_j + \omega_j\right) + \upsilon(AOG)$$
$$\text{s.t.} \quad \sum_j p_j x_j + AOG \leq I, \quad AOG \geq 0, \quad x_j \geq 0 \tag{1}$$

where j is the index of the origin of apples, in this model, us, jp, and $other$. x_j is the quantity of apples j and $\mathbf{x}$ are the vectors of those. AOG is an aggregate of all other consumer goods, assumed to be numeraire. GDP is the gross domestic product per capita as the socio-demographic information of the importing country having an impact on preference for x_j through parameters η_j. δ_j is the parameter of preference not based on socio-demographics. ε_j indicates the unobserved error components. ω_j is the parameter that indicates that minimum consumption does not depend on the taste of consumers. GDP and these parameters construct the preference for each type of apple in the form of an exponential function. Further, AOG creates utility through function υ. In a budget constraint, p_j is the consumer price faced by the importing country. This price includes trade costs, for instance, transportation costs and trade barriers. I is the income of the representative consumer.

The consumer price p_j can be decomposed into an export price, transportation cost, tariffs, and technical barriers to trade. In this analysis, the technical barrier to apple trade is the SPS:

$$p_j = \left(wp_j + \gamma d_j\right)\left(1 + t_j + SPS_j\right) \tag{2}$$

where wp_j is an export price and d_j represents the distance between exporting countries and destinations, affecting consumer price through parameter γ (unit rate of transportation cost).[1] t_j is the ad-valorem tariff of the importing country. Finally, SPS_j represents the ad-valorem tariff equivalents of the SPS trade barrier. This analysis focuses on Japanese SPS measures to imports from the U.S., so SPS is the only set for which the Japanese consumer price is decomposed.

The corresponding first-order necessary and sufficient Kuhn-Tucker conditions are obtained as follows. Rearranging these conditions yields the following equations for observation $i = 1, \cdots, N$:[2]

$$g_{us}^{i} \equiv \ln\left[v'(AOG)\left(wp_{us}^{i} + \gamma d_{us}^{i}\right)\left(1 + t_{us}^{i}\right)\left(x_{us}^{i} + \omega_{us}\right)\right] - \delta_{us} - \eta_{us} GDP^{i} \tag{3}$$

$$g_{jp}^{i} \equiv \ln\left[v'(AOG)\left(wp_{jp}^{i} + \gamma d_{jp}^{i}\right)\left(1 + t_{jp}^{i}\right)\left(x_{jp}^{i} + \omega_{jp}\right)\right] - \delta_{jp} - \eta_{jp} GDP^{i} \tag{4}$$

$$g_{other}^{i} \equiv \ln\left[v'(AOG) p_{other}^{i}\left(x_{other}^{i} + \omega_{other}\right)\right] - \delta_{other} - \eta_{other} GDP^{i} \tag{5}$$

In equation (5), import price p_{other}^{i} is used in place of export price plus transport cost because of multiple sourcing and distances associated with other imported apples. For observation in Japan, equations (3) and (5) are modified to include the tariff equivalent as follows:

$$g_{j}^{jp} \equiv \ln\left[v'(AOG)\left(wp_{j}^{jp} + \gamma d_{j}^{jp}\right)\left(1 + t_{j}^{jp} + SPS_{j}^{jp}\right)\left(x_{j}^{jp} + \omega_{j}\right)\right] - \delta_{j} - \eta_{j} GDP^{us} \tag{6}$$

In addition, for observations i, the following equations are used:

$$X_{us}^{i} = \begin{cases} \phi\left(g_{us}^{i}\right) \cdot \left|J_{us}^{i}\right| & \text{when} \quad x_{us}^{i} > 0 \\ \Phi\left(g_{us}^{i}\right) & \text{when} \quad x_{us}^{i} = 0 \end{cases} \tag{7}$$

$$X_{jp}^{i} = \begin{cases} \phi\left(g_{jp}^{i}\right) \cdot \left|J_{jp}^{i}\right| & \text{when} \quad x_{jp}^{i} > 0 \\ \Phi\left(g_{jp}^{i}\right) & \text{when} \quad x_{jp}^{i} = 0 \end{cases} \tag{8}$$

[1] For simplicity, assume the unit rate of transportation to be the same per unit of distance.
[2] For more details, refer to Yue and Beghin (2009).

$$X_{other}^{i} = \begin{cases} \phi\left(g_{other}^{i}\right) \cdot \left|J_{other}^{i}\right| & \text{when} \quad x_{other}^{i} > 0 \\ \Phi\left(g_{other}^{i}\right) & \text{when} \quad x_{other}^{i} = 0 \end{cases} \tag{9}$$

where $\left|J_j^i\right|$ is the absolute value of the Jacobian for the transformation from g_j^i to x_j^i. Φ is the cumulative density function of standard normal distribution for the goods that are consumed. ϕ is the density function of standard normal distribution for the goods that are consumed. Using equations (3) to (9), the log-likelihood function of this analysis is as follows:

$$l = \sum_{i=1}^{N} \ln\left(X_{us}^{i} \cdot X_{jp}^{i} \cdot X_{other}^{i}\right) \tag{10}$$

By maximizing equation (10), the parameter SPS that represents the ad-valorem tariff equivalent of Japanese SPS to the imports of apples and other parameters $\left(\upsilon'(AOG), \gamma, \omega_j, \delta_j, \text{and } \eta_j\right)$ are estimated. The optimization method used in maximum likelihood estimation is the Newton-Raphson method. The program is run in Stata version 11.1.

3. Data

This framework is applied to Japanese SPS measures to use equation (6). In this analysis, as mentioned above, three types of apples are considered. To estimate the tariff equivalent of Japanese SPS, the study considers the entire world and time series and incorporates an unbalanced pooled data of 148 countries from 1991 through 2007, including 1117 observations. The countries, including the data set, are listed in Table 1.

This approach requires apple consumption per capita from each point of origin, GDP per capita as the socio-demographic information of the importing countries, export unit price, distance between the importing and exporting countries, and the tariff rate. The apple consumption per capita is derived from the trade flow data on apple imports and domestic production data. Bilateral export quantities and export prices (FOB price) data come from the UN Comtrade database. Domestic production data is reported by FAO. Outside of U.S. and Japan, the price of aggregated other apples is a consumption-weighted average of other imported fresh apples and domestically produced apples. I use the import CIF price reported by FAO instead of FOB prices plus transportation cost to overcome multiple sourcing and distances with respect to other imported apples. Data regarding the population and GDP per capita are derived from the World Development Indicator. Distance data comes from CEPII. Finally, the tariff rates are obtained from TRAINS database. The descriptive statistics are shown in Table 2.

4. Estimation Results

I take account two different situations for estimating the tariff equivalent of Japanese SPS. In the first situation, the same stringency of SPS is assumed for all countries, but is separated between the periods of actual prohibition on imports before 1993 and the periods of actual quarantine limitations on import after 1994. In the second situation, to identify the effect on U.S., I assume the same parameters for all-periods considering it to be an all period average including the import prohibitive effect, but discriminate between the restriction on U.S. apples and other apples. This case is unrealistic from a viewpoint of actual external policy that must be imposed on all countries equally. However, it is justified that the SPS measures have relatively different effects on different countries as per the domestic levels of quarantines for apples.

The estimation results of the first situation are shown in Table 3. All the parameters have problem-free signs and statistical significance of at least 10%. In addition, these parameters are statistically significant at the 1% level, excluding δ_{jp} and ω_{jp}. During prohibitive periods, the ad valorem equivalent of the SPS barriers to the FOB price, inclusive of transportation cost, is approximately 966.9%. Later, with the lifting of the prohibitive constraint, the tariff equivalent is diminished to 120.0%. The estimated preference parameters, as constant term, are in the order of U.S. apples, other apples, and Japanese apples. Moreover, the preference parameters with respect to GDP per capita of importing countries $\hat{\eta}$ are high in the order of other apples (0.000116), Japanese apples (0.0000372), and U.S. apples (0.0000123). These imply that the consumers prefer U.S. apples initially, but the preference moves in this order as the consumer's income increases. All of ω as threshold minimum consumption levels does not depend on taste are positive and significant. The average unit fee for transportation and insurance parameter γ is significant and estimated to be \$0.0581/(km*kg). Finally, the point estimate of the marginal utility of AOG is positive and significant.

The estimation results of the second scenario are shown in Table 4. Most of the preference parameters are similar to those in scenario 1 in terms of sign, magnitude, and significance other than δ_{jp}. The average tariff equivalent of SPS to U.S. apples is approximately 118.9%. This estimate value is considerably higher than the previous results; however, it is considered to be the aftereffects of including the prohibitive effect of Japanese SPS, particularly, from 1991 to 1993 as well as the difference of the sample period and functional form. The average tariff equivalent of SPS to other apples is approximately 281.0%. This suggests that U.S. apples are less regulated in comparison to other apples. In any case, the Japanese SPS measures for overseas apples are too stringent to exceed 100% in tariff equivalent.

5. Conclusion

This analysis employs Yue and Beghin’s approach for the estimation of tariff equivalents of Japanese SPS to U.S. apple imports. Previous studies use the price-wedge method to evaluate the tariff equivalent of Japanese SPS, but it is inappropriate when SPS is prohibitive. In this study, I attempt to econometrically estimate the tariff equivalent of these as prohibitive trade barriers. Yue and Beghin (2009) derive a method to econometrically estimate the tariff equivalent and forgone trade effects of a prohibitive TBT, on the basis of the Kuhn-Tucker approach, to corner solutions in consumer choice. Our estimated results show that the ad-valorem tariff equivalent of the Japanese prohibitive SPS measures is extremely high, and its average effect on U.S. apples for the entire period is 118.9%. It is considered to be the aftereffects of including the prohibitive effect of SPS measures. In the view of the estimation results and the case study of the Australian SPS policy analyzed by Yue and Beghin (2009), the Japanese SPS policy for overseas apples is stringent; hence, it is expected that Japan would benefit from the elimination of the SPS barriers.

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Table 1. Countries included in the data set

Countries	# of obs.	Countries	# of obs.	Countries	# of obs.
Albania	5	France	15	Nigeria	2
Algeria	6	Gabon	5	Norway	5
Angola	3	Georgia	5	Pakistan	9
Antigua and Barbuda	4	Germany	16	Panama	7
Argentina	14	Ghana	4	Paraguay	15
Armenia	1	Greece	16	Peru	9
Australia	3	Grenada	3	Philippines	13
Austria	16	Guatemala	7	Poland	16
Azerbaijan	3	Guinea	1	Portugal	16
Bangladesh	9	Guyana	4	Romania	5
Barbados	5	Haiti	1	Russian Federation	4
Belarus	2	Honduras	8	Rwanda	2
Belgium	8	Hungary	15	Saudi Arabia	8
Belize	6	Iceland	6	Senegal	7
Benin	7	India	5	Seychelles	5
Bermuda	2	Indonesia	10	Slovak Republic	14
Bolivia	14	Ireland	16	Slovenia	15
Bosnia and Herzegovina	2	Israel	1	Solomon Islands	2
Botswana	2	Italy	16	South Africa	3
Brazil	17	Jamaica	6	Spain	16
Brunei Darussalam	8	Japan	15	Sri Lanka	9
Bulgaria	5	Jordan	6	St. Kitts and Nevis	2
Burkina Faso	7	Kazakhstan	1	St. Lucia	7
Burundi	2	Kenya	7	St. Vincent and the Grenadines	7
Cambodia	5	Kuwait	4	Sudan	3
Cameroon	6	Kyrgyz Republic	5	Swaziland	1
Canada	14	Lao PDR	6	Sweden	16
Cape Verde	2	Latvia	15	Switzerland	10
Central African Republic	4	Lebanon	7	Tajikistan	2
Chad	2	Libya	2	Tanzania	7
Chile	2	Lithuania	15	Thailand	7
China	14	Luxembourg	8	Togo	7
Colombia	14	Madagascar	3	Trinidad and Tobago	9
Congo, Dem. Rep.	3	Malawi	6	Turkey	8
Congo, Rep.	5	Malaysia	9	Turkmenistan	2
Costa Rica	8	Maldives	7	Uganda	9
Cote d'Ivoire	9	Mali	6	Ukraine	3
Croatia	5	Malta	16	United Arab Emirates	4
Cuba	7	Mauritius	7	United Kingdom	16
Cyprus	13	Mexico	11	United States	16
Czech Republic	14	Moldova	4	Uruguay	12
Denmark	16	Mongolia	3	Uzbekistan	2
Djibouti	2	Morocco	8	Vanuatu	3
Dominican Republic	1	Mozambique	8	Venezuela, RB	11
Ecuador	12	Namibia	5	Vietnam	9
Egypt, Arab Rep.	5	Nepal	7	Yemen, Rep.	2
El Salvador	10	Netherlands	16	Zambia	5
Estonia	15	New Zealand	6	Zimbabwe	7
Ethiopia	4	Nicaragua	9		
Finland	16	Niger	7		

Table 2. Descriptive statistics

Variables	Unit	Obs	Mean	Std. Dev.	Min	Max
x_{jp}	kg	1117	0.095	0.823	0.000	8.350
x_{us}	kg	1117	0.407	1.546	0.000	14.736
x_{other}	kg	1117	7.324	11.254	0.000257	68.238
p_{jp}	\$/kg	1117	5.020	2.160	0.562	15.620
p_{us}	\$/kg	1117	0.708	0.252	0.152	5.638
p_{other}	\$/kg	1117	0.673	0.473	0.0462	6.286
t_{jp}		1117	0.134	0.146	0.000	1.000
t_{us}		1117	0.141	0.146	0.000	1.000
t_{other}		1117	0.134	0.146	0.000	1.000
d_{jp}	km	1117	10196.960	3696.476	0.000	18740.370
d_{us}	km	1117	8500.901	3512.908	0.000	16357.830
GDP per capita	$	1117	9073.752	11031.210	83.00292	72295.980

Table 3. Estimation results (Scenario 1)

Parameters	Coef.	Std. Err.	z-value	p-value
SPS during prohibitive periods	9.669	2.438	3.97	0.000
SPS during quarantine periods	1.200	0.355	3.38	0.001
$v'(AOG)$	2.907	0.0215	135.17	0.000
η_{us}	0.0000123	0.00000413	2.98	0.003
η_{jp}	0.0000372	0.00000502	7.41	0.000
η_{other}	0.000116	0.00000629	18.38	0.000
δ_{us}	5.00499	0.0826	60.57	0.000
δ_{jp}	-0.682	0.378	-1.80	0.071
δ_{other}	0.476	0.0852	5.59	0.000
ω_{us}	0.102	0.00874	11.63	0.000
ω_{jp}	0.00203	0.000831	2.45	0.014
ω_{other}	0.176	0.0191	9.21	0.000
γ	0.0581	0.000692	84.05	0.000

Table 4. Estimation results (Scenario 2)

Parameters	Coef.	Std. Err.	z-value	p-value
SPS to U.S. apples	1.189	0.589	2.02	0.043
SPS to other apples	2.810	1.0173	2.76	0.006
$v'(AOG)$	4.595	0.0446	103.04	0.000
η_{us}	0.0000119	0.00000426	2.79	0.005
η_{jp}	0.0000372	0.00000502	7.40	0.000
η_{other}	0.000116	0.00000650	17.85	0.000
δ_{us}	5.474	0.0834	65.63	0.000
δ_{jp}	-0.220	0.384	-0.57	0.567
δ_{other}	0.932	0.0858	10.86	0.000
ω_{us}	0.102	0.00873	11.68	0.000
ω_{jp}	0.00203	0.000828	2.45	0.014
ω_{other}	0.176	0.0193	9.11	0.000
γ	0.0586	0.000456	128.60	0.000