Tariff Equivalent of Technical Barriers to Trade with Imperfect Substitution and Trade Costs

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Abstract

The price-wedge method yields a tariff-equivalent estimate of technical barriers to trade (TBT). An extension of this method accounts for imperfect substitution between domestic and imported goods and incorporates recent findings on trade costs. We explore the sensitivity of this revamped tariff-equivalent estimate to its determinants (substitution elasticity, preference for home good, trade cost, and to the reference data chosen). We use the approach to investigate the ongoing U.S.-Japan apple trade dispute and find that removing the Japanese TBT would yield limited export gains to the United States. We then draw policy implications of our findings.

Keywords: apple trade, Japan, price wedge, sanitary and phytosanitary (SPS), tariff equivalent, technical barriers to trade (TBT), trade cost, trade dispute.

JEL Code: F1, F18, Q17, Q18

Introduction

Article 20 of the General Agreement on Tariffs and Trade (GATT) permits governments to set their own standards and regulations on trade in order to protect human, animal, or plant life or health, provided they do not discriminate among countries or use this motive as concealed protectionism. In addition, two specific World Trade Organization (WTO) agreements deal with food safety and animal and plant health, and with product standards: the Sanitary and Phytosanitary Measures Agreement (SPSA) and the Technical Barriers to Trade Agreement (TBTA). The SPSA allows countries to set their own standards, but it requires that the standards should not arbitrarily discriminate between countries with similar conditions. The TBTA is generated to minimize unnecessary obstacles in regulations, standards, and testing and certification procedures. In practice, however, some governments use stricter health and safety regulations than necessary to isolate domestic producers from international competition. The stricter regulations may lead to questionable impediments to imports that compete with domestic products, in addition to the existing tariff barriers. When the possibility of a disease or pest transmission is very low or threat to food safety is small, these trade impediments often cause welfare losses for importing countries and mercantilist losses for exporting countries due to reduced exports.

These issues have of course attracted the attention of economists (Anderson, McRae, and Wilson 2001; Bureau, Marette, and Schiavina 1998; Josling, Roberts, and Orden 2004; Roberts and Krissoff 2003). The growing literature on sanitary and phytosanitary (SPS) regulations and other TBTs often uses a price-wedge approach to quantify the impact of a barrier on market equilibrium and trade (see Calvin and Krissoff 1998; Campbell and Gossette 1994; and Beghin and Bureau 2001 for a review). Although not unique or sophisticated, the method has been legitimized in the economics literature with some prescriptions and qualifiers to account for transportation cost and quality differences (Baldwin 1991; Beghin and Bureau 2001; and Deardorff and Stern 1999). The use of a price-wedge approach often abstracts from quality differences or simply addresses the difference by choosing “close” substitutes. Transportation costs may be reduced to the CIF-FOB (cost, insurance, and freight–free on board) differential and abstract from the internal transportation cost once imports are landed. All price-wedge estimates we are aware of rely on the assumption of homogeneous commodities and a price arbitrage condition. By assuming that domestic and imported goods are perfect substitutes, the gap between their prices reflects trade impediments from various policies and natural protection. Border tariffs and transportation and transaction costs prevent full arbitrage between the two prices (Head and Mayer 2002; Baldwin et al. 2003). Hence, in principle, the price gap can yield an estimate of the TBT once transportation and trade costs and other impediments have been taken into account.

In this paper we derive a revamped tariff equivalent of a TBT. We extend the price-wedge framework by first relaxing the homogeneous commodity assumption, a straightforward but instrumental step overlooked in the literature on TBT measurement. We account explicitly for commodity heterogeneity and perceived quality of substitutes. Next, we incorporate recent developments and findings on large and costly border effects arising from transportation, linguistic differences, and poor infrastructure and law enforcement (Anderson and van Wincoop 2004; Baldwin et al. 2003; Head and Mayer 2002; and Hummels and Skiba 2003). Two major findings of this new literature are particularly relevant to our work. First, trading costs are very large and often greater than policy impediments (Anderson and van Wincoop 2004; Hummels and Skiba 2003) and cannot be ignored. While CIF/FOB ratios have fallen over time, other transportation and trade costs have remained high and have been underestimated. Second, these costs are structured on a per-unit basis rather than following the so-called iceberg method; that is, they act as a specific tariff rather than an ad valorem tax (Hummels and Skiba 2003). These per-unit costs shift supply in a parallel manner rather than proportionally, which influences the estimate of the TBT.

We systematically explore the robustness of the tariff-equivalent estimate to underlying assumptions, that is, commodity heterogeneity, consumer preference for the home good, trading and transportation costs, and the chosen reference data. Using a simple approach, we derive the sensitivity of the tariff equivalent to varying assumptions on these determinants and its implications for welfare analysis.

Our paper bridges two methods often used to estimate the trade effects of TBTs: the tariff-equivalent–price-wedge approach mentioned previously and use of a gravity equation. Recent conceptual developments have provided theoretical foundations to the gravity equation approach and account explicitly for relative prices of traded and domestic substitutes and for trading costs. In addition, they attempt to better measure and decompose "border effects" of trade barriers and transportation costs between trade partners. These new approaches have been applied to aggregate trade data but not to individual commodities (Anderson and van Wincoop 2004; Head and Mayer 2002).

In an often-cited paper, Calvin and Krissoff (1998) provide a tariff equivalent of phytosanitary barriers in the Japanese apple market regarding the risk of contamination by fire blight and coddling moths that has been the origin of a long WTO dispute between Japan and the United States (WTO 2002–2004). The dispute has attracted much attention and has not yet been resolved (as of winter 2005). Calvin and Krissoff use the law of one price under a homogeneous commodity assumption (arbitrage condition) to calculate the tariff equivalent of SPS barriers affecting apple imports in Japan to avoid damages from fire blight and coddling moths. By assuming that Japan's domestic apples and imported apples are perfect substitutes, the gap between the prices of domestic and imported apples accounts for the border tariff and other trade impediments that prevent full arbitrage. The authors also abstract from other border effects (internal transportation and transaction costs), leading to a likely overstatement of the TBT barrier. They use several reference years to mitigate annual variations in the reference data used to calibrate the tariff equivalent to the TBTs. Using recent data and the proposed revamped approach, we provide a new investigation of the Japan-U.S. apple dispute. We compute the tariff equivalent of associated Japanese TBT regulations and quantify the impact of removing these policies on welfare and apple trade flows. We also draw policy implications. The apple dispute offers an opportunity to validate our contention that departures from perfect substitution, significant trade costs, and reference data have a substantial impact on the tariff equivalent estimate of SPS/TBT regulation and hence on welfare and policy implications derived from this estimate.

Analytical Framework

As in the gravity equation, we use the simple constant elasticity of substitution (CES) model to incorporate the heterogeneity of goods in consumers' preferences and eventually to calculate the tariff equivalent of a TBT (Hummels and Skiba 2003). Define domestic and imported goods, *D* and *I*. We assume the case of a small country facing a parametric exogenous world price of imports. The price P_D of the domestic good is determined by the domestic good market equilibrium, as explained later in the paper. The representative consumer maximizes utility U subject to a budget constraint:

$$\underset{D,I}{Max} \quad U(D,I) = (\alpha D^{\rho} + (1-\alpha) I^{\rho})^{1/\rho} \quad s.t. \quad p_D D + p_I I = M \, , \tag{1}$$

where M is expenditure; α, ρ are parameters reflecting preferences; and p_D and p_I are retail prices of the two goods *D* and *I*. Home-good preference implies $\alpha > ½$. The associated Marshallian demand functions are

$$D(p_D, p_I, M) = \left(\frac{\alpha}{p_D}\right)^{\sigma} \frac{M}{\alpha^{\sigma} p_D^{1-\sigma} + (1-\alpha)^{\sigma} p_I^{1-\sigma}} \, , \tag{2}$$

$$I(p_D, p_I, M) = \left(\frac{1-\alpha}{p_I}\right)^{\sigma} \frac{M}{\alpha^{\sigma} p_D^{1-\sigma} + (1-\alpha)^{\sigma} p_I^{1-\sigma}} \, , \tag{3}$$

and with $\sigma = \dfrac{1}{1-\rho}$ being the elasticity of substitution. The corresponding indirect utility function is

$$V(p_D, p_I, M) = M(\alpha^{\sigma} p_D^{1-\sigma} + (1-\alpha)^{\sigma} p_I^{1-\sigma})^{\frac{1}{\sigma-1}} \, , \tag{4}$$

and adding the corresponding expenditure function, we have

$$e(p_D, p_I, u) = u(\alpha^{\sigma} p_D^{1-\sigma} + (1-\alpha)^{\sigma} p_I^{1-\sigma})^{\frac{1}{1-\sigma}} \, . \tag{5}$$

The importing price p_I includes the import unit cost (CIF price inclusive of the international component of trade cost), the tariff, the tariff equivalent of the SPS or TBT barriers, and the internal transportation cost. All these components translate into a definition of the price $p_I = p_{CIF}(1+t+t_{TBT})+t_R$, where p_{CIF} is the observed CIF (unit cost plus insurance and freight and other international trade costs) price of I, t is the tariff rate, t_{TBT} is the tariff equivalent of the TBT or SPS measure, and t_R is the per-unit transportation and transaction cost from the harbor to the wholesale internal market. The CIF price can itself be decomposed into an export price from the originating country and an international transportation cost component.

From utility maximization, we know that the marginal rate of substitution is equal to the relative price of the substitute goods or

$$MRS = \frac{MU_D}{MU_I} = \frac{p_D}{p_I} = \frac{p_D}{p_{CIF}(1+t+t_{TBT})+t_R} \tag{6}$$

where MRS is the marginal rate of substitution, and MU_j indicates the marginal utility of good j. From (8), the ad valorem tariff equivalent t_{TBT} is solved after deriving the MRS from (1) and substituting it back into (6). The equivalence between the price-wedge measure t_{TBT} and the TBT holds D/I constant. The ad valorem tariff equivalent is a function of the relative cost of the two goods, their volumes, the elasticity of substitution, the preference parameter, internal transaction and transportation cost, and ad valorem border tariff:

$$t_{TBT} = \frac{p_D}{p_{CIF}}\frac{1-\alpha}{\alpha}\left(\frac{D}{I}\right)^{\frac{1}{\sigma}} - 1 - t - \frac{t_R}{p_{CIF}}\,. \tag{7}$$

Here we treat internal transaction and transportation cost as specific instead of ad valorem, which mitigates the variability of t_{TBT} to different CIF price values across different reference years. For example, assuming σ=10, when transportation and transaction cost is treated as specific, t_{TBT} is 170 percent, 86 percent, and 131 percent for years

1998, 1999, and 2000 respectively; but when the cost is treated as ad valorem, t_{TBT} is 186 percent, 72 percent, and 137 percent for the corresponding three years.

To measure the sensitivity of the t_{TBT} to assumptions on unobservables, we hold "observed" variables D, I, P_D, P_{CIF}, and t_R constant and obtain the following sensitivity elasticities of the tariff equivalent of the TBT with respect to its determinants σ, and α, $\varepsilon_{(.)} = \dfrac{\partial \ln t_{TBT}}{\partial \ln(\cdot)}$:

$$\varepsilon_\sigma = \frac{\partial \ln t_{TBT}}{\partial \ln \sigma} = -\frac{\frac{p_D}{p_{CIF}} \frac{1-\alpha}{\alpha} \left(\frac{D}{I}\right)^{\frac{1}{\sigma}} \ln\left(\frac{D}{I}\right) \frac{1}{\sigma}}{t_{TBT}} < 0 \text{ if } D > I, \tag{8}$$

$$\varepsilon_\alpha = \frac{\partial \ln t_{TBT}}{\partial \ln \alpha} = -\frac{\frac{p_D}{p_{CIF}} \frac{1}{\alpha} \left(\frac{D}{I}\right)^{\frac{1}{\sigma}}}{t_{TBT}} < -1. \tag{9}$$

Reference data used to calibrate (7) also matter greatly. To measure the sensitivity of t_{TBT} to the chosen reference data, we derive similar elasticities with respect to quantity volumes D and I, relative prices P_D and P_{CIF}, and transportation cost and ad valorem tariff t_R and t:

$$\varepsilon_D = \frac{\partial \ln t_{TBT}}{\partial \ln D} = \frac{\frac{1}{\sigma} \frac{p_D}{p_{CIF}} \frac{1-\alpha}{\alpha} \left(\frac{D}{I}\right)^{\frac{1}{\sigma}}}{t_{TBT}} > 0, \tag{10}$$

$$\varepsilon_I = \frac{\partial \ln t_{TBT}}{\partial \ln I} = -\frac{\frac{1}{\sigma} \frac{p_D}{p_{CIF}} \frac{1-\alpha}{\alpha} \left(\frac{D}{I}\right)^{\frac{1}{\sigma}}}{t_{TBT}} < 0, \tag{11}$$

$$\varepsilon_{p_D} = \frac{\partial \ln t_{TBT}}{\partial \ln p_D} = \frac{\frac{p_D}{p_{CIF}} \frac{1-\alpha}{\alpha} \left(\frac{D}{I}\right)^{\frac{1}{\sigma}}}{t_{TBT}} > 1, \tag{12}$$

$$\varepsilon_{p_{CIF}} = \frac{\partial \ln t_{TBT}}{\partial \ln p_{CIF}} = \frac{-\dfrac{p_D}{p_{CIF}} \dfrac{1-\alpha}{\alpha} \left(\dfrac{D}{I}\right)^{\frac{1}{\sigma}} + \dfrac{t_R}{p_{CIF}}}{t_{TBT}} < -1, \tag{13}$$

$$\varepsilon_{t_R} = \frac{\partial \ln t_{TBT}}{\partial \ln t_R} = -\frac{t_R}{t_{TBT}\, p_{CIF}} < 0, \tag{14}$$

and

$$\varepsilon_t = \frac{\partial \ln t_{TBT}}{\partial \ln t} = -\frac{t}{t_{TBT}} < 0. \tag{15}$$

Elasticity ε_σ is large in absolute value for small values of σ and converges to zero as σ increases. Elasticity ε_α, in absolute value, is the largest of the sensitivity measures; it decreases as goods D and I become closer substitutes but remains larger than 1. This fact has implications for gravity equation analyses, which often impose α =0.5. This restriction may strongly bias the estimates of impediments to trade. The measures ε_D and ε_I are equal and opposite in sign and also depend on the value of σ. The values decrease in absolute value as D and I become closer substitutes. Sensitivity measures ε_{P_D} and $\varepsilon_{P_{CIF}}$ are equal in absolute value and larger than 1 but smaller than ε_α by a factor of (1-α). They decrease as goods are closer substitutes but remain larger or equal to 1 in absolute value. The sensitivity measures ε_{t_R} and ε_t will be small (large) in absolute value if the transportation costs, t_R, and the tariff, t, were to be small (large) and if the estimate of the TBT, t_{TBT}, were to be large (small).

Hence, we can identify a taxonomy of the cases. If goods D and I are known to be poor substitutes (presumption of small σ), the TBT estimate will be very sensitive to the value of σ and parameter α and to chosen reference prices and quantities. However, if goods D and I are known to be very close substitutes (with presumption of high σ), the tariff estimate of the TBT will be much less sensitive to pinning down the exact elasticity of substitution, and to reference data volumes D and I. Sensitivity to chosen reference prices and preference parameter α will still be important and larger than 1 in absolute value. Sensitivity to changes in internal transportation or transactions costs and the tariff rate will depend on their initial values and could be large for protected and poorly integrated sectors.

For the welfare analysis, we use the usual equivalent variation (EV) and compensating variation (CV) measures of the consumer's welfare, with $EV = e(\vec{p}_0, u_1) - m_0$ and $CV = m_1 - e(\vec{p}_1, u_0)$, where $\vec{p} = (p_D, p_I)$ and subscripts 0 and 1 indicate initial and new prices.

We use a small displacement model to determine the price of domestic apples and eventually infer the impact of removing the TBT barrier on imports and domestic market equilibrium. Let S be the retail supply of domestic apples, which is an increasing function of domestic apple price and exogenous parameter λ:

$$S(p_D, \lambda) = \lambda p_D^{\varepsilon_S}. \tag{16}$$

where ε_S represents the own-price elasticity of the domestic apple supply. Decreases in parameter λ would reflect upward shifts in supply if contamination occurs and induce an increase in the cost of production. Using equation (2) and S, the equilibrium domestic price p_D^e and quantity are determined by market equilibrium condition, or

$$D(p_D^e, p_I) = S(p_D^e, \lambda). \tag{17}$$

Equations (2), (3), (7), and (16), and condition (17) constitute the model. With the elimination of t_{TBT}, p_I decreases and p_D will fall as a result if there is no risk of contamination from the increased imports. The demand for domestic products declines with the change in p_I. Then the domestic market adjusts at a lower price such that demand equals supply. Imports expand as the direct effect of the decrease in the import price is larger than the feedback effect of the lower domestic price, by stability. If contamination occurs, the price of domestic apples may not decrease, as the domestic supply shifts upward to reflect the increased cost from contamination. The domestic apple equilibrium quantity is further reduced by the contamination. Imports increase. For simplicity, we assume away feedback effects from apple suppliers into the income of the representative consumer. We turn next to our investigation of the Japan-U.S. apple dispute starting with some key stylized facts on the dispute.

The Japan-U.S. Apple Dispute

The high technical barriers to importing apples into Japan have brought repeated complaints from several exporting countries and have led to a 30-year dispute (Elms 2004). The latest episode of this dispute has been taking place within the WTO. *Japan-Measures Affecting the Importation of Apples* (WTO 2002-2004) relates to the United States' complaint about the Japanese requirements imposed on apples imported from the United States and their inconsistency with WTO principles. The prohibitions and requirements included, for example, the prohibition of imported apples from states other than designated areas in Oregon and Washington; the prohibition of imported apples from any orchard (whether it is free of fire blight or not) if fire blight was detected within a 500-meter buffer zone surrounding such orchard; the requirement that export orchards be inspected three times a year (at blossom, fruitlet, and harvest stages) to check if fire blight is present in order to apply the aforementioned prohibitions; the requirement that at the post-harvest stage apples for export to Japan be separated from fruits for export to other markets; and chlorination of apples for export to Japan.

In 1997, the United States requested that Japan modify its import restrictions on apples based on published scientific evidence that mature, symptomless apples are not carriers of fire blight. In 2000, the United States agreed to carry out joint research proposed by Japan to confirm the results of those earlier studies. The USDA's Agricultural Research Service (ARS) and Japan's Ministry of Agriculture Forestry and Fisheries (MAFF) (various) conducted the joint research. The research results confirmed that mature, symptomless apples are not carriers of fire blight. This finding provided additional scientific support for the U.S. position. Since the results of this research were released in February 2001, the U.S. government has repeatedly pressured Japan to modify its import restrictions. After extensive bilateral discussions with USDA scientists, Japan refused to modify its import restrictions in October 2001.

In March 2002, the United States requested WTO consultations concerning Japan's import restrictions on U.S. apples. Consultations in April 2002 failed to settle the dispute. In May 2002, the United States requested that the WTO establish a panel to consider the Japanese restrictions. In June 2002, a panel was established by the Dispute Settlement Body (DSB) of the WTO to consider this issue. Before the panel, the United States claimed that Japan was acting inconsistently with some articles of the SPSA, certain articles of the Agreement on Agriculture, and the so-called "GATT 1994." In July 2003, the panel found that Japan's phytosanitary measures were maintained without sufficient scientific evidence and inconsistent with Japan's obligation, did not qualify as a provisional measure, and were not based on a risk assessment. In September 2003, Japan appealed the WTO panel ruling. In addition to Japan's appeal, the United States cross-appealed the panel report. At the same time, third participants, such as Australia, Brazil, the European Communities, and New Zealand, filed their submissions. After more investigations, in November 2003, the DSB upheld the findings of July 2003. Therefore, the appellate body recommended that the DSB request that Japan bring its inconsistent measures into conformity with SPSA.

Half a year later, in July 2004, the United States held that Japan failed to comply with the recommendations and rulings of the DSB by the end of the reasonable period of time. Therefore, the United States requested that the DSB establish a panel and simultaneously requested authorization on suspension of concessions and other obligations in one or more of the following: tariff concessions and related obligations under the GATT 1994 on a list of products; and concessions and other obligations under the SPS Agreement and the Agreement on Agriculture. Because Japan objected to the United States' suspension request, this matter has been referred to arbitration. Because of the need to consult scientific experts, the panel expects to finish its final report by May 2005, nearly nine years after the initial U.S. complaint.

Between 1971 and 1992, Japan imported only 4,500 boxes of apples, all from South Korea and North Korea. In June of 1993, Japan permitted some import of New Zealand apples. After that, the United States and Australia also exported apples to Japan from year to year. Although Japan opened its door to foreign apples, the quantity of import has been quite low compared with the domestic production. As shown in Table 1, the import shares never exceeded 0.1 percent between 1998 and 2000. The low import share is partly due to the high tariff and TBT barrier. Table 1 shows that the border price is much lower than the domestic wholesale price.

TABLE 1. Japanese apple production and imports

Year	Domestic Production (mt)	Domestic Wholesale Quantity (mt)	Domestic Wholesale Price (yen/kg)	Import Quantity (mt)	Import CIF Price (yen/kg)	Import Share (%)
1998	879,100	753,000	217	221	136	0.03
1999	927,700	668,200	264	308	233	0.05
2000	799,600	691,600	238	594	156	0.09

Source: Data is from Japan Customs.
Note: mt denotes metric tons.

In addition to the high technical barrier referred to in the dispute, the higher quality of the domestic product cannot be neglected. Fruits in general and apples in particular are an important part of the Japanese diet (Huang 2004). Japanese consumers exhibit a strong home-good preference relative to imported apples. This fact has been repeatedly established (Kajakawa 1998; USDA 1997; and American University n.d.). According to Japanese consumers, domestic apples have a higher quality because of their sweeter flavor and bigger size. For instance, after Japan opened its apple market to imports in 1995, U.S. apples entered Japan at much lower prices than Japanese domestic products. However, after an initial success, the sales of U.S. apples declined because Japanese consumers complained that U.S. apples were too sour and did not cater to Japanese tastes (American University n.d.). Japanese consumers prefer apples with brix (a measure of sugar level) in a certain range and a specific brix-to-acid ratio. But imported apples do not meet these requirements. In addition, imports are smaller in size and less juicy (Kajikawa 1998). For Japanese consumers who believe that apples must have an appropriate brix and acid level, firmness, juice, size, and flavor, imported apples cannot be a perfect substitute for domestic products.

Japanese farmers produce apples with great care and the production of apples is labor intensive. Leaves near each apple are usually plucked away when the fruit is still on the tree, which ensures that the apple receives enough and balanced sunlight to insure full ripening. Several weeks before harvesting, bags are used to protect individual apples in order to prevent any kind of surface marring. This labor-intensive production leads to a higher quality and at the same time comes at a higher cost. Because of the quality difference and trade barriers, Japanese producers are able to pass the higher costs to consumers in the form of a higher price. Hence, the trade barriers do not explain the entire price wedge. A price differential reflecting the quality premium would remain under free trade. In addition, as a fresh fruit, the internal transportation cost for apples is high and cannot be ignored.

Quantifying the Apple Dispute

We apply the framework described earlier to imported apples in Japan. We use all imported apples to estimate I and the average import unit cost measured as the CIF price, shown in Table 1, and to compute the tariff equivalent of the Japanese TBT regulations.[1] Then we estimate α the impact of eliminating the TBT. The transportation and transaction cost, t_R, is approximately 96 yen/kg. The latter is obtained from Anderson and van Wincoop (2004), who provide a median estimate for transportation and transaction costs of 55 percent (percentage of CIF unit value), which includes domestic distribution from harbor to wholesale market, border barriers, language, and currency barriers. We apply this estimate to each year and average over the corresponding three years 1998-2000 to obtain the 96 yen/kg as a per-unit cost. The tariff rate is listed in Table 2; the average rate of the three years is 17.6 percent. As in Calvin and Krissoff (1998), the long-run supply elasticity of domestic apples is assumed to be 1. We follow the estimate of the Australian Department of Primary Industries and Fisheries and assume that with the transmission of pest and disease the production of apples would decrease by a fixed proportion of 20 percent with the TBT in place.

To test the sensitivity of the value of t_{TBT} to the elasticity of substitution, we assign different values to σ, with 5 unit increments. Estimates for σ = 5, 10, and 15 are shown in Table 2. To test the sensitivity of the value of t_{TBT} to α and to t_R, the transportation

TABLE 2. Technical barriers to trade tariff equivalent with different values of σ

Year	Tariff Rate	t_{TBT} (σ=5)	t_{TBT} (σ=10)	t_{TBT} (σ=15)
		(*Percent*)		
1998	18.20	621.58	170.46	85.14
1999	17.60	368.74	85.81	30.52
2000	17.00	447.76	130.54	65.70

Source: WTO schedules and Japan Customs.
Note: Transportation plus transactions costs equal 96.19 yen/kg. α =0.5.

and transaction rate, different values are assigned to them (for example, see Tables 4 and 5). The default value for is 0.5 as assumed in many gravity equation analyses.

Technical Barriers to Trade Tariff-Equivalent Estimate and Its Sensitivity Analysis

The last three columns of Table 2 show the tariff equivalent of the TBT when σ is assigned to different values. The t_{TBT} value is relatively low in 1999 compared with the other two years. This is because the border price of that year is much higher than the other two years. The reason is that in 1999, the world price of oil doubled relative to 1998 because of strong world oil demand, an OPEC oil production decline, and low oil stock levels. The higher oil price made the international transportation cost much higher than for other years, which in turn led to a higher border price and domestic wholesale price (this phenomenon also occurred for other fruits such as summer oranges, Japanese pears, and peaches). We can see that t_{TBT} changes noticeably with different values of σ. The higher the value of σ, the lower the tariff equivalent t_{TBT}. The intuition behind this is straightforward. The higher the elasticity of substitution, the smaller the required change in price P_I in order to have consumers switching to domestic apples.

Table 3 gives the elasticity of t_{TBT} with respect to σ (holding t_R, α constant). Measures of ε_σ show that t_{TBT} is sensitive to σ, especially when the value of σ is low (imperfect substitutes). For example, when σ=5, ε_σ is less than -1.4, a value which indicates t_{TBT} would differ a lot even if the change in σ was to be small. Tripling σ reduces the tariff-equivalent estimate by one order of magnitude. Thus, σ plays an important role in the calculation of t_{TBT}. When σ gets larger, the sensitivity gets smaller in absolute value. When σ=50 (approximating perfect substitution), the sensitivity is not as high as before, but it is still significant.

TABLE 3. Elasticity of t_{TBT} with respect to σ (α=0.5; t_R = 96 yen/kg)

σ	**5**	**10**	**15**	**20**	**25**	**30**	**50**
ε_σ 1998	-1.627	-0.813	-0.54	-0.407	-0.325	-0.271	-0.163
ε_σ 1999	-1.536	-0.768	-0.51	-0.384	-0.307	-0.256	-0.154
ε_σ 2000	-1.412	-0.706	-0.47	-0.353	-0.282	-0.235	-0.141

Table 4 gives the elasticity of t_{TBT} with respect to α (holding σ, t_R constant); t_{TBT} is highly sensitive to α around α=0.5 but this high sensitivity decreases somewhat as α increases. Good information on α appears to be critical in estimating the tariff equivalent of the TBT.

Table 5 gives the elasticity of t_{TBT} with respect to t_R (holding σ, α constant) and shows that t_{TBT} is sensitive to t_R when the latter gets large but goes to zero as t_R decreases. Around the central value (96 yen/kg) used in our computation, the elasticity of t_{TBT} to t_R is approximately -0.5 and hence plays an important role in the calculation of the t_{TBT}. Additional analyses of the elasticity of t_{TBT} with respect to the domestic and imported quantities shows the tariff equivalent t_{TBT} is much less sensitive to the domestic and imported quantities than it is to their prices (Appendix Tables A.1 and A.2). The moderate elasticities remain nearly constant as quantity levels change. In contrast, the elasticity of t_{TBT} with respect to the domestic price is always greater than 1 and gets larger as the domestic price increases (Table A.3), and the elasticity of t_{TBT} with respect to the CIF price is less than –1 and gets smaller as the CIF price increases (Table A.4). The elasticity of t_{TBT} with respect

TABLE 4. Elasticity of t_{TBT} with respect to α (σ=10; t_R = 96 yen/kg)

α	**0.50**	**0.52**	**0.54**	**0.56**	**0.58**	**0.60**	**0.62**
ε_α 1998	-4.22	-3.45	-2.86	-2.39	-2.02	-1.71	-1.46
ε_α 1999	-5.71	-4.43	-3.53	-2.87	-2.36	-1.96	-1.64
ε_α 2000	-4.74	-3.80	-3.11	-2.57	-2.15	-1.81	-1.53

TABLE 5. Elasticity of t_{TBT} with respect to t_R (σ=10, α=0.5)

t_R	**17.5**	**35**	**52.5**	**70**	**87.5**	**105**	**122.5**
ε_{t_R} 1998	-0.056	-0.119	-0.190	-0.271	-0.363	-0.469	-0.594
ε_{t_R} 1999	-0.063	-0.134	-0.220	-0.310	-0.420	-0.550	-0.706
ε_{t_R} 2000	-0.062	-0.132	-0.210	-0.304	-0.412	-0.539	-0.690

Note: t_R is measured as yen/kg.

to *t* (holding σ and α constant) indicates that the sensitivity of t_{TBT} goes up as the value of the tariff rate increases, although all of the estimated values are less than -0.5 (in absolute value) for *t*, ranging from 0.1 to 0.3 (Table A.5).

Welfare Analysis of the Removal of Technical Barriers to Trade

The import increases are shown in Table 6 for different values of σ. By eliminating the TBT (alone and with border tariff elimination), apple imports would increase substantially, between 33 and 145 10^3 metric tons, depending on the base year and the assumed elasticity of substitution. These magnitudes are in a range of values comparable to those of Calvin and Krissoff. These larger imports remain moderate relative to domestic apple consumption. Japan imports apples from Australia, New Zealand, South Korea, and the United States. The U.S. share of apple imports by Japan has varied widely over time. In 2000, the value share of U.S. apples into total apple imports was 24 percent; in 1999, it was 54 percent; and in 1998, it was 0 percent. Based on the 2000 share, and σ=5, the expansion of U.S. imports by Japan would only amount to US$48 million, and even less, about US$13 million, if one assumes σ=15.[2] The losses to U.S. exporters and producers would be smaller than the value of imports, first because they would valued at lower FOB prices and farmgate prices, respectively, and because producer surplus losses are always smaller than the gross value of forgone production opportunities. The US$48 million figure is about a third of the lost exports claimed by the United States at the WTO (US$143.4 million).

Figure 1 shows the demand and supply of domestic apples in year 2000. Curve D (solid line) is the initial demand for domestic apples in 2000. D1 is the demand after the

TABLE 6. Increase in imports (10^3 mt) with the elimination of t_{TBT} and tariff (α=0.5)

	Increase in Imports with the Elimination of					
	t_{TBT}			t_{TBT} +Tariff		
Year	σ=5	σ=10	σ=15	σ=5	σ=10	σ=15
1998	144.5	69.8	32.6	196.9	124.3	81.8
1999	66.6	13.4	0.67	102.2	33.0	4.32
2000	139.5	70.5	37.7	187.4	122.9	89.3

elimination of the TBT and D2 is the demand after the elimination of both TBT and the tariff. S is the supply curve of domestic production without the transmission of disease and pests. St is the supply of domestic apples with the transmission of disease and pests. We can see that the demand for domestic apples shifts inward with the elimination of either TBT or the tariff. And the supply of domestic apples shifts to the left (decreases) with the transmission of disease and pests.

Changes in welfare with elimination of TBT and the tariff under different assumptions on the transmission of disease indicate the relative magnitude of impacts. Table 7 shows the welfare implications of eliminating the TBT and the tariff for 2000, when assuming α =0.5, transportation plus transaction costs of 96 yen/kg, and under the condition of no disease transmission. The table shows that the EV (and CV) and the producer's

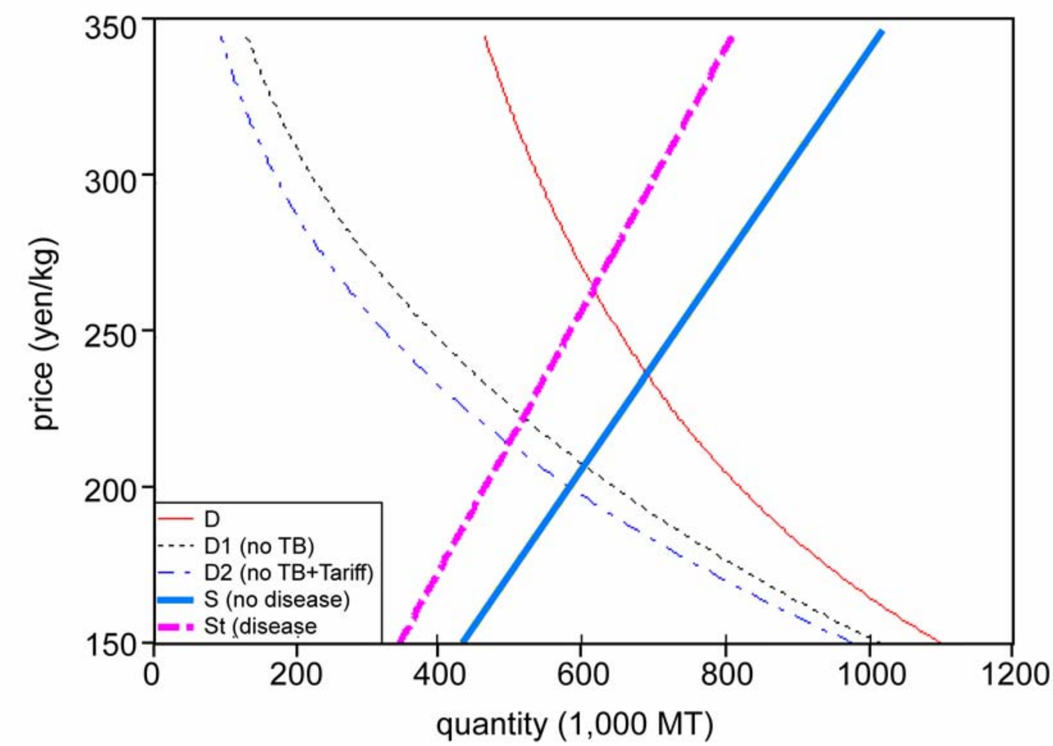


FIGURE 1. The demand and supply curve of domestic apples in 2000 (σ =5, α =0.5)

surplus change dramatically with the change of σ. However, when there is no disease transmission, CV net of tariff revenue loss is greater than the loss of the producer's surplus for both elimination of t_{TBT} and elimination of t_{TBT} and the tariff no matter what value σ takes. Table 8 shows the welfare implications with disease transmission holding other conditions the same as in the previous analysis. When σ=5, the net welfare is positive. But when the value of σ is equal to 10 and above, EV plus the tariff revenue do not exceed the loss of the producer's surplus when there is disease transmission. So the elimination of the TBT would not always improve welfare. The results apply to the case when both the TBT and the tariff are eliminated.

The results are sensitive to the transportation and transaction cost assumption, as shown in Tables 9 and 10. When the transportation and transaction costs, t_R, are decreased by 64 percent (from 96 yen/kg to 35 yen/kg), the elimination of the TBT leads to an EV net of tariff revenue loss always greater than the loss of the producer's surplus when values of σ are less than 30, hence guaranteeing social welfare gains. This is the case either with or without the transmission of disease. When both the TBT and the tariff are eliminated there are social welfare gains for all values of σ. From the welfare analysis (Tables 7-10) we see that the welfare implications differ greatly with different values of transportation and transaction costs and a different value of the elasticity of substitution.

Tables 11 and 12 give the welfare implications of eliminating the TBT and the tariff assuming home preference, but now the home good preference increases to α=0.55. Results differ from those obtained when an equal preference (α=0.5) is assumed. All welfare measures decrease substantially. For example, under the assumption of no disease transmission, consumer gains (EV) from an elimination of the TBT for σ=5 drop from 36,784 under the assumption of α=0.5 (Table 7) to 27,191 when α=0.55 (Table 11). When α takes on different values, the net welfare changes accordingly. The effect of α on the change to consumers' and producers' welfare suggests the need for decisionmakers to account for differences in α in deciding whether the TBT is worth eliminating or not. Again, gauging α properly is important in providing dependable estimates of the effect of the TBT.

TABLE 7. Welfare analysis with elimination of t_{TBT} (and tariff) (t_R = 96 yen/kg, α =0.5, without disease transmission)

	Welfare by Elimination of t_{TBT}					Welfare by Elimination of t_{TBT} +Tariff			
σ	Change of Tariff Revenue	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue-Loss of Producer Surplus)	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue - Loss of Producer Surplus)
5	3700	36784	30070	19496	20987	47441	36834	23670	23755
10	1869	13302	12308	9879	5292	22379	19703	15543	6820
15	1001	6343	6108	5318	2026	14443	13279	11308	3119
20	530	3176	3116	2846	861	10347	9736	8640	1691
25	269	1564	1549	1472	360	7801	7448	6787	998
30	127	731	728	728	130	6053	5838	5422	615

Note: Welfare is measured in million yen (2000 prices).

Table 8. Welfare analysis with elimination of t_{TBT} (and tariff) (t_R = 96 yen/kg, α =0.5, with disease transmission)

	Welfare by Elimination of t_{TBT}					Welfare by Elimination of t_{TBT} +Tariff			
σ	Change of Tariff Revenue	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue-Loss of Producer Surplus)	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue - Loss of Producer Surplus)
5	4603	26258	22648	24014	6847	37765	30722	28380	9369
10	2822	3731	3648	16105	-9552	14660	13462	22565	-7921
15	1853	-3411	-3483	11971	-13529	7480.3	7155	19558	-12093
20	1260	-7107	-7428	9355	-15202	3812	3726	17669	-13873
25	875	-9417	-9988	7527	-16068	1540	1526	16356	-14832
30	617	-11013	-11801	6169	-16565	-21	-22	15384	-15421

Note: Welfare is measured in million yen (2000 prices).

TABLE 9. Welfare analysis with elimination of t_{TBT} (and tariff) (t_R =35yen/kg, α =0.5, without disease transmission)

	Welfare by Elimination of t_{TBT}					Welfare by Elimination of t_{TBT} +Tariff			
σ	Change of Tariff Revenue	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue- Loss of Producer Surplus)	EV	CV	Loss of Producer Surplus	Net Welfare (EV+ Change of Tariff Revenue - Loss of Producer Surplus)
5	7345	66890	47574	30145	44089	87881	57309	35848	52017
10	6123	40975	32813	25137	21961	62114	45107	33599	28499
15	5500	33042	27522	22583	15960	54718	41075	32528	22174
20	5114	29039	24687	20999	13154	51151	39032	31895	19240
25	4849	26585	22891	19911	11523	49039	37790	31477	17546
30	4654	24914	21641	19112	10456	47640	36954	31180	16444

Note: Welfare is measured in million yen (2000 prices).

TABLE 10. Welfare analysis with elimination of t_{TBT} (and tariff) (t_R = 35yen/kg, α =0.5, with disease transmission)

	Welfare by Elimination of t_{TBT}					Welfare by Elimination of t_{TBT} +Tariff			
σ	Change of Tariff Revenue	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue- Loss of Producer Surplus)	EV	CV	Loss of Producer Surplus	Net Welfare (EV+ Change of Tariff Revenue - Loss of Producer Surplus)
5	7345	58335	43080	34892	30788	80169	53926	40430	39723
10	6793	35240	29030	32273	9760	57543	42647	40205	17322
15	6787	28548	24331	31011	4324	51403	39178	40104	11283
20	6778	25300	21932	30262	1816	48539	37492	40047	8476
25	6767	23370	20466	29764	372	46881	36495	40010	6855
30	6757	22086	19475	29408	-565	45799	35837	39984	5799

Note: Welfare is measured in million yen (2000 prices).

TABLE 11. Welfare analysis with elimination of t_{TBT} (and tariff) (t_R = 96 yen/kg, α =0.55, without disease transmission)

	Welfare by Elimination of t_{TBT}					Welfare by Elimination of t_{TBT} +Tariff			
σ	Change of Tariff Revenue	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue- Loss of Producer Surplus)	EV	CV	Loss of Producer Surplus	Net Welfare (EV+ Change of Tariff Revenue - Loss of Producer Surplus)
5	1587	27191	23339	10616	8767	36545	29910	13817	22712
10	267.1	5887	5684	2281	768	12129	11297	4747	7366
15	37.65	1548	1533	409	40	5482	5306	1542	3924
20	-------	------**	-------	-------	-------	2823	2775	450	2356
25	-------	------	-------	-------	-------	1590	1575	113	1461
30	-------	------	-------	-------	-------	949	944	15	918

Note: ** TBT is negative, which is of no economic meaning.

TABLE 12. Welfare analysis with elimination of t_{TBT} (and tariff) (t_R =96 yen/kg, α =0.55, with disease transmission)

	Welfare by Elimination of t_{TBT}					Welfare by Elimination of t_{TBT} +Tariff			
σ	Change of Tariff Revenue	EV	CV	Loss of Producer Surplus	Net Welfare (EV + Change of Tariff Revenue- Loss of Producer Surplus)	EV	CV	Loss of Producer Surplus	Net Welfare (EV+ Change of Tariff Revenue - Loss of Producer Surplus)
5	2066	17796	16061	14065	5796	24152	21064	17780	6356
10	437	2782	2736	4975	-1756	6016	5804	9154	-3154
15	88	411	410	1622	-1122	1731	1713	5000	-3285
20	9	3	3	405	-392	446	445	2705	-2275
25	------	------	-------	-------	-------	70	70	1393	-1339
30	------	------	-------	-------	-------	------	-------	-------	-------

Combining welfare's sensitivity to both elasticity of substitution and transportation and transaction cost, a series of three-dimensional diagrams is drawn in Figures 2-1 through 2-3.

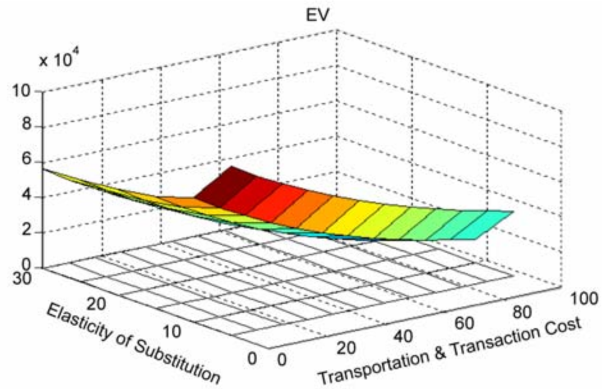
Figures 2 and 3 summarize the sensitivity of estimates of welfare and import effects to removing the TBT for varying assumptions on the level of σ and t_R change when there is no disease transmission. The welfare measures include EV, producer surplus, and net welfare (EV+Tariff Revenue -Loss of producer's surplus). The transparent plate is the zero plate, provided for reference. Figures 2-1 and 2-2 show the decrease in estimates of EV and producer surplus loss when either σ or t_R increases, and that EV decreases faster when σ is smaller and t_R is bigger. Figure 2-3 shows change in the net welfare: net welfare is large when σ or t_R is small and eventually approaches zero when either σ or t_R takes on a larger value. Figure 3 shows that imports decrease as σ or t_R increases.

Conclusions

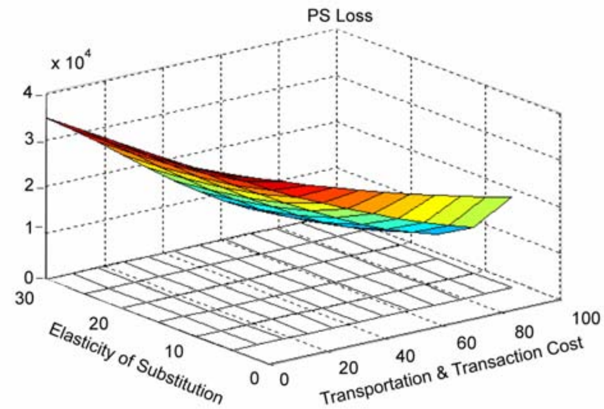
In this paper, we revamped the tariff equivalent of a TBT by relaxing the homogeneous commodity assumption, accounting for perceived quality of substitutes, and incorporating recent findings on trade costs. The latter are often larger than policy impediments and cannot be abstracted from them. Transportation and trade costs are structured on a per-unit basis rather than following the so-called iceberg method. Specific (as opposed to proportional) trade costs reduce the variability of the tariff-equivalent estimate of the TBT with respect to the variability of import unit value across different reference years. Their influence on the TBT estimate is mitigated as the import unit value increases. Trade costs and imperfect substitution have offsetting influences in the computation of the tariff estimate of the TBT. Since most previous applications have abstracted from both of them, they have somewhat mitigated the error implied by these two simplifications and dissimulated the inherent sensitivity of the TBT estimate to each of these underlying parameters.

We explored the sensitivity of the tariff equivalent of the TBT with respect to a series of parameters. The tariff equivalent and hence welfare analysis based on the tariff equivalent measures are sensitive to several key parameters, such as the elasticity of substitution, consumers' home preference, and, to a lesser extent, transportation and transaction cost. The sensitivity to the consumers' home preference has some implications for gravity equation models that impose restrictions of equal preference for imported and domestic goods. These models are likely to provide biased measures of trade impediments and should relax this assumption.

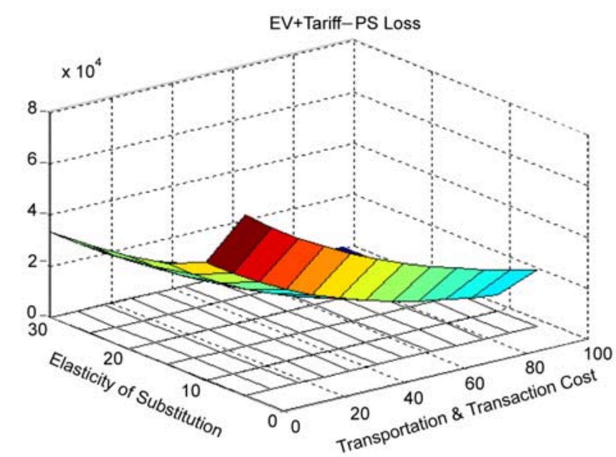
We then provided a rigorous investigation of the Japan-U.S. apple dispute. The investigation first validates the approach and indicates the importance of empirical estimates of the magnitude of preferences and trade costs (α, σ, and t_R). More importantly, it raises interesting policy implications. A striking result in the analysis of the apple dispute is that the increase in apple imports would be small (in value) no matter what parameter estimates are used. It appears that the alleged damage in lost exports claimed by the United States at the WTO (US$143.4 million) is substantially overstated. The political economy of the case is also intriguing. Much political goodwill has been spent on this dispute relative to the small size of the potential direct gains in agricultural exports. Ancillary benefits may exist if the United States eventually succeeds in opening the Japanese market and establishes a reputation as a persistent negotiator. Other countries or protected industries may pay attention to the United States' resolve in opening markets and may refrain from engaging in costly disputes.



(2-1) EV's Sensitivity to σ and t_R



(2-2) Producer Surplus Loss Sensitivity to σ and t_R



(2-3) Sensitivity of net welfare
(EV+Tariff Revenue−Loss of PS) to σ and t_R

FIGURE 2. Welfare's sensitivity to σ and t_R with elimination of technical barriers to trade (without disease transmission, α =0.5)

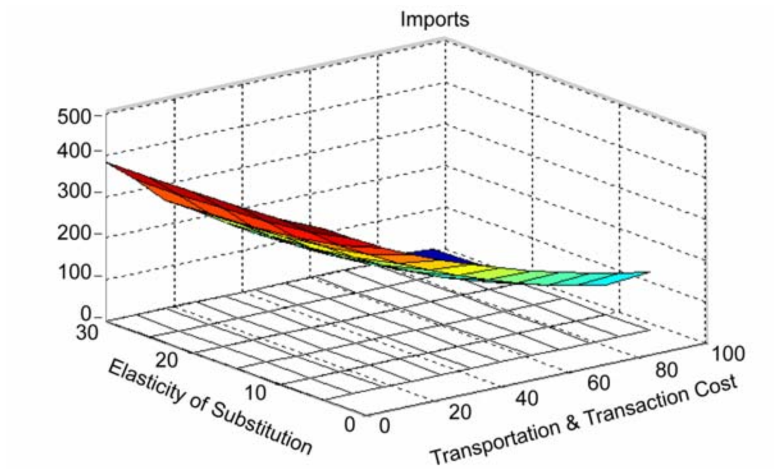


FIGURE 3. Increase in imports' sensitivity to σ and t_R with elimination of the technical barriers to trade (10^3 mt)

Endnote

1. Alternatively, we treat imports from different countries as imperfect substitutes using a double-nested CES model and calculate the tariff level of TBTs. Results are quite similar to what we present in this paper. For example, when we assume the elasticity of substitution among imports as 10, and $\sigma=10$, the TBT is 145 percent, which is quite close to the 130.54 percent TBT level obtained by aggregating all imports into one good.

2. The incremental US$48 million of U.S. imports comes from the 2000 U.S. value share of all apple imports by Japan, or 22249000/92630000=24 percent, applied to the expansion in import value (139.5 10^3 mt *155.91 yen/kg), expressed in U.S. dollars with an exchange rate of 107.765 yen/$.

Appendix

Additional Elasticity Tables

TABLE A.1. Elasticity of t_{TBT} with respect to domestic quantity D (1,000 mt) ($\sigma = 10, \alpha = 0.5$)

D	600	620	640	660	680	700	720	740	760	780
ε_D 1998	0.216	0.215	0.215	0.214	0.213	0.212	0.212	0.211	0.211	0.210
ε_D 1999	0.291	0.289	0.288	0.286	0.284	0.283	0.281	0.280	0.279	0.277
ε_D 2000	0.242	0.241	0.239	0.238	0.237	0.236	0.236	0.235	0.234	0.233

TABLE A.2. Elasticity of t_{TBT} with respect to imported quantity I (mt)($\sigma = 10, \alpha = 0.5$)

I	200	240	280	320	360	400	440	480	520
ε_I 1998	-0.208	-0.213	-0.217	-0.220	-0.223	-0.226	-0.229	-0.231	-0.234
ε_I 1999	-0.265	-0.273	-0.280	-0.287	-0.294	-0.300	-0.306	-0.311	-0.317
ε_I 2000	-0.208	-0.212	-0.216	-0.219	-0.222	-0.225	-0.228	-0.230	-0.233

TABLE A.3. Elasticity of t_{TBT} with respect to domestic price p_D ($\sigma = 10, \alpha = 0.5$)

p_D	210	215	220	225	230	235	240	245	250	255	260	265
ε_{p_D} 1998	2.19	2.13	2.08	2.03	1.98	1.94	1.91	1.87	1.84	1.81	1.78	1.76
ε_{p_D} 1999	5.45	4.94	4.53	4.2	3.93	3.7	3.5	3.33	3.18	3.05	2.94	2.83
ε_{p_D} 2000	2.9	2.78	2.67	2.57	2.49	2.41	2.34	2.28	2.22	2.17	2.12	2.08

TABLE A.4. Elasticity of t_{TBT} with respect to CIF price ($\sigma = 10, \alpha = 0.5$)

p_{CIF}	130	140	150	160	170	180	190	200	210	220	230	240
$\varepsilon_{p_{CIF}}$ 1998	-1.64	-1.73	-1.82	-1.93	-2.04	-2.18	-2.33	-2.51	-2.71	-2.95	-3.24	-3.59
$\varepsilon_{p_{CIF}}$ 1999	-1.48	-1.53	-1.59	-1.66	-1.73	-1.81	-1.9	-1.99	-2.09	-2.21	-2.34	-2.48
$\varepsilon_{p_{CIF}}$ 2000	-1.65	-1.74	-1.83	-1.94	-2.06	-2.2	-2.36	-2.54	-2.75	-3	-3.3	-3.67

TABLE A.5. Elasticity of t_{TBT} with respect to t (σ =10, α =0.5)

t	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3
ε_t 1998	-0.059	-0.0704	-0.08	-0.094	-0.106	-0.117	-0.129	-0.141	-0.153	-0.164	-0.176
ε_t 1999	-0.117	-0.1398	-0.16	-0.186	-0.21	-0.233	-0.256	-0.28	-0.303	-0.326	-0.35
ε_t 2000	-0.077	-0.0919	-0.11	-0.123	-0.138	-0.153	-0.169	-0.184	-0.199	-0.214	-0.23

References

American University. n.d. "Japan-U.S. Apple Trade." Case Study of the Mandala Projects. American University, Washington, D.C. http://www.american.edu/TED/esp/japan-apple.htm (accessed February 2005).

Anderson, J.E., and E. Van Wincoop. 2004. "Trade Cost." *Journal of Economic Literature* 42(September): 691-751.

Anderson, K., C. McRae, and D. Wilson, eds. 2001. "The Economics of Quarantine and the SPS Agreement." Centre for International Trade Studies, University of Adelaide.

Baldwin, R.E. 1991. "Measuring the Effects of Nontariff Trade-Distorting Policies." In *Trade Theory and Economic Reform: North, South, and East,* pp. 25-42. J. de Melo and A. Sapir, eds. Cambridge, MA: Basil Blackwell.

Baldwin, R.E., R. Forslid, P. Martin, G. Ottaviano and F. Robert-Nicoud. 2003. "The Core-Periphery Model: Key Features and Effects." In *The Monopolistic Competition Revolution in Retrospect*. S. Brakman and B.J. Heijdra, eds. Cambridge: Cambridge University Press.

Bureau, J-C., S. Marette, and A. Schiavina. 1998. "Non-tariff Trade Barriers and Consumers' Information: The Case of the EU-US Trade Dispute over Beef." *European Review of Agricultural Economics* 25: 437-62.

Calvin, L., and B. Krissoff. 1998. "Technical Barriers to Trade: A Case Study of Phytosanitary Barriers and US-Japanese Apple Trade." *Journal of Agricultural and Resource Economics* 23(2): 351-56.

Campbell, K., and R. Gossette. 1994. "A Study of Canada's Nontariff Trade Barriers: The Equivalents of Quantitative Import Restrictions." Research Branch, Canadian International Trade Tribunal, Ottawa, Ontario.

Deardorff, A.V., and R.M. Stern. 1999. *Measurement of Nontariff Barriers.* Studies in International Economics Series. Ann Arbor, MI: The University of Michigan Press.

Elms, D.K. 2004. "Large Costs, Small Benefits: Explaining Trade Dispute Outcomes." *Political Psychology* 25(2): 241-70.

Head, K., and T. Mayer. 2002. "Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade." CEPII Working Paper 2002 -01. Centre d'Etudes Persepectives et d'Informations Internationales, Paris. January.

Huang, S.W. 2004. "Global Trade Patterns in Fruits and Vegetables." Agriculture and Trade Report Number WRS-04-06. U.S. Department of Agriculture, Economic Research Service.

Hummels, D., and A. Skiba. 2003. "Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture." NBER Working Paper 9203. National Bureau of Economic Research. Washington, D.C. http://www.nber.org/papers/w9203 (accessed February 2005).

Japan Customs. n.d. Trade Statistics online. http://www.customs.go.jp/index_e.htm (accessed February 2005).

Josling, T., D. Roberts, and D. Orden. 2004. *Food Regulation and Trade: Toward a Safe and Open Global System.* Washington, DC: Institute for International Economics, p. 14.

Kajakawa, C. 1998. "Quality Level and Price in Japanese Apple Market." *Agribusiness: An International Journal* 14(3, May/June): 227-33.

Ministry of Agriculture, Forestry and Fisheries, Japan (MAFF). Various. *Monthly Statistics of Agriculture, Forestry and Fisheries*.

Roberts, D., and B. Krissoff. 2003. "The WTO Agreement on the Application of Sanitary and Phytosanitary Barriers." U.S. Department of Agriculture, Economic Research Service. Washington, D.C.

U.S. Department of Agriculture (USDA). 1997. "Japan: Annual Fresh Deciduous Fruit Report." Agricultural Trade Reports. Washington, D.C. September 24.

World Trade Organization. 2002. "Japan—Measures Affecting the Importation of Apples. Request for Consultations by the United States." Document WT/DS245/1 G/L/520 G/SPS/GEN/299 G/AG/GEN/50. 6 March 2002. Geneva.

———. 2003. "Japan—Measures Affecting the Importation of Apples," Notification of an Appeal by Japan under Paragraph 4 of Article 16 of the Understanding on Rules and Procedures Governing the Settlement of Disputes (DSU). Document WT/DS245/5. 28 August 2003. Geneva.

———. 2003. "Japan—Measures Affecting the Importation of Apples. Communication from the Appellate Body." Document WT/DS245/6. 23 October 2003. Geneva.

———. 2003. "Japan—Measures Affecting the Importation of Apples. AB 2003-4. Report of the Appellate Body." Document WT/DS245/AB/R. 26 November 2003. Geneva.

———. 2003. "Japan—Measures Affecting the Importation of Apples. Communication from the Appellate Body." Document WT/DS245/7. 26 November 2003. Geneva.

———. 2003. "Japan—Measures Affecting the Importation of Apples. Appellate Body Report and Panel Report. Action by the Dispute Settlement Body." Document WT/DS245/8. 16 December 2003. Geneva.

———. 2004. "Japan—Measures Affecting the Importation of Apples. Agreement under Article 21.3(b) of the DSU." Document WT/DS245/9. 12 February 2004. Geneva.

———. 2004. "Japan—Measures Affecting the Importation of Apples. Recourse to Article 21.5 of the DSU by the United States Request for the Establishment of a Panel." Document WT/DS245/11. 20 July 2004. Geneva.

———. 2004. "Japan—Measures Affecting the Importation of Apples. Recourse to Article 21.5 of the DSU by the United States. Constitution of the Panel." Document WT/DS245/14. 30 July 2004. Geneva.

———. 2004. "Japan—Measures Affecting the Importation of Apples. Request by Japan for Arbitration under Article 22.6 of the DSU. Communication from the Arbitrator." Document WT/DS245/16. 10 August 2004. Geneva.