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Technical Barriers to Trade: A Case Study of Phytosanitary Barriers and U.S.-Japanese Apple Trade

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Concern about the use of technical barriers as restrictions to trade has increased since the World Trade Organization Agreement on Agriculture. In this analysis, we quantify the phytosanitary barriers to U.S. apple exports to Japan by calculating tariff-rate equivalents. We examine the trade and welfare impacts of removing phytosanitary barriers and tariffs under two assumptions regarding transmission of the bacterial disease fire blight: first, that transmission via commercial fruit is not possible, and second, that it can occur. The disease losses required to eliminate the gains to trade are estimated to be much larger than those experienced in other countries.

Key words: apples, cost-benefit analysis, Japan, phytosanitary barriers, tariff-rate equivalents, technical barriers, welfare analysis

Introduction

When the World Trade Organization (WTO) Agreement on Agriculture was negotiated during the Uruguay Round of the General Agreement on Tariffs and Trade, many feared that reducing traditional supports to the agriculture sector would lead governments to place more reliance on technical barriers (TBs)—particularly sanitary and phytosanitary barriers—to protect producers. TBs are defined as import standards or regulations that reflect a country's concern and valuation for safety, health, food quality, and the environment (Roberts and DeRemer; Hillman). TBs include sanitary and phytosanitary regulatory measures related to food safety and animal and plant health; food standards of definition, measurement, and quality; and environmental or natural resource conservation measures. To date, TBs generally have not been quantified, and therefore cannot be easily compared with other trade barriers.

The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), also negotiated during the Uruguay Round, allows sanitary and phytosanitary regulatory measures to protect plant, animal, and human health. Each member country determines its own level of protection, and adoption of a zero-risk tolerance level is allowed. The regulatory measures used to achieve a particular level of protection require a sound scientific base, although the standards for assessing the scientific

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criteria are unclear and debate is frequently contentious (Thilmany and Barrett). There is often uncertainty regarding the level of disease and pest risk associated with trade which can provide either the basis of a legitimate concern or a convenient excuse to justify a trade barrier. This scientific uncertainty, particularly in cases of low-probability but high-consequence events, can lead to an extremely conservative approach to setting phytosanitary barriers and, as a result, potential welfare gains to trade may be lost (Bigsby).

The SPS Agreement is rooted more in the risk-assessment tradition, which focuses only on losses to producers, than it is in the economic cost-benefit analysis tradition (Roberts; James and Anderson). Economists consider welfare analysis that evaluates the costs and benefits of a TB on producers, consumers, and net social welfare as a critical first step of any policy assessment.

A TB can function solely as a means to provide economic rents to domestic producers, as does a tariff, although TBs provide no revenue to the government. Unlike a tariff, a TB may increase national social welfare if it rectifies a failure of the market to incorporate important product externalities in the product price. These attributes can be important to consumers and producers. For example, if a country is free of a damaging pest, imports from a country with that pest may be regulated on the grounds that the market price does not reflect the potential costs to society of reduced yields or export opportunities, increased production expenses, or eradication programs.

If the sole intent of a phytosanitary TB is to protect domestic producers from import competition, relaxing the TB would improve consumer welfare, reduce producer welfare, and yield a net gain in social welfare. Conceptually, both consumers and producers potentially could gain if consumers compensate producers for the removal of an artificial TB. If a phytosanitary TB protects an industry from the costs associated with the introduction of a foreign plant disease or pest, relaxing the TB would further reduce producer welfare. If the disease or pest has a serious impact on yield or production costs in the new environment, the additional reduction in producer welfare could be so significant as to eliminate any consumer welfare gains and justify the TB on economic as well as scientific grounds. Alternatively, if producer losses are relatively small, removing the TB could still increase net welfare, and the TB would not be justified on an economic basis.

The growing literature on TBs in agriculture falls into three categories. First, there is a nascent literature identifying TBs for different commodities and countries (Roberts and DeRemer; Petrey and Johnson; and Ndayisenga and Kinsey). Second, economists have developed several methods for measuring TBs. Baldwin surveys the literature on the measurement of TBs and identifies a few empirical examples for agriculture. The third strand of the literature focuses on the welfare effects of TBs. A number of papers have addressed the theory of welfare effects of TBs (Josling; Sumner and Lee; and Thilmany and Barrett). A small and growing literature of empirical examples illustrates the welfare impacts of altering TBs on U.S. imports of avocados (Romano; Orden and Romano), U.S. imports of beef (Paarlberg and Lee), and Australian imports of bananas (James and Anderson).

In this study, we investigate the role of TBs in the highly contentious U.S.-Japanese apple trade dispute. The United States is a major apple exporter, but Japan imposes rigorous phytosanitary TBs on U.S. imports to control against transmission of disease and pests. The article begins with a discussion of U.S. and Japanese apple markets,

phytosanitary TBs, and trade. In the following section, we present an analytical model for measuring TB tariff-rate equivalents for Fuji apples and the welfare effects associated with removing trade barriers. Next, the empirical results are reported. We estimate TB tariff-rate equivalents, and the trade and welfare effects in Japan of removing tariff rates and TBs. Japan's phytosanitary TBs are predicated upon the potential introduction of fire blight, codling moth, and apple maggot. We focus on the bacterial disease fire blight, which lies at the center of long-running scientific debate regarding the level of inspection needed to protect against transmission. The U.S. Department of Agriculture's (USDA's) Animal and Plant Health Inspection Service (APHIS) contends there is virtually no risk of transmission of fire blight on commercial fruit. Evaluation of the scientific evidence is beyond the scope of this research. Instead, we examine the welfare effects of removing the TB under the assumption that fire blight *cannot* be transmitted, and find substantial gains to trade. Alternatively, we then assume fire blight *can* be transmitted, and investigate how large a disease loss would be required to eliminate the gains from trade. The article concludes with comments on the value of this type of research and a review of assumptions that may influence the empirical results.

U.S.-Japanese Apple Markets and Trade

The United States is one of the world's largest fresh apple exporters. In the 1996/97 marketing year (August 1996 through July 1997), 24% of U.S. fresh apples were exported, with Washington State apples accounting for an estimated 86% of the total. While many varieties of apples are produced in the United States, Red and Golden Delicious remain the most common, accounting for an estimated 56% of the 1996 U.S. crop. The Fuji apple is a relatively new variety in the United States and production is concentrated in the western states. While Fuji apples represented only 5% of the 1996 apple crop, production increased from 90,758 metric tons in 1993, to 241,794 metric tons in 1996. Fuji production in the year 2005 is forecast to be 460,000 metric tons (O'Rourke). This is an important structural change in the industry as producers respond to opportunities in the fresh export market and to changing consumer preferences for sweeter apples.

Most countries accept the U.S. systems approach to disease and pest management for apple exports as an adequate precaution to protect their domestic industries. Fresh produce can harbor diseases and pests which could survive shipment and endanger production in other countries. The systems approach uses a combination of risk-mitigating measures which individually and cumulatively reduce the risk of the target diseases or pests to an insignificant level. This approach is employed in cases where a country or region cannot qualify as a disease-free or pest-free zone, or the postharvest treatment damages the commodity or leaves unacceptable chemical residues (Roberts and Orden). For example, the systems approach for Washington State apples consists of good commercial production practices, grading and sorting that further eliminate fruit with any disease or pest infestation or damage, and visual inspection. Systems approaches can vary by state or region.

Japan is a major apple producer, famous for its high-quality fruit, but largely isolated from world apple markets. Both imports and exports account for 1% or less of Japanese

Table 1. U.S. and Japanese Apple Production, Trade, and Consumption Patterns (1994/95–1996/97 marketing years)

Description	United States			Japan		
	1994/95	1995/96	1996/97	1994/95	1995/96	1996/97
Production ^a (MT)	5,139,836	4,712,824	4,673,815	989,300	963,300	899,200
Fresh imports (MT)	130,149	173,913	169,318	8,900	1,089	338
Fresh exports (MT)	692,511	552,129	688,697	1,800	2,506	3,625
Processing (MT)	2,252,176	2,062,393	1,814,415	182,400	163,000	135,000
Consumption (MT)	2,325,298	2,272,215	2,340,021	814,000	798,883	760,913
Import share of consumption (%)	6	8	7	1	< 1	< 1
U.S. share of imports (%)	NA	NA	NA	95	77	31

Sources: USDA/Economic Research Service; USDA/Foreign Agricultural Service 1996, 1997.

Notes: The marketing year for the U.S. is August–July, and for Japan is July–June; MT denotes metric tons, and NA signifies not applicable.

^aProduction indicates utilized commercial production in the U.S., and total commercial and noncommercial production in Japan.

consumption. (See table 1 for an overview of U.S. and Japanese apple production, trade, and consumption patterns.) In 1996/97, Japan imported apples from New Zealand, the United States, the Republic of Korea, and Nepal. Fuji apples totaled 52% of domestic Japanese apple production in 1996/97, and Red Delicious apples accounted for about 2% of production (USDA/Foreign Agricultural Service 1997).

In 1994, Japan lifted its long-standing ban on imports of U.S. apples and authorized imports of Red and Golden Delicious apples from Washington and Oregon under rigorous phytosanitary requirements. This decision followed the 1993 threat by the U.S. Trade Representative to impose general trade sanctions over the apple issue. The Japanese phytosanitary requirements on apple imports are commonly viewed as the most restrictive of any country, short of an outright ban.¹ Japan is concerned with the spread of fire blight, codling moth, and apple maggot. Only U.S. Red and Golden Delicious apples are allowed into Japan because tests of the effectiveness of quarantine treatments have been completed for these two varieties. Cold treatment and methyl bromide fumigation quarantine treatments control codling moth and apple maggot. Here we address only fire blight. The inspections for fire blight are the most costly portion of the apple export program.

Fire Blight

Fire blight is a bacterial disease that affects apple trees and other plants in the family Rosaceae. Fire blight is indigenous to the eastern United States and is now widespread throughout the country. A search of world scientific literature indicates virtually no risk, and no confirmed cases, of fire blight transmission by commercial fruit (van der Zwet

¹ Other prominent examples of countries that completely ban imports of U.S. fresh apples on phytosanitary grounds are Korea and Australia. Chile opened its market to U.S. apples in late 1997.

and Keil). Fruit from a diseased tree would be deformed and would not meet commercial quality standards. It is difficult to prove the negative case that it is not possible to transmit. Scientists believe the disease has more potential to spread through trade in propagative plant material.

Fire blight is currently widespread in North America, New Zealand, Europe, Egypt, and western Asia (van der Zwet). Trade in propagative plant material is suspected in transmission to New Zealand, England, and Egypt. Environmental conditions, such as warm and humid weather at bloom time, can promote an outbreak. The disease can spread under these conditions if infectious material is in the air. Affected branches are pruned to prevent the spread of the disease. In a severe case, a tree might be removed. Although it is virtually impossible to eradicate fire blight, because the bacterium has many cultivated and wild hosts, standard commercial orchard operations such as use of prediction models, spraying, and pruning are usually adequate to prevent serious outbreaks of the disease. Yield may be affected, but increases in per acre production costs are relatively small. Individual orchard owners deal with the problem if it occurs, but there is no government intervention in control activities for fire blight in the United States.

It is difficult to estimate actual losses due to fire blight. Incidence of the disease in a given location depends on many factors in addition to climate, particularly the varieties of apple trees in the area as well as the presence of other susceptible hosts (pear trees are more susceptible to fire blight damage). In the United States, serious outbreaks of fire blight are rare. In 1991, Michigan production losses due to a severe outbreak were estimated at almost 4% of the value of production (Smith and Lattimore).

In Washington State, there are fire blight outbreaks almost every year, but serious problems occur in only a small percentage of orchards about one year in five (Smith). The worst outbreak of fire blight in Washington in decades occurred in the spring of 1988, but had little impact on overall production. Of course, it is difficult to compare potential fire blight outbreaks in other countries to those in the United States, where the apple industry has had decades to adjust both location and varieties to cope with this disease. Washington State is cooler and drier than many other U.S. production areas, a factor that reduces the problem of fire blight, and the Red Delicious apple grown in Washington is also highly resistant to the disease. Fuji apples, however, are less resistant to fire blight (van der Zwet and Beer).

Japan claims its apple production areas to be free of fire blight, thereby justifying its rigorous regulations regarding the disease. Nevertheless, fire blight was reported in that country in 1903, and up through the 1930s (Roberts et al.). In addition, a closely related bacterial shoot blight of Asian pear, caused by a slightly different form of the bacterium, was reported recently (Beer et al.).

For import purposes, Japan requires a chlorine dip as one of several precautions against fire blight. Chlorine dip is an inexpensive procedure and does not damage apples. U.S. growers who wish to export apples to Japan also must register their acreage in advance for the Japanese protocol, and must comply with all phytosanitary requirements. An orchard shipping apples to Japan must be inspected three times each season by representatives of APHIS. The inspections must occur at bloom time, when the fruit is three centimeters in size, and just prior to harvest when a Japanese inspector also must be present. The Japanese inspector examines every tree in an orchard block registered for the export program for evidence of fire blight. Further, the area must

have a 500-meter buffer zone with no pear trees or other natural fire blight hosts. This buffer zone also is inspected. If fire blight is found in the orchard or buffer zone, all apples in that orchard block are banned from export to Japan for the season. Growers registered for the export program pay the inspection costs. The certification must be renewed annually. This is a risky protocol because there is no guarantee, after all expenses are incurred, that a grower will have any apples of the appropriate size and quality for the Japanese market.

Estimates put the likelihood of an outbreak of fire blight, based on the level of recent trade in commercial apples under the current export protocol for Japan, to be one outbreak in every 38,462 years. In comparison, based on only the standard export procedures used for trade with most countries, the likelihood is one outbreak in 11,364 years (Roberts et al.).

U.S.-Japanese Apple Trade

During the 1994/95 season (the first year of apple trade with Japan), U.S. exports of Red and Golden Delicious apples to Japan totaled 8,497 metric tons. Growers enrolled 2,406 acres in the export program in the first season (with 2,508 acres in buffer zones) (Scarlett). Since then, exports have declined drastically, and no apple growers registered their acreage for the 1997/98 crop year. Limited demand for Red and Golden Delicious apples in Japan, a high tariff, and the costly and risky phytosanitary requirements have led to less profit in exporting to Japan than originally anticipated (Krissoff, Calvin, and Gray).

The United States currently is attempting to expand Japanese import approval to other apple varieties. Japan bans imports of a variety until tests for quarantine treatment for that variety have been completed, even if tests for other varieties of apples have been successful. New Zealand, where tests were completed earlier, already exports six varieties of apples to Japan. The United States contends that each variety of apple should not have to be tested individually for the efficacy of the treatment for a quarantine insect because a quarantine treatment to kill an insect on one variety of apple is equally effective on another variety of apple. Different varieties, however, may have varying susceptibility to disease. Following talks in June 1997, the United States and Japan failed to reach an agreement, and the United States called for a WTO dispute panel to resolve the issue. In October 1998, the WTO found that Japan's variety testing procedure violates its WTO obligations.

An Analytical Framework

Tariffs and TBs alter relative prices between world and national markets. To compare the effects of the two types of policies, we estimate a tariff-rate equivalent to measure the magnitude of the TBs. The price wedge approach is used to measure the TB tariff-rate equivalent. The price wedge is the difference between the domestic Japanese price, P , and the price of similar U.S. apples delivered to Japan, WP , a proxy for the world price [see figure 1(a)]. The price wedge is divided into the known ad valorem tariff rate (τ) and the TB tariff-rate equivalent (τ_{TB}), which is the residual. With this method, the TB tariff-rate equivalent is the tariff rate that would restrict trade to the same level

as the TB. While straightforward, this methodology requires the strong assumption that no other significant factors contribute to the price wedge between two countries (Baldwin).

Another alternative for estimating the impact of TBs is measuring actual costs involved in preparing a product to comply with phytosanitary requirements in other countries. Even if the phytosanitary standards for Fuji apples were made equivalent to those for Red and Golden Delicious apples, the regulatory cost for exports still would be difficult to estimate, since the protocol targets specific inspection practices in a particular growing area as well as quarantine treatments for the final product to be shipped.

To measure the trade and welfare impacts of reducing trade barriers, we develop a simple partial-equilibrium, two-equation modeling system that endogenously determines the TB tariff-rate equivalent and the level of trade. This system is shown by equations (1) and (2):

$$(1) \quad \begin{aligned} P &\leq WP(1 + \tau + \tau_{TB}) & \text{if } T = 0, \\ P &= WP(1 + \tau + \tau_{TB}) & \text{if } T > 0; \end{aligned}$$

$$(2) \quad T = D(P) - S(P),$$

where T is imports from all sources, D is consumer demand, S is domestic supply, P is domestic wholesale price, WP is the world price adjusted for freight and insurance to the Japanese market, τ is the ad valorem tariff rate, and τ_{TB} is the ad valorem TB tariff-rate equivalent. Here, we assume that the WP reflects costs for the standard exported apple, not the costs of the specific TB which regulates only that small portion of apples intended for the Japanese market.

We solve equation (1) for the unknown τ_{TB} . If there is trade, equation (1) is a strict equality. Without trade, equation (1) is an inequality, and τ_{TB} is a lower-bound estimate of the barrier. The TB may be just sufficient to cut off trade, it may be larger, or it may be a complete ban. In all three cases, the observable impact on trade is identical, as is the estimate of τ_{TB} . In the case of Red and Golden Delicious apples, the combination of tariff and TB is at least adequate to cut off trade completely. If the TB is even greater, the prohibitive TB can be relaxed but still be sufficiently stringent to eliminate trade.

Then we differentiate equations (1) and (2) to estimate the effects of eliminating the tariff and TB (τ and τ_{TB}) on the value of trade:

$$(3) \quad dT = \epsilon_D D(WP/P) d(\tau + \tau_{TB}) - \epsilon_S S(WP/P) d(\tau + \tau_{TB}),$$

where ϵ_D and ϵ_S are the price elasticities with respect to demand and supply, and the remaining terms are as previously defined. Equation (3) requires the strong assumption that the small-country case applies, i.e., that changes in Japanese imports would have no impact on world prices.

Figures 1(a) and 1(b) illustrate the trade and welfare effects of removing the trade barriers. Figure 1(a) represents the case when a combination of the tariff and the TB tariff-rate equivalent brings the price of imports up to the domestic price, P , and cuts off trade. When only the TB is eliminated, domestic price falls to the world price plus

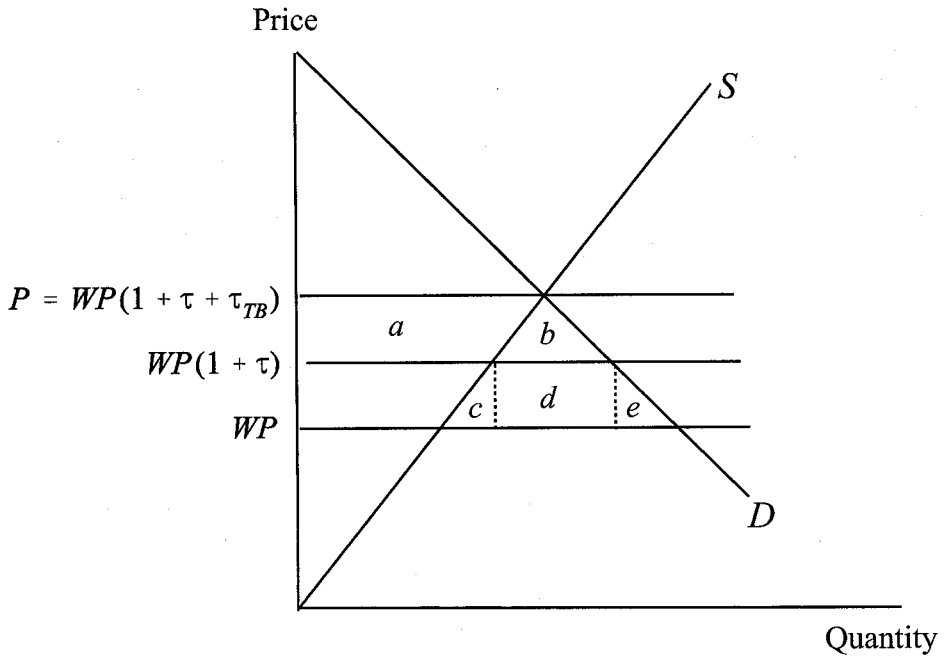


Figure 1(a). Trade and welfare effects of removing TB, with no disease or pest transmission

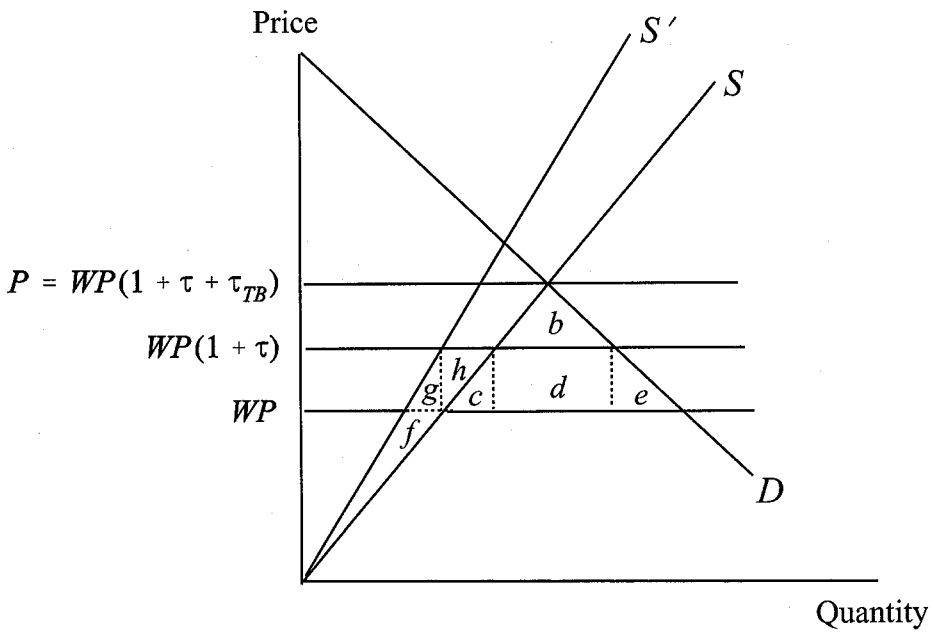


Figure 1(b). Trade and welfare effects of removing TB, with disease or pest transmission

the tariff, $WP(1 + \tau)$. Consumers gain area $\{a + b\}$, producers lose area a , the government gains tariff revenue equal to d , and the net welfare gain is the area $\{b + d\}$. Consumers and the government gain at the expense of producers. Transfer payments from consumers and the government could potentially compensate producers for their loss. The analysis is similar when both TBs and tariffs are eliminated, although in this case there is no tariff revenue, with the net welfare gain equal to area $\{b + c + d + e\}$. These results, however, assume that trade poses no chance of transmission of diseases or pests and that consumers have no concerns regarding the risk of fire blight, which might shift the demand curve.²

If trade introduces diseases or pests that reduce yield, the Japanese supply curve would rotate from S to S' [figure 1(b)]. We assume a multiplicative incidence of disease, i.e., that a fixed proportion of production is lost, regardless of production volume. In the case of fire blight, the per acre production cost increase likely would be minimal (for example, the cost of additional tree pruning). The main impact would be a reduction in yield during periods of severe outbreak, which would increase the cost per unit of apple produced. Then, in addition to the trade effect of eliminating the TB, Japanese producers would lose area $\{f + g + h\}$ due to the disease effect. If Japanese production declined, both imports and tariff revenue $\{c + d + h\}$ would increase. The empirical question is whether the disease effect would be so severe as to eliminate the overall welfare gain due to trade—that is, whether area $\{f + g + h\}$ is greater than or equal to area $\{b + c + d + h\}$. We assume that even if fire blight is transmitted, imports still would be allowed. If imports were banned, consumers would get the worst of both worlds—no trade combined with reduced domestic production, and even higher prices than in the original situation. If both the TB and tariff were eliminated, the disease loss of f would be compared with the net welfare gain to trade of $\{b + c + d + e\}$.

Since Japan has not provided a detailed risk assessment, it is not possible to estimate the expected loss due to fire blight if the disease were transmitted.³ Such an estimate requires detailed information on the probability and consequences of disease introduction. Although a likelihood model estimating the probability of disease transmission was available, there was no epidemiological study on the physical consequences of fire blight in Japan if it were transmitted. A complete fire blight epidemiological analysis would require investigating the impact of fire blight on other hosts, particularly pears. A more complete model also would consider potential losses due to transmission of codling moth and apple maggot.

Instead of measuring the expected loss due to a possible disease infestation and the resulting supply shift, we estimate the threshold where the loss associated with the supply curve shift precisely offsets the gains from trade. Some of the recent environmental economics literature criticizes the use of expected utility models in cases where the probability of outcomes cannot be determined, and advocates the use of other types

² In this case, the TB appears to benefit only producers. Since apples that are damaged by fire blight would not meet grading standards, Japanese consumers would be unconcerned about whether or not the TB is in place. The trade effects of a TB may differ from the simple diagram if the measure affects consumers' demand for the product (Thilmany and Barrett). For example, a country-of-origin label may stimulate or deter consumer demand for the foreign product.

³ Other empirical studies have used risk assessments. Orden and Romano consider a range of probabilities of a pest infestation and a variety of cost estimates to the U.S. avocado industry in their study of the U.S.-Mexican phytosanitary barrier dispute. Paarlberg and Lee investigate potential losses due to transmission of foot-and-mouth disease and estimate the welfare-compensating tariff.

of choice models such as a minimax-type decision rule that emphasizes the most extreme possible outcomes (Woodward and Bishop). In the case of fire blight, experts may not be able to agree on the expected loss, yet they may be able to identify the most extreme outcome and compare that with the estimated threshold.

Empirical Results

The Fuji variety was selected for our TB analysis since it is the most common Japanese apple, even though Japan currently bans imports of U.S. Fuji apples on phytosanitary grounds. The empirical model looks at the benefits and costs of reducing barriers to Fuji trade from marketing years 1994/95 through 1996/97, assuming that fire blight affects only Fuji production. To calculate the tariff-rate equivalent of the TB regulations, we compare the monthly world Fuji price, WP , with the monthly national wholesale Fuji price in the Japanese market, P . To approximate WP , we estimate the CIF cost (cost of apples plus insurance and freight) of Washington Fuji apples if they could be sent to Japan.⁴ We assume the Japanese wholesale price represents very high-quality apples and compare this price with the estimated CIF price for the high end of the price range for Washington Extra Fancy Fuji apples (Schotzko).⁵ We select U.S. size 72 Fuji apples—the largest size for which we have data—for comparison with Japanese apples because consumers there prefer larger sizes. Transportation costs are assumed to be equal to those of Red and Golden Delicious apples, which are based on data from AMS and industry estimates. Because we do not have data on internal transactions costs for Japan, which are thought to be considerable, we understate the costs of bringing a U.S. apple to the foreign wholesale market.⁶

TB Tariff-Rate Equivalents

The first two columns of table 2 show the tariff rates and TB tariff-rate equivalents for the 1994/95–1996/97 marketing years. Recall that since the United States does not currently export Fuji apples to Japan, the TB tariff-rate equivalents represent a lower-bound estimate. The average tariff rate over the three-year period was 19.3%, compared with a 27.2% TB tariff-rate equivalent. TB tariff-rate equivalents vary between years. In a case like Japan, where there is virtually no trade, the TB we measure also could be described as the opportunity cost to Japanese consumers of having no trade—the cost

⁴ We assume the Washington State price represents the world price because the United States is a major world apple exporter, Washington State is the largest source of U.S. apples, and Washington State supplies Fuji apples nearly year-round (generally October–July).

⁵ We use USDA's Agricultural Marketing Service (AMS) data on apple prices. The first Fuji apples of the season are generally exported, and AMS reports begin only when there are adequate domestic shipments to establish a price. Also, for both the 1994/95 and 1995/96 seasons, AMS data for Extra Fancy Washington Fuji apples are available only for regular storage apples, not controlled atmosphere apples—which means the time series ends midway through the season. To complete the time series, we use data from the Washington Growers Clearing House Association (WGCHA) on average monthly prices for all Fuji apples as a basis to estimate a price for Washington Extra Fancy apples during those months without AMS prices. An average premium for the higher quality Fuji apples is estimated from the AMS and WGCHA data during the months when both are available. This premium is used with the average monthly WGCHA prices for all Fuji apples during the rest of the season to obtain estimates for the higher quality Fuji.

⁶ Even if information on internal transactions costs were available, the costs may reflect an inefficient distribution system. Opening the market to more competition might result in efforts to streamline the marketing structure.

Table 2. Short-Run Changes in Japan's Fuji Apple Imports with Elimination of Trade Barriers (1994/95–1996/97 marketing years)

Year	Tariff Rate (%)	TB Rate (%)	TB + Tariff Rate (%)	Elasticity of:		Increase in Imports with the Elimination of:			
						TB		TB + Tariff	
				Demand	Supply	Quantity (000s MT)	Value (\$ mil.)	Quantity (000s MT)	Value (\$ mil.)
1994/95	19.8	51.4	71.2	-0.2	0.1	38.9	71.6	53.8	99.1
1995/96	19.3	20.6	39.9	-0.2	0.1	18.3	31.3	35.5	60.6
1996/97	18.8	9.7	28.5	-0.2	0.1	9.0	13.7	26.4	40.1
Average	19.3	27.2	46.5	-0.2	0.1	22.1	38.9	38.6	66.6

Note: MT denotes metric tons.

facing consumers in any highly protected industry. In years when the gap between U.S. and Japanese prices increases, the opportunity cost to Japanese consumers of foregone consumption also increases. Therefore, the difference between P and WP could vary from year to year as a function of world and domestic supply and demand conditions. The TB tariff-rate equivalent for 1994/95 (51.4%) is considerably larger than that for the other two years examined because the United States produced a record apple crop that year, lowering U.S. apple export prices and generating a larger price gap.

Short-Run Changes in Trade from Eliminating TB Tariff-Rate Equivalents and Tariffs

We estimate the quantity and value of trade that would have occurred if TB requirements were harmonized to the current Washington State systems approach to disease and pest management and if tariffs were eliminated. In this case, Japan could import apples at the world price. We assume that when TB tariff-rate equivalents are harmonized, the standard U.S. practices are continued without any additional costs of compliance. To attain results, we assume a demand elasticity of -0.2 and a short-run supply elasticity of 0.1 .⁷

Table 2 shows the range of annual and average results for the short-run impact of eliminating the TB tariff-rate equivalent and for eliminating both the TB tariff-rate equivalent and tariff. Here, we discuss only the results for the average of the three years considered. If just the TB tariff-rate equivalent were removed, the average quantity of apples imported from all sources would rise by 22,100 metric tons, up from an average of 3,442 metric tons. If both the TB and tariff were eliminated, average imports would rise by 38,600 metric tons, equivalent to 16% of total 1996/97 U.S. production of Fuji apples.

⁷ Cho and Cho estimate an own-price elasticity of demand for Korean apples of -0.2 , and Huang estimates a complete price and expenditure system for specific U.S. fruits and reports a -0.2 demand elasticity. We assume the same demand elasticity for Japan. Baumes and Conway estimate a U.S. supply elasticity at the farm level of 0.007 for fresh apples, but we assume a slightly larger elasticity for Japan.

Japanese Welfare Effects from Eliminating TB Tariff-Rate Equivalents and Tariffs

Changes in welfare for the three seasons and an average, assuming time for a long-run adjustment, are presented in table 3. The long-run analysis is based on the same elasticity of demand used in the short-run analysis and a long-run constant elasticity of supply of 1. The larger supply elasticity allows growers to change their production plans in response to new economic conditions.⁸ If just the TB were removed and there was no possibility of disease transmission, trade would increase, and the annual net welfare gain for the three years would be \$70.9 million, which includes a gain of \$35.6 million in tariff revenue. Producer loss would be \$210.4 million, a loss of 31% of the original producer welfare. In this case, imports of Fuji apples, from all sources, would increase by 88,200 metric tons. This increase in imports represents 36% of U.S. Fuji apple production in 1996/97. At this level of imports and standard Washington export procedures for apples, the Roberts et al. model predicts an outbreak of fire blight once in every 475 years.

Under the removal-of-TB-only scenario, if fire blight were transmitted, it would take a decrease in yield of 26% to eliminate the positive gains to trade. In this case, producers would incur a 15% decline in producer welfare solely due to the disease loss, in addition to the 31% loss due to trade (table 3). The occurrence of a 26% annual loss, or a complete crop loss about once every four years, is unprecedented. The very large yield loss due to disease required to eliminate the gains to trade appears improbable. The welfare gain associated with the trade effect is much larger than the likely loss associated with transmission of the disease.

If both the TB and tariff were removed and there were no chance of fire blight transmission, the net welfare gain due to trade would be \$84.7 million (table 3). The net welfare gain is only slightly larger than when just the TB is removed since there is no longer a tariff revenue gain. The trade effect on producer welfare is \$330.3 million, a loss of 51% of the original producer welfare. Imports would increase by 154,300 metric tons. This change in trade would represent 64% of the 1996/97 U.S. Fuji production. Because the welfare gains when the tariff is also removed are larger, the annual yield disease loss would increase to 30% to eliminate the larger overall welfare gain due to trade. This level of loss would require a complete loss of production about once every three years. Again, required losses appear to be unreasonably large compared with experiences of other countries. Therefore, even if there were a legitimate scientific justification for a TB, there seems to be no economic justification for the restrictive TB.

With our simple model, we cannot estimate potential world price increases—but we can assess the impact of a world price increase. If world Fuji prices increased due to Japanese imports, producer losses, consumer gains, and net welfare gains would decline. The required disease losses would also decrease. As the world price approaches the pre-trade Japanese domestic price, net welfare gains would fall to zero. For example, if Fuji prices increased 10% when the TB was eliminated, the disease loss required to eliminate gains to trade would fall from 26% to 15%, which would imply a complete crop failure

⁸ Romano follows similar reasoning in his study of avocados.

Table 3. Long-Run Welfare and Trade Impacts for Fuji Apples with Elimination of Trade Barriers

Year	Elimination of:	Rate (%)	Original Producer Welfare (\$ mil.)	Decrease in Producer Welfare (\$ mil.)	Tariff Revenue (\$ mil.)	Net Welfare Gain (\$ mil.)	Long-Run Change in Trade Volume (000s MT)	WITH NO DISEASE LOSS			WITH DISEASE LOSS		
								Long-Run Change in Trade Volume as a Percent of 1996/97	Percent Fall in Original Producer Welfare with Trade Loss (%)	Long-Run Change in Trade Volume (000s MT)	Net Welfare Gain (\$ mil.)	Percent Yield Loss Required to Eliminate Net Welfare Gain (%)	Percent Fall in Original Producer Welfare with Disease Loss (%)
1994/95	TB	51.4	791.2	403.8	65.9	153.1	155.4	64	51	59	29		
	TB + Tariff	71.2	791.2	521.3	NA	168.2	215.3	89	66	62	21		
1995/96	TB	20.6	586.5	159.9	28.6	44.0	73.3	30	27	15	11		
	TB + Tariff	39.9	586.5	286.8	NA	58.2	142.2	59	49	19	10		
1996/97	TB	9.7	463.4	67.6	12.3	15.5	36.0	15	15	5	4		
	TB + Tariff	28.5	463.4	182.9	NA	27.8	105.4	44	39	10	6		
Average	TB	27.2	613.7	210.4	35.6	70.9	88.2	36	31	26	15		
	TB + Tariff	46.5	613.7	330.3	NA	84.7	154.3	64	51	30	12		

Notes: MT denotes metric tons; NA signifies not applicable.

approximately once every seven years. With a 20% increase in the world Fuji price, the required disease loss would fall to 8%.

While the increased demand for Fuji apples would account for a large percentage of U.S. Fuji production, many countries, including the United States, are rapidly increasing Fuji apple production and are anxious to supply the Japanese market. The small-country assumption will become more realistic with time. Between 1997 and 2005, Fuji production by the main supplying nations, excluding China and Japan, is predicted to increase 43% (O'Rourke). China, the world's largest apple (and Fuji apple) producer, experienced 88% growth in total apple production between 1993/94 and 1996/97 (USDA/Foreign Agricultural Service 1998). The change in trade implied by the removal of the TB and tariff would be 50% of the estimated 1997/98 U.S. Fuji crop, 23% of the estimated world crop excluding Japan and China, and 6% of the world crop excluding Japan but including a crude estimate of Chinese Fuji production (15% of total Chinese apple production). Availability of other apple varieties would also dampen any increase in Fuji prices. The increase in Fuji imports in Japan would represent 22% of 1996/97 total U.S. apple exports and about 4% of world apple exports.

Conclusions

Although the WTO does not require a complete welfare analysis to justify a TB, this type of cost-benefit analysis is critical for understanding the social welfare effects of regulatory policies. Our results show that, on average, TBs in Japan are even more important than tariffs in deterring trade. Moreover, the primary role of Japanese TBs for apples appears to be to protect economic rents of domestic producers from foreign competition and not to maximize social welfare. However, this analysis gives equal weight to consumer and producer welfare. When governments choose regulatory policies, other objectives often necessitate unequal weights for different groups. There are many similar examples of regulatory capture by producers who exert strong influence to maintain TBs that protect economic rents. The long-standing U.S. ban on Mexican avocados, which was only partially lifted in 1997, is viewed by many as another example of regulatory capture (Romano).

While measuring TB tariff-rate equivalents and determining the welfare impacts of removing barriers are simple concepts, the empirical application is complex and the results are highly dependent on a number of simplifying assumptions. Some assumptions may lead to our overstating the estimates of the TB tariff-rate equivalent and trade effects. We assumed that world prices are not affected by the changes in Japanese imports. The estimated large increases in Japanese imports if barriers were eliminated, however, likely would have an impact on world prices. This would suggest that the Japanese price would not decline as much as indicated in our analysis, and the disease loss required to eliminate consumer gains would be less. We may have overstated the price differentials between Japanese and U.S. apples. To the extent that Japanese Fuji apples are of higher quality than the top Extra Fancy Washington State Fuji apples, the price differentials also will reflect quality differences rather than just regulatory barriers. Additionally, our price wedge calculations did not reflect the transactions costs of moving U.S. apples from the Japanese port of entry to wholesale markets, which also leads to an overestimate of the price gap. Alternatively, we may underestimate the magnitude of the TB by using the price wedge method to calculate TB tariff-rate

equivalents when there is no trade. The TB tariff-rate equivalents reported are lower-bound estimates.

Other assumptions affect the welfare measures specifically. First, of course, are the particular assumptions regarding demand and supply specifications and parameter estimates. The Japanese supply curve might change when faced with new competition. With fewer trade barriers, the Japanese apple industry would have incentives to reduce costs which would increase producer surplus. Second, a more complete analysis would include potential disease losses for codling moths and apple maggots. And third, we should consider any changes in Japanese production costs due to combating new diseases or pests. Fourth, and finally, in this model the gains to trade and required disease losses refer only to Fuji apples. Since Fuji apples account for just over half of the Japanese crop, if fire blight were established in Japan, the disease loss for all apples required to eliminate gains to Fuji trade would decline. Considering potential losses to pears would further reduce the required losses. Of course, opening markets to other types of apples and pears would provide additional consumer gains to compensate for potential disease losses.

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