Quantification of Sanitary, Phytosanitary, and Technical Barriers to Trade for Trade Policy Analysis

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Abstract

This paper presents promising methodologies for modeling and quantifying non-tariff barriers (NTB) to trade in the agricultural and food sectors. We limit the analysis to sanitary, phytosanitary, and technical regulations that can have an impact on trade and to methods that provide some quantitative estimates of the impact of such barriers on market equilibrium, trade flows, economic efficiency, and welfare. Given the heterogeneous nature of these regulations, a unifying methodology does not exist. Quantification of the effects of such measures has focused on a particular product and has relied on methods that belong to different fields of the economic literature. We provide a concise description and evaluation of the various methods available for a more comprehensive assessment of the impact of NTBs on trade and welfare. We conclude by identifying promising areas for future applied research.

Key words: agriculture, non-tariff barriers, NTB, policy, sanitary and phytosanitary, SPS, TBT, technical barriers to trade, trade.

QUANTIFICATION OF SANITARY, PHYTOSANITARY, AND TECHNICAL BARRIERS TO TRADE FOR TRADE POLICY ANALYSIS

Introduction

The goal of this paper is to present promising methodologies to model and quantify non-tariff barriers (NTB) to trade in the agricultural and food sectors. We limit the analysis to sanitary, phytosanitary, and technical regulations that can have an impact on trade. We focus on methods that provide some quantitative estimates of the impact of such barriers on market equilibrium, trade flows, economic efficiency, and welfare. Given the heterogeneous nature of these regulations, a unifying methodology does not exist. Attempts to quantify the effects of such measures have often focused on a particular product and have relied on methods that belong to different fields of the economic literature. We provide a concise description and evaluation of the various methods available for a more comprehensive assessment of the impact of NTBs on trade and welfare. We conclude by identifying promising areas for future applied research.

The demand for better estimates of the impact of these regulations on trade matches several preoccupations of policymakers. First, domestic regulations may constitute major trade impediments, and their use is proliferating. However, it may be that these NTBs are simply becoming more visible because of international scrutiny, or more trade restrictive because of the decrease in tariffs. A comprehensive assessment of the actual impact of these regulations is necessary in order to address the role to be given to non-tariff instruments and barriers in a future trade agreement. Second, quantification of the economic effects of sanitary and phytosanitary (SPS) measures and technical regulations is an important step in the regulatory reform process that Organization for Economic Cooperation and Development (OECD) countries have been involved in since 1997 (OECD 1997). Quantitative analyses help to inform governments of the costs of their SPS policies and provide the tools necessary to define more efficient regulations (Antle 1995). Third, more satisfactory techniques for estimating damages to trade partners caused by foreign regulations may help solve disputes and serve as a basis for calculating

compensation claims. Finally, sectoral studies suggest that technical regulations in developed countries constitute a considerable obstacle to agricultural food and exports of developing countries (Cato and Lima dos Santos 1998; Otsuki, Wilson, and Sewadeh 2000). During the Uruguay Round, developing countries saw access to northern markets in the food sector as a main motivation for participating in multilateral agreements, where they felt they had otherwise a lot to lose (e.g., on intellectual property). Because they feel that their access to northern markets did not improve because of technical requirements, they see little interest in participating in a new round of trade negotiations. More information on the effect of regulatory barriers could help account for developing countries' claims, a key condition for successful multilateral negotiations.

Several recent papers have surveyed policy-relevant issues in the sanitary and phytosanitary area (OECD 1999a; Orden and Roberts 1997). Government agencies have listed regulations that they see as illegitimate obstacles to exports (EU Commission 2000; USTR 2001). Researchers have proposed various definitions of NTBs and have tried to distinguish between those regulations designed to protect local industry and those designed to protect consumers (Hillman 1997; Roberts and DeRemer 1997). The legitimacy of such regulations has been discussed, as well as the rationale behind purely science based versus economic approaches (Neven 2000; James and Anderson 1998; Bureau and Marette 2000). Frameworks for estimating the effects of such barriers have also been proposed (Bigsby and Whyte 2000; Roberts, Josling, and Orden 1999; Maskus and Wilson 2000; Maskus, Wilson, and Otsuki 2001; Ganslandt and Markusen 2000). However, a lot of work remains to be done on quantitative estimates of the impact of regulations on trade.

Definitions of a Non-trade Barrier

Different Conceptions of a Non-trade Barrier

Hillman (1991) defines NTBs as "Any governmental device or practice other than a tariff which directly impedes the entry of imports into a country and which discriminates against imports, but does not apply with equal force on domestic production or distribution." Thornsbury et al. (1999) endorse this concept. Their definition includes standards of identity, measure, and quality, SPS measures, and packaging measures.

Roberts (1998) and Thornbury (1998) have classified regulations by policy instrument, by scope of the barrier, by regulatory goal, by legal discipline, by type of market restriction, by product category, and by geographical region. Such a classification helps to identify differences in food safety and quality standards among counties that could have protectionist tendencies.

However, distinguishing an NTB from a legitimate regulation for protecting consumers can be difficult. That is why other authors emphasize that the term "barrier" should not be applied to measures that may have an incidental effect of restricting trade but whose principal objective is to correct market inefficiencies. On the basis of a definition of NTBs given by Baldwin (1970), who restricted the concept to measures that decrease world global revenue, trade-restricting regulations that have overall positive welfare effects should not be considered NTBs. Mahé's (1997) definition of an NTB as a restriction other than a tariff that leads to a decrease in world welfare falls into this category. The idea of qualifying as protectionist a standard that differs from the one that would be chosen by a world-welfare-maximizing social planner also relies on the same idea. Other authors suggest using cost-benefit criteria to decide whether regulations that affect trade are legitimate.[1]

A third definition of NTBs relies on the idea that a regulatory measure should be compared to the measure that would have been implemented if it had been designed for domestic purposes only (Maskus, Wilson, and Otsuki 2001). Fisher and Serra (2000), for example, characterize a standard (in an open economy) as non-protectionist if it corresponds to the standard that the social planer would use if all firms were domestic. This makes it possible to account for the welfare-enhancing effect of a standard in the presence of negative externalities.

Consequences for Measurement

The distinction between a trade-oriented definition and a welfare-oriented definition of an NTB is not just theoretical. It has direct consequences on empirical measurement, because the two conceptions lead to different approaches. Some methods rely on the measurement of possible trade impacts only (such as methods based on price-wedge estimation, surveys, and gravity models). Other methods are grounded in welfare economics and measure NTBs through a larger range of effects than trade alone (such as

methods based on comparative-statics or cost-benefit analysis and general equilibrium analysis). Welfare-based approaches are conceptually superior because they capture a larger range of effects (e.g., they account for the positive externality of a regulation that, say, protects consumers). However, because NTBs are debated in multilateral negotiations, negotiators focus on trade expansion, measuring the impact in terms of volume of trade for other countries.

An Analytical Framework for Measurement

Measurement

Measurement in economics attempts to capture complex effects into one scalar. One possibility is to measure NTBs through their synthetic effect on the volume of imports at world prices. More general effects can be taken into account by assessing the effect of NTBs on welfare, which is the most synthetic indicator of the effects of a given measure on a whole economy. To account for the revenue that is diverted between different agents, distributional effects of NTBs must be taken into account, for example, by using a social accounting matrix that represents the effect on different categories of agents. General measures can also be based on the resource costs of NTBs. In such a case, the measure would include not only the deadweight losses but also the administrative costs of enforcing NTBs and the costs of the resources lost to rent seeking (Deardorff and Stern 1998).

Measures of NTBs can be based on how a given regulation affects the overall equilibrium in the sector or in the economy. Roberts, Josling, and Orden (1999) propose an analytical framework for analyzing NTBs that summarizes most of what the various authors have adopted. They distinguish three economic effects: (*i*) the "regulatory protection effect," i.e., the fact that a regulation provides some rents to the domestic sector; (*ii*) the "supply shift" effect, which focuses on the effects of imports on the domestic supply and the costs of enforcing compliance; and (*iii*) the "demand-shift" effect, which takes into account the fact that a regulation may bring information and increase consumer demand for the product. Using comparative statics in a partial equilibrium framework, the authors illustrate the different effects of these three components of NTBs, in particular in terms of welfare.

Compliance with a regulation involves a cost to foreign suppliers, which acts like a trade tax, resulting in a deadweight loss in the importing country as well as transfers from consumers to producers. Because there is no tariff revenue, the welfare loss is potentially higher than with the tariff equivalent. This shows that all the methods relying on the construction of a tariff equivalent (described in some of the following sections, such as the price-wedge method) are only appropriate for measuring trade volume effects but do not give a tariff equivalent that has welfare interpretations.

The supply-shifts component of an NTB captures both the effect of imports on the domestic supply (in the absence of regulation) and the potentially beneficial impact of the regulation, should it limit the cost of pathogens for example (even if this involves some additional costs of testing and detection). Other features can be added to the framework proposed by Roberts, Josling, and Orden (1999). In particular, the cost of regulations affects small and large firms differently, and regulations modify the structure of competition or the size of the relative markets, affecting markups and rents (Neven 2000; Fisher and Serra 2000). Ganslandt and Markusen (2000) also account for the fact that standards can impose a fixed cost of entry that affects competition and may also lead to multiple equilibria, an effect well known in the literature on industrial organization. Maskus, Wilson, and Otsuki (2001) account for the discriminatory nature of the regulation towards imported products through relative shifts in the excess supply curve of the exporting country and excess demand curves of the importing country.

Finally, the regulation affects domestic demand. This, as well as possible shifts in supply, opens the possibility for the regulation to generate welfare gains that could offset, at least partially, the losses involved in the "regulatory protection" effect. The large literature derived from industrial organization has made it possible to account for effects more sophisticated than the simple shift in supply curves. Bureau, Marette, and Schiavina (1998), for example, specifically include the information aspect in the "demand shift" effect. The regulation brings information and therefore avoids the "lemon problem," or reduces the cost that consumers face in assessing product quality. Casella (1996), and Fisher and Serra (2000) explicitly account for the public good effect of regulations. It is also possible to include the reduction of transaction costs induced by some regulations and standards. The analytical frameworks proposed by Roberts, Josling, and Orden

(1999) can be extended to the multimarket case, which makes it possible to include extra effects of regulations. These include the fact that regulations (at least those that promote standards) can raise the elasticity of substitution in demand and bring network externalities and even economies of scale by permitting producers to settle on a limited range of product characteristics or processes, or other forms of transaction facilitation (Harrison, Rutherford, and Tarr 1996; Maskus, Wilson, and Otsuki 2001).

Practical Obstacles to Measurement

There is, however, still a large gap between the ambitious analytical framework and the applied estimates of the effects of NTBs. In practice, the way regulations affect supply, the extra costs induced, and the price differences between foreign and domestic products are key components of model simulations. Information on these aspects is still incomplete. Even when it is possible to observe what actually occurs as a result of the NTB, this does not in itself measure only the NTB but captures other information, for example the supply elasticity.[2] The sophisticated effects of extra information and trade facilitation addressed in stylized microeconomic models are hard to quantify. The impact of standards on consumers' confidence and willingness to pay, for example for credence attributes (genetic engineering, ethical, animal welfare, or environmental attributes) remain uncertain. While in theory, applied general equilibrium (GE) models are able to account for the complex effects of regulations on trade, in practice, many simulations rely on crude estimates at an aggregated level. Most of the time, the results are questionable. In the next sections, we turn to a description and a brief assessment of the various methods that have been used in the empirical estimation of the effect of non-trade barriers.

The Price-Wedge Method

Principle

Price-wedge methods rely on the idea that NTBs can be gauged in terms of their impact on the domestic price in comparison to a reference price. The main use of this method is to provide a tariff equivalent. That is, the method is conceptually oriented toward measuring the trade impact of NTBs. However, the estimate of the price wedge

(or the tariff equivalent) can be used as an input in a partial or even a general equilibrium model that focuses more on the welfare effect of NTBs.

The tariff equivalent is estimated by calculating the price wedge between the imported good and the comparable product in the domestic market. The correct measure would be to compare the price that would prevail without the NTB to the price that would prevail domestically in the presence of the NTB if the price paid to suppliers were to remain unchanged (Deardorff and Stern 1998). However, these prices usually are unobservable, and actual measures focus instead on a comparison of the domestic and foreign price in the presence of the NTB. Adjustment can be made for retrieving the price situation in the absence of an NTB using trading quantities and supply and demand elasticities of domestic and imported goods (Laird and Yeats 1990).

The domestic price of the imported good should be compared with the invoice price, i.e., the cost, insurance, and freight (CIF) price of the imported good as paid by the domestic importer to the foreign exporter, inclusive of transport costs but exclusive of tariffs. If this price is not available, it is possible to use alternative measures such as the price of imports taken from a variety of exporters (although Deardorff and Stern 1998 provide evidence of possible bias when this convention is used). The tariff equivalent of a regulation can be measured as a residue when the price difference is corrected for tariff, handling, and transportation costs and for product quality differences.

Existing Studies

Such a method was used by Campbell and Gossette (1994) for a large number of sectors, including food and agriculture. They made sophisticated quality adjustments to make products homogenous. The U.S. International Trade Commission (USITC) uses the method on a regular basis. The USITC measures the price gap of U.S. tariff equivalents by sector and also adjusts for quality differences (USITC 1995). The method was used in two studies specific to the agriculture and food sector. Calvin and Krissoff (1998) estimated the tariff rate equivalents of the technical regulations in the apple sector. In order to do so, they compared CIF prices (landed prices including freight and insurance costs) of U.S. apples in a foreign country with wholesale prices in the foreign market. They assumed that the price gap consists of the tariff and technical barrier tariff rate equivalent. They used monthly data, and attempted to focus as much as possible on the

price of a like apple (i.e., same variety, grade, and size) during the same time and at a similar place in the marketing chain. They constructed transport costs that correspond to the cost of bringing U.S. apples to various wholesale markets. Once the difference in price between the U.S. apple delivered in the foreign country and the wholesale price for a similar apple in the foreign wholesale market was known, the monthly price wedge (in percentage terms) was calculated. The monthly price wedge was divided into the known tariff rate and the technical barrier tariff rate equivalent, which was the residual.

This approach was also used in a study for the European Commission that compared monthly CIF prices of U.S. pig and poultry meat as well as apples in the European Union (EU) with their wholesale price in the EU market (European Commission 2001). The difference in price between the U.S. product and the wholesale price of the comparable product was calculated as the price wedge in percentage terms. Within the same EU-sponsored project, a similar approach was implemented for the measurement of U.S. non-tariff barriers in tomatoes and apples. While Calvin and Krissoff's (1998) study leads to the conclusion that the price-wedge method can provide useful estimates of the tariff equivalent of technical barriers, the authors of the EU study are pessimistic about the practical validity of the method. In the case of tomatoes, their results are highly sensitive to the choice of a price series. Export prices show considerable variations over time and across various origins, and quality effects cannot explain this fact. The importance of the efficiency of the marketing channels of existing relations is such that, for commodities like tomatoes, results were not reliable. Even with a relatively narrow list of commodities, there are quality differences that might affect the measure of NTB tariff equivalent as a price-wedge residual. Calvin and Krissoff, for example, acknowledge that, in spite of their efforts to use like products, South Korean Fuji apples are different from Extra Fancy Washington apples.

Practical Validity of the Method

The price-wedge method has several limitations. First, the method makes it possible to quantify the effect of a set of NTBs present on the market but seldom makes it possible to identify what those NTBs are precisely. Second, formulas that measure the NTB in an implicit way, as a percentage price wedge between imports and domestic prices, are valid only under the assumption that imported goods are perfect substitutes. A barrier that

raises the domestic price of an import good by 10 percent raises its price in the domestic market by less than that if imports are a small part of the market and if imports are a poor substitute for domestic goods. That is, comparisons between a good's domestic and international prices can be biased by cross-country differences in supply and demand elasticity. Price can also be affected by differences in the ability of foreign and domestic firms to appropriate rents from non-tariff restrictions. If exporting firms are able to price discriminate, the price-wedge method will also reflect rents rather than NTBs.

The main limitation of the method lies in its practical difficulties. For large-scale studies, available data are often too aggregated to reflect differences in the quality of imported goods. Even when prices can be observed at the border of the importing country, inclusive of international transportation costs, price differential calculations do not fully reflect the transaction costs of moving goods from the border to wholesale markets. Traded products are different from the domestic ones in some aspects. If domestic varieties are of a higher quality than imports, such measures find protection even where there is none.

Overall, because of data limitations, the analysis can only be performed successfully on a few case studies, focusing on a particular product that is relatively standardized. For larger-scale studies, the price-wedge method does not appear reliable. Particularly questionable are the (numerous) studies where crude estimates of tariff equivalents of regulatory measures using the price-wedge method have been introduced in large-scale models. The price-wedge method applied to a level of detail such as the two-digit level of the Harmonized System or the Standard Global Trade Analysis Project classification is unlikely to reflect the true effect of technical regulations but will instead capture many other unwanted effects.

Inventory-Based Approaches

Principle

Inventory-based approaches can be used both in a quantitative perspective as well as in a qualitative perspective to assess the importance of domestic regulations as trade barriers. Three sources of information can be used: (*i*) data on regulations, such as the number of regulations, which can be used to construct various statistical indicators, or proxy variables,

such as the number of pages of national regulations; (*ii*) data on frequency of detentions; and (*iii*) data on complaints from the industry against discriminatory regulatory practices and notifications to international bodies about such practices.

Quantitative estimates can rely on the catalog of all technical barriers (identification and description) based on data sets that list the various regulations in the sanitary, phytosanitary, and technical area.[3] Simple statistics, such are frequency-type measures, can be used to provide an indication of the frequency of occurrence of NTBs. Such measures may be unweighted or they may be weighted by imports of by production. Measures include (*i*) the number of restrictions; (*ii*) frequency ratios (the number of product categories subject to an NTB as a percentage of the total number of product category in the classification); and (*iii*) the import coverage ratio, constructed as the value of imports of each commodity subject to an NTB, as a percentage of imports in the corresponding product category. More refined indicators can provide some extra information, albeit under somewhat tenuous assumptions. For example, the percentage of standards based on international ones can be an indication of the overall compliance of a national standard with widely used international standards.[4]

Data on detentions at the border is also a relevant source of information. In the United States, data are readily available on border inspection, reasons for detention, and the frequency of rejected shipments for technical, sanitary, and phytosanitary reasons.

Existing Studies

The inventory-based approach has recently gained momentum, and two studies have related trade flows to measures of a country's stock of standards. Swann, Temple, and Shurmer (1996) used counts of voluntary national and international standards recognized by the United Kingdom and Germany in an econometric study, where the authors regressed British net exports, exports, and imports over the period 1985–1991 on variables including frequency indicators of standards. Moenius (1999) also used the inventory-based method as an input in econometric approaches. Both studies used counts of binding standards in a given industry as a measure of stringency of standards. Otsuki, Wilson, and Sewadeh (2000) went further and employed a direct measure of the severity of food safety standards expressed in maximum allowable contamination. Fontagné, von Kirchbach, and Mimouni (2001) used a more sophisticated indicator for assessing the

impact of environmental regulations and their potential use as a trade barrier. The underlying idea is that when a barrier is set by only a limited number of countries, it is more likely to be used for protectionist purposes. Employing a large dataset, they used frequency statistics with different thresholds on the number of countries that have implemented a trade-restrictive regulation for a given product.

In their study on the food sector for the European Commission, Henson, Lux, and Traill (2001) used several approaches to assess the importance of regulatory obstacles in the European Union and the United States, including the inventory approach. They compared the regulatory food quality and safety regimes of the European Union and the United States and identified differences in food quality and safety standards by classifying these measures by policy instruments and regulatory goal or aim. They used a database of mandatory governmental regulations and standards from the United States (447 regulations published in the *Code of Federal Regulation*) and the European Union (279 regulations published in the *European Official Journal*).

Other studies have used data on border detention rather than regulations. For example, Lux and Henson (2000) have performed an analysis of border detentions in the United States in order to assess how EU exports could be harmed by import procedures and border inspection. Their analysis shows that problems mainly arise in specific sectors, such as dairy. Henson et al. (2000) have studied the import rejections by the United States of products coming from Africa, Asia, and Latin America because of sanitary and technical reasons.

Practical Validity of the Method

Standards vary in importance across sectors and products. Different standards would not be expected to have similar effects, and the number of standards or the number of pages of domestic regulations is a poor proxy for the trade restrictiveness of the whole regulatory set. It is not clear if there is any correlation between the number of measures and the effect on trade. When based on international data sets, estimates based on the occurrence of the measure can also be misleading because of the uneven reporting by countries and the non-uniform coverage of measures across countries. Measures based on actual detention at the border are more reliable but run into the limited availability of data. With the exception of the United States, countries do not make information readily available.

With these limitations, inventory-based approaches can be useful for directing attention to the frequency of occurrence and the trade or production coverage of various types of NTBs. Inventory-based methods do not really provide a quantification of the effect of regulations on trade per se. However, they can provide useful indications on the importance of the problem and on which sectors' and countries' NTBs are more likely to be found. An interesting use of this method is the construction of indicators that can be used in econometric estimates of trade. Their use as a proxy variable in econometric models (e.g., gravity models) is a method of research that deserves more exploration.

Survey-Based Approaches

Principle

Inventory-based approaches do not make it possible to differentiate between regulations that have a major trade restriction effect and those that do not. By asking practitioners which measures have more impact on their activity, surveys make it possible to narrow the scope of the analysis and to focus on the relevant issues. When coupled with in-depth interviews of a sample of the population surveyed, these approaches have sometimes provided counterintuitive assessments of the importance of trade barriers.

Surveys can also be designed to provide information (such as ranking the importance of the measures on a scale) that can be used in econometric studies. An extensive study conducted by the U.S. Department of Agriculture (USDA) on estimates of the trade impact of foreign technical regulations illustrates interest in the method when basic information is missing . The econometric exploitation of the USDA survey shows that surveys can be used as a basis for more refined measures of NTBs (Thornsbury 1998).

Existing Studies

Information provided by the industries that face restrictions to their exports is an input for the European Commission's annual report on U.S. trade barriers (2000) and the U.S. Trade Representative's annual report on foreign trade barriers (USTR 2001). In some areas (the information technology industry in particular), the U.S. International Trade Commission also performs informal interviews of corporate executives, officers of

trade associations, and government officials for their reviews of the importance of standards as trade impediments.

The OECD (1999b) conducted a survey of 55 firms in three sectors in the United States, Japan, the United Kingdom, and Germany on exports impediments. One of the sectors surveyed was the dairy industry. In 1996, the USDA conducted a survey providing a cross-sectional accounting of technical barriers to U.S. agricultural exports. The USDA cross-sectional data set was used to characterize the extent of economic-based protection provided. Several studies derived from this survey quantified the trade impact of questionable technical barriers on U.S. agricultural exports (Roberts and DeRemer 1997; Thornsbury et al. 1999; and Thornsbury 1998).

Specific surveys were conducted concerning the problems developing countries face in meeting the SPS requirements of the developed countries and adhering to the provisions of the SPS agreement. Henson, Loader, and Swinbank (1999) conducted surveys (by fax) coupled with in-depth interviews. The questionnaires were sent to contact points (e.g., the contact point of the Codex Alimentarius in a given country) in developing countries rather than to industry representatives. Several studies conducted by the University of Reading used a combination of surveys and in-depth interviews. This approach proved particularly interesting for identifying the most relevant issues and for debunking some common misconceptions. For example, from the work of Henson, Lux, and Traill (2001) for the European Commission, it appears that one major complaint of European exporters to the United States is not the tariff or the sanitary requirements but the administrative burden, in terms of both delays and lack of predictability.[5] A finding of the OECD (1999b) survey on dairy was that few firms considered standards to be of great concern. In the dairy industry, there were problems in certification and approval delays for exporters of specialty products, but dealers in bulk dairy goods reported few difficulties.

Practical Validity of the Method

Survey-based methods are useful when other sources of information are lacking. Combined with interviews, they also have shed considerable light on the important issue of barriers faced by developing countries willing to export to the United States and to the European Union, for example. Another useful feature of the survey-based approaches is

the ability to identify barriers that are diffuse and difficult to measure, such as the administrative ones. Survey-based methods also show that the regulations of greater concern for the industry are not always those that economists would have identified and attempted to include in their models.

However, the ability of surveys to actually help quantifying NTBs is questionable. The firms consulted are likely to be biased if there is a perception that the agency conducting the survey will use the information for policy purposes. Even the experts surveyed can have the perception that their responses could be used to initiate dispute-settlement procedures.[6] The definition of the questionnaire and the way the survey is conducted are likely to affect the NTB estimate. The cost of the method, in view of the results, suggests that it should be restricted to cases where no other sources of information are available.

Gravity-Based Approaches

Principle

When trying to quantify NTBs, an obvious technique is to consider the foregone trade that cannot be explained by tariffs. A typical approach is to look at the residuals in economic regressions of trade flows on the various determinants of trade. In these approaches, gravity models are of particular interest since they have long been used as a way to estimate the "home bias" or the "border effect" in trade, a part of it reflecting national regulations that hamper trade. The basic principles of gravity models are summarized by Head (2000). Gravity models rely on Newton's "Law of Universal Gravitation" formula, which holds that the attractive force F_{ij} between two objects i and j is given by $F_{ij} = G*(Mi*Mj)/D_{ij}^2$, where M_i and M_j are the masses, D_{ij} is the distance between the two objects and G is a gravitational constant. In a similar way, economists discovered in the 1960s that the equation $F_{ij} = G*(M_i^a*M_j^b)/D_{ij}^2$ performed well at explaining trade flows if F_{ij} is the "flow" from origin i to destination j; M_i and M_j are the relevant economic sizes of the two locations; D_{ij} is the distance between the locations; and G, a, and b are constant (G, a, and b have subsequently been related to the form of economic functions). For a long time, gravity models performed relatively well but lacked theoretical foundations. However, Anderson (1979) gave a theoretical foundation

of the model in the presence of imperfect substitutability between goods, and further developments have shown that the gravity equation was consistent with situations characterized by monopolistic competition (Bergstrand 1989; Deardorff 1998). This foundation, together with new developments in this approach, has renewed interest in the method (Hummels 2000; Anderson and van Wincoop 2001).

An interesting application of the method estimates how much trade is foregone because of the "border" effect only. For example, McCallum (1995) showed that in 1988 the U.S.-Canadian border showed an effect that, all things being equal (in particular, distances and costs), intra-Canadian province trade was 22 times higher than transborder trade. Since that study, numerous attempts have been made to include some explanatory variables in the analysis, including language, indicators of "remoteness," and cultural differences. Dummy variables have been introduced to deal with various types of local characteristics. However, administrative barriers have seldom been taken explicitly into consideration.

It seems possible to use information on regulations, for example, estimates using the methods described above (number, frequency of regulations, survey-based impacts), or, in certain cases, the level of standards themselves, provided that there is some variability across countries or over time (e.g., the level of chemical residues, of aflatoxins, of antibiotics, etc.) as explanatory variables. Robust methods such as variance analysis or principal component analysis applied to the border-effect term could help quantify the impact of NTBs on trade. Gravity-based techniques attempt to measure the trade impact of NTBs, rather than their welfare impact, and may therefore ignore some of the effect of the regulations that correct market failures but restrict trade. However, the sign of the variables that capture the NTB effect in the regression is not constrained, and it is possible to capture also the trade-enhancing effect of regulations when they act as standards that facilitate trade.

Existing Studies

A study by Moenius (1999) is one of the most direct attempts to measure the trade impact of technical barriers to trade (TBT) using gravity-based analysis of bilateral trade volumes. He focused on the trade impact of standards (voluntary norms) rather than on regulations due to data limitations. Moenius's panel covers 471 industries in 12 western

European nations from 1980 to 1995. He found that a shared standard has a large trade promoting effect between the nations sharing the standard. He incorporated econometric refinements (correction for autocorrelation, causality testing, etc.). This makes it possible to estimate the impact of a 1 percent increase in the number of bilaterally shared standards on bilateral trade volume.

In the food and agriculture sector, Otsuki, Wilson, and Sewadeh (2000) used the gravity equation method to explain trade patterns between countries and to determine the effect of European aflatoxin standards on African exports. Their results show that new (and more stringent) EU standards are likely to be a major barrier to African exports of dried fruits and nuts. Although their approach is not characterized by econometric refinements, they exploit the possibility of using the level of standard itself as an explanatory variable because the aflatoxin maximum residue shows statistical variation in their panel. Recently, several gravity equation models have been estimated, focusing on the food sector. They might provide a basis for measurement of NTBs (Hillberry 2001; Burfisher et al. 2001; Vido and Prentice 2001).

Practical Validity of the Method

The caveats of these approaches is that they attribute departures of trade from what the model can explain to a mix of national effects, including NTBs, while the model is unlikely to be able to explain correctly all trade flows, even in the absence of domestic regulations and other factors entering into the "border effect." When focusing on detailed products and spatial trade flows among given countries, the prediction is likely to be sensitive to the assumptions of the models.

However, many econometric refinements are possible with this type of approach. The method could help sort out the share of the regulations in the "border" effect. It could also make it possible to deal with binary variables (allowed or banned) or with discrete variables—which often are the only characterization of NTBs—when standards do not show enough statistical variability to be used as regressors. Overall, gravity-based approaches, coupled with the use of proxy variables from survey- or inventory-based methods, are a promising area of research.

Risk-Assessment-Based Cost-Benefit Measures

Principle

Risk assessment approaches seem far away from the measurement of NTBs. However, these methods have been coupled with cost-benefit calculations and indirectly contribute to the measurement of the effect of regulations, and therefore of NTBs. Rather than quantifying the actual impact of this measure on trade, they provide some indication of what should be included as trade barriers on the basis of the effect of regulations on welfare. When SPS regulations aim at correcting market failures, one difficulty often is the identification of the protectionist component of the regulation. There are only limited cases where the efficiency assessment is straightforward.[7] In other cases, comparing the costs of compliance to the gains associated with the reduction of an externality, say, the prevention of contamination or pest infestation, can help unravel the efficiency and the protectionist effect of a regulation. By decomposing the welfare effects, it is possible to assess the welfare loss associated with a measure whose costs exceed benefits. This can be used to estimate the extent to which this measure qualifies as an NTB. When the benefits are found negligible, this approach provides a sufficient test of trade distortion. Such estimates can also shed light on the scientific and economic rationale for the regulation and therefore help define what regulation would have been implemented if there were only domestic firms. This provides a gauge against which present regulations could be compared in order to assess the presence of a protectionist component (Fischer and Serra 2000).

Existing Studies

Bigsby and Whyte (2000) proposed a way to measure both economic effects and probability aspects of risk and developed a methodology in the case of pest infestation. James and Anderson (1998) used economic assessment of quarantine regulation. They concluded that there is a need for a comprehensive economic review of quarantine restrictions to determine those that pass the test of cost-benefit analysis. More generally, Arrow et al. (1996) argued for a more systematic use of the cost-benefit analysis in the environment and health sectors so as to assess the legitimacy of the regulations that can be excessively costly for taxpayers and consumers in view of their actual effect on health or the environment.

The USDA analysis of trade policy with Mexico on avocados illustrates that the mix of science-based evaluation and cost-benefit analysis can be useful in the estimation of NTBs as well as the settlement of SPS trade disputes (Orden and Romano 1996). The evaluation of pest risk; the definition of measures that help reduce the risk of spreading pests to a low, albeit non-zero, level; and the combination of these assessments with a comprehensive evaluation of the potential costs to the benefits, including impact on consumers, were pivotal in the analysis. Pest infestation reduces domestic supply, generates costs, and affects prices. The economic assessment of a partial ban was tested against various probabilities of pest infestation. Overall, this approach showed that the U.S. import ban resulted in large transfers to U.S. producers, through higher prices for domestic over foreign goods, in order to avoid relatively small potential costs of a pest infestation.[8] That is, this analysis proved useful in differentiating between the protection motive and the legitimate pest avoidance component of the ban.

Practical Validity of the Method

The combined use of scientific and cost-benefit assessment is one of the most promising areas of research in the identification and assessment of the effects of NTBs. The SPS Agreement pays little attention to economic analysis. Scientific evidence of contamination, or spread of a disease through trade, is the relevant criterion (OECD 1999a). Despite this lack of economic consideration, the idea of including more cost-benefit analysis in the assessment of NTBs and in the settlement of disputes has progressed substantially in international fora. Should this concept translate into giving more weight to economics in international agreements in the future, the scope of the cost-benefit-based method would be even greater.

The main limitations of this approach are the great uncertainty that surrounds the level of risks and the economic consequences. In the case of sanitary or phytosanitary measures, for example, the method requires an assessment of the probability of contamination or spread of a disease or of a pest and the associated cost.[9] There is also little reason for limiting the scope of cost-benefit analysis to sanitary or phytosanitary risks. Other regulatory barriers could be addressed with cost-benefit analysis. However, the effect of standards on consumers' willingness to pay is perhaps even more difficult to quantify, especially in the case of imaginary risks or in the case of ethical characteristics of the goods.

Stylized Microeconomic Approaches

Principle

Cost-benefit analysis methods can be refined by accounting for more sophisticated effects in an analytical representation of producers and consumers. The effect of NTBs can be assessed by looking at the displacement of the market equilibrium induced by a regulation. Provided that microeconomic data (preferably cross-section or panel) are available, the effect of regulations on supply and demand can be measured by standard estimates of cost or profit functions, as well as by utility or demand functions estimated econometrically. Duality theorems can be used to estimate a shadow price associated with the variable representing a standard or a binding regulation, for example. However, the classical framework of price-taking firms and perfectly informed consumers is seldom appropriate to assess the effects of regulations on supply and demand. A large body of literature, derived from research in industrial economics, has focused on the complex effects of regulations and standards. This literature makes it possible to account for a variety of effects on competition, information, and economies of scope or scale when a regulation is adopted.

Existing Studies

The literature dealing with these issues has remained largely theoretical, and the goal has often been to illustrate economic mechanisms at stake rather than providing quantitative estimates of the impact of non-tariff barriers. Some authors have included in stylized partial equilibrium models the effect of standards on the structure of competition between firms (Boom 1995; Crampes and Hollander 1995a). The strategic interactions between firms reacting to new regulations has been the topic of many papers (Grossman and Horn 1988; Crampes and Hollander 1995b). So has the way regulations modify the information available for consumers (Shapiro 1983; Donnenfeld, Weber, and Ben-Zion 1985). For example, welfare effects of a regulation are different depending on whether consumers can or cannot assess the quality of the products, and whether they can do it before or after consumption (Marette, Bureau, and Gozlan 2000). It has also been shown that regulations may change the costs of signaling quality (Falvey 1989), which may result in network externalities and economies of scale (Katz and Shapiro 1985; Barrett

and Yang 1999). Because of all these properties, a regulation has complex and sometimes opposite effects on prices and welfare.

Practical Validity of the Method

While there is still a gap in the literature between stylized models and large-scale quantifications, a fruitful area of research would be to include more sophisticated supply and demand equations, with parameters estimated econometrically. This could help to assess how much trade is foregone because of regulations, how much consumers preferences are affected, and what the effect of harmonization of regulations versus mutual recognition agreements might be for particular nations.

A major obstacle to quantification of the effect is that the analytical framework that makes it possible to account for sophisticated effects becomes rapidly intractable unless one makes drastic simplifying assumptions on the shape of demand curves and on competition (e.g., duopoly or monopoly competing in prices or quantity). Limiting these approaches is their robustness to the simplifying assumptions and their difficulty in providing estimates of the various effects. The calibration of the demand functions—the response to standards that affect consumers' willingness to pay, for example—is difficult, in particular when one deals with the demand for ethical or environmental attributes. So is the displacement of the various equilibria when, for example, the structure of competition is modified by standards that act as barriers to entry.

However, accounting for imperfect competition, imperfect information, and strategic effects often makes it possible to point out some non-intuitive effects of standards on trade or welfare. Overall, the industrial organization approach has mainly been useful for providing a "toolbox" for integrating competition or informational effect into more traditional quantitative approaches, such as partial equilibrium based estimates.

Quantification Using Sectoral or Multi-market Models

The distinctions among the previous categories (cost-benefit analysis and microeconomic approaches) are quite arbitrary. Partial equilibrium models rely on microeconomic representations of supply and demand and are used most often to assess the effects of a particular policy on equilibrium, i.e., on the changes in price, quantity, and welfare. They are a way to perform cost-benefit analysis. We make this distinction in

order to discuss relatively large-scale models with parameters estimated so as to represent real life empirical cases, rather than the stylized mechanisms that characterize most of the microeconomic approaches previously reviewed.

Principle

Partial equilibrium models provide a framework for analyzing tariff-rate equivalents of standards and technical regulations. Their main feature, compared to gravity models, is that they make it possible to assess not only the impact of regulations on trade flows but also on welfare. Compared to the stylized approaches used in industrial economics that focus on qualitative effects, partial equilibrium models provide more quantitative results.

Most of the models that quantify the effects of regulations use some of the techniques that were presented above (price-gap method, the inventory approach, or the risk-based assessment) to provide a more explicit summary of the effect of the regulations on production, consumption, trade, and welfare. These effects can be included in large-scale models, which most often have focused on classical forms of protection, such as tariffs, and whose specification did not make it possible to account for effects of regulations. This sometimes requires including some particular specifications, for example, imperfect competitions or product differentiation, although in a relatively simplified framework (e.g., Spence-Dixit-Stiglitz or Lancaster-based product differentiation). Important linkages to other markets are included.

Existing Studies

Partial equilibrium models have been a natural extension of the approaches described previously. For example, an explicit specification of supply and demand functions was used by Orden and Romano (1996) to assess the costs and benefits of a ban on avocados as an extension of their risk-based assessment. Calvin and Krissoff (1998) also combined the price-wedge method with a simple partial equilibrium framework (using only estimated supply and demand elasticities) when they studied Japanese imports of U.S. apples. Paarlberg and Lee (1998) included a risk-based approach to a partial equilibrium framework. They studied the case of U.S. tariff protection against beef imports from countries that may transmit foot-and-mouth disease (FMD). In their approach, the domestic government is assumed to maximize the country's welfare by setting the

optimal tariff rate, where expected loss of domestic beef production due to FMD infection in U.S. livestock has been incorporated ex ante into the tariff rate. James and Anderson (1998) also included the probability of contamination in a partial equilibrium framework in order to assess the costs and benefits of quarantine restrictions.

Some studies, however, put more emphasis on economic modeling, and estimate (or calibrate) more sophisticated forms of the demand and supply function. Thilmany and Barrett (1997) studied the implications of technical regulations for dairy exports from the United States within the NAFTA (North American Free Trade Agreement). In their approach, the shift in the demand curve reflects the effect of standards to alleviate consumer uncertainty about product quality, and the shift in the supply curve is due to increased transaction costs of export, including compliance costs. They compared domestic and international prices to estimate the producer subsidy equivalent and import tariff-rate equivalent of these trade barriers. Sumner and Lee (1997) explore the ways in which TBTs can impose costs at various stages of the marketing chain. They identify where in the food marketing chain SPS regulations, such as those intended to eliminate the risk of infestation, can impose costs. Their model is applied to regulations imposed by Asian importers on U.S. vegetables.

An illustration of the usefulness of the partial equilibrium multimarket approach is provided by the simple framework proposed by Overton, Beghin, and Foster (1995) in the case of the EU restriction on chemical residues in tobacco. The low EU restriction on residues of maleic hydrazide (MH) not only affects U.S. tobacco producers but also affects the U.S. and EU tobacco cigarette industries. The latter uses only a share of U.S. tobacco in its blend, for which the maximum residue is not a problem (MH contaminated U.S. tobacco is diluted with MH-free EU tobacco). A standard affects the relative composition of cigarettes, as far as origin of tobacco is concerned, and leads to greater costs for foreign producers. The partial equilibrium model makes it possible to take into account the substitution in demand (foreign and domestic tobacco are substitutes), as well as increases in production costs, and provides quantitative estimates of trade flows, rents, and welfare. While the model is quite simple, it shows some counterintuitive effects, for example, that if the regulation is non-binding for domestic manufacturers (because they use a low proportion of MH-contaminated tobacco), the residue regulation that is

protectionist in the tobacco output market can actually increase trade flows in the tobacco input market. Further, under a fixed U.S. production quota, the EU regulation could have a surprising anti-protective effect on EU growers. Surprisingly, U.S. cigarette manufacturers appear to have the most to gain from the EU regulation.

Practical Validity of the Method

The work by Overton, Beghin, and Foster (1995) shows that even a simple two-market model can provide useful estimates of the trade and welfare effects of regulations such as SPS or TBT measures. Even if one is reluctant to use economic assessments of the sanitary aspects (using relatively controversial methods such as the Cost of Illness, or the Value of a Statistical Life Saved; see Bowland and Beghin 2001 and OECD 1999a), such approaches make it possible to quantify the economic impacts. These economic impacts then can be compared with the effect of the measures on illness reduction, consumer valuation of SPS, or other process attributes.

With the ongoing research in the field of econometrics of product differentiation and imperfect competition, the gap between the stylized models derived from industrial organization and the applied partial equilibrium models is narrowing. This means that quantification of the trade and welfare effects of SPS and TBT regulations will be possible when taking into account more sophisticated mechanisms related to imperfect competition or consumer information in the future. This is clearly a promising area of research.

Concluding Remarks: Setting a Research Program

Focusing on the Policy-Relevant Issues

There are many disagreements between exporting countries and potential importers in OECD countries. Because the various issues refer to different empirical methods, defining a list of the most relevant empirical issues is a first step in setting a research agenda. In some cases, the issues at stake are mainly technical; countries disagree, for example, on the relevance of particular sanitary and phytosanitary standards, and these standards are seen as excessively restrictive by some exporters. Countries may also disagree on technical requirements and conformity assessments that impose costs on exporters. These issues are, in general, well known by trade negotiators (see USTR 2001;

European Commission 2000).[10] Less is known about how severely the corresponding regulations constrain exports. Estimation of their actual effect on trade can rely on some of the methods described above (survey, price wedge, gravity, or spatial trade model approaches). Cost-benefit analysis may also help in identifying the costs of the regulations and assess whether they are in proportion to the externality they address, or whether they are mainly implemented for protecting domestic producers. These methods are relatively well known and their application is straightforward.

However, the issues that involve cultural, ethical, or environmental aspects are the ones most likely to lead to severe disputes (Caldot and Vogel 2001). They are also the ones for which the multilateral framework is less adapted and for which analyses are most lacking.[11] Research programs particularly should address the difficult cases where regulations affect trade and the protectionist component is unclear, but the program should also address the genuine concerns of consumers or citizens. This includes regulations that may be at odds with the existing agreements (for example, ones based on process and production methods and on an extensive conception of precaution, and ones that aim to protect global commons) and regulations that address concerns specific to a group of countries (animal welfare and acceptance of genetically modified organisms, for example). In such cases, it is necessary to address not only the trade effect but also the supply shift and demand effect of regulations. This requires less familiar and robust techniques for assessing the effect of regulation on consumers and citizens.

Impact of Regulations on Existing Trade Flows

Technical regulations, such as those on the spreading of pests, on aflatoxins, on pesticide residues, and on the use of antibiotics, affect trade. While these measures might be legitimate, the amount of trade foregone is not always well known by decisionmakers. Combining gravity models or spatial trade models with econometric estimates is a potentially useful approach for identifying the role of regulations (as opposed to the "home bias," i.e., the natural preference for trading with compatriots) in foregone trade. Recent developments suggested by Anderson and van Wincoop (2001), who introduce the concept of "multilateral resistance" (i.e., the more a country is resistant to trade with all other regions, the more it is pushed to trade with a given bilateral partner), and by Cheng and Wall (1999), who use a fixed-effects model for eliminating heterogeneity bias,

should make it possible to provide more interpretation of the border effect. The use of appropriate variables, some of them taken from inventory-based approaches, should help to unravel the various effects explaining trade foregone. In this area, the combination of different methods should surpass the usual literature in identifying the causes of the "border effect" and the role of regulations compared to other effects.[12]

Impact of Regulations on Domestic and Foreign Firms

Minimum quality standards, mandatory labeling, and certification impose costs on would-be exporters. Even though these costs are not necessarily discriminatory (local producers face the same standards), this might lead to fixed (or sunk) costs. When a firm faces different standards in its own country, the costs of producing under two standards may lead it to specialize or to give up trade opportunities. This applies, for example, to controversial issues such as mandatory segregation of genetically modified (GM) and non-GM crops in a particular country, the requirements of traceability in meat, compliance to animal welfare or environmental standards, or mandatory labeling in a country.

A first step is to estimate the costs of regulations. This requires microeconomic, firm-level approaches, surveys in the industry, and information from engineers. For many of these issues, regulations involve a set of standards (e.g., animal welfare and environmental standards in pig-meat production). An appropriate representation is the classical standard proposed by Rosen (1974). Production can be modeled by using a cost, profit, or supply function that includes discrete variables, so that the production costs increase with the standard if the standard is adopted. While econometric techniques exist for estimating dichotomic supply functions in a duality framework, research should focus on the possibility of calibrating simple functions that do not require sophisticated econometric procedures (on the basis of the framework described in Fisher and Serra 2000).

The overall effects of the regulations may be relatively complex and counterintuitive, as shown by Overton, Beghin, and Foster (1995). This is particularly the case if they involve externalities. For example, the decision of allowing trade in GM crops imposes a cost of segregation for traders of standard crops that acts as an externality. It is not clear who is most affected by the regulation or what the overall impacts on trade would be, given that the regulation may also lead to product differentiation. Similar questions arise with animal welfare requirements. Dealing with these issues requires solving the puzzle

of calibrating models that are sophisticated enough to account for producers' heterogeneity, for product differentiation, and for information effects. Calibration of supply and demand for vertically differentiated products (as in Flam and Helpman 1987) or for horizontally differentiated products (as in Stokey 1991) should make it possible to account for these phenomena in empirical applications.

Impact of Regulations on Competitiveness of Third Markets

Simulations using trade models make it possible to assess the impact of a given regulation that hampers the competitiveness of the particular country that implements it. This approach could be used to assess the effects of SPS-related standards, but it also could assess new technical standards related to animal welfare and environmental management emerging in the European Union, the United States, Australia, and elsewhere (e.g., Beghin and Metcalfe 2000; Mitchell 2001). Given this rising presence of process standards in many OECD countries, it would be interesting to assess their impact on international competitiveness of these countries in third markets. An interesting case study would be the combination of animal welfare and environmental constraints in a sector such as pork. Several EU members and the United States compete in third export markets, for example, in pork markets in Asia. The accumulation of new standards may affect their competitiveness in these markets by raising their cost of production. Similar questions arise for the impact of regulations on GM organisms in the crop sector.

Sectoral trade models are useful instruments for estimating the effects of these regulations. When there are large sectors affected by a regulation (e.g., entire grain or soybean exports affected by regulations on GM organisms, or entire exports of beef affected by sanitary restrictions), applied GE models can be useful.

Valuation of Attributes and Information by Consumers

Because the most sensitive trade issues are the regulations that hamper trade while also involving genuine consumer (and citizen) concerns, there is a need for more research in valuing the positive effect of regulations that affect product attributes related to SPS and other TBTs. This includes health, animal welfare, veterinary standards, and environmental standards. The established approach of Mussa and Rosen (1978) has been used in hedonic studies and in analytical models of process attributes of goods (Nimon

and Beghin 1999a,b; Bureau, Marette, and Schiavina 1998). However, the willingness to pay for these attributes often is not distributed uniformly, as most often assumed in that approach. Based on the few studies available, most consumers agree to pay a small premium (often less than 10 percent) for these attributes, but very few are willing to pay much more than that. Hence, the distribution of consumers is not uniform over the quality spectrum. The other issue is the multiple dimension of the attribute space (sanitary, veterinary, several environmental, animal welfare). The approach should be able to aggregate these attributes into a valuation function in a consistent fashion. The logit model (Anderson, de Palma, and Thisse 1988, 1992, 1994) has potential and should be used as a foundation for the empirical investigation of consumers' valuation of these attributes. Consumer surveys could elicit consumers' valuation of these attributes, and panel regression techniques could be used to estimate the attributes' value or lack of value.

Endnotes

1. This could involve an economic analysis similar to what is often used in competition policy, where non-competitive practices are sometimes seen as legitimate if they are welfare improving. This idea, suggested by the OECD (1999a), has been recently developed by Neven (2000).

2. Deardorff and Stern (1998) show that one cannot hold the import price constant and isolate the effect on the NTB, unless world markets are infinitely elastic. There are several conceptual obstacles to summarizing the effect of an NTB as a scalar (e.g., a tariff equivalent) in a general case. The various components include the direct effect of NTBs on the quantity of imports; the change in elasticity of demand for imports, the variability of NTBs over time, and the uncertainty of NTBs.

3. The database MAST compiled by UNCTAD and the data used by Ndayisenga and Kinsey (1994) are examples of such an inventory. The UNCTAD database on Trade Control Measures (TCM) also provides quantity controls such as automatic licensing, money and finance measures, price control measures, etc. The UNCTAD database relies on government notifications to GATT and the WTO.

4. As an illustration, Barrett and Yang (1999) note that the U.S. Congressional Research Service found that only 17 out of the approximately 89,000 standards recognized in the United States had international origin in the whole set of industrial sectors (USHR 1989). This indicator of the lack of compatibility between U.S. and international standards suggests likely difficulties for potential exporters to the United States. However, it does not provide compelling evidence that trade is actually restricted by such standards.

5. When they conducted interviews to complement the survey, Lux and Bureau found out that large-sized firms in the European dairy industry did not mention foreign regulations as a major issue. These large firms have learned how to cope with existing barriers, especially in the United States, either by defining a particular range of product for this market (pasteurized cheese adapted to U.S. regulations) or by relocating production. Some even used this experience as a competitive instrument and were not keen on international actions for easing these barriers.

6. Weyerbroeck and Xia (1998) and USGAO (1997) therefore expressed reservations on surveys, such as that of the USDA in 1996, when used for quantifications.

7. For example, if a standard or its enforcement only raises cost (e.g., through delays in inspection or fees), it is inefficient for consumer protection and classifies as an NTB.

8. Most of the costs borne by producers after the lifting of the U.S. ban on Mexican avocados, a ban that arose under high probability of infestation, come from the effect of free trade on domestic prices and not from the pest infestations (see Orden and Romano 1996).

9. It is difficult to base sound economic analysis on estimates that are subject to controversies when the figures at stake are high: a general estimate has been made of U.S.$138 billion/year lost due to all invasive species—over 50,000—that have entered the United States (see Pimentel et al. 2000; and Mumford 2000).

10. Negotiators in developed countries consult with industry and work with them. In developing countries, basic information is lacking; however, The World Bank has included such works in its research agenda. See the ongoing program, "The Post-Seattle Agenda of the WTO in Standards and Technical Barriers to Trade: Issues for the Developing Countries," currently under the responsibility of John S. Wilson at The World Bank.

11. While the multilateral framework has been largely successful in addressing the most technical issues (most of them have been solved within formal panels), it has performed rather poorly when it has addressed regulations that had trade effects but that were largely the result of genuine concerns of citizens. For example, the tuna/dolphin GATT panels added a large number of people concerned about the environment to the ranks of the opponents of globalization. The 1997 hormones panel spread the belief that the goals of the WTO overshadowed the right of a democratically elected government to protect its consumers.

12. For example, Head and Meyer (1999) find a significant decrease in the border effect in agriculture within the European Union in the 1990s but fail to identify the source—why the ending of the green rates and the monetary compensatory amounts obviously play a role.

References

Anderson, J.E. 1979. "A Theoretical Foundation for the Gravity Equation." *American Economic Review* 69(March): 106-16.

Anderson, J.E., and E. van Wincoop. 2001. "Gravity with Gravitas: A Solution to the Border Puzzle." NBER Working paper 8079, National Bureau of Economic Research, Cambridge, MA.

Anderson, S.P., A. de Palma, and J.F. Thisse. 1988. "A Representative Consumer Theory of the Logit Model." *International Economic Review* 29(3): 461-66.

———. 1992. *Discrete Choice Theory of Product Differentiation*. Cambridge, MA: MIT Press.

———. 1994. "Demand for Differentiated Products, Discrete Choice Models and the Characteristic Approach." In *The Economics of Product Differentiation*, vol. 1. Edited by J.F. Thisse and G. Norman. Elgar Reference Collection: International Library of Critical Writings in Economics. Aldershot, UK: Edward Elgar, pp. 98-112.

Antle, J.M. 1995. *Choice and Efficiency in Food Safety Policy*. Washington, D.C.: The American Enterprise Institute Press.

Arrow, K.J., M.L. Cropper, G.C. Eads, R.W. Hahn, L.B. Lave, R.G. Noll, P.R. Portney, M. Russell, R. Schmalensee, V.K. Smith, and R.N. Stavins. 1996. "Is There a Role for Benefit-Cost Analysis in Environmental, Health and Safety Regulation?" *Science* 272: 221-22.

Baldwin, R. 1970. *Non Tariff Distortions in International Trade*. Washington, D.C.: Brookings Institution.

Barrett, C., and Y.N. Yang. 1999. "Rational Incompatibility with International Product Standard." International Agricultural Trade Research Consortium Working Paper 99, 9. International Agricultural Trade Research Consortium, University of Minnesota.

Beghin J., and M. Metcalfe. 2000. "Environmental Regulation and Competitiveness in the Hog Industry. An International Perspective." *Choices*, vol. 15, no. 1, pp. 28-33.

Bergstrand, J. 1989. "The Generalized Gravity Equation, Monopolistic Competition and Factor Proportions Theory in International Trade." *Review of Economics and Statistics* 71(February): 143-53.

Bigsby, H.R., and C.F. Whyte. 2000. "Quantifying Phytosanitary Barriers to Trade." In *Interdisciplinary Food Safety Research*. Edited by N. Hooker and E. Murano. Boca Raton: CRC Press.

Boom, A. 1995. "Asymmetric International Minimum Quality Standards and Vertical Differentiation." *The Journal of Industrial Economics* 43(1): 101-19.

Bowland, B.J., and J.C. Beghin. 2001. "Robust Estimates of Value of a Statistical Life for Developing Economies." *Journal of Policy Modeling*, in press.

Bureau, J.C., and S. Marette. 2000. "Accounting for Consumers Preferences in International Trade Rules." In *Incorporating Science Economics and Sociology in Developing Sanitary and Phytosanitary Standards in International Trade*. Edited by the Board of Agriculture and Resources, National Research Council. Washington, D.C.: National Academy Press, pp. 170-98.

Bureau, J.C., S. Marette, and A. Schiavina. 1998. "Non-tariff Trade Barriers and Consumers' In formation: The Case of EU-US Trade Dispute over Beef." *European Review of Agricultural Economics* 25(4): 437-62.

Burfisher, M., D. Pick, G. Pompelli, and S. Zahniser. 2001. "North American Trade in an Era of Multiple Trade Agreements: A Gravity Analysis." Paper presented at the American Agricultural Economics Association annual meeting, Chicago, August 5-8.

Caldot, O., and D. Vogel. 2001. "France, the United States, and the Biotechnology Dispute." The Brookings Institution, Washington, D.C., January. Available at: http://www.brook.edu/fp/cusf/analysis/biotech.htm (accessed August 2001).

Calvin, L., and B. Krissoff. 1998. "Technical Barriers to Trade: A Case Study of Phytosanitary Barriers and U.S.-Japanese Apple Trade." *Journal of Agricultural and Resource Economics* 23(2): 351-66.

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

Casella, A. 1996. "Free Trade and Evolving Standards." In *Fair Trade and Harmonization, Prerequisites for Free Trade*? Edited by J.N. Bhagwati and R.E. Hudec. Cambridge, MA: MIT Press.

Cato, J.C., and C.A. Lima dos Santos. 1998. "European Union 1997 Seafood Safety Ban: The Economic Consequences on Bangladesh Shrimp Processing." *Marine Resources Economics* 13: 215-27.

Cheng, I.H., and H.J. Wall. 1999. "Controlling for Heterogeneity in Gravity Models of Trade." Working Paper No. 99-01013, March, Federal Reserve Bank of St. Louis, St. Louis, MO.

Crampes, C., and A. Hollander. 1995a. "Duopoly and Quality Standards." *European Economic Review* 39: 71-82.

———. 1995b. "How Many Karats is Gold: Welfare Effects of Easing a Denomination Standard." *Journal of Regulatory Economics* 7: 131-43.

Deardorff, A.V. 1998. "Determinants of Bilateral Trade: Does Gravity Work in a Neo-Classical Framework?" In *The Regionalization of the World Economy*. Edited by J. Frankel. National Bureau of Economic Research Series, No. 7. Chicago: University of Chicago Press, p. 32.

Deardorff, A.V., and R.M. Stern. 1998. *Measurement of Nontariff Barriers*. Studies in International Economics Series. Ann Arbor, MI: The University of Michigan Press.

Donnenfeld, S., S. Weber, and U. Ben-Zion. 1985. "Import Controls under Imperfect Information." *Journal of International Economics* 19: 341-54.

European Commission. 2000. "Report on United States Barriers to Trade and Investment." European Commission, Brussels, Belgium, July.

———. 2001. "A Set of Coordinated Studies for the Preparation of the Next Round of Trade Negotiations." Final Report, Project FAIR-97-CT3481, Task 3. Agricultural Directorate, Brussels, Belgium.

Falvey, R.E. 1989. "Trade, Quality Reputations and Commercial Policy." *International Economic Review* 30(3, August): 607-22.

Fisher, R., and P. Serra. 2000. "Standards and Protection." *Journal of International Economics* 52: 377-400.

Fontagné, L., F. von Kirchbach, and M. Mimouni. 2001. "Une Première Évaluation des Barrières Environnementales au Commerce International." Working Paper, United Nations Conference on Trade and Development, Geneva, and Université Paris I, Paris.

Ganslandt, M., and, J.R. Markusen. 2000. "Standards and Related Regulations in International Trade: A Modeling Approach." Working paper, University of Colorado, Boulder.

Grossman, G.M., and H. Horn. 1988. "Infant Industry Protection Reconsidered: The Case of Informational Barriers to Entry." *Quarterly Journal of Economics* 103(4): 767-87.

Harrison, G., T.F. Rutherford, and D.G. Tarr. 1996. "Increased Competition and Completion of the Market in the European Union: Static and Steady State Effects." *Journal of Economic Integration* 11(3): 332-65.

Head, K. 2000. "Gravity for Beginners." Teaching notes, Department of Economics, University of British Columbia, Vancouver.

Head, K., and T. Meyer. 1999. "Non-Europe: The Magnitude and Causes of Market Fragmentation in the EU." Mimeo., University of British Columbia, Vancouver.

Helpman, E., and J. Flam. 1987. Vertical Product Differentiation and North-South Trade. *American Economic Review* 77: 810-22.

Henson, S.J., R. Loader, and A. Swinbank. 1999. "The Impact of Sanitary and Phytosanitary Measures on Developing Country Exports of Agricultural and Food Products." Paper presented at the World Trade Organization meeting, "Agriculture and the New Trade Agenda from a Development Perspective: Interests and Options in the WTO 2000 Negotiations," World Bank, Geneva, November.

Henson, S.J., R. Loader, A. Swinbank, M. Bredahl, and N. Lux. 2000. "Impact of Sanitary and Phytosanitary Measures on Developing Countries." Center for Food Economics Research, University of Reading, Reading, UK.

Henson, S.J., N. Lux, and B. Traill. 2001. Unpublished, Final Report: Partner 4. FAIR97-CT34-81 program, European Commission, Agricultural Directorate. Brussels, Belgium.

Hillberry, R. 2001. "Disaggregating the 'Border Effect': What Can We Learn from U.S. Commodity Flow Data?" Paper presented at the American Agricultural Economics Association annual meeting, Chicago, August 5-8.

Hillman, J.S. 1991. *Technical Barriers to Agricultural Trade.* Boulder, CO: Westview Press.

———. 1997. "Non-Tariff Agricultural Trade Barriers Revisited." In *Understanding Technical Barriers to Agricultural Trade*. Proceedings of a conference of the International Agricultural Trade Research Consortium (IATRC). Edited by D. Orden and D. Roberts. St. Paul, MN: IATRC.

Hummels, D. 2000. "Towards a Geography of Trade Costs." Working Paper, Purdue University.

James, S., and K. Anderson. 1998. "On the Need for More Economic Assessment of Quarantine Policies." *Australian Journal of Agricultural and Resource Economics* 42(4): 425-44.

Katz, M.L., and C. Shapiro. 1985. "Network Externalities, Competition and Compatibility." *American Economic Review* 75(June): 424-40.

Laird, S., and A. Yeats. 1990. *Quantitative Methods for Trade-Barrier Analysis*. London: The Macmillan Press.

Lux, N., and S.J. Henson. 2000. "The Impact of Food Safety and Quality Standards in EU Cheese Exports to the United States." Working Paper, Department of Agricultural and Food Economics, The University of Reading.

Mahé, L.P. 1997. "Environment and Quality Standards in the WTO: New Protectionism in Agricultural Trade? A European Perspective." *European Review of Agricultural Economics* 24: 480-503.

Marette, S., J.C. Bureau, and E. Gozlan. 2000. "Product Safety Provision and Consumers' Information." *Australian Economic Papers* 39(4, December): 426-41.

Maskus, K.E., and J.S. Wilson. 2000. "Quantifying the Impact of Technical Barriers to Trade: A Review of Past Attempts and the New Policy Context." Paper presented at the World Bank Workshop, "Quantifying the Trade Effect of Standards and Technical Barriers: Is it Possible?" April 27.

Maskus, K.E., J.S. Wilson, and T. Otsuki. 2001. "An Empirical Framework for Analyzing Technical Regulations and Trade." In *Quantifying Trade Effect of Technical Barriers: Can It Be Done?* Edited by K.E. Maskus, and J.S. Wilson. Ann Arbor, MI: University of Michigan Press.

McCallum, J. 1995. "National Borders Matter: Canada-US Regional Trade Patterns." *American Economic Review* 95(June, 3): 615-23.

Mitchell, L. 2001. "Impact of Consumer Demand for Animal Welfare on Global Trade." In *Changing Structure of Global Food Consumption and Trade*. Edited by A. Regmi. Agriculture and Trade Report WRS-01-1. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service.

Moenius, J. 1999. "Information versus Product Adaptation: The Role of Standards in Trade." Working paper, University of California, San Diego.

Mumford, J.D. 2000. "Environmental Risk Evaluation in Quarantine Decision Making." Working paper, T.H. Huxley School of Environment, Earth Sciences and Engineering, Imperial College of Science, Technology and Medicine, London.

Mussa, M., and S. Rosen. 1978. "Monopoly and Product Quality." *Journal of Economic Theory* 18: 301-17.

Ndayisenga, R., and J. Kinsey. 1994. "The Structure of Nontariff Trade Measures on Agricultural Products in High-Income Countries." *Agribusiness* 10(4): 275-92.

Neven, D. 2000. "Evaluating the Effects of Non Tariff Barriers: The Economic Analysis of Protection in WTO Disputes." Working Paper, Centre for Economic Policy Research.

Nimon, W., and J. Beghin. 1999a. "Are Eco-Labels Valuable? Evidence from the Apparel Industry." *American Journal of Agricultural Economics* 81: 801-11.

———. 1999b. "Ecolabels and International Trade in the Textile and Apparel Market." *American Journal of Agricultural Economics* 81: 1078-84.

Orden, D., and D. Roberts, eds. 1997. *Understanding Technical Barriers to Agricultural Trade*. Proceedings of a conference of the International Agricultural Trade Research Consortium (IATRC). St. Paul, MN: IATRC.

Orden, D., and E. Romano. 1996. "The Avocado Dispute and Other Technical Barriers to Agricultural Trade under NAFTA." Paper presented at the conference, "NAFTA and Agriculture: Is the Experiment Working?" San Antonio, TX, November.

Organization for Economic Cooperation and Development (OECD). 1997. "Regulatory Reform in the Agro-Food Sector." *Regulatory Reform,* vol. 1: *Sectoral Studies*. Paris, pp. 233-74.

———. 1999a. "Food Safety and Quality Issues: Trade Considerations" In *Sécurité et qualité des produits alimentaires: considérations pour le commerce international*. Paris.

———. 1999b. *An Assessment of the Costs for International Trade in Meeting Regulatory Requirement*s. Paris.

Otsuki, T., J.S. Wilson, and M. Sewadeh. 2000. "Saving Two in a Billion: A Case Study to Quantify the Trade Effect of European Food Safety Standards in African Exports." Working paper, The World Bank, Washington, D.C.

Overton, B.E., J. Beghin, and W.E. Foster. 1995. "Phytosanitary Regulations for U.S. and Agricultural Trade Flows: Tobacco Inputs and Cigarette Output." *Agricultural and Resource Economic Review* 24: 221-31.

Paarlberg, P.L., and J.G. Lee. 1998. "Import Restrictions in the Presence of a Health Risk: An Illustration Using FMD." *American Journal of Agricultural Economics* 80(1): 175-83.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. "Environmental and Economic Costs Associated with Non-indigenous Species in the United States." Working paper, College of Agriculture and Life Sciences, Cornell University. *http://www.news.cornell.edu/releases/Jan99/species_costs.html* (accessed August 2001).

Roberts, D. 1998. "Preliminary Assessment of the Effects of the WTO Agreement on Sanitary and Phytosanitary Trade Regulations." *Journal of International Economic Law* 1(3): 377-405.

Roberts, D., and K. DeRemer. 1997. "Overview of Foreign Technical Barriers to U.S. Agricultural Exports." ERS Staff Paper No. 9705. U.S. Department of Agriculture, Economic Research Service, Washington, D.C., March.

Roberts D., T. Josling, and D. Orden. 1999. "A Framework for Analyzing Technical Trade Barriers in Agricultural Markets." Technical Bulletin No. 1876, U.S. Department of Agriculture, Economic Research Service, Washington, D.C.

Rosen, S. 1974. "Hedonic Prices and Implicit Markets : Product Differentiation in Pure Competition." *The Journal of Political Economy* 82(1): 34-55.

Shapiro, C. 1983. "Premiums for High Quality Products as Returns to Reputations." *Quarterly Journal of Economics* 98: 659-79.

Stokey, N.L. 1991. "The Volume and Composition of Trade between Rich and Poor Countries." *Review of Economic Studies* 58(1): 63-80.

Sumner, D., and H. Lee. 1997. "Sanitary and Phytosanitary Trade Barriers and Empirical Trade Modeling." In *Understanding Technical Barriers to Agricultural Trade*. Proceedings of a conference of the International Agricultural Trade Research Consortium (IATRC). Edited by D. Orden and D. Roberts. St. Paul, MN: IATRC, pp. 273-83.

Swann, P., P. Temple, and M. Shurmer. 1996. "Standards and Trade Performance: The UK Experience." *Economic Journal* 106: 1297-313.

Thilmany, D.D., and C.B. Barrett. 1997. "Regulatory Barriers in an Integrating World Food Market." *Review of Agricultural Economics* 19(1): 91-107.

Thornsbury, S. 1998. "Technical Regulations as Barriers to Agricultural Trade." PhD dissertation, Virginia Polytechnic Institute.

Thornsbury, S., D. Roberts, K., DeRemer, and D. Orden. 1999. "A First Step in Understanding Technical Barriers to Agricultural Trade." In *Food Security, Diversification and Resource Management: Refocusing the Role of Agriculture?* Edited by G.H. Peters and J. von Braun. Brookfield, VT: Ashgate, pp. 453-63.

U.S. Government Accounting Office (USGAO). 1997. "Agricultural Exports. US Needs a More Integrated Approach to Address Sanitary/Phytosanitary Issues." Report to Congressional Requesters 98-32. Washington, D.C.

U.S. House of Representatives (USHR). 1989. "International Standardization: The Federal Role." Hearing before the Subcommittee on Science, Research, and Technology, House of Representatives Committee on Science, Space, and Technology. Government Printing Office, Washington, D.C.

U.S. International Trade Commission (USITC). 1995. "The Economic Effect of Significant US Import Restraints." Investigation 322-325, 2699, U.S. International Trade Commission, Washington, D.C.

U.S. Trade Representative (USTR). 2001. 2001 National Trade Estimate Report on Foreign Trade Barriers: European Union. Office of the U.S. Trade Representative, Washington, D.C. http://www.ustr.gov/html/2001_contents.html (accessed August 2001).

Vido, E., and B. Prentice. 2001. "Methodological Issues in Gravity Model Analysis with Applications to Canadian Pork and Lentil Trade." Paper presented at American Agricultural Economics Association annual meeting, Chicago, August 5-8.

Weyerbroeck, S., and T. Xia. 1998. "Technical Trade Barriers in U.S./Europe Agricultural Trade." Working paper, University of Delaware.