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QUANTITATIVE POLICY ANALYSIS OF SANITARY, PHYTOSANITARY AND TECHNICAL BARRIERS TO TRADE

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ABSTRACT. This paper surveys and analyses existing methodologies to model and quantify non-tariff trade barriers (NTBs) in the agricultural and food sectors. The analysis centers on sanitary, phytosanitary, and technical regulations that can have an impact on trade. The paper stresses methods that provide some quantitative estimates of the impact of such barriers on market equilibrium, trade flows, economic efficiency, and welfare. Potential areas for future applied research are identified.

JEL Classification: F13; Q18.

Keywords: Agricultural Policy; Non-Tariff Barriers; Border Effect; Empirical Estimation.

RÉSUMÉ. Cet article passe en revue et analyse les méthodes actuellement utilisées pour modéliser et quantifier les barrières non tarifaires dans le secteur agricole et agro-alimentaire. L'analyse est axée sur les réglementations en matière sanitaire, phyto-sanitaire et technique susceptibles d'avoir un impact sur les échanges commerciaux. L'article insiste particulièrement sur les méthodes qui donnent des estimations quantifiées de l'impact de telles barrières sur l'équilibre de marché, les flux commerciaux, l'efficacité économique et le bien-être. Il met aussi en évidence les domaines dans lesquels des recherches appliquées pourraient à l'avenir être engagées.

Classification *JEL*: F13; Q18.

Mots-clefs: Politique agricole; barrières non tarifaires; effet frontière; estimation empirique.

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A longer version of this paper was prepared for the OECD Agriculture and Food Directorate (Beghin and Bureau, 2001). The views presented here should not be attributed to the OECD.

This paper presents promising methodologies to model and quantify non-tariff trade barriers (NTBs) in the agricultural and food sectors. The analysis centers on sanitary, phytosanitary, and technical regulations that can have an impact on trade. While standards and regulations can facilitate trade (by ensuring a controlled quality for processors and by increasing consumers' confidence), it has been acknowledged that they sometimes also act as trade impediments, and can be used for protectionist purposes (OECD, 1999a). We focus on methods that provide some quantitative estimates of the impact of such barriers on market equilibrium, trade flows, economic efficiency, and welfare. Attempts to quantify the effects of such measures have often centered on a particular product and have relied on methods from other economic fields. 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 potential areas for future applied research.

The demand for better estimates of the impact of these regulations on trade is emerging among policy makers. Such domestic regulations may constitute major trade impediments and their use is proliferating. However, it is possible that those regulations that act as NTBs may only be becoming more visible, because of international scrutiny or because of the decrease in tariffs. A comprehensive assessment of the actual impact of these regulations is necessary to address the role to be given to non-tariff instruments and barriers in a future trade agreement. Further, quantitative analyses help to inform governments about the costs of their SPS policies, and provide the determinants necessary for defining more efficient regulations (Antle, 1995). Moreover, a better estimation of the damage caused to a country by foreign regulations may help solving 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 other exports from developing countries (Cato and Dos Santos de Lima, 1998; Otsuki et al., 2001). During the Uruguay Round, developing countries saw access to developed countries' markets in the food sector as a major motivation for participating in multilateral agreements, despite the concessions they would have to make in other areas (e.g. on intellectual property). However, there is a general sentiment that their access to developed countries' markets has not improved and are less interested in participating in a new round of negotiations which they believe will be dominated by the EU and the United States. More information on the effect of regulatory barriers would help quantify developing countries' claims and provide strong evidence for future multilateral negotiations.

■ DEFINITIONS OF A NTB

Hillman (1991) defines NTBs as all restrictions, other than traditional customs duties, which distort international trade. Precisely it is "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, and SPS, and packaging measures. Roberts (1998) and Thornsbury (1998) consider as NTBs a set of regulations that include many policy instruments. Their classification by scope of the barrier, by regulatory goal, by legal discipline, by type of market restriction, product category, and geographical region helps to identify differences in food safety and quality standards among countries that could have protectionist effects.

However, in recent disputes dealing with food quality and safety issues, the term “NTB” has been used mainly for isolating those trade restrictive measures that have as primary motive the protection of national producers. This approach implies that measures restricting trade incidentally while correcting market inefficiencies and addressing legitimate concerns (e.g. in the sense of the legitimate objectives of the Technical barriers to trade Agreement), would not be qualified as NTBs. Hence the definition of a NTB is linked to the legitimacy of the measure. However, distinguishing NTB from a legitimate regulation for protecting consumers can be difficult. Authors who have provided definitions of NTBs that are based on economic theory, often emphasize that the term “barrier” to trade should not be used for measures that may have incidentally the 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 the measures that decrease the world global revenue, they consider that trade restricting regulations that have overall positive welfare effects should not be considered as NTBs. Mahé's definition of a NTB as a restriction other than tariffs that leads to a decrease in world welfare, falls into this category (Mahé, 1997). The idea of qualifying as protectionist a standard if it 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 define whether a regulation that affects trade has some legitimacy.

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 et al., 2001). Fisher and Serra (2000), for example, characterize a standard (in an open economy) as non-protectionist if the social planner would use it 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.

The distinction between a trade-oriented concept and a welfare-oriented definition of a NTB has direct consequences on empirical measurement since the two conceptions lead to different approaches as explained in the next section.

■ AN ANALYTICAL FRAMEWORK FOR MEASUREMENT

Measurement

Measurement attempts to map complex effects into a scalar include, for example, the volume of imports at world prices (which would correspond to a mercantilist measure, e.g. of the trade effects of NTBs) or the level of welfare (which would summarize the effect of NTBs on

the aggregate economy under the assumption of a representative agent). If distributional effects of NTBs are of interest, one must use a representation of different categories of agents, such as a social accounting matrix. 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 their impact on the overall equilibrium in the sector, or in the economy. Roberts et al. (1999) propose an analytical framework to analyze NTBs that summarizes most of what the various authors have adopted. They distinguish three economic effects: *i*) the "regulatory protection effect", i.e., the rents to the domestic sector; *ii*) the "supply shift" effect on the domestic supply induced by compliance cost, and *iii*) the "demand-shift" effect arising from new information that increases consumer demand for the product. Using comparative-statics in a partial equilibrium framework, they 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 often has a fixed component. This cost increases the supply price of imports, 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 unless rent-seeking activities induce further waste. 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 NTBs 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). A measure of NTBs based on aggregate welfare must take both effects into account. Other features can be added to the framework proposed by Roberts et al. In particular, the cost of regulations affects in a different way small and large firms, and regulations modify the structure of competition or the size of the relative markets, affecting mark-ups 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 et al. (2001) account for the discriminatory nature of regulation towards imported products, through relative shifts in the excess supply curve of the exporting country and excess demand curve 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 by the "regulatory protection" effect. It is noteworthy that this must be taken into account in a welfare-based measure of NTBs as well as in a mercantilist

measure (the demand side effect may in fact increase access to a market which would otherwise have been limited to an exporter because of sub-standard protection). The large literature derived from industrial organization has made it possible to account for more sophisticated effects than the simple shift in supply curves. Bureau et al. (1998), and Bureau and Marette (2001), for example, include specifically the information aspect in the “demand shift” effect. The regulation brings information and therefore avoids or reduces the cost of assessing product quality (the “lemon problem”). Casella (1996), and Fisher and Serra (2000), account explicitly 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 et al. (1999) can be extended to the multimarket case to include extra effects of regulations. For example, regulations can raise the elasticity of substitution in demand, bring network externalities and even economies of scale by permitting producers to settle on a limited range of product characteristics or processes, but may also lead to the supply of a range of product that do not necessarily fit consumers' demand for a variety of attributes (Harrison et al., 1996; Maskus et al., 2000).

Practical obstacles to measurement

There is 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, the price differences between foreign and domestic products are key components of model simulations. Information on these aspects is still partial. The observable impact of a NTB does not in itself measure only the NTB but also captures other information, such as supply elasticity. The effects of extra information and trade facilitation addressed in stylized microeconomic models are hard to quantify in practice. 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. In the next sections, we turn to a description and an 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 partial or even general equilibrium model, that focus 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 com-

pare 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 are usually unobservable and actual measures of NTBs 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 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 c.i.f. price of the imported good as paid by the domestic importer to the foreign exporter, inclusive of transport costs but excluding 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, 1996, 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. It is also necessary to correct for product quality differences, which is clearly a limitation of this approach because of the empirical difficulty of quantifying such differences.

Existing studies

Campbell and Gossette (1994) used such a method on a large number of sectors including food and agriculture. They made sophisticated quality adjustments to make products homogenous. The US 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) estimate the tariff rate equivalents of the technical regulations in the apple sector. They compare monthly c.i.f prices (landed prices including freight and insurance costs) of U.S. apples in a foreign country with wholesale prices in the foreign market. They assume that the price gap consists of the tariff and technical barrier tariff rate equivalent for like apples (i.e., same variety, grade, and size, same time period, at a similar place in the marketing chain). They also accounted for transport costs. 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 c.i.f. prices of U.S. pig and poultry meats as well as apples and tomatoes 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. While Calvin and Krissoff's 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, which cannot be explained by quality effects. 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 price wedge residual of NTB tariff equivalence.

Practical validity of the method

There are several limitations with the price wedge method. 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 precisely are. 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% 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. They 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 the practical difficulties of its application. For large-scale studies, available data are often too aggregated to reflect differences in quality of imported goods. Even when one can observe prices 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 higher quality than imports, such measures find protection even where there is none.

For larger scale studies, the price wedge method does not appear reliable. A question arises with regard to the application of the price-wedge method to aggregate industries. 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 2-digit level of the Harmonized System, or the Standard Global Trade Analysis Project classification are unlikely to reflect the true effect of technical regulations, but capture other unwanted effects.

INVENTORY-BASED APPROACHES

Principle

Inventory-type approaches can be used both in quantitative and qualitative assessments of 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; *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 catalogue of all technical barriers (identification and description) on the basis of datasets that list the various regulations in the sanitary, phytosanitary and technical area (see for example Ndayisenga and Kinsey, 1994). Simple statistics, such as frequency type measures can be used to provide an indication of the frequency of occurrence of NTBs. Such measures may be unweighed, or may be weighed by the size of imports. Measures include *i*) the number of restrictions; *ii*) frequency ratios (number of product categories subject to a NTB, as a percentage of the total number of product category in the classification); and *iii*) import coverage ratio, constructed as the value of imports of each commodity subject to a NTB, as a percentage of imports in the corresponding product category. More refined indicators can provide some extra information, albeit under tenuous assumptions. For example, the percentage of standards based on international ones can be an indication of the overall compliance of national standard with widely used international standards².

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.

Complaints against discriminatory regulatory practices are often used to support claims of the existence of NTBs. Various national agencies use such information in periodical reports on barriers to their exports. However, there are large differences between countries in their ability and perhaps their administrative procedures to file complaints against third parties, within as well as outside the notification procedure of the WTO. Because of the intrinsic bias in the sample of complaints, the information is perhaps best used in a qualitative way.

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 et al. (1996) use counts of voluntary national and international standards recognized by the United Kingdom and Germany in an econometric study, where they regressed British net exports, exports, and imports over the period 1985-1991 on variables which include frequency indicators of standards. Moenius (1999) also uses the inventory-based method as an input in econometric approaches. Both studies use counts of binding standards in a given industry as a measure of stringency of standards. Otsuki et al. (2001) go further and employ a direct measure of the severity of food safety standards expressed in maximum allowable contamination.

2. Barrett and Yang (1999) show the limitations of such an approach using a data set from the US House of Representatives (USHR).

Fontagné et al. (2001) assess the impact of environmental regulations and their potential use as trade barriers. 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. On the basis of a large dataset, they use frequency statistics with different thresholds on the number of countries that have implemented a trade restrictive regulation for a given product.

Henson et al. (1999) (2000) and (2001) used several approaches to assess the importance of regulatory obstacles in the EU and U.S. food sectors, including the inventory approach. They compared the regulatory food quality and safety regimes of the EU 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) 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 products. Henson et al. studied the rejection from the United States for sanitary and technical reasons, of imports originating from Africa, Asia, and Latin America.

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 their effect on trade. When based on international datasets, 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.

Despite these limitations, inventory-based approaches can be useful for directing attention to the frequency of occurrence of various types of NTBs and the trade or production coverage of NTBs. Inventory-based methods do not really provide a quantification of the effect of regulations on trade per se. However, they can provide indications on the importance of the problem, and on which sectors and countries NTBs are more likely to be found. In spite of the drawbacks of inventory-based approaches, indicators such as the ones estimated by Fontagné et al. (2001) might be used in econometric estimates of trade. Their potential use as a proxy variable in econometric models (e.g. gravity models) deserves more exploration.

■ SURVEY-BASED APPROACHES

Principle

Inventory-based approaches do not make it possible to identify regulations that have a major trade restriction effect from 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 on a sample of the population surveyed, these approaches have sometimes provided some counterintuitive assessments of the importance of trade barriers.

Surveys can also be designed to provide some 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 United States Department of Agriculture (USDA) on estimates of the trade impact of foreign technical regulations illustrate the interest of 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

Most existing studies emanate from governmental and international institutions. Information provided from the industry that face restrictions to its exports is an input for the annual report on U.S. trade barriers (European Commission, 2000) and the US Trade Representative annual reports on foreign trade barriers (USTR, 2001). In some areas (the information technology industry in particular) the USITC also performs informal interviews of corporate executives, officers of trade associations and government officials for their views on 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 dairy products. In 1996 the USDA conducted a survey providing a cross-sectional accounting of technical barriers to U.S. agricultural exports. The USDA's set of cross-sectional data was used to characterize the extent to which economic-based protection exists. Several studies derived from this survey quantified the trade impact of questionable technical barriers on U.S. agricultural exports (Roberts and De Remer, 1997; Thornsbury et al., 1999; and Thornsbury, 1998).

Specific surveys were conducted on the problems developing countries face to meet the SPS requirements of the developed countries and in adhering to the provisions of the SPS Agreement. Henson et al. (2000) conducted surveys together with detailed interviews. Rather than being sent to an industry, the questionnaires were sent to contact points (e.g. the contact point of the Codex Alimentarius in a given country) in developing countries.

Several studies conducted by the University of Reading for the European Commission combined surveys and in depth interviews (European Commission, 2001). This approach proved

particularly interesting to identify the most relevant issues and for debunking some common ideas. For example, from the work of the task force of the European Commission, it appears that one major complaint of European exporters to the United States is not the tariff rate or the sanitary requirements, but the administrative burden, both in terms of delays and in terms of lack of predictability. A finding of the OECD (1999b) survey on the dairy sector was that few firms considered standards to be of great concern. In dairy products 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 have also brought considerable light on the important issue of barriers faced by developing countries willing to export to developed countries. Another useful feature of the survey-based approaches is the ability to identify hidden barriers, those which are particularly difficult to measure, such as the administrative ones. Survey-based methods also show that the regulations that are of most concern to the industry are not always those that economists include in their models.

However, their ability to actually help quantify NTBs is questionable. The firms consulted are likely to be biased if there is a perception that the agency conducting the survey would use it for policy purposes. Even experts surveyed can have the perception that their response could be used to initiate dispute settlement procedures³. The definition of the questionnaire and the way the survey is conducted are likely to affect the NTB estimates. 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

The method

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. The bias stems partly from national regulations that hamper trade. Head (2000) summarizes the basic principles of gravity models. Gravity models rely on Newton's "Law of Universal Gravitation" formula, that holds that the attractive force between two objects i and j is given by: $F_{ij} = G \cdot (M_i \cdot M_j) / D_{ij}^2$, where M_i and M_j correspond to the masses of objects i and j , D_{ij} is the distance between the two objects and G is a gravitational constant.

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

In a similar way, economists have been using this equation to explain trade flows with F_{ij} being the "flow" from origin i to destination j , M_i and M_j being the relevant economic sizes of the two locations, D_{ij} denoting the distance between the locations, and G , a , b and c being constant, yielding $F_{ij} = G \cdot (M_i^a \cdot M_j^b) / D_{ij}^c$, which is the Tinbergen (1962) version of the gravity equation (G , a and b have subsequently been related to the form of economic functions). Gravity models performed relatively well but lacked a theoretical foundation until Anderson (1979) provided a such foundation in the presence of imperfect substitutability between goods. Further developments have shown that the gravity equation was consistent with situations characterized by monopolistic competition (Bergstrand, 1989). Deardorff (1998) established links between the Heckscher-Ohlin model and the gravity equation. These foundations have provided a surge of interest together with new developments in this approach (Hummels, 2000; Anderson and van Wincoop, 2001).

An interesting application of the method estimates how much trade is foregone only because of the "border" effect. For example McCallum (1995) showed that in 1988 the U.S.-Canadian border led to an effect that all things being equal (in particular distances and costs), intra-Canadian province trade was 22 times higher than trans-border trade. Since that controversial study, numerous attempts were made to include some explanatory variables in the analysis, including language, indicators of "remoteness," cultural differences, etc.⁴. 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 introduce as explanatory variables, information on regulations, 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.). 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. Recent developments provide new interpretation of the border effect Anderson and van Wincoop (2001) 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); Cheng and Wall (1999) use a fixed-effects model to eliminate heterogeneity bias.

Gravity based techniques attempt to measure the trade impact of NTBs, rather than their welfare impact, and may therefore ignore some of the effects that the regulations have to 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 the trade enhancing effect of regulations, when they act as standards that facilitate trade.

4. Mc Callum's results have namely been challenged by Anderson and Van Wincoop (2001).

Existing studies

One of the most direct attempts to measure the trade impact of Technical Barriers to Trade (TBTs) using gravity-based analysis of bilateral trade volumes was carried out by Moenius (1999). He focuses 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 finds that a shared standard has a large trade promoting effect between the nations sharing the standard. He incorporates econometric refinements (correction for autocorrelation, causality testing, etc.). This makes it possible to estimate the impact of a one percent increase in the number of bilaterally shared standards on bilateral trade volume.

In the food and agriculture sector, Otsuki et al. (2001) use 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 econometric approach remains very simple, because the aflatoxin maximum residue shows statistical variation in their panel, they exploit the possibility of using the level of standard itself as an explanatory variable. 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 caveat of these methods 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 in the "border effect". When focusing on detailed products and spatial trade flows between given countries, the prediction is likely to be sensitive to the assumptions of the models.

However, the use of multivariate analysis could help sorting out the share of the regulations in the "border" effect. Furthermore, when standards do not show enough statistical variability to be used as regressors, econometric refinements could also make it possible to deal with binary variables (allowed or banned), or with discrete variables, that are often the only characterization of NTBs. Overall, these approaches, coupled with 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 integrated into 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 on 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 which arises is often the identification of the protectionist component of the regulation. There are only limited cases where the efficiency assessment is straightforward. In other cases, comparing the costs of compliance to the gains associated with the reduction of an externality (such as 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 to a measure whose costs exceed benefits. When the benefits are found negligible, this approach provides a sufficient test to classify a NTB as a trade distortion. Such estimates also shed a light on 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) have proposed to measure both economic effects and probability aspects of risk and have developed a methodology in the case of pest infestation. James and Anderson (1998) provided an economic assessment of quarantine regulation. They conclude 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) argue 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.

The analysis carried out by the USDA in the case of trade policy with Mexico on avocados is a compelling illustration that the mix of science-based evaluation and cost-benefit analysis can be useful in the identification of NTBs (defined as measures which have a negative impact on welfare) as well as the settlement of SPS trade disputes (Orden and Romano, 1996). Pivotal to their analysis was the evaluation of pest risk, the definition of measures that help reduce the risk of spreading pests at a low, albeit non zero, level and the combination of these assessments with a comprehensive evaluation of the potential costs to the benefits, including the impact on consumers. 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 domestic than foreign prices, to avoid relatively small potential costs of a pest infestation.⁵ That is, this analysis proved useful in identifying the protection motive based on the legitimacy of pest avoidance.

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

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 criteria (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 a lot in international fora. The frequent use of cost-benefit analysis in environmental program decisions in the United States and cases where it has been used to influence policy decisions in the sanitary area suggest that such analysis could be used more widely to distinguish those measures that restrict trade but address a market failure, from those that have negative welfare impacts. Should this concept translate into more weight given to economics in international agreements in the future, the scope of the cost-benefit based method would even be greater.

The main limitations of this approach are the large levels of uncertainty which surround the size of risks and their economic consequences. In the case of sanitary or phytosanitary measures, for example, it is necessary to assess the probability of a spread of a disease from a pest, and the associated costs.⁶ 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, effect of standards on consumers' willingness to pay for goods is perhaps even more difficult to quantify, especially in the case of subjective risks, or in the case of the ethical characteristics of the goods.

■ STYLIZED MICROECONOMIC APPROACHES

Principle

Methods of cost-benefit analysis 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 (cross section or panel, preferably) are available, the effect of regulations on supply and demand can be measured by standard estimates of cost or profit functions, as well as utility or demand functions estimated econometrically. Duality theorems can be used to estimate a shadow price associated to the variable representing a standard (or a binding regulation). However, the classical framework of price taking firms and perfectly informed consumers is seldom appropriate to assess the effects of regulation 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 (OECD, 1999a). This

6. It is difficult to base sound economic analysis on estimates that are subject to controversies; a general estimate has been made of US\$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).

body makes it possible to account for a variety of effect that regulation has on competition, information, economies of scope or scale.

Existing studies

The literature that has dealt with these issues has remained largely theoretical, and the goal has often been to illustrate the 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 have been the topic of many papers (Grossman and Horn, 1988; Crampes and Hollander, 1995b), as well as the way regulations modify the information available for consumers (Shapiro, 1983; Donnenfeld et al., 1985). For example, welfare effects of a regulation are different if consumers can assess or not the quality of the products, and if they can do it before or after consumption (Marette et al., 2000). It has also been shown that regulations may modify the costs of signaling quality (Falvey, 1989) and possibly result in network externalities and economies of scale (Katz and Shapiro, 1985; Barrett and Yang, 1999). Because of all these effects, regulations have 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 would help assess how much trade is foregone because of regulations, how much consumers preferences are affected, and what would be the effect for particular nations to harmonize regulations versus mutual recognition agreements.

An analytical framework that makes it possible to account for sophisticated effects become rapidly intractable unless one makes drastic simplifying assumptions on the shape of demand curves and on competition (e.g. duopoly or monopoly structures competing in prices or quantity). Limitation of these approaches is their robustness to the simplifying assumptions, and the difficulty to provide estimates of the various effects in empirical implementations. The quantification of consumer responses and market equilibrium displacements induced by new NTBs is difficult.

However, accounting for imperfect competition, imperfect information and strategic effects often makes it possible to highlight 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

Principles

Partial equilibrium models provide a framework for analyzing tariff-rate equivalents of standards and technical regulations. The main interest, 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, these models aim to yield 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 that 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 competition 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.

General equilibrium models can include similar features, and in addition allow for the analysis of cross-sectoral effects and explicitly take into account the impact on factor markets. Like partial equilibrium models, they can be used to model other trade policies than just tariffs, but can account for intra sectoral linkages within a consistent microeconomic framework, and add the possibility of including the government as an agent (and hence budgetary costs) in the overall evaluation of the welfare impact of such or such measure. The weaknesses of these approaches are the level of aggregation and quality of data that are typically used.

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 associated with a ban on avocados as an extension of their risk based assessment. Calvin and Krissoff (1998) also combined the price wedge method to 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 the FMD infection to 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 demand and supply functions. Thilmany and Barrett (1997) studied the implications of technical regulations for dairy exports from the United States within NAFTA. 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 exports including compliance costs. They compared domestic and international prices to estimate the producer subsidy equivalent and import tariff-rate equivalent of these trade barriers. Summer and Lee (1997) explore how TBT's 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 partial equilibrium multimarket approach is provided by the simple framework proposed by Overton *et al.* (1995) in the case of EU restrictions on chemical residues in tobacco. The low EU restriction on residues of maleic hydrazide (MH), not only affects U.S. tobacco producers, but it affects the U.S. and EU tobacco cigarette industries. The latter uses only a share of U.S. tobacco in its blend, and 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 the origin of tobacco is concerned, and leads to greater costs to foreign producers. The partial equilibrium models 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 which is protectionist in the tobacco output market can actually increase trade flows in the tobacco input market.

Practical validity of the method

The work by Overton *et al.* (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 Statistical Life Saved, see Bowland and Beghin, 2001; and OECD, 1999a), such approaches make it possible to quantify the economic impacts, and these economic impacts can be compared against the effect of the measures on illness reduction and 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. Quantification of the trade and wel-

fare effects of SPS and TBT regulations will be possible when taking into account more sophisticated mechanisms related to imperfect competition or consumers' information.

CONCLUDING REMARKS

The impact of regulations on existing trade flows

Technical regulations on pest infestation, aflatoxins, pesticide residues, antibiotic use, and other sanitary standards affect trade. While these measures might be legitimate, the amount of trade foregone is not always well known by decision makers. The combination of gravity models with econometric estimates is a potentially useful approach to identify the role of regulations in foregone trade (as opposed to the "home bias", i.e. the natural preference for trading with compatriots). Recent developments in the area of gravity models and the use of statistical techniques (data analysis, latent variables, econometrics) 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 make it possible to unravel the various determinants of foregone trade. In this area, the combination of different methods should allow to advance the literature in identifying the causes of the "border effect" and the role of regulations compared to other effects.

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 a research agenda. In some cases, the issues at stake are mainly technical: for example, countries disagree on the relevance of certain sanitary and phytosanitary standards, which are viewed as excessively restrictive by some exporters. They 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). Less known is how severely the corresponding regulations constrain exports. Estimations of their actual effect on trade can rely on some of the methods described above (surveys, price wedge, gravity or spatial trade model approaches). Cost-benefit analysis may also help identifying the costs of the regulations and assess whether they are in proportion of 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. In particular, a research program should tackle the difficult issues where the protectionist component is unclear, where regulations affect trade but also address a genuine concern from consumers or citizens. This includes regulations that may be at odds with the existing

agreements (such as those based on process and production methods, those with an extensive conception of precaution, and those which aim to protect global commons), and regulations that address concerns specific to a group of countries (animal welfare, acceptance of genetically modified organisms). In such cases it is necessary to address not only the trade effect, but also the supply shift and demand effect of regulations. The latter requires less familiar and robust techniques for assessing the effect of regulation on consumers and citizens.

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