A Framework for Analyzing Technical Trade Barriers in Agricultural Markets. By Donna Roberts, Timothy E. Josling, and David Orden. Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1876.

Abstract

Technical trade barriers are increasingly important in the international trade of agricultural products. Designing technical trade measures that can satisfy the growing demand for food safety, product differentiation, environmental amenities, and product information at the lowest cost to the consumer and to the international trading system requires an understanding of the complex economics of regulatory import barriers. This report proposes a definition and classification scheme to frame discussion and evaluation of such measures. Open-economy models that complement the classification scheme are developed graphically to highlight the basic elements that affect the economic impacts of changes in technical trade barriers.

Keywords: technical trade barriers, sanitary and phytosanitary, agricultural trade policy, environmental trade measures

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Summary

Technical trade barriers—measures that restrict imports of products that fail to meet a country's health, quality, safety, or environmental standards—are increasingly important in international agricultural trade. Income growth is fueling demand for environmental amenities, food safety, product differentiation, and product information, and regulators are being asked to provide these services when markets fail to do so. Economic analysis that can inform policy decisions about the design of regulations and standards to satisfy these growing demands and that improves the understanding of the trade and welfare implications of alternative policies has been slow to develop. Technical trade barriers are a difficult conceptual and empirical topic, and it may be some time before key questions about optimal policies are resolved. This report provides a preliminary framework for analyzing this vast array of trade-restricting measures so as to foster research that will provide the answers to these questions.

Specifically, this study proposes definitions and a classification scheme to:

- Provide a conceptual foundation for evaluation of technical trade barriers;
- Guide the specification of economic models used to gauge the trade and welfare impacts of these measures; and
- Provide policymakers and analysts with an organizing framework for discussing and possibly negotiating international guidelines for their use.

Technical trade barriers are defined as regulations and standards governing the sale of products into national markets that have as their prima facie objective the correction of market inefficiencies stemming from externalities associated with the production, distribution, and consumption of these products. An externality is defined by economists as a direct and unintended side effect of an activity of one individual or firm on the welfare of other individuals or firms (such as the use of food processing methods in foreign countries that result in microbial contamination in food that subsequently causes consumers to fall ill). Given such an occurrence, authorities might choose to adopt a technical trade barrier (in the form of a process standard) if it were judged that market incentives alone had not produced the "efficient" amount of food safety—that is, if consumers would have been willing to pay more (perhaps through higher food prices caused by restricting imports from some sources) to avoid illness. Thus, technical trade barriers can be welfare-enhancing, a feature generally absent from other trade-restricting measures. The words prima facie in the definition acknowledge that technical trade measures have sometimes been used to shield domestic producers from international competition.

A classification scheme is proposed to set up the economic analysis of these measures in a systematic framework. Technical barriers are first classified by policy instrument and by scope, which provides a basis for evaluating these measures as if they were standard trade barriers. They are then classified by regulatory goal, to further understanding of how their effects might differ from standard barriers.

The classification criteria are then used to analyze the results of a U.S. Department of Agriculture (USDA) survey of foreign technical barriers to U.S. agricultural exports. A rating of the relative importance of different regulatory goals emerges from this analysis. The regulatory objectives of most of the barriers identified in the survey were protection of commercial crops and livestock (62 percent) and food safety (22 percent). Conservation or protection of the natural environment from harmful non-indigenous species were objectives for only a few of the trade barriers. The classification also permits examination of the distribution of the most trade-restrictive measures across regulatory goal categories. The analysis indicates that import bans constitute 27 percent of the measures used to protect crops and livestock, a higher percentage than for any other regulatory goal category.

Models that complement the classification scheme are developed graphically to highlight three basic elements that affect the economic impacts of changes in technical measures in an open economy framework: the case where there is no valid rationale for the barrier, and supply shifts and demand shifts that might result from changes in policy if the barrier has a significant technical basis.

In addition to modeling the effect of the technical barrier on the parameters of supply and demand in the market in question, a full analysis of the trade impacts of a technical measure requires consideration of its scope. That is, does the barrier apply to all exporters or only to particular exporters, and are such barriers applied by only one importer or by many importers? These distinctions essentially govern the incidence of the cost of compliance with import regulations. The trade and welfare effects of different technical trade barriers are analyzed from both the importer and exporter perspective in these models.

An application of this analytical framework is illustrated by an assessment of the price, quantity, and welfare effects of alternative phytosanitary measures that would allow imports of Mexican avocados into the United States. The effects on American producers and consumers are examined under different assumptions about the probability of a pest infestation affecting domestic production and about the costs of an infestation in terms of pest-control expenses and reduced yields. The analysis indicates that, in certain scenarios, technical barriers that restrict trade to minimize the probability of trade-related pest infestations can create welfare losses that exceed the domestic costs arising from these infestations.

Glossary

AMS—Agricultural Marketing Service, USDA

APHIS—Animal and Plant Health Inspection Service, USDA

CODEX—Codex Alimentarius Commission

EU—European Union

FSIS—Food Safety and Inspection Service, USDA

GATT—General Agreement on Tariffs and Trade

GIPSA—Grain Inspection, Packers and Stockyards Administration, USDA

HNIS—Harmful Non-Indigenous Species

IPPC—International Plant Protection Convention

NAFTA—North American Free Trade Agreement

NTB—Non-tariff Trade Barrier

OECD—Organization for Economic Cooperation and Development

OIE—Office International des Epizooties (International Office of Epizootics)

PPM—Production and Processing Methods

SPS—Sanitary and Phytosanitary

TBT—Technical Barriers to Trade

WTO—World Trade Organization

A Framework for Analyzing Technical Trade Barriers in Agricultural Markets

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Introduction

The deepening integration of world markets in recent decades has blurred the lines of the formerly sharp distinctions between "domestic" and "international" policies. In the past, the predominant view was that domestic policies should be determined by the preferences of a nation's citizens, with little regard to any effects the policies might have on other countries. More recently, the exponential growth in worldwide trade flows has led to closer international scrutiny of the differences among some domestic policies that were formerly overlooked. Of the domestic polices now subject to such scrutiny, technical trade barriers—measures that sometimes restrict imports to prevent entry of products that fail to meet the health, quality, safety, or environmental standards of importing countries—were among the first to attract attention. The enforcement mechanism of these policies, which is to restrict entry of unsatisfactory imports, often made them indistinguishable from explicit trade policies that likewise limited entry of goods at the border.

Although economists have found it difficult to evaluate the effects of technical trade barriers or to assess their relative importance in the world trading system, the consensus has been that these measures can significantly impede trade. Consequently, disciplines on technical trade barriers were adopted by the Contracting Parties to the original General Agreement on Tariffs and Trade (GATT) in 1947, while multilateral trade rules for other "domestic policies" such as investment, services, and intellectual property measures were left to future negotiations. The fact that disciplines on the use of technical barriers were subsequently expanded and strengthened in multilateral trade negotiations that took place during the 1973-1979 Tokyo Round and again in the 1986-1993 Uruguay Round is further evidence of the broad recognition that these measures can effectively thwart the commercial opportunities created by other trade liberalization policies.

Technical trade barriers exist in most industries, but are particularly important in the international exchange of primary and processed agricultural products. Agricultural exporters may be required to demonstrate that native plant species or human health are not endangered by their products, while simultaneously complying with standards that stipulate everything from ingredients to packaging materials. The regulatory environment for agricultural and agroindustrial producers is expected to become more complex, even though reform initiatives aimed at reducing the number and rigidity of regulations faced by the private sector are currently underway in many countries. Income growth is fueling demand for environmental amenities, food safety, product differentiation, and product information in developed and developing countries alike. Regulators are increasingly being asked to provide these services when markets fail to do so.

Designing technical trade measures that can provide nonmarket goods and attributes at the lowest cost to the consumer and to the international trading system requires an understanding of the complex economics of regulatory import barriers. Technical barriers are a difficult conceptual and empirical topic, and it may be some time before key questions about optimal regulatory trade regimes for agricultural and agroindustrial products are resolved. The objective of this report is to strengthen the conceptual basis for understanding technical trade barriers as a distinct class of non-tariff barriers (NTB's) that are becoming increasingly important to trade in agricultural products.

To achieve this objective, this report discusses alternative terminology found in the literature about technical trade barriers, proposes definitions that appear to be most useful for the study of these barriers in agricultural markets, examines why technical barriers are becoming an increasing focus of public policy debates, and suggests classifications for the myriad individual barriers that are observed. These classification schemes focus on characteristics of technical trade barriers related to the policy instrument used, the scope of the measure, and the regulatory goal.

The report then turns to empirical and theoretical evaluation of the prevalence and economic effects of technical trade barriers. Results of a 1996 USDA survey of foreign technical barriers to U.S. agricultural exports are examined using the proposed classification criteria. In the following section, models are developed graphically to highlight three basic elements that affect the economic impacts of changes in technical measures:

1. The case where there is no valid rationale for the barrier,
2. Supply shifts that might result from changes in policy if the barrier has a significant technical basis, and
3. Demand shifts that might result from changes in policy if the barrier has a significant technical basis.

An application of this analytical framework is illustrated by an assessment of the price, quantity, and welfare effects of modifications to the quarantine rules for importing Mexican avocados into the United States.

Defining Technical Trade Barriers

There are differing views on what constitutes a technical trade barrier. Earlier literature recognized quarantine policies and an amorphous array of other measures that restricted or delayed entry of products at the border as technical barriers. More recently, agricultural technical barriers have been viewed as a subset of environmental regulations (Hillman). We define technical barriers as regulations and standards governing the sale of products into national markets that have as their prima facie objective the correction of market inefficiencies stemming from externalities associated with the production, distribution, and consumption of these products. These externalities may be regional, national, trans-national, or global. This definition centers the analysis of technical trade barriers on the economic concept of market failure rather than on a mutable list of policy instruments.

Technical trade barriers may be adopted in instances when:

- a country's regulators conclude that market mechanisms alone will fail to prevent or correct negative externalities that arise when imported goods may be accompanied by pests or diseases that may reduce domestic output and/or increase production costs;
- regulators or industry representatives believe that information about the health, hedonistic, or ethical attributes of agricultural products is either unknown or asymmetrically distributed between producers and consumers, and the transaction costs of obtaining this information are prohibitively high for consumers;
- coordination costs and free-rider behavior in an industry prevent development of compatibility standards that could increase firms' potential for realizing economies of scale; or
- regulatory authorities judge that markets fail to provide optimal amounts of unowned or commonly owned environmental resources.

We use *prima facie* in our definition to acknowledge the existence of regulatory capture, when domestic groups with a vested interest in limiting competition successfully lobby for technical measures having questionable legitimacy and that potentially represent a net cost to a country.

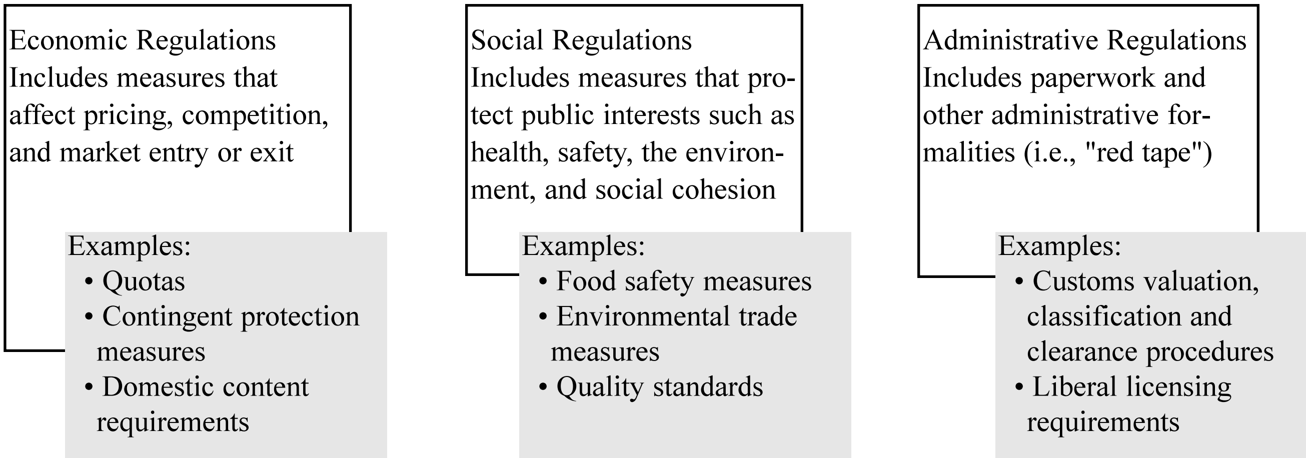
In this report, a "standard" is a technical specification or set of specifications related to characteristics of a product or its manufacturing process. From this perspective, standards can be either voluntary or established by government fiat.[1] Several authors have pointed out that voluntary standards can effectively bar imports if they become standard business practice in the importing country, especially if they are accepted as a legal defense against product liability claims (Bredahl and Zaibet; Sykes). However, our primary focus is on command and control measures, the most prevalent type of technical barrier in markets for primary and processed agricultural goods.

This view of technical trade barriers is both broader and narrower than previous perspectives. We exclude incentive measures such as taxes and subsidies, even though these measures may have been established to address externalities. For example, our definition would not include a product packaging tax with rates that varied with the degradability of the packaging material, incorporating the social costs of disposal into firms' private costs. Our definition also excludes other regulatory NTB's, such as quotas or domestic content regulations, whose primary objective is redistribution, not efficiency. However, this view of technical barriers is broader than others in that it comprises more than just a small set of border measures, such as import bans, which often dominate discussion of agricultural technical barriers. It also includes measures ranging from maximum residue standards for pesticides on fresh horticultural products to eco-labeling requirements for processed foods.

Given this definition, technical trade barriers can be characterized as a subset of "social regulations" (OECD, 1997; Viscusi et al.). Social regulations are all of those measures adopted by a country to achieve health, safety, quality, and environmental objectives; technical trade barriers can help realize these policy

[1] See OECD (1998) for an extensive discussion of alternative definitions of the term "standard."

Figure 1: Trade measures viewed as subsets of regulations



Source: USDA, Economic Research Service, adapted from OECD.

objectives by restricting entry of unsatisfactory products at the border (fig.1). By limiting imports, these measures might result in substantial "regulatory protectionism" for domestic producers, although (absent political economy considerations) this is not their primary intent. As noted above, technical barriers are potentially welfare enhancing, a feature generally absent from other NTB's, such as those that are a subset of economic regulations (fig. 1). A key point from the theory of distortions and welfare is that the optimal policy will correct the market failure as close as possible to the source of the distortion (Bhagwati).

Although the public-good dimensions associated with legitimate technical barriers are universally acknowledged, even well-intentioned measures can create impediments to trade that lower net welfare, often as a byproduct of different bureaucracies in different countries autonomously developing national standards. This regulatory heterogeneity imposes costs for producers who must comply with multiple regulatory regimes. Harmonizing regulations among countries would help limit the unintended trade-restrictive consequences of legitimate technical standards. But achieving such harmonization is itself complicated by differences among nations in tastes and income, or, absent such factors, may be too costly. Regulatory heterogeneity can also result from differences in objectively assessed risk factors such as the presence of host organisms in some, but not all, importing countries as well as differences in trans-scientific factors such as risk attitudes rooted in different cultural norms and experiences. Thus, a certain amount of regulatory heterogeneity is inevitable in international markets. More problematic is the widespread acknowledgment that agricultural technical barriers have often provided an attractive pretext for regulatory protectionism (Kramer; Roberts and Orden).

Prominence of Technical Trade Barriers in Current Public Policy Debates

The focus on technical trade barriers in the 1990's stems from a number of developments in both the public and private sectors. The single most important factor behind the rising interest in these measures has likely been the Uruguay Round multilateral trade negotiations, which culminated in the 1994 Agreement Establishing the World Trade Organization (the WTO Agreement). The WTO Agreement continues the historical progression of multilateral trade negotiations that periodically augmented and steadily reinforced rules for the use of technical trade barriers over the past 50 years (Roessler).

Most of the principal multilateral disciplines on the use of technical trade barriers are found in the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the WTO Agreement on Technical Barriers to Trade (TBT Agreement).[2] Another annexed Agreement, the Agreement on Agriculture (Agriculture Agreement), contains no disciplines on the use of technical measures, but rather provides a key motivation for adoption of disciplines on regulatory measures. Negotiators recognized that the reinstrumentation of policies under the Agriculture Agreement, and subsequent lowering of the level of protection provided by tariffs and many NTB's, would increase the relative and absolute importance of existing and potential technical barriers in international markets. The new trade regime was especially important in agricultural markets, since the use of most agricultural NTB's had not been disciplined before the Uruguay Round. By reducing the ability of governments to protect domestic producers through various other border and domestic support measures, negotiators feared that the Agriculture Agreement would inadvertently create an incentive to replace former NTB's with new technical barriers. The new disciplines in the SPS and TBT Agreements were viewed as critical to prevent governments from resorting to regulatory compensation to appease domestic interests.

The most significant of these new disciplines on technical measures that affect trade in primary and processed agricultural goods are in the new SPS Agreement. The agreement defines SPS measures as regulations adopted by a nation to protect human, animal, or plant life and health within its territory from certain enumerated biological and toxicological risks. The new substantive requirements in the SPS Agreement suggest a normative basis for technical barriers, while new procedural obligations facilitate decentralized policing of such measures (Roberts, 1998a). In broad terms, the SPS Agreement recognizes the right of each WTO member to adopt measures that provide any chosen level of health and environmental protection for its citizens, but requires such measures to be based on a scientific assessment of the risks and to be applied only to the extent necessary to achieve its public health or environmental goals. The principal procedural obligation in the SPS Agreement is the requirement to notify trading partners of changes in SPS measures that could affect trade. Together, the substantive and procedural requirements of the SPS Agreement have generated a broad-based regulatory review among WTO members as major agricultural exporters and importers determine whether they and their trading partners are in compliance with the new disciplines (Thiermann).

Most of the principal substantive and procedural provisions of the Uruguay Round TBT Agreement are

[2] Although the new SPS Agreement and the revised TBT Agreement establish most of the current multilateral rules for the use of technical trade barriers, other Uruguay Round legal instruments discipline the use of these measures as well (GATT, 1994). The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), for example, establishes rules for the use of geographical indications to differentiate products in the market. Even the General Agreement on Trade in Services contains provisions related to technical trade barriers: Article XIV allows WTO Members to adopt restrictions on trade in services (such as tourism or shipping) if "necessary to protect human, animal or plant life or health." Some of the WTO rules for the use of technical trade barriers remain unchanged from the Tokyo Round, most significantly GATT Article XX, which disciplines the use of measures related to the conservation of exhaustible natural resources, or protection of animal, plant, and human health in circumstances not covered by other agreements.

unchanged from the Tokyo Round. Countries are still permitted to adopt technical measures to realize legitimate objectives (inter alia, the quality of exports, protection of the environment, and the prevention of deceptive practices) as long as imported products are treated no less favorably than "like" domestic products. However, three key revisions in this agreement will affect the multilateral legal environment for technical measures related to trade in agricultural products. First, the TBT Agreement was converted from a plurilateral to a multilateral agreement so that all WTO members must comply with the terms of the treaty. Second, the legal definition of "technical regulation" now includes measures that regulate "related processes and production methods," which the Tokyo Round Agreement had omitted. Finally, although the Uruguay Round TBT Agreement continues to discipline the use of many technical measures that affect agricultural trade, it explicitly notes that its provisions no longer apply to health and environmental measures that the SPS Agreement defines as SPS measures.

The new multilateral rules on technical trade barriers, together with strengthened dispute settlement procedures,[3] have increased requests for WTO panels to review technical restrictions, which has heightened their profile. Two of the most prominent cases have been the U.S./Canadian complaint against the European Union's (EU) ban on imports of hormone-treated beef and the complaint by several Asian countries against the U.S. prohibition on imports of shrimp caught with nets lacking turtle extruder devices. Other formal complaints have led to negotiated settlements, such as South Korea's change in policy regarding government-mandated shelf-life standards. The U.S. Government questioned the scientific basis for uniform shelf-life requirements during formal WTO consultations in 1995, after which South Korea agreed to allow manufacturers of frozen foods and vacuum-packed meat to set their own use-by dates. Public debate over GATT/WTO jurisprudence on technical barriers has raised provocative questions about issues such as the use of trade measures to protect the global commons, "downward harmonization" of standards, and recognition of the "precautionary principle" as a justification for technical barriers (Farber and Hudec; GATT, 1995).

Regional trade liberalization agreements have also put technical barriers in the public policy spotlight. When nations within a region try to harmonize their technical regulations so as to permit the free intra-regional movement of goods, their external trading partners frequently face new technical requirements for gaining entry to the unified market. These external regulatory changes, or even proposed regulatory changes, can create trade conflicts. New regional trade alliances—as well as the enlargement and deeper integration of older alliances— have been one of the most important factors in the increase in technical barriers that have been brought to the attention of U.S. policymakers by exporters who face either new requirements or uncertainty about potential requirements.

Incipient regulatory reform initiatives in some developed countries have likewise brought technical barriers to the fore of trade policy, particularly in the United States (Roberts, 1998b). These initiatives aim to improve the quality of regulatory decisions, primarily by establishing guidelines for assessing costs and benefits of measures, as well as guidelines for the subsequent use of such assessments as a normative basis for decisions. These reform efforts have led to a widespread reexamination of health and environ-

[3] The new WTO Understanding on Rules and Procedures Governing the Settlement of Disputes (known as the Dispute Settlement Understanding) provides the legal infrastructure for enforcement of the provisions of the WTO Agreement. It establishes rules for all legal proceedings, from initial consultations to the final review of a ruling by the Appellate Body. If formal consultations do not result in a mutually agreeable solution between the parties to a dispute, a member can request a WTO panel to rule whether the measure is in compliance with the disciplines set forth in the agreement. The panel submits its recommendations for consideration by the WTO Dispute Settlement Body, where all WTO member countries are represented. If a panel finds that a measure violates one or more provisions of the WTO Agreement, the member is obliged to implement the panel's recommendations and to report on how it has complied, unless the DSB decides by consensus not to adopt the panel's report, or unless one of the parties appeals the decision. Appeals are limited to issues of law and legal interpretation by the panel. It is no longer possible, as it was before the Uruguay Round, for a single country to block DSB adoption of a report.

mental regulations, including those that affect trade (OECD, 1997). A few recent studies of agricultural technical barriers have raised the prospect that this reexamination has been overdue (Orden and Romano; MacLaren; Paarlberg and Lee). Another study notes that most countries' national quarantine policies pay virtually no attention to the effect of SPS trade restrictions on consumer prices, and further that "SPS policy assessment currently is about where environmental policy assessment was two or three decades ago" (James and Anderson). Regulatory reform initiatives have prompted substantial debate among elected officials and regulatory authorities as injunctions to weigh the costs and benefits of technical barriers and other health and environmental measures often run counter to the longstanding practice of promulgating measures that reduce risks to negligible levels (Kopp, Krupnick, and Toman).

However, the current prominence of technical barriers does not arise solely from recent public-sector policy events. Changes in regulatory policies that track private sector innovations in products, production and processing technology, and pathogen detection and control are routine, and these changes continue to spawn disagreements between importers and exporters. Bio-engineered products, for example, have been at the center of perhaps the most prominent debate over technical trade barriers in recent years, as importing countries consider whether these products pose a risk to consumers or to biodiversity, or violate ethical norms. Trade officials are drawn into public debate when exporters believe that lengthy regulatory review of new products or new pathogen-reducing technology might be motivated by a desire to protect the commercial interests of domestic producers, rather than by public health or environmental concerns. There is no reason to expect that the number of agricultural product and technology innovations—or the number of measures to regulate their entry into importing countries—will diminish. Technical trade barriers will therefore remain an important topic of discussion in both the international regulatory and trade policy venues well into the foreseeable future.

A Classification Scheme for Technical Trade Barriers

The specificity of individual technical barriers to particular risk-related or non-risk-related public externalities creates a diverse array of measures. This diversity makes it appear difficult to systematically examine the use and proliferation of technical barriers. For this reason, it is useful to structure the array of technical barriers along various functional dimensions. The objectives of such taxonomies are to provide a conceptual foundation for evaluating technical barriers; to guide the specification of economic models used to gauge the trade and welfare effects of these measures; and to provide policymakers and analysts with an organizing framework for discussing and possibly negotiating international guidelines for their use. We first classify technical barriers by policy instrument and by scope, which provides a framework for evaluating these measures as if they were standard trade barriers. Technical barriers are then classified by regulatory goal, to further understanding of how their effects might differ from such standard barriers. Finally, we propose a matrix of technical trade barrier regimes that takes into account both regulatory goals and policy choice among instruments.

Classifying Technical Trade Barriers by Policy Instrument

A large and increasing number of policy instruments are available to governments to correct perceived market failures (OECD, 1997). The search for ameliorative measures broadly entails governments in the roles of lawmaker, tax collector, and/or regulator. Regulatory trade measures are generally preferred by governments when risks associated with generic products are great, delayed, or imperfectly known, and when an efficient legal system is missing (i.e., when citizens find it impossible, costly, or slow to prosecute claims related to imported goods under property or product liability laws) (Mahè). These concerns (in addition to political economy factors) explain governments' extensive recourse to technical barriers—in the form of bans, mandatory technical specifications, or information requirements—to remedy failures in markets for agricultural and agroindustrial goods (table 1).

Import bans, the first broad category of technical measures, might be adopted when great risks or uncertainties are posed by a hazard (a substance, activity, or event that can cause potential harm), and alternative measures to effectively reduce the risk are technically infeasible (for example, if current monitoring and detection technology cannot distinguish between hazardous and nonhazardous products, or effective treatments or eradication programs do not exist). A total ban, the most restrictive type of technical barrier, is most frequently used to protect crops, herds, and/or native species of flora and fauna from foreign pests and diseases. Examples include a prohibition on imports of pork from a country with endemic hog cholera, or imports of horticultural products from a country with large and widely distributed fruit fly populations. Import bans have also been adopted to protect globally endangered species (Krissoff et al., 1996; Hudec). For example, Germany unilaterally banned importation of frogs from Indonesia after unsuccessful attempts to gain multilateral consensus on adding several frog species to the list of protected species of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).[4] Other countries have banned entry of products intended for industrial uses that authorities fear could be deflected into the domestic food chain, violating religious proscriptions.

Partial bans include seasonal or regional bans that do not entirely prohibit entry of a given product from the exporting country. These measures are also used extensively to protect animal and plant health, typically when regulatory authorities' understanding of risk factors is more comprehensive, and when a targeted ban can effectively reduce the risks to acceptable levels. For example, regulatory authorities may implement a seasonal ban that allows imports of certain horticultural products for part of the year if they have detailed knowledge about the effects of climatological factors on the biology of identified quarantine

[4] Parties to CITES agree not to import or export endangered species and products made therefrom. CITES, as well as other international environmental agreements that require or authorize trade restrictions among signatories, can be viewed as a waiver of any conflicting GATT disciplines that might prohibit such measures (Hudec).

Table 1--Classification of technical barriers by policy instrument

Import bans	
	Total bans
	Partial bans
Technical specifications	
	Process standards
	Product standards
Information remedies	
	Packaging standards
	Labeling requirements
	Controls on voluntary claims

pests, together with an understanding of how the host status of the commodity might vary over the growing season. Regional bans are perhaps the most common type of partial ban.[5]

Technical specifications, the second broad category of policy instruments (table 1), stipulate technically feasible requirements that exports must meet to gain entry to the home country market. In principle, any firm in any country willing to expend resources to meet these conditions can export to the home country, although, in practice, some firms may be prevented from doing so in the absence of satisfactory private- or public-sector certification services. It is an empirical question whether standards are more trade restrictive than partial bans. Exporting firms may find that complying with a foreign standard is too costly if the standard is stringent or varies significantly from a domestic or international standard. Standards can also be written to favor domestic producers by requiring the use of an input that is more widely available in the home country than in potential exporting countries. An infamous example of the latter type of measure was Italy's "pasta purity" regulations, which allowed only products made entirely with durum wheat (grown throughout southern Italy, but found in few other areas in Europe) to be marketed under the generic term "pasta."

Technical specifications are partitioned into three types of standards relevant to primary and processed agricultural goods in table 1. *Packaging standards* regulate a broad range of container attributes, from dimensions to biodegradability of packaging material, to realize a wide range of regulatory goals. *Process standards* (sometimes referred to as production standards) dictate the means (inputs and/or production technology) by which firms are to realize different regulatory targets. *Product standards* specify the ends (characteristics of a product related to its size, weight, or any number of other product attributes). A product standard for imported lumber, for example, might state that the product must be free of any trace of pinewood nematodes (*Bursaphelenchus Xylophohilus*), a status that could be objectively verified by phytosanitary authorities in the importing country by means of tests on shipments at the border. A process standard might alternatively stipulate that all lumber must be kiln-dried at a specific temperature for a certain time to exterminate pests.

Economists usually argue that product standards are more efficient regulatory tools than process standards, since the former allow heterogeneous firms to choose the technology that minimizes the resource costs of achieving a specific regulatory target while the latter does not (Antle). However, as MacDonald and Crutchfield point out in the context of food safety regulations, process standards can sometimes be the optimal regulatory option. They note that a Hazard Analysis and Critical Control Point (HACCP) system, which includes flexible process standards designed to reduce microbial contamination in food, might be superior to specific product standards, given the expense of microbiological tests and the recurrent nature of the pathogen hazard. The costs of enforce-

[5] The use of regional bans may increase given the WTO Agreement disciplines on SPS measures. The SPS Agreement requires countries to consider imports from sub-national areas that the exporting country claims are free of diseases or pests, or where the prevalence of diseases or pests is low (GATT, 1994). A prominent example of the consequences of this new provision is the U.S. action to allow animal and animal product imports from regions where the scientifically assessed risk of transmitting a particular disease, such as foot-and-mouth disease, is negligible. This change in U.S. regulatory policy represents a significant departure from the longstanding practice of only recognizing entire countries as "free" or "not free" of a particular disease (Ahl and Acree).

ment and the degree of administrative discretion in enforcement are also important considerations in any evaluation of the relative efficiency of process or product standards.

Informational remedies are the third broad category of technical trade barriers (table 1). When market failures stem from information failures, information remedies may be preferred over other fiat measures to redress the inefficiencies that arise. In recent years, regulatory authorities have given more consideration to these tools as a means of influencing economic behavior (Caswell and Mojduszka). Two different policy instruments, *labeling requirements* and *controls on voluntary industry claims*, when combined with credible certification institutions, can transform an experience or credence attribute of a food product into a search attribute;[6] the purchasing patterns of well-informed consumers will then be sufficient incentive for producers to provide the range of quality that consumers are willing to pay for without further government intervention. Information requirements, such as mandatory safe-handling labels, are also increasingly being proposed to increase food safety, although usually as complements, not substitutes, for other safety standards (OECD, 1997).[7]

Information remedies have generally been viewed as the least onerous form of government regulation, although Sykes points out that if requirements vary from market to market, manufacturers must incur not only the costs of producing different labels, but also possibly substantial costs of maintaining distinct inventories for each market. Manufacturers' concerns about heterogeneous labeling requirements, however, are not always limited to the label and inventory control expenses. Recent controversies have centered on proposed labeling regimes for bioengineered products, which manufacturers believe could unjustifiably stigmatize their products, thereby substantially reducing consumer purchases. One argument is that public policy should not inadvertently create the impression that a health risk is associated with consumption of products, if scientific evidence does not support that conclusion (World Bank). At the other end of the spectrum, the argument is that consent criteria and minority rights imply that public policy should permit individuals to avoid the consumption of food that they perceive as possibly unsafe (Thompson). Regulatory authorities in different countries have adopted different positions on this "science versus consumer sovereignty" issue, resulting in trade frictions over mandatory labeling regimes.

Classifying Technical Trade Barriers by the Scope of the Measure

A feature of some technical measures which distinguishes them from other trade policy instruments is that they may increase costs for domestic as well as foreign producers. This type of technical measure (e.g., a new product standard that is mandatory regardless of source) is classified as *uniform* (table 2). Increased compliance costs associated with uniform measures will shift the aggregate domestic supply curve up/back, as well as potentially affecting foreign excess supply curves. The magnitudes of the upward or leftward shifts, if any, in the excess supply curves depend on whether the new measure differs substantially from international norms or standards in the exporting countries.

Other technical measures are applied only to imported goods. The scope for legitimate use of *universal* technical barriers, which apply to all imported goods but not domestically produced goods, is narrow under the WTO Agreement. Examples of acceptable universal technical barriers are a maximum residue level (MRL) for a particular pesticide that is widely

[6] Consumers can establish the quality or characteristics of a search good or attribute (e.g., color, size) before purchase through examination or research. Without information remedies, consumers cannot determine experience attributes of food products (e.g., taste, shelf life) until after purchase, while credence attributes (e.g., free-range, organic) cannot be determined even after purchase and consumption.

[7] Kinsey notes, however, that rising incomes may counterbalance this regulatory trend. She points out that the microeconomics of time allocation and household technology suggest that consumers will be more willing to pay others to assure the safety of their food than to produce it themselves. Rising incomes and the higher opportunity costs of time may imply that consumers are increasingly willing to pay for a reduction in health risks by means of increasingly exigent safety standards, administered by regulatory authorities.

Table 2--Classification of technical trade barriers by scope

	Uniform	Border (universal)	Border (specific)
Measure directly affects:			
Domestic production	Yes	No	No
Imports	Yes	Yes	Some

used in countries that export a given product but is not registered for use in the importing country, or a process standard (such as a required treatment) that reduces the risk of introducing a pest that is present in every exporting country but not in the importing country.

Frequently, technical measures applied only to imports are limited to imports from certain sources, in contrast to most-favored-nation (MFN) trade policy instruments.[8] These *specific* technical barriers are most commonly used to mitigate different levels of risk posed by imports from different sources. Under a regime of specific technical barriers, an importing country will have multiple measures, which may range from routine border inspections to a complete ban, to mitigate the risks associated with importing one product from different sources.

Whatever the measure, the scope of a technical measure has implications for where the cost of the barrier will be borne. Four stylized cases illustrate these effects. Assuming that the actions of any one specific country have little or no effect on the world market (the usual "small country" assumption), when one importer imposes a barrier against one exporter, either one can avoid the costs by choosing alternative sources (for the importer) or outlets (for the exporter). Costs of a regulation imposed by one importer on all exporters are borne by the importer alone. Conversely, should all importers target a specific exporter for compliance with a given technical barrier, then the cost of the regulation is borne by the exporter. Finally, when all importers impose a regulation on all exporters, the small country assumption breaks down. The cost of the regulation is shared by exporters and importers as the price received by suppliers falls and the price paid by consumers rises.

This potentially complex web of technical barriers for agricultural products poses substantial challenges for economists. These barriers may segment international markets in some instances, fundamentally altering the nature of the competition. Technical barriers may transform a "small" country into a "large" country in international markets, facilitate product differentiation, or create market power on the part of individual firms (Sumner and Lee). There is an extensive literature on the incentives for producers to lobby for socially sub-optimal measures that may even raise their own unit costs (identified as uniform measures above) if such regulations limit competition. The incentives for such behavior vary with the number and relative size of firms, production technologies, and the type of good (Thilmany and Barrett; Hoekman and Leidy).

Classifying Technical Trade Barriers by Regulatory Goals

Knowledge of the type of policy instrument chosen by regulatory officials, together with information on the scope of the measure, provide two criteria by which to classify technical trade barriers. Absent any changes in domestic demand and supply due to externalities associated with trade, these criteria may be sufficient to gauge the effects of a technical barrier. Technical trade barriers can further be classified by the regulatory goal by which they are justified. This classification begins to address the question of how and why domestic demand and supply schedules could change as a result of the success or failure of a technical measure in correcting the market inefficiency. These potential changes can determine whether a measure is welfare-reducing or welfare-enhancing.

[8] Most-favored-nation trade policy instruments are applied equally to the products of all exporting countries by the importing country, in accordance with Article I of GATT 1994. A tariff is the most common example of an MFN policy instrument.

Table 3--Classification of technical trade barriers by regulatory goal

Societal interests	Risk-reducing measures	Non-risk reducing measures
Producers/processors	Commercial animal and plant health protection	Compatability
Consumers	Food safety	Quality attributes
Natural environment	Protection of natural environment from harmful non-indigenous species	Conservation

A classification of regulatory goals emerges from first recognizing three broad societal objectives of technical measures that restrict trade: protecting the economic interests of producers, protecting the health and economic interests of consumers, and protecting the environment. These broad objectives can be further segregated into those that reduce biological and toxicological risks, and those that do not but which serve some other public goal (table 3). Commercial Animal and Plant Health Protection and Compatibility measures potentially protect crops and livestock from pests and diseases or increase the efficiency of marketing channels, respectively. Food Safety measures potentially reduce involuntary risks associated with the consumption of foodstuffs; Quality Attribute measures may aid consumers in making prudent or informed choices with respect to experience and credence attributes of goods in the marketplace. Measures that protect the natural environment from harmful non-indigenous species [HNIS] regulate stochastic mishap associated with biological hazards, while Conservation measures alter the intertemporal utilization of natural resource stocks.

This classification highlights some relevant distinctions in the evaluation of technical trade barriers. Commercial Animal and Plant Health Protection and Compatibility measures could likely be analyzed largely on the basis of observable market data for prices and quantities of private goods. An evaluation of a measure in these two categories would gauge whether losses in consumer surplus caused by restricting trade were offset by the prevention of negative external effects of foreign production on domestic production, in the first case, or attainment of economies of scale, in the second. The next two categories (Food Safety and Quality Attribute) comprise measures that could prompt or prevent demand shifts that counterbalance the losses (gains) associated with restricting (liberalizing) trade. An evaluation of environmental measures in the last two categories (HNIS Protection and Conservation) must consider whether the losses from restricting trade exceed the benefits from providing non-excludable environmental amenities, for which market prices are generally unavailable.[9]

Risk-Reducing Measures

The first column of table 3 identifies risk-reducing measures. Here, we define "risk" as the product of the quantified likelihood and magnitude of the adverse consequences, should they occur (USDA). Regulatory authorities around the world use a wide variety of trade-restricting measures to mitigate the diverse "public risks" associated with imported agricultural goods. Public risks are risks that are "centrally produced or mass-produced, broadly distributed, often temporally remote, and largely outside the individual risk bearer's direct understanding and control" (Huber). Thus, public risks are in a sense involuntary. These risks potentially threaten commercial crops and herds, human health, and/or the natural environment. The array of measures that have been adopted to mitigate two different forms of public

[9] A non-excludable good is a good for which there is no mechanism that can ration or control consumption (i.e., someone can consume the good without paying a price). Environmental amenities are typically non-excludable goods that can be rival (consumption by one precludes consumption by another), non-rival (consumption by one does not preclude consumption by another) or congestible (the good is non-rival for some number of users, while rivalness sets in as the number of consumers increases) (Randall).

risk—high-probability, low-consequence risks (e.g., some food additives) and low-probability, high-consequence risks (e.g., pest infestations)—account for a great deal of regulatory heterogeneity in the international trading system (May; Sykes; Kinsey).

Commercial Animal and Plant Health Protection measures protect crops and livestock from biological stressors such as pests, diseases, and disease-causing organisms. Viewed from the perspective of the physical sciences, measures that protect crops and livestock could, in most cases, be considered together with those measures in the *HNIS Protection* category that safeguard native flora and fauna. From an economic perspective, however, a key distinction is that measures in the first category protect private goods, while those in the latter category protect public goods. As noted above, this distinction fundamentally alters the economic methodology one would use to assess whether the measure is optimal in an open-economy framework.

Food Safety measures reduce risks from both biological stressors, such as microbial contaminants, as well as chemical stressors, such as food and feed additives, to protect consumers from involuntary risks. When health effects are known (e.g., possible hazards associated with voluntary consumption of raw oysters), the demand curve for the product implicitly reflects risks associated with consumption of that product. When formerly unknown or new risks are made public, consumers may adopt private risk-reducing strategies that shift or rotate the domestic demand curve (van Ravenswaay and Hoehn). Strategies include product avoidance (reducing purchases of food associated with a contaminant) and brand-switching (selection of a close substitute that differs in the amount of the contaminant and related quality factors). Food Safety measures that successfully mitigate public risks associated with food consumption will reduce the frequency and magnitude of private risk-reduction strategies that can seriously disrupt agricultural markets.

Sources of International Heterogeneity for Risk-Reducing Measures

Heterogeneity in risk-reducing regulations among countries stems from differences in actual risk factors; the degree of uncertainty or ambiguity about risk factors; and differences in risk tolerances that might reflect variation in, among other things, incomes, experiences, and tastes. The trade restrictiveness of a country's regulatory regime can be expected to vary directly with the degree of risk or uncertainty, and inversely with the degree of a society's willingness to accept risk.

Differences in risk factors. Differences in import protocols based on assessments of risks associated with imports of primary and processed agricultural goods have had a "profound impact" on the pattern of trade in these products (Bredahl and Forsythe). One prominent example is the emergence of a segmented beef market over the past decades, with different markets for fresh and frozen beef from exporting countries that are free of foot-and-mouth disease, exporting countries where vaccination occurs, and exporting countries that have experienced outbreaks of this disease (Forsythe and Bredahl).

For any technical measure, an assessment of risk includes identification of a hazard, an estimate of the probability of introducing the hazard, and an evaluation of the consequences of the hazard. Few disagreements generally arise over the identification of hazards for well-known risks, a process that has been aided by the efforts of the International Organization of Epizootics (OIE), the International Plant Protection Convention (IPPC), and the Codex Alimentarius Commission (CODEX) to disseminate relevant scientific information on hazards associated with food, beverages, and feedstuffs. The identification of hazards associated with recent technology and product innovations, such as bio-engineered products, can be more controversial. It takes years to develop international standards, and, in the interim, regulatory authorities in some importing countries may refuse to allow the entry of products that have been approved for sale in others.

The probability of the transmission of the hazard depends on factors that may vary among exporters (source variation), as well as factors in the importing country (destination variation). These factors include the incidence and distribution of the hazard in the exporting country, and elements such as the presence (or absence) of a host organism in the importing country. Evaluation of the consequences of the hazard includes consideration of several factors that determine exposure to the hazard, such as husbandry practices, average daily intakes, climate, and spatial distribution of production or natural habitats. An importing country may therefore adopt measures of varying degrees of trade restrictiveness to mitigate the risks associated with one product from different foreign sources. It is equally possible that one exporting country can face import barriers of varying degrees of stringency at different borders to mitigate the risks associated with exports of just one product.

Objectively assessed risks and understanding of risk factors also change over time, with investments in basic science and advances in detection and eradication technology. These changes in some instances lead to increasingly trade-restrictive measures. In other instances, advances in science or in technology permit regulatory authorities to design less trade-restrictive measures that still effectively target the hazard. The United States, for example, replaced its 83-year ban on imports of Mexican avocados in 1997 with a process standard based, in part, on the results of a new risk assessment by USDA's Animal and Plant Health Inspection Service (APHIS). APHIS scientists and regulators concluded that the risks associated with importing Mexican Hass avocados were lower than when last reviewed in the 1970's because of innovations in chemical controls and cultural practices in Mexico, and recent research results that indicated that the Hass avocado variety displayed a natural resistance to fruit fly infestations (Roberts, 1997). This assessment facilitated a policy decision to partially ease the longstanding ban.

Uncertainty. In response to the WTO Agreement and domestic regulatory reform initiatives, many countries are trying to formalize the risk assessment process used by their regulatory authorities, with quantitative models supplanting heuristic decision trees in some instances. Emphasis is increasing on documentation of sources, transparency of assumptions, and provision for public input and comment. Even so, risk-reducing import protocols inevitably are designed based on information characterized by different degrees of uncertainty, where decisionmakers are unsure of the probability distribution of the identified hazard(s). At one end of the spectrum are issues such as the human health risks associated with long-studied and widely used food preservatives that do not vary significantly by country; at the other end are issues such as risks posed by HNIS, where, in many instances, there is immature science to either defend or refute the use of trade measures to protect the environment (Ervin).

Ambiguity or uncertainty about the magnitude of unmitigated risks associated with imports may stem from different expert opinions about the interpretation of available evidence or the need to collect additional information. Estimates of mitigated risks under different import protocols—which provide key information for the policy decisionmaker—likely involve further uncertainty. These estimates can draw on the results of controlled laboratory experiments and other countries' experiences (as reported, for instance, to international standards-setting organizations and/or their regional counterparts) but may still require judgment about the probability and consequences of events that have never been observed in the importing country. There is substantial scope for disagreement among scientists and between trading partners. In these situations, "ambiguity averse" behavior on the part of regulators may lead to conservative import protocol decisions. These conservative decisions result from perceptions that the economic and political costs of lost opportunities (e.g., lower costs for consumers, reciprocal liberalization) are less than the economic and political costs of a mistake (i.e., importation of hazards) (MacLaren).[10]

[10] Some results from experimental economics, such as the fact that ambiguity can affect a difference in an individual's willingness to pay to avoid a risk or the required payment to take on a risk, violate the assumptions upon which well-known normative theories of rational choice in non-deterministic situations (e.g., expected utility, subjective expected utility) are based. Ambiguity aversion may be an especially relevant descriptive theory for sanitary and phytosanitary decisionmaking, which involves low-probability, high-consequence outcomes.

Differences in risk tolerances. In some instances, the import protocols of different countries vary substantially even though there is strong international consensus about the risks posed by high probability, low consequence hazards that do not significantly vary by country. An example is differences in allowable levels of a food additive that has been in use by some processing industries for decades, been extensively studied, and for which a long-standing CODEX standard exists. In such cases, different countries' decisions to accept, accept with deviation, or not accept the international standard could stem from differences in incomes, as food safety attributes are viewed as normal goods in the familiar Lancaster model of consumer demand.

Differences among income levels may explain some, but not all, of the observed variation in import protocols. There are several prominent examples of nations with comparable levels of income and facing comparable levels of risk which have made starkly different risk-management decisions. This variation may in part be accounted for by differences in the shared experience of a country's citizens. For example, a low-probability, high-consequence event may cause the public's estimate of the probability of the re-occurrence of the event to be biased upward, fomenting demand for stricter regulations. The influence of the emotional dimensions of risk on public policy decisions is well documented (Camerer and Kunreuther). Although experts, focused on the statistical measurement of risk likelihood, may not concur with public opinion about the need for revision of technical measures in such circumstances, regulators in some such instances have decided to design policies that reflect public risk perceptions, defending their choices by pointing to the democratic foundations of their actions.[11] The EU's decision to ban production and imports of bovine animals and animal products treated with growth-promoting hormones is an oft-cited example of the science versus consumer sovereignty dilemma that periodically faces regulators.[12]

National differences in tolerances for risk associated with certain products may also be rooted in different cultural norms. "Traditional" foods that have figured importantly in the diets and/or ceremonies of different countries for centuries or decades may nonetheless be rejected by regulatory authorities in importing countries because of the presence of substances that could constitute chronic (or, more unusually, acute) health hazards. And geographically isolated countries (often islands) in many instances have adopted sanitary and phytosanitary that are very conservative relative to choices made by other countries at comparable income levels. This practice, in the view of their trading partners, reflects a "fortress mentality" on the part of regulatory authorities who implicitly impute a very high shadow price to every hazard.

Non-Risk-Reducing Measures

Non-risk-reducing technical measures affecting producers, consumers, and the environment are identified in the second column of table 3. *Compatibility* refers to the capacity of products to function in association with others, such as mandatory dimensions for produce containers that ensure compatibility with handling equipmenet. Some product incompatibilities may in fact enhance welfare if they emerge from the development of superior technology that leads to

[11] And because of the small sample of occurrences of low-probability, high-consequence events, experts and the public may never reconcile differences in their views.

[12] In the early 1980's, European authorities first proposed the ban in part to allay public anxieties that emerged following widely publicized reports of an "estrogen scandal" in Italy when residues of the illegal growth promotant DES were found in manufactured baby food. The ban was eventually adopted in 1988, but consumer fears were heightened once more following subsequent reports of the significant illegal use of hormonal substances in European countries. The European Parliament established a Committee of Enquiry into the Problem of Quality in the Meat Sector, which issued a report that endorsed continuation of the ban in 1989 because, among other reasons, the ban "was the only way to restore consumer confidence in the meat sector." The EU maintained the ban although assessments by experts over the past four decades, including those by European experts, have indicated that there is no evidence that the hormones at issue pose risks to human health when used according to good animal husbandry practices. (The six hormones evaluated by these experts do not include DES, which has been widely banned since the 1970's.) In 1997, a WTO dispute panel found the EU ban not in compliance with the disciplines in the SPS Agreement and, in 1998, the WTO Appellate Body upheld the judgment (WTO, 1997, 1998).

Table 4--Examples of regulatory regimes that affect trade in agricultural and agroindustrial products

Regulatory goal/ policy instrument	Risk-reducing measures: Food safety	Risk-reducing measures: Commercial animal and plant health protection	Risk-reducing measures: Protection of natural environment from HNIS[1]
Import bans			
• Total ban	Ban on ingestible products harmful to human health	Ban on imports to exclude quarantine pests[2] and diseases	Ban on imports to minimize risk of introduction of pests or diseases that threaten native flora or fauna
• Partial ban	Ban on imports of individual varieties or species of ingestible products harmful to human health	Seasonal ban on imports to minimize risk of introduction of quarantine pests and diseases	Regional ban on imports to minimize risk of introduction of pests or diseases that threaten native flora or fauna
Technical specifications			
• Process standard	Measures that require specific time/temperature regimes for imported foods	Required treatments for products to prevent introduction of quarantine pests in production areas	Ban on imports of bio-engineered products because of potential risks to native flora and fauna
• Product standard	Measures that specify maximum residue levels for specified pesticides on horticultural products	Standards that establish threshold levels for presence of disease-causing organisms that threaten crops or livestock	Standards that establish threshold levels for presence of disease-causing organisms that threaten indigenous species
• Packaging standard	Specifications for packaging technology that minimize probability of microbial contamination	Sealed container requirements for imported products to minimize probability of infestation of production areas	Sealed container requirements for imported products to minimize probability of introduction of harmful non-indigenous species
Information remedies			
• Labeling requirements	Requirements for labels that indicate safe handling procedures or whether product poses risks for sensitive sub-populations	Required labeling of individual items of produce or containers to minimize probability of infestation of production areas by illegally transshipped imports	Required labeling for safe handling of bio-engineered commodities and products so that they are not distributed outside circumscribed marketing channels
• Controls on voluntary claims	Measures that govern use of voluntary hygiene claims	NA	NA

[1] Harmful non-indigenous species.

[2] A quarantine pest is defined by the North American Plant Protection Organization as "a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled."

NA = not applicable

Non-risk-reducing measures		
Quality attribute	Compatibility	Conservation
Ban on imports of products proscribed by state religion	NA	Ban on imports of animal products (e.g., meat and eggs) that threaten global stocks of endangered species
Ban on imports of “inferior” breeds or varieties of agricultural products	NA	Seasonal ban on imports that threaten global stocks of endangered species
Animal welfare measures	NA	Required harvesting techniques for imports of renewable resource-based products
Measures that regulate size, appearance, and other attributes of agricultural products	NA	Measures that requires harvested product (e.g., lobsters) to reach a certain size to prevent depletion of natural resource stocks
Regulations that prohibit misleading or fraudulent packaging	Mandatory dimensions for wholesale and/or retail containers to facilitate handling/transportation in marketing channels	Requirement that packaging materials are biodegradable
Measures that mandate labels that indicate nutritional profile or whether the product contains bio-engineered ingredients	NA	Mandatory eco-labels
Measures that govern use of claims on labels, such as fresh, genuine, free-range, and low-fat	NA	Measures that establish rules for claims that products are produced using renewable resources

product differentiation, or in response to heterogeneity in consumer preferences. Other product incompatibilities, however, result from autonomously developed, divergent national standards, which can increase production costs and reduce variety in the marketplace. Manufacturing different products for different markets may prevent firms from realizing economies of scale in the production of these products, which may lead some firms to choose to exit some markets.

Although enormously important for trade in products of the industrial sector, compatibility measures are far less important in the trade of primary and processed agricultural products.[13] Governments have sometimes justified restrictions on container or package dimensions at the wholesale or retail level as the solution to a collective action problem, where the market provides insufficient incentives for producers or manufacturers to establish standards that ensure container compatibility with handling, transport, and/or storage equipment to increase the efficiency of the marketing channel for products. However, these instances are relatively rare, as governments in most instances prefer to allow firms to adapt to innovations in transport and storage technology or respond to shifts in consumer preferences.

Quality Attribute refers to any characteristic of a product other than safety that might enter a consumer's utility function. These characteristics include health (e.g., nutrition, energy), hedonistic (e.g., fresh, genuine), and ethical (e.g., free-range) attributes. A market's ability to satisfy diverse preferences regarding quality is an important virtue since not all consumers are willing to pay the same for particular product attributes. Absent effective reputation mechanisms (often the case for unbranded foodstuffs), the market may not supply optimal amounts of quality. Consumers' willingness to pay will not adjust to improvements in quality if they do not know, and cannot cheaply ascertain, the experience or credence attributes of what they buy. Because quality is generally costly to produce, poor-quality products can outcompete high-quality products, and the market equilibrium may entail the production of a suboptimal share of low-quality products (Akerlof). Information regulations or standards that lower the transaction costs of obtaining relevant product information could potentially correct market failures that stem from imperfect information about health, hedonistic, or ethical characteristics of agricultural products.

Conservation measures are aimed at preserving natural resources through technical trade barriers. Measures in this category have been at the center of some prominent international trade disputes (Hudec). These multilateral or unilateral trade measures aim to curb economic activity, such as trade in wildlife or wildlife products, thought to threaten the biosphere—the basic stock of plant and animal life on the planet—that some regard as part of the global commons. Requirements that packaging materials for imported and domestic products be either recyclable or biodegradable so as to preserve resources for future generations also fall into this category. Regulatory authorities may adopt these measures when consumers' and/or external agents' willingness-to-pay (whether ascertained informally or formally by means of revealed preference or stated preference methodologies) is judged to exceed the producer and consumer surplus generated by international exchange. Measures in this category have been extensively examined in the environmental literature (Anderson).

A Matrix of Regulatory Regimes

The three classification criteria considered above suggest the multi-dimensional characteristics of technical trade barriers that make their economic quantification and evaluation particularly time-intensive and complex. One useful two-dimensional classifi-

[13] In manufacturing, good examples are divergent voltage/hertz standards that hinder international trade in electrical appliances, and different broadcast formats that segment the international market for televisions. Many incompatibilities emerged as historical accidents, predating extensive international trade or modern international standardization efforts. In recent decades, however, incompatibilities have sometimes stemmed from strategic choices made by governments to foster domestic industrial development.

cation of technical barriers partitions these measures into a set of distinct regulatory regimes, taking into account both the goal of the measure and the policy instrument (table 4).[14] Each column of this policy regime matrix indicates that a variety of instruments may be available to achieve the same regulatory goal. For example, for Quality Attribute measures, labels are only one option for remedying instances where information about the experience and credence attributes of a product are asymmetrically distributed between producers and consumers. Bans or standards may be chosen over information remedies when regulators judge that consumers' cognitive failures would lead to the imprudent purchase of a product that is inferior in some respect.

The rows of table 4 reinforce the point that one type of policy instrument can be used to accomplish a wide range of regulatory goals, a fact that is sometimes overlooked. For example, labels may be required as a component of a quarantine policy designed to reduce the risk of entry and spread of harmful arthropods, to warn susceptible individuals of the risks of consuming a product that has been judged to be safe for the general population, or to provide a food product's nutritional profile so that consumers can make informed choices about the composition of their diet. Thus, the range of regulatory goals for different types of policy instruments can reduce the scope for meaningful "generalizations" about classes of measures. A qualitative assessment of the effect on a market equilibrium of one type of policy instrument—for example, packaging standards—may require knowledge of the regulatory goal. Standards that mandate the use of biodegradable packaging materials (Conservation goal) might affect domestic and foreign firms' marginal costs only, while adoption of a standard that prohibits fraudulent packaging of a product (Quality Attribute goal) could produce both demand and supply shifts.

[14] A variation of this two-dimensional classification can be found in Hooker and Caswell, who examine food quality regulations in terms of regimes (i.e., policy instruments) and regulatory targets (i.e., product attributes or characteristics).

Classification of Foreign Technical Trade Barriers Facing U.S. Agricultural Exports

In 1996, the U.S. Department of Agriculture (USDA) asked field personnel in its Foreign Agricultural Service (FAS), who collectively cover 132 countries, to identify questionable foreign measures that threatened, constrained, or blocked U.S. exports of primary and processed agricultural, forestry, and fishery products. Each producer group that participated in the FAS Cooperator Program was also asked to identify foreign technical trade barriers.[15] This information was subsequently vetted by scientists and analysts in USDA's regulatory agencies,[16] who recommended deletion of identified barriers in the data set that were judged to be in conformity with international legal commitments, such as the WTO and NAFTA SPS Agreements.

The USDA survey results provide the most comprehensive view to date of regulatory regimes facing an important agricultural exporting nation.[17] The results confirm the importance of technical barriers in international agricultural markets. Questionable technical barriers were reported for 62 countries. Over 300 market restrictions were identified that threatened, constrained, or blocked an estimated $5.0 billion of U.S. agricultural, forestry, and fishery exports, 7.1 percent of the $69.7 billion total exported in 1996. Market retention issues accounted for 61 percent of the estimated export revenue losses, with market expansion issues (24 percent) and market access issues (15 percent) accounting for the remainder.[18] A wide range of products was affected by these measures, but four commodity groups accounted for most of the estimated export revenue losses: processed products (26 percent), grains and oilseeds (24 percent), animal products (19 percent), and horticultural products (13 percent). The restrictions identified in the survey were dominated by risk-reducing measures, particularly those addressing commercial plant and animal heath issues (210 measures, which produced estimated export revenue losses equal to 61 percent of the total) and food safety (76 measures, which resulted in estimated export revenue losses equal to 48 percent of the total).[19]

The survey data on foreign technical barriers are classified by the regulatory regimes identified in the preceding matrix, both to permit examination of the distribution of measures likely to be most trade-restrictive and to provide perspective on the relative importance of measures that fall in different regulatory goal categories (table 5). The proportion of the observations that fall in the category of risk-reducing

[15] The Cooperator Program at FAS includes approximately 40 groups representing specific U.S. commodity sectors such as horticultural products, feed grains, wheat, soybeans, and rice. These groups are funded by their members, primarily agricultural producers and processors. FAS and the cooperators share in the cost of overseas market-development activities.

[16] These agencies include the Animal and Plant Health Inspection Service (APHIS), the Food Safety and Inspection Service (FSIS), the Agricultural Marketing Service (AMS), and the Grain Inspection, Packers and Stockyards Administration (GIPSA).

[17] Prior to USDA's 1996 survey, the only institutional attempt known by the authors to systematically identify technical barriers has been the United Nations Committee on Trade and Development's (UNCTAD's) Trade Control Measure (TCM) database. In addition to technical barriers, the TCM database records the use of other NTB's, such as quotas, licensing measures, price controls, and monopolistic practices. The shortcomings of this database are widely recognized, such as the lack of any information on health or safety regulations in most EU countries (Ndayisenga and Kinsey). The fact that the TCM database indicated that the United Kingdom employed only one kind of NTB—bilateral quotas—illustrates the piecemeal nature of the data collected.

[18] Market retention issues involve regulations under consideration by a foreign government in 1996 that could have prevented or curtailed ongoing U.S. exports of a product or products. Market expansion issues are those where a foreign regulation imposes restrictions on allowable varieties, breeds, or provenance of U.S. agricultural exports. Expansion issues also include instances where a foreign country's rigorous conformity assessment requirements impede, but do not preclude, U.S. exports. Market access issues include those foreign regulations that prohibit any entry of U.S. exports.

[19] The percentages sum to more than 100 because some measures span regulatory goals. Details of the survey design as well as summary descriptive statistics of foreign technical barriers to U.S. agricultural exports can be found in Roberts and DeRemer (1997). Summaries of the aggregated survey results are also provided in Thornsbury, Roberts, DeRemer, and Orden (forthcoming).

Table 5--Classification of technical trade barriers to U.S. agricultural exports identified in USDA survey

Regulatory goals/policy instruments	Risk-reducing measures: Food safety	Commercial animal and plant health protection	Protection of natural environment from HNIS[1]	Non-risk-reducing measures: Quality attributes	Compatibility	Conservation	Non-classifiable	Total
	number of barriers							
Import bans	12	56	3	1	0	0	—	72
Partial bans	0	21	0	0	0	0	—	21
Input standards	0	0	0	0	0	0	—	0
Process standards	32	78	1	15	0	0	—	126
Product standards	26	33	0	13	0	0	—	72
Package standards	1	0	0	2	5	0	—	8
Label requirements	2	2	2	7	0	1	—	14
Controls on voluntary claims	0	0	0	1	0	0	—	1
Non-classifiable	3	20	0	0	0	0	2	25
Total	76	210	6	39	5	1	2	339

* The 1996 USDA survey of questionable foreign technical barriers to U.S. agricultural exports identified 302 market restrictions in 62 countries. The number of entries in this table exceeds that total primarily because some identified barriers were comprised of more than one policy instrument. A small number of individual measures spanned regulatory goals. For example, a product standard that was justified on the basis of preventing entry of zoonoses (viruses that are communicable between animals and humans) was classified as both a food safety and animal health measure.

[1] Harmful non-indigenous species

measures—just over 86 percent—is striking. The number of measures with the cited rationale of protection of commercial production (62 percent) and protection of human health (22 percent) accounted for nearly all of the risk-reducing measures.[20]

Closer examination of the observations in the three risk-reducing regulatory goal categories (table 5) indicates that the number of measures aimed at the reduction of risk presented by biological stressors such as noxious weeds, yield-reducing arthropods, or food-borne microbial pathogens was far greater than the number of measures that target risks posed by chemical stressors such as food and feed additives. All of the 210 measures in the Commercial Animal and Plant Health Protection category are justified on the basis of reducing risks posed by biological hazards. More than half (47) of the 76 measures in the Food Safety category also target biological stressors. The principal differences between chemical and biological stressors are that biological organisms grow, reproduce, and may multiply; actively and passively disperse; interact with ecosystems in unpredictable ways; and randomly evolve (Powell, citing Simberloff and Alexander). Powell notes that the principles, methods, data, and conventions for chemical risk assessments are far more advanced than for the assessment of risks associated with biological stressors and that, in many cases, there may be "large, irreducible uncertainties" in assessing the potential consequences of biological hazards (*op. cit*., p. 8). Recalling the discussion above (p. 14) about ambiguity-averse behavior by regulatory authorities, it is perhaps not surprising that the large majority of the most trade-restrictive measures, import bans, mitigate risks posed by biological hazards that fall in the Commercial Animal and Plant Health Protection category. A less charitable view of the large number of trade-restrictive measures in this category is that the large uncertainties and relatively immature state of risk assessment for biological hazards offer, in some instances, a convenient veil for regulatory protectionism.

[20] A small number of observations could not be classified, a fact which perhaps should not be unanticipated in view of the fact that the survey targeted questionable barriers. In some instances, the rationale for import restrictions is unclear, either because the foreign government provides no explanation or provides conflicting explanations for the policy. In other cases, the prima facie regulatory goal is clear, but the policy instruments could not be clearly identified because of erratic enforcement of de facto measures that had never been formally promulgated by the foreign government.

The relatively small number (six) of risk-reducing measures aimed at protecting the natural environment from HNIS might be explained by the fact that regulators typically examine the potential harm to native flora and fauna only after an evaluation indicates that the proposed imports present negligible risks to commercial crops and livestock. Consequently, some measures justified only on the basis of reducing the biological risks to crops and livestock likely protect native flora and fauna as well. The U.S. ban on entry of commercial cultivars of the genus *Rhododendron* in growing media illustrates this point. For years the ban was rationalized on the basis of protecting domestic nursery stock. APHIS's reexamination of the risks posed by allowing entry of *Rhododendron spp*. in the early 1990's led to a determination that these imports posed negligible risks to the domestic industry if imported under the proposed risk management protocol. However, the measure remained in place because the agency had insufficient information to conclude that the proposed imports did not threaten wild *Rhododendron spp*., which are protected by the Endangered Species Act (Romano and Orden).

Most of the nearly 14 percent of measures identified in the three non-risk-reducing regulatory goal categories were Quality Attribute measures. A review of the survey responses in this category indicates that, in many instances, Quality Attribute measures were identified as barriers because of the administration or enforcement of the measure, rather than the measure per se. For example, compliance with the grading regimes of foreign countries was sometimes difficult or impossible for exporters of perishable products in view of the importing country's conformity assessment requirements. Other Quality Attribute measures spanned a wide range of issues, from government-mandated shelf-life periods to bans on "inferior" breeds of livestock. The number of measures identified in the Compatibility category, as anticipated, was small. Four of the five identified measures established dimensions for fresh produce containers that were mandatory for imports but not enforced nationally.

The identification of only one Conservation measure is somewhat surprising in view of the prominent controversies over the use of import restrictions to achieve environmental goals in the 1980's and 1990's (Esty, McDorman). One hypothesis is that while foreign environmental measures such as container-recycling requirements might have increased costs for U.S. exporters of agroindustrial products, they were not viewed by USDA field personnel and U.S. producer groups as questionable measures if domestic firms were obliged to comply with the requirements as well. There could be two explanations for why survey respondents did not identify more foreign trade restrictions (adopted either unilaterally or as a part of a multilateral coalition) which were aimed at preventing environmental harm outside the importing country. The first is that the United States is often a member of these multilateral coalitions, and usually enforces its obligations under treaties, such as the International Convention for the Regulation of Whaling, to place restrictions on domestic production practices related to preservation of the global biosphere. Thus exports of products that might be denied entry to foreign markets because they deplete stocks of globally endangered species, for example, are likely not produced by the United States, either for domestic consumption or export. A second reason emerges from a recent study of the use of trade measures against foreign environmental practices. Hudec notes that "only a few GATT Members have both the power and the inclination to make significant use of unilateral trade restrictions for environmental purposes" (*op.cit*., p. 145). The EU and the United States most frequently adopt these kinds of measures, Hudec observes, but "no other government comes close to matching" the volume of U.S. legislation that authorizes or mandates the use of externally directed trade restrictions. This may change over time, of course, but survey respondents identified only one foreign Conservation trade barrier in the 1996 USDA study.

More generally, evaluation of the data requires that the results be examined within the context of the survey design. For example, a broader sample that included major food manufacturers would likely have led to the identification of more measures in the Food Safety and Quality Attribute categories, even though the estimated export revenue losses attributed to technical barriers for processed agricultural products in the 1996 survey were already greater than for any other product category (Roberts and DeRemer).

Also, since only questionable barriers were targeted in the survey, the distribution of policy instruments could be skewed toward toward those that are generally more trade restrictive (the top of table 5). Twenty-six percent of the measures used to protect commercial production agriculture are bans; had respondents identified all technical measures limiting or potentially limiting U.S. exports rather than only questionable ones, this proportion might well be smaller. And finally, it is not known how robust the profile of regulatory regimes that emerges from the survey results is across countries (see box). A different country could face a substantially different distribution of questionable regulatory regimes if the commodity composition of its exports varies from that of the United States. The destination of exports is also likely to be a relevant factor—a country that exports primarily to developing countries may face different regimes than one that ships to markets in North America, Japan, and Europe.

It should also be noted that the estimated trade impacts reported in the survey were expert consensus estimates of U.S. producer revenue losses resulting from a restricted quantity of U.S. exports at a fixed world price. These estimates were not derived from formal economic models–a difficult task in view of the fact that restrictions were identified for products ranging from grass seed to goats– but nonetheless aided USDA's program agencies in identifying priorities by providing an order-of-magnitude indication of the economic significance of these measures to U.S. producers. The profile of technical barriers that emerged from the survey estimates thus provided USDA with a starting point for targeting technical assistance funding; developing proposals to spur effective multilateral implementation of the WTO SPS and TBT Agreements; and crafting U.S. strategies for participation in international standards-setting organizations. Formal empirical models can be used to corroborate or challenge the estimated trade impacts reported in the survey, but clearly these tools can also be used to furnish policymakers with other important information. For example, models can be used to assess the welfare costs of current measures as well as to evaluate proposed alternatives, thereby enabling a ranking of regulatory options. Models can also provide estimates of the distributional effects of alternative measures, information which is sometimes regarded as an important factor in regulatory decisions.

U.S. Technical Trade Barriers

In 1997, ERS expanded its efforts to widen the information base on technical trade barriers by collecting data on U.S. import policies that foreign exporters had raised for discussion with U.S. officials. These measures were identified in interviews with officials in the regulatory agencies of the Executive Branch that are responsible for enforcing regulations and standards that affect imports, as well as individuals in USDA's Foreign Agricultural Service. The regulatory agencies include four USDA agencies (Animal and Plant Health Inspection Service; Food Safety and Inspection Service; Agricultural Marketing Service; Grain Inspection, Packers and Stockyards Administration), the Environmental Protection Agency, and the Food and Drug Administration.

Individuals in these 7 agencies reported that representatives from 14 countries had collectively identified 63 contentious U.S. measures. These data were then classified by regulatory goal, using the same taxonomy as the one developed for foreign technical barriers (the data were not sufficiently detailed to further classify the measures by policy instrument). The results of this classification indicate that the distribution of U.S. and foreign technical trade across regulatory goals are approximately the same. Risk-reducing measures dominate the identified U.S. barriers, as they dominate the identified foreign barriers. Quality Attribute measures represent the largest category of non-risk-reducing measures in both samples. Further examination of the data on U.S. barriers indicates that the development status of the foreign country is correlated with the number of identified measures.

Table--U.S. technical barriers to imports

Regulatory goal/measure identified by:	Risk-reducing measures			Non-risk-reducing measures			Total
	Food safety	Commercial animal and plant health protection	Protection of natural environment from HNIS[1]	Quality attribute	Compatability	Conservation	
	Number of measures						
Developed countries	5	17	1	8	0	2	33
Upper middle income countries	1	15	0	4	0	4	24
Lower middle income countries	1	8	0	0	0	0	9
Least developed countries	0	2	1	0	0	0	3
Total*	7	42	2	12	0	6	69

[1] Harmful non-indigenous species

* The total number of measures classified by regulatory goal (69) exceeds the total number of identified measures (63) because some measures spanned regulatory goals.

A Modeling Framework for Assessing the Trade Effects of Technical Trade Barriers

The quantification of the trade effects of the types of technical measures identified and classified above poses several problems for trade policy analysts. That trade is affected by such regulations is clear. But the magnitudes of these trade effects are in doubt, as are the consequent effects on the gains from trade; few studies have attempted to quantify these magnitudes. Without such information one cannot know how significant technical barriers are in international agricultural markets or how best to modify existing technical barriers to reduce unwanted trade effects. Considerably more information is needed to assess the trade effects of technical trade barriers than is needed to assess the effects of standard tariffs and non-technical NTB's. Unlike standard trade barriers, the effects of technical barriers on international flows of goods is mainly indirect, through the additional cost of compliance that producers or traders face. Moreover, to the extent that these regulations affect production functions and consumption decisions, the import demand and export supply curves themselves can shift if such measures are imposed or rescinded.

The task of assessing the effect of technical regulations on trade flows requires detailed knowledge of the regulations themselves, the process by which companies or individuals meet those regulations, and the implications of not conforming to the rules. To put this technical information to use requires a simple economic framework that should be easily understood yet comprehensive enough to satisfactorily answer a range of questions. The framework should yield a modeling structure into which to place empirical data for the calculation of the trade impacts and welfare effects. The framework proposed here is based on a synthesis of the different approaches taken in five papers published since 1996, each of which emphasizes one aspect of the relevant issues. Considering these approaches as separate aspects within the commonality of technical barriers allows them to be combined in any empirical case. This framework, which complements the classification of technical trade measures, integrates the five approaches in a flexible and general model that can be customized to specific measures. The classification criteria illustrated that technical trade barriers must be treated as bundles of characteristics related to goals, instruments, and scope; accordingly, the goals, instruments, and scope can be modeled separately and combined in studying specific cases.

The contributions of the five recent approaches to modeling technical trade barriers can be summarized as follows. Krissoff, Calvin, and Gray examine the tariff and technical trade barriers facing U.S. apples in three different markets, Japan, Korea, and Mexico, and calculate the tariff-equivalent of the technical (phytosanitary) measures that constrain exports. With these estimates, they calculate how much trade is impeded by the phytosanitary measures in addition to the standard trade barriers. Their model is a static partial equilibrium analysis of the three apple markets. Although the authors acknowledge that the technical measures may be justified, the model does not estimate any effect on production in the importing country of removing the trade restrictions.

Sumner and Lee develop a model pitched primarily at the problem of Asian import regulations facing U.S. vegetables. The paper's emphasis is on the different ways in which the regulations can impose costs at different points in the marketing chain. In a trade model this can affect foreign and domestic price levels and foreign exchange flows as well as quantities traded. Although Sumner and Lee mention the possibility of shifts in the supply and demand curves, they do not pursue the matter in their analytical model. Compliance costs are added like tariffs to the relevant excess supply curves in an otherwise conventional trade analysis.[21]

[21] Josling laid out a similar model, using compliance costs of environmental regulations differentiated by whether the producer was a domestic or a foreign supplier. The trade effects were shown to be sensitive to the incidence of the relative costs of compliance with regulations, and to be similar to the trade effects of tariffs representing the difference between foreign and domestic compliance costs. However, this model also allowed for no supply shifts, though there was provision for consumer gains from the information value of the regulation.

Shifts in the supply curve when trade introduces pests or diseases is at the heart of the justification for many SPS trade barriers. Orden and Romano develop a model that focuses directly on the effect of imported pests on domestic production costs. Referring to the U.S. ban on avocado imports from Mexico (since partially rescinded), they model a market for avocados in the United States where domestic supply shifts backwards/upwards when imports are allowed into the country, if the imports result in a pest infestation. As the ban has a consumer cost, the welfare effect of removing it is a combination of trade gains from cheaper avocados and resource losses as the cost of producing any given quantity of avocados at home increases. Compliance costs, such as border inspections, do not play an explicit role in the model.

The consumer reaction to a technical barrier, as opposed to effects on supply, is central to a model of information externalities developed by Thilmany and Barrett. They emphasize the role of regulation of imports in giving consumers confidence in buying a product, thus avoiding the problem of "lemons" or unreliable goods bought by the unsuspecting consumer from foreign producers who may not have to rely on reputation for repeat business. If a regulation requires the provision of information that does not inform consumer choice, there is a welfare loss, but informative regulations can correct market failures and add to social welfare. The authors use the dairy trade between the U.S. and Mexico as an example.

The fifth recent study of technical trade barriers, by Paarlberg and Lee, addresses foot-and-mouth disease (FMD) and trade in beef from countries where the disease is endemic. Using the language of tariff theory, the authors calculate the "optimum tariff" that, when placed differentially on imports from the infected country, would maximize the difference between the gains from trade and the costs to the domestic industry from the spread of the disease. The costs are related to the number of outbreaks, which in turn are related to the volume of imports. By using the concept of an optimum tariff, the authors emphasize that SPS issues involve a trade-off between standard commercial considerations and health and technical considerations, though most countries ban products from infected sources rather than taxing them at the border.

Our framework includes three different but combinable components drawn from the five studies described above. The first component is the element of *regulatory protection*, the fact that a regulation gives some rents to the domestic sector. A purely *protective regulation* is a special case: most barriers have at least a minimal technical justification. A variant of this model, compensatory protection, assumes that a regulation similar to that faced by domestic producers is imposed on imports solely to keep the "playing field" level: the import regulation has no effect on the domestic supply and demand curves. Such protection is likely to be contrary to multilateral trade rules, however.

The second component of the framework developed herein is a *supply-shift* element that focuses on the effects of imports on the domestic supply and the costs of enforcing compliance at the border (or in the supplying country), which will eliminate the threat of infestation. The supply-shift element introduces the rationale for the trade barrier, though of course it does not follow that the particular measure chosen is always appropriate for the circumstances. The task of the model is to make that calculation.

The third component of the framework for economic evaluation of technical trade barriers is a demand-shift element. If the effects of the regulation on imports, in addition to the cost involved, is to impart information, it may increase consumer demand for the product. The information can be related to quality (that the imported product meets a particular standard) or to geographical origin (which gives consumers additional knowledge about expected characteristics).[22] The same approach may be used when the technical measures cover areas such as packaging that are presumably intended to lower the cost of distribution. An important use of the model covers the case where unregulated imports would have a nega-

[22] The analysis in this report assumes that the imported product sells for the same price as the domestic product on the importer's market. Thus the increase in demand for imports with the provision of information is not captured by an increase in the relative price of imports. The goods are perceived as perfect substitutes by the consumer once the information imparted by the regulation has been absorbed.

Table 6--Scope of measure from importer and exporter perspective

	Regulation imposed on one exporter (specific)	Regulation imposed on all exporters (universal)
Regulation imposed by one importer (specific)	Either can avoid compliance costs by selling to or buying from other markets. "Potential" rather than actual trade impediment.	Importer bears cost of compliance as this cost becomes built in to selling price by all exporters.
Regulation imposed by all importers (universal)	Targeted exporter bears cost of compliance as importers can choose to buy from other sources.	Importers and exporters share the cost of compliance as the world market price adjusts to the cost. Price to buyers goes up and to sellers goes down.

tive impact on consumption, if not through actual harm to consumers then by causing consumers to reevaluate their consumption patterns. The information imparted by the regulation causes consumers to increase demand for the product.

The first of these components, regulatory protection, is similar to the traditional analysis of tariffs where the intervention is assumed to have no other purpose than to protect producers at the expense of consumers. By contrast, the supply-shift and demand-shift components allow for the regulation to have a beneficial impact, even if overdone at times, and again susceptible to political capture of the regulatory process.

Scope of Measures

In addition to modeling the effects of the technical barrier on the parameters of supply and demand in the market in question, a full analysis of the trade effects requires consideration of the scope of those regulations. This is particularly important in the calculation of the incidence of the burden of such regulations. For each of the model elements, we need to consider the situation from the viewpoint of both the exporter and the importer, taking into account the range over which the measures operate. In the classification, we distinguished between technical measures that apply to all exporters (exporter-universal) and those that only apply to particular exporters (exporter-specific). In making economic assessments, technical measures that are applied only by one importer (importer-specific) and those that are generally applied (importer-universal) need to be distinguished as well. These distinctions essentially govern the incidence of the cost of compliance with the import regulations.[23] Table 6 illustrates four possible combinations of scope for the regulations.

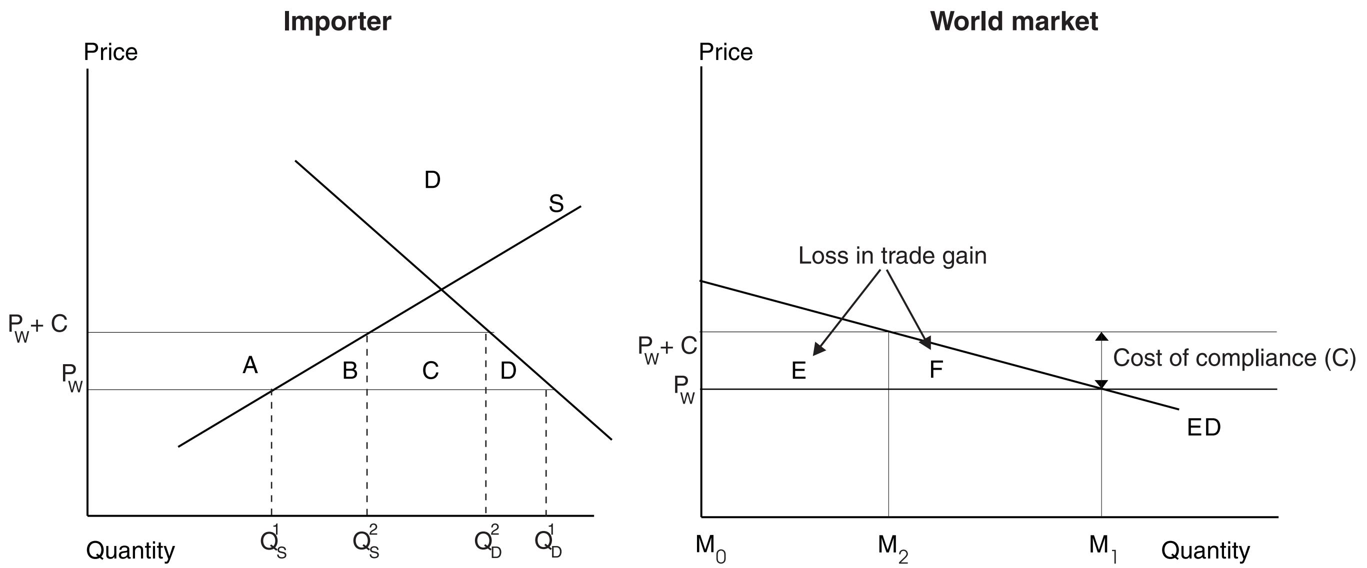
The Regulatory Protection Model

The simple small-country model of regulatory protection postulates a situation where the foreign supplier of the good is required to comply with some form of regulation as a condition of importation—essentially the model used by Krissoff, Calvin, and Gray. Compliance with this regulation is assumed to involve a cost, which acts like a tariff on the quantity of trade (but without tariff revenue). As a result, the importing country suffers a loss, essentially forgoing some of the potential gain from trade. Domestic producers gain and consumers pay both for the producer gain and for the cost of the useless regulation. Consumers also pay indirectly for the distortion in consumption and production decisions, the traditional "welfare triangles" of deadweight losses. The regulatory protection model can be used to gauge the effects of different policy regimes characterized in table 4. One can analyze, for example, the effects of

[23] Similar issues would be relevant in the case of export regulations, but are not pursued here. An exporter may produce to different standards depending upon the import market. In the models that follow, any regulation imposed by an exporter is merely a manifestation of the importer's regulation. The exporter authorities are acting in proxy for the importer authorities. The distinction between specific and universal application of a regulation is not the same as that of few or many suppliers or buyers in the market (conditions of competition). The competition issue is addressed below as a part of the discussion on the world price effects of technical barriers. The incidence of the burden of the technical measure is analytically separate from that of the world price (terms of trade) effect, although both are relevant to the trading countries.

Figure 2

Regulatory protection with no trade externalities: importer perspective



This figure illustrates the trade and welfare effects in the regulatory protection model, viewed from the perspective of the importing country. Assume the "small-country" case for the importer, with domestic producers and consumers facing the world price, P_W. At this price, the quantity demanded by consumers is QD_1 , the quantity supplied by domestic producers is QS_1, and the difference between these two amounts is the quantity imported (seen as QD_1 - QS_1 in the left-hand panel and M_1 in the right hand panel). When this importer alone adopts a universal border regulation intended solely to protect domestic producers, the price in the importing country increases. In this scenario, imports fall to M_2 (seen as QD_2 - QS_2 in the left hand panel), determined by the intersection of the excess demand curve ED and the new compliance cost-inclusive product price P_W + C. Consumer surplus also falls, by the area A + B + C + D, while producer surplus increases by A. The regulation therefore results in net welfare losses (or a reduction in the gains from trade relative to the free trade equilibrium at the intersection of ED and P_W) equal to the area E + F.

a (superfluous) process standard which has the prima facie objective of protecting domestic crops. In the regulatory protection model, there are no actual phytosanitary risks associated with imports of the product; the process standard simply exists to raise costs for foreign producers.

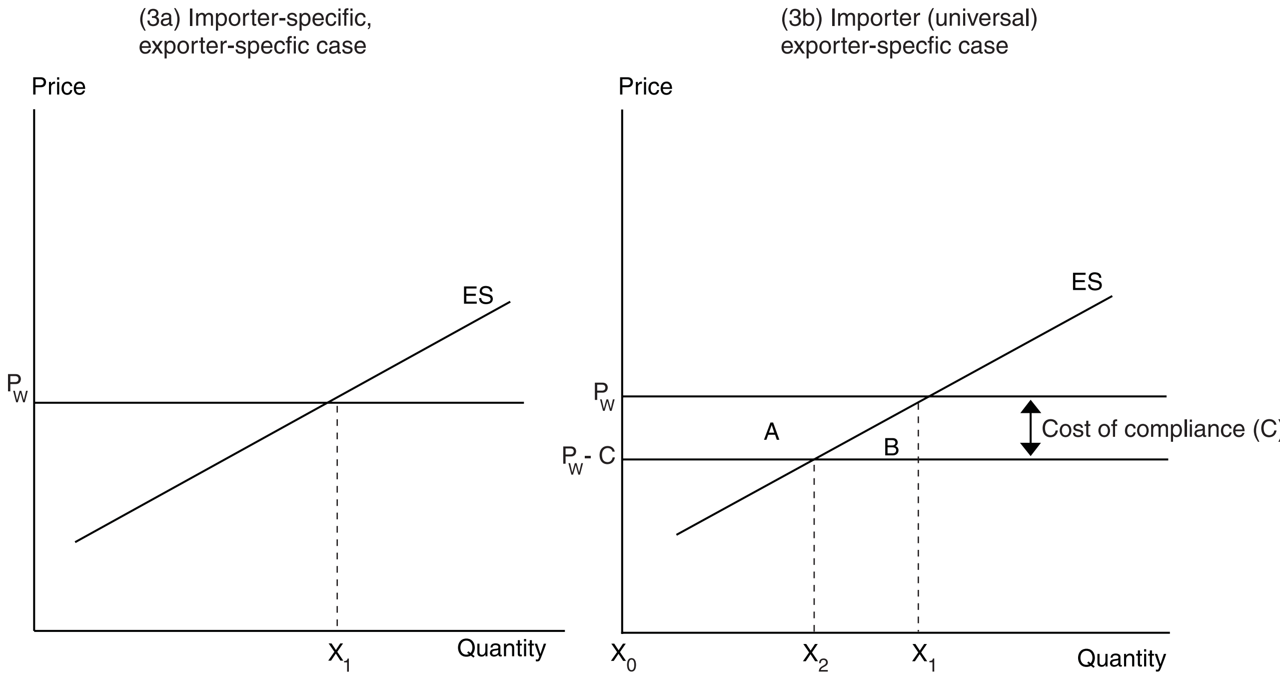
Importer Perspective

The trade and welfare effects in a regulatory protection model that are seen in figure 2 reflect the following assumptions: (1) the regulation applies to all countries exporting to the importing country (exporter-universal), (2) only this importer applies the regulation (importer-specific), and (3) the level of imports is small relative to the total world market (the small country case). A prohibitive regulation on imports, such as a total ban, would lead to trade volume at zero or M_0. Trade in the absence of the regulation would lead to import volume M_1, with the usual gains from trade. With the non-prohibitive regulation imposed on imports, the price of those imports rises and trade shrinks (M_2), reducing the gains from trade by areas E + F. Note that the welfare loss is not just the triangle familiar from tariff analysis but also the rectangular area that depends on the total level of imports and the height of the regulatory compliance cost. Thus we can say with reasonable certainty that the potential welfare losses from unwarranted regulatory protection exceed those from tariffs, which would result in a tariff-inclusive product price equal to Pw + C in the importing country, as tariffs at least generate tariff revenue.

The easiest way to characterize the trade effects of regulatory protection policies is to use the concept of a tariff equivalent (as chosen by Krissoff, Calvin, and Gray). This can be defined as the tariff that would restrict trade to the same extent as the regulatory protection. In the simple example given here, the tariff equivalent is equal to the cost of compliance. This

Figure 3

Regulatory protection with no trade externalities: exporter perspective



This figure illustrates the trade and welfare effects in the regulatory protection model, viewed from the perspective of the exporting country. In the importer-specific, exporter-specific case (3a), one importer adopts a regulation targeted at a single exporter in a small-country case. The exporter continues to export X_1 (the open economy equilibrium at the intersection of the exporter's excess supply curve ES and the world price P_W) by simply shipping the product to other destinations. In the case where all importers adopt a regulation (3b) that targets a single exporter, the compliance costs are borne by the exporter. In this scenario, the exporter faces the world price of $P_W - C$, exports decline to X_2, and the gains from trade decline by area A.

gives a fair indication of the price support provided to domestic producers. With knowledge of elasticities of supply and demand, the effects on the trade volume of the regulation can be computed. It should be remembered, however, that the welfare effect of a technical trade barrier can be much greater than a tariff equal to C.[24] It follows from the discussion of the incidence of the burden that if all importers impose the same regulation (importer-universal), then the increase in the compliance cost inclusive price, PW + C, will be less, as the cost of compliance is shared with exporters through the world price change.

Exporter Perspective

Exporters in general should not notice the effect of the technical measure if the technical measure is imposed only by one importer, and if the world market price is not affected by the importer policy. In this case, the world market shrinks, but by an amount too small to be noticeable, as other importers will be willing to buy the displaced goods.[25] Bilateral trade flows are modified and individual firms can be disadvantaged, but the aggregate impact is small (fig. 3a). Although the exporter may protest, there is little real economic cost to the exporting country if other market outlets exist.[26]

[24] An important implication of this is that the tariff equivalent is appropriate only for comparing trade volume effects (not the welfare effects) of technical and standard trade barriers of different types.

[25] Exporters may still experience costs in searching for alternative markets, even if such markets, by assumption, do exist.

[26] In practice, exporters usually are observed to care when even small markets are denied. For each firm wishing to get into the market each barrier appears significant, even though the actual ex post effect on total export earnings may be insignificant. Thus exporter concern may be a political reality even if an economic illusion.

Alternatively, if the technical barrier is differentially applied, aimed by all importers at one exporter alone, the targeted exporter cannot merely switch supply to another market. The exporter alone will bear the compliance costs of the (exporter-specific, importer-universal) regulation because importers can simply buy from other exporting countries at the world price (fig. 3b). This reinforces the importance of knowing whether any particular technical trade barrier applies to all other exporters, or whether other importers also use the same barrier applied to a certain exporter. The incidence of the barrier will depend on these two aspects of universality versus specificity.

The Supply-Shift Model

Many SPS trade barriers purport to protect the domestic farm and food sector from unwanted pests or diseases that might accompany imports. An importing country might initially maintain a ban on the importation of a good from other countries on the grounds that a pathogen is endemic in those countries. Importing the pathogen, along with the traded product, would lead to the spread of the disease domestically. The pathogen's effect on domestic production would increase production costs (shift up the supply curve) or cut production from a part of the country (shift back the supply curve).[27] Assume that the importing country is small in terms of the world market for the product, so its trade volume will not affect the world price; that there are no pathogen-free suppliers, so the same regulations apply to all exporters; and that testing at the border will assure conformity with a product standard (e.g., disease-free status). These assumptions provide the basis for a simple partial-equilibrium model from which the trade and welfare effects of alternative technical measures can be derived. This analysis provides a means for comparing two regulatory regimes characterized in table 4: a total ban versus a product standard to protect commercial crops or livestock.

Importer Perspective

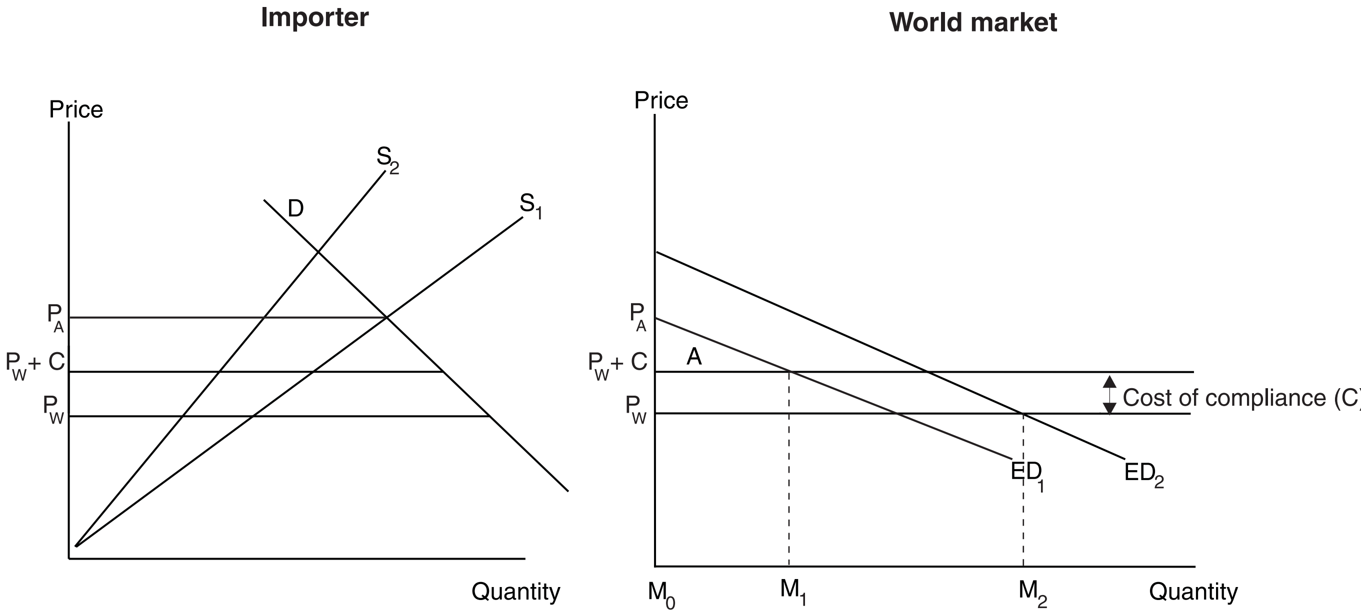
The supply-shift model can be used to compare two potential SPS policy instruments (fig. 4). In this case, testing is less trade-distorting than a ban—when the importer uses testing rather than a ban to mitigate risks, the quantity imported is M_1 instead of M_0. To quantify these effects, assuming the market parameters (supply and demand elasticities) are known, requires additional technical information about the extent to which testing raises the cost of imports, and the extent to which the import of the pathogen would shift the domestic supply curve. With this market and technical information, one could assess the impact on domestic price and trade volume of the alternative SPS measures, as well as the welfare gains and losses from each instrument.

Exporter Perspective

The effect on the exporter in the case of supply shifts associated with pathogens depends on whether the SPS measure is specific or universal, and hence on the incidence of the cost of compliance. In the example discussed here, the testing is assumed to be exporter-universal, so no one exporter faces all the costs. And if it is assumed that just one importing country imposes the regulation, then the cost will be absorbed by that importer. Therefore, the effect on any (small) exporter is insignificant. The importer makes the calculations, bears the costs, and reaps the benefits. The exporter rationally would just absorb the measure as a quirk of this particular import market, much like characteristics of consumer taste. Alternatively, if the regulation affects only one exporter (exporter-specific) and is applied by all importers (importer-universal) then the calculation is different. The targeted exporter would bear the compliance costs, with an economic loss to the exporting country. If all importers impose the same regulations on all exporters then once again

[27] The externalities arising from imports can be measured by the cost of avoiding the pathogen by domestic action (such as vaccination), rather than as the effect on production or demand of the domestic release of the pathogen per se. There may indeed be many alternative ways of intervening, each of which should be analyzed separately. However, in each case there will be a change in the relation between price and quantity supplied, i.e. it can be represented by a shift in the supply curve. Paarlberg and Lee decompose the relationship between imports and domestic supply into that between imports and outbreaks of FMD and that between outbreaks and production loss. Such disaggregation is a useful way of formulating the technical information needed to estimate the relationship.

Figure 4
Supply-shift model



S_1 represents the supply curve in the absence of trade. With the ban in place, domestic equilibrium is at P_A. The corresponding hypothetical import demand curve is ED_1, which assumes no shift in supply if imports occurred. Opening up to trade (and not testing) instead will shift the supply curve up (or back) to S_2, corresponding to an import demand curve of ED_2 and imports of M_2. The domestic price level is now P_W, the world price. There is an apparent gain from trade, but this must be offset by the loss due to the pathogen, which is a negative externality that shifts the supply curve adversely. Testing for the pathogen at the border removes this externality but raises the domestic price by the cost of compliance, C. This in essence corrects the externality, so that P_W + C represents the world price for the product without the pathogen. Excess demand for imports is ED_1 again, reflecting the supply that obtains in the absence of the pathogen, and the quantity imported under this import protocol is M_1. This gives a gain from trade equal to A. (Note that the intersection of P_W + C and ED_2 has no meaning as an equilibrium.)

the cost of compliance is shared between importers and exporters through the changes in market price.

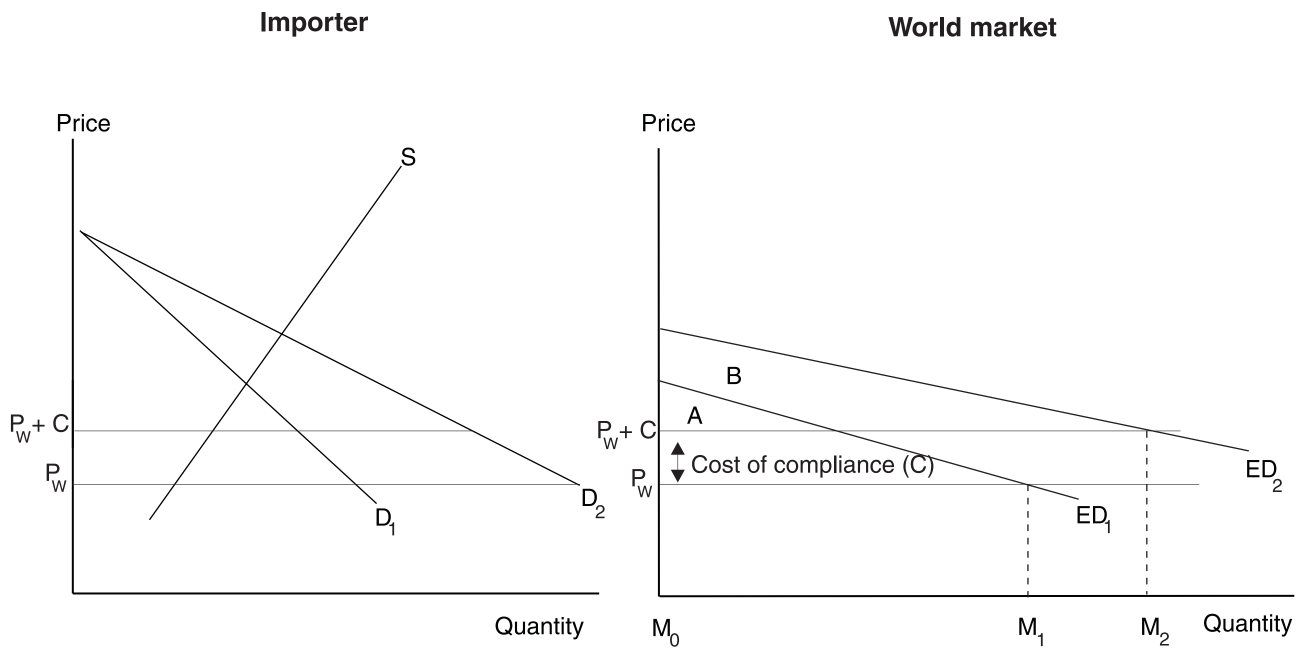
The Demand-Shift Model

The analysis in the supply shift model was based on the existence of a link between imports of a product and domestic supply conditions. If instead the link were between trade and domestic demand through information imparted by the import regulation, demand would shift outward (as in Thilmany and Barrett) as consumers benefit from knowing what to expect from the imported good as the result of the regulation. In effect, the initial demand curve is assumed to reflect limited information about foreign supplies. This demand shift model could be used to analyze a Quality Attribute/mandatory labeling regime as depicted in table 4—for example, a regulation requiring the identification of the production technology (e.g, confined feeding or free-range) on product labels.

Importer Perspective

In this model, not conforming with the regulation would cause some consumer confusion and, on this account, would lower trade volumes, rather than the spread of disease and higher imports. But there also will usually be a "cost of conforming" to the regulations, which will have much the same analytical effect as the "cost of testing" in the supply-shift case (fig. 5).[28] The net welfare effect of the technical trade regulation (versus trade without the regulation) is ambiguous. The producers at home gain, but on

Figure 5
Demand-shift model



Trade in the absence of the informative regulation is given by M_1, corresponding to the import demand curve ED_1, in turn derived from domestic demand D_1 and supply S. Enforcing the regulation raises the demand to D_2, but incurs the cost of compliance C, which raises the domestic price in the importing country to $P_W + C$. This leads to trade of M_2, which can be above or below M_1. The domestic supply curve does not shift, as the regulation does not change the cost of domestic production. The gains from trade are now unambiguously larger (area A + B) than if the compliance costs had been borne with no shift in demand (area A), as would occur in the case of regulatory protection.

this occasion there is no presumption of distortion: the question is whether the consumer benefits from the information are greater than the cost of providing that information.

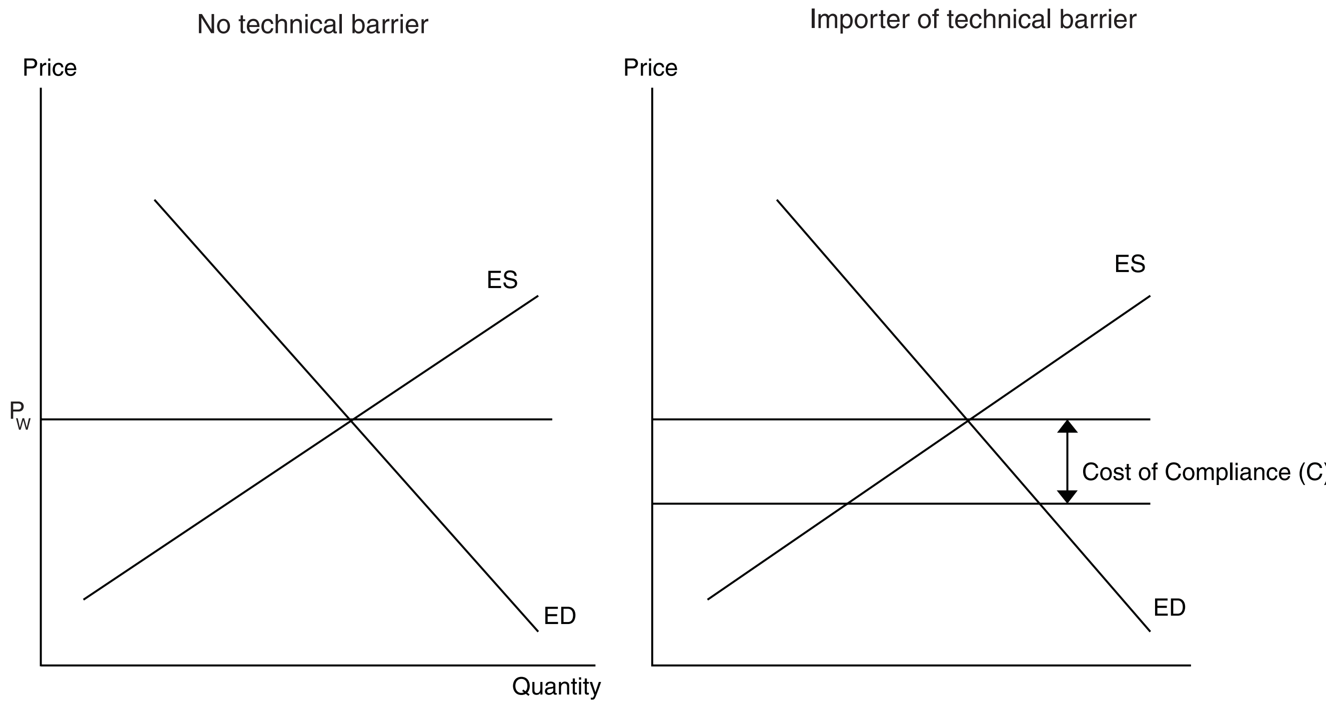
The implied assumption made above is that information makes the import more useful to the consumer. This allows one to interpret the model as one of reacting to perceived negative externalities associated with the unregulated import good. If the "true" demand for the product is at the higher level D_2, then imports entering unregulated cause the demand to drop to D_1 as uncertainty spoils the market for both domestic and foreign products. Regulation of imports, through standards or information remedies, restores consumer confidence and, hence, the demand curve returns to its previous level. Thus, the analysis of regulations that relate to trade in agricultural products can take account of consumer "scares." Whether or not there is any credible scientific justification behind the consumer reaction, the demand for food and agricultural products can certainly be affected by such sentiment.

Exporter Perspective

The analytical model for the exporter in the demand-shift case is similar to that of the supply-shift case. When an exporter-universal introduction of information regulations by one country (importer-specific) does not change the world price, then again it has no measurable effect on the exporters; the compliance costs are borne by the importing country. If all importers impose the informative regulation on just

[28] For convenience we assume that the cost of conforming is constant per unit sold. Other functional forms for the costs under each of these models can be accommodated with appropriate changes in specification.

Figure 6
Large-county case, sharing of compliance costs



one exporter (importer-universal, exporter-specific), then that exporter will have to bear the cost.

World Price Effects

The models above assume that no country is, by itself, large enough to influence world prices by its actions. If a country changes the world price by its decision to adopt a measure that affects the quantity of the product it imports, or if importers uniformly impose a barrier against all exporters, then the small country assumption is not appropriate. A terms-of-trade effect, which will affect the gains from trade, must then be included in the analysis. The terms-of-trade effect can be thought of as apportioning the cost of compliance (figs. 6a and 6b). When a single importer is assumed to face a single exporter, the cost of compliance becomes a wedge between the price that the importer pays and the price that the exporter receives, net of compliance costs. The incidence is therefore simply determined by the ratio of the elasticities of excess supply and excess demand. The less flexible side of the market bears the larger part of the cost.

Does the large country case raise the possibility of strategic games to maximize welfare? It is always possible that a country might use its technical barriers to gain a terms-of-trade advantage for the nation as a whole, as opposed to profits for protected sectors, though this seems unlikely. The Paarlberg and Lee case of foot-and-mouth disease assumes a large country, as appropriate for the U.S. case that they explore. However, they postulate the use of tariffs for SPS purposes, rather than the more common use of command and control measures for SPS policy purposes. The crucial difference between tariffs and technical regulations is that the cost of the regulations involves a real resource outlay rather than a financial transfer. Thus the terms-of-trade gain is much less likely to offset the distortion loss, as this loss is much larger than the efficiency loss "triangle" of tariff theory.

For a demand-shift model, if new import regulations cause the world price to change (e.g., the effect on demand increases world price) then there might be some terms of trade effect as well. In general, the effect on world price of informational regulations is likely to be small. This is not always going to be the case where consumer confidence, as opposed to marginal convenience, is concerned.

One possible market structure is monopolistic competition. Products in such markets are differentiated by some characteristic. Assuming such Armingtonian conditions, each supplier has a monopoly on selling a particular differentiated product.[29] Consumers in the importing country will consequently be more affected by their own targeted import regulations as the range of suppliers decreases. If, however, all importers impose the same regulation on one supplier, then, as before, the cost is borne by the supplier who has to meet the importers' standards.

Customizing the Model

Several additional aspects can be incorporated in these basic models of technical trade barriers to make them more specific to particular examples. Two such aspects are the location of testing and the issue of risk assessment.

Testing Location

One aspect of the modeling framework that can affect the incidence of the burden of technical trade barriers is the location of testing.[30] If testing were done by the foreign producer rather than at the border (essentially requiring the foreign producer to adapt all production, not just the amount exported), then foreign consumers would be affected as well. They would not be able to "escape" the testing costs on output retained at home. This testing location requirement would not have any effect in the small country case but would influence the exporter's excess supply curve, and hence modify the terms-of-trade change if the importer is a large country. The point at which the cost is imposed affects foreign exchange flows, as pointed out by Sumner and Lee. If the cost is borne by the importer, the foreign exchange cost of the imports is less than if the exporter has to bear the costs.

Probabilities and Risk Assessment

Most situations of pest and disease control or food contamination involve probabilities of infestation rather than certainties. Uncertainty about an outcome makes it necessary to couch the analysis in terms of expected values. When the risks of producer or consumer effects are slight, the shifts in the supply or demand curves can be reinterpreted as "worst-case scenarios" and the calculations must take into account that, in many instances, the effects will be nil. The costs and benefits from the various SPS policy instruments may then be expressed in terms of means and variances rather than as simple point estimates. Much of the skill in modeling SPS barriers will be in the translation of scientific knowledge of animal and plant health effects into probabilities of loss and valuations of that loss.

[29] The Armington assumption, often used in spatial and general equilibrium models, is that the domestic and imported goods are close but not perfect substitutes.
[30] This issue is not unrelated to the "equivalency" issue (whether a production or processing method regulation can substitute for a product standard) and the question of "mutual recognition of testing methods" (whereby regulatory authorities accept the results of each other's tests).

Illustrating the Modeling Framework: The Economic Effects of the U.S. Ban on Avocados from Mexico

Orden and Romano's work on the economic effects of an SPS regulation provides a useful example to illustrate our modeling framework. To evaluate the economic effects of full or partial easing of a long-standing ban on U.S. importation of avocados from Mexico, they examined the effects on American producers and consumers under alternative assumptions about the probability of a pest infestation affecting domestic production and about the costs of an infestation in terms of pest-control expenses and reduced yields. An initial equilibrium representing the U.S. avocado market was calculated for various estimated supply and demand functions.[31] For Mexican supply, Orden and Romano assumed that export availability was perfectly elastic at the wholesale price ($878/ton) for delivery of avocados from Mexico to New York as calculated by the industry (Garoyan). The assumption of a perfectly elastic supply is analytically plausible for a partial easing of the import ban, as approved by USDA in 1997, but would be an oversimplification for an evaluation of the effects of the quarantine being removed completely, since the expanded trade would then put upward pressure on the Mexican price.

Estimates of the probabilities of pest infestations have been pivotal to the dispute over the legitimacy of the U.S. avocado ban. Firko estimated the trade-related pest infestation probabilities that were used by APHIS. Among four potential pests (fruit flies, seed weevil, stem weevil, and seed moth), he estimated that the maximum probability of an infestation occurring in the United States for partial easing of the import ban under a systems approach to risk mitigation was $\pi_{AM} = 0.00345$, the probability of a pest infestation associated with the introduction of stem weevil. Firko estimated that the probability of infestation of stem weevil had a minimum value $\pi_{Am} = 1.35x10^{-6}$.

Firko's estimates of the probabilities of pest infestations have been considered too low by the domestic industry. Nyrop estimated that the time expected to pass before an infestation of stem weevils occurred under the proposed partial lifting of the ban ranged from less than 1 year to 20 years. Orden and Romano treated the corresponding probabilities of pest infestation due to stem weevils in a particular year as $\pi_{NM} = 1.0$ and $\pi_{Nm} = 0.05$. The four alternative probability estimates from Firko and Nyrop were used to characterize the range of risks of pest infestation (from essentially zero to certainty) that might be associated with complete removal or partial easing of the avocado import ban.

The final parameters affecting the economic analysis were estimates of the costs associated with a pest infestation, which were modeled as a proportional leftward shift in the domestic supply function (as in figure 4). The magnitude of the shift depends on the increase in production costs caused by the pests. Evangelou et al. estimated that weevil infestation would cause a 41-percent increase in marginal cost due to increased application of pesticides and a 20-percent reduction in yield, but considered that those estimates somewhat overstated the likely increase in production costs. Thus, to provide a range of possible results, Orden and Romano considered three possible effects on production costs of a pest infestation centered on the estimates by Evangelou et al. The largest effects were assumed to involve a 60-percent increase in marginal costs and a 20-percent reduction in yield.

For a partial lifting of the U.S. ban on importation of avocados from Mexico, Orden and Romano divided the domestic market into submarkets—the northeastern winter regional market (for which the ban was lifted) and the national aggregate for all other regions and seasons. The domestic price in the northeastern winter regional market was assumed to fall to the

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[31] Orden and Romano derived estimates of a linear U.S. avocado supply function that is inelastic in the short run (0.28, when lagged quantity is held constant) and elastic in the long run (1.18, when quantity is in a steady state). Linear estimates of demand were inelastic (-0.45), but reestimation of a nonlinear Box-Cox transformation demand specification (Carman and Cook) yielded a price flexibility of -0.65, corresponding to an elasticity of -1.53. Thus, the estimated supply and demand functions gave point estimates that spanned a range from inelastic to elastic behavioral responses.

Table 7--Expected economic effects of avocado imports from Mexico, long-run model with free trade

	Domestic price	Domestic output	Domestic consumption	Import values	Consumer surplus		Producer surplus			Net welfare gain
					Total	Gain	Total	Transfer to consumer	Infestation loss	
	$/short ton	*thousand short tons*		*Million dollars*						
Autarchy	1,385	132.34	132.34		134.38		91.64			
Free Trade (no risk)	878	83.90	222.72	121.88	221.93	87.55	36.83	55.19	0	32.36
Free trade (no risk)										
NM(π_{NM}=1)		41.95		158.72			18.42		18.42	13.94
Nm(π_{Nm}=.05)		79.91		125.39			35.08		1.75	30.60
AM(π_{AM}=.00345)		83.62		122.14			36.71		0.13	32.23
Am(π_{Am}=1.35E-06)		83.90		121.88			36.83		0.05	32.36

Table 8--Expected economic effects of avocado imports from Mexico, long-run model with limited trade

	Domestic price*	Domestic output	Domestic consumption	Import values	Consumer surplus			Producer surplus			Net welfare gain[1]
					Total	Gain	Loss	Total	Gain	Loss	
	$/short ton	*thousand short tons*		*Million dollars*							
Autarchy	1,385	132.34	132.34		134.38			91.64			
Limited Trade (no risk)	1,368	130.73	137.15	5.64	139.10	4.72		89.41		2.22	2.49
Limited trade (no risk)											
NM(π_{NM}=1)	1,795	85.75	92.18		93.35	2.53	43.55	76.95	31.13	45.82	-55.72
Nm(π_{Nm}=.05)	1,396	127.07	133.50		135.46	2.53	1.45	88.71	1.43	4.36	-1.85
AM(π_{AM}=.00345)	1,370	130.46	136.89		138.84	4.46		89.36		2.27	2.18
Am(π_{Am}=1.35E-06)	1,368	130.72	137.15		139.10	4.72		89.41		2.22	2.49

* Average national domestic price (excluding the northeastern winter regional market, when limited trade occurs).

[1] - implies loss.

free-trade level for imports from Mexico, inducing greater consumption than at past domestic prices. An aggregate price for the rest of the U.S. market was determined by an equilibrium of domestic supply and demand with the northeastern regional demand excluded.

Tables 7 and 8 present some alternative estimates of the economic effects of lifting the avocado ban using a long run model with elastic supply and demand. The initial equilibrium with avocado imports prohibited occurs at a domestic price of $1,385 per ton and output of 132,340 tons. Consumer surplus is $134.4 million and producer surplus is $91.6 million. When trade is completely liberalized and no pest infestation occurs, the domestic price falls to $878, consumption increases 68 percent (to 222,722 tons), and domestic production declines 47 percent (to 83,904 tons) (table 7). Consumer surplus rises by $87.5 million, producer surplus falls by $55.2 million, and the net welfare gain is $32.3 million (14 percent of initial consumer plus producer surplus). Consumers benefit, but free trade resulting in decreased domestic output has a devastating effect on the domestic industry because it eliminates higher domestic prices sustained by the import ban.

A pest infestation associated with imports would have a further negative effect on domestic avocado producers, and would reduce the net welfare gain from free trade. In the worst case scenario of certain infestation and highest costs, producer surplus falls by an additional $18.4 million in the long run model. A net welfare gain remains even in this case, although it is reduced to $13.9 million. Thus, in this example, even when a pest infestation occurs with certainty and causes maximal damage (so free trade is bad phytosanitary policy), trade raises net national welfare. For probabilities of pest infestation at Nyrop's minimum or lower, the effect of an infestation on expected producer surplus (taking the probability of an infestation into account) is less than $2 million, and the expected net welfare gain remains above $30 million.

The partial easing of the import ban, which opens the market in the northeastern United States to imports for 3 winter months, has smaller economic effects than free trade when no pest infestation occurs (table 8). The domestic price (for the aggregate market excluding northeastern winter regional demand) falls by 1.2 percent (from $1,385 to $1,368), as domestic consumption displaced from the northeastern winter market is absorbed by a combination of expanded consumption elsewhere and reduced domestic supply. Consumer surplus increases by $2.2 million outside of the northeast (not shown separately in the table) and producer surplus falls by a similar amount (the net welfare gain is only $33,337 outside of the northeastern winter market). In the northeastern region, winter consumption increases and consumer surplus rises by $2.5 million as the price falls to that of imports from Mexico. The net national welfare gain is $2.5 million (about 1 percent of initial total consumer plus producer surplus). Thus, the limited opening of trade under the 1997 partial easing of the import ban has positive effects on northeastern winter consumer surplus, limited positive effects on other consumers and net welfare, and slightly lowers domestic output and the profits of domestic producers.

A pest infestation associated with imports substantially affects the domestic market when only limited trade is allowed under partial easing of the import ban. In the worst case, increased marginal costs and lowered yields reduce producer surplus by $45.8 million, far exceeding the price effect of limited trade without pest infestation. The reduced total supply also pushes the equilibrium domestic price (excluding the northeastern winter regional market) up from $1,385 to $1,795 in the long-run model. The increased price offsets $31.1 million of the loss of producer surplus, leaving a net producer surplus loss of $14.7 million, still almost seven times as large as the loss from limited trade alone.

An economic effect of the pest infestation also affects consumers outside of the northeastern winter market. With the increased domestic price caused by pest damage, consumer surplus falls by $43.5 million. Thus, most of the economic effect of pest risk is borne by consumers outside the northeastern winter market, not by producers, when trade is opened only to the limited extent adopted in 1997.

Conclusions

When approaching the economic analysis of technical trade barriers, a set of questions arises. The most fundamental refers to the nature of the barrier. Is it related to plant and animal health, food safety, or conservation? The answer will give a preliminary indication of the relevant economic model to use for analysis, although since many regulations have multiple objectives, the appropriate model may combine elements from those described earlier.

The second broad question is to ask what policy instruments are used. Does the importer establish product standards (together with conformity assessment requirements), or are there geographical restrictions on the source of the product? Are there special labeling, package dimension or production method requirements? The translation of such instruments into variables, equations, and constraints in economic models requires imagination and experimentation. But all policy instruments have some measurable effect on markets, through their cost of compliance or their restriction on prices or quantities. Any analysis that fails to account for such costs and impacts is crucially incomplete.

The next set of questions involves the effect of the implementation (or non-implementation) of the regulation on market behavior. This effect is different from the effect on the market of the instrument used. The essence of a technical trade barrier is that it potentially changes the conditions of supply or demand (or both) as well as imposing a direct compliance cost. In the example discussed above, the effect of allowing potentially pest-infested avocados into the United States is quite clearly different from the cost of a ban on Mexican avocados.[32] What would happen to domestic supply if the regulation were not in force? Would the domestic supply curve be shifted by the importation of unregulated goods? What would this do to domestic costs? How could the infestation be controlled, and at what expense? A wealth of technical information is needed to estimate such effects and put them in a form usable for an economic model. But without such estimates, however crude, there is no way to judge whether the regulation is justified, whether it has trade implications, and whether there are better (and less trade-distorting) ways to achieve the same level of protection for plant, animal, or human health.

[32] To put it another way, both the opportunity cost and the monetary cost of the regulation are needed.

The same question needs to be asked with respect to the impact on consumption. Are there implications for consumer behavior of regulations on imports? Would consumers lose confidence if the product were not held to specific standards? Would consumers be able to recognize qualities of products without the help of regulations? What is the net effect of the regulations on the consumer demand curve? Addressing these questions entails estimation that may be even more difficult than for supply-shifting regulations. We know little about how consumers react to information, and hence to regulations that require labeling and origin specification. But if regulations are to be defended on their ability to inform the consumer, and if these regulations treat domestic and foreign products differently, there is little alternative to attempting such analysis.

Another issue is the relative position of particular exporters and importers in the marketplace. Are the regulations common to all importers, implying that there is no unregulated market available to exporters? Do the regulations apply to all exporters or is there differentiation by source? Knowledge of the regulations of all countries would be ideal, but, in practice, some indication of the behavior of competitors is needed to be able to estimate the incidence of the burden of complying with regulations.

Finally, it is worth considering the structure of the market in which the goods are sold. Does either the importer or the exporter have any market power? Is the market characterized by competition or could dominant players influence the world price through their action? This requires some indication of the nature of the world market for the commodity in question, in order to impute the terms-of-trade effect of the regulations under study.

These and similar questions define the challenges facing those who seek to bring economic analysis to bear on policy decisions about technical trade barriers. This report provides an initial framework in which to place such an inquiry. The suggested classification scheme sets up the economic analysis. The analysis prompts the researcher for answers to particular questions. The questions, as often as not, will serve to demonstrate how little information we have in a systematic and usable form to address these issues. Case studies are needed, as others have recognized. But case studies are more useful if framed in a classification system such as we have proposed. And these case studies in turn can become examples of various types of economic models such as those discussed above, and can be built on by others.

We have not dealt with the issue of the political economy of such trade barriers, nor with the ways in which international regulations can be improved to prevent tensions in the world (and regional) trade system. But the classification and quantification of technical barriers is a necessary first step in any further analysis. Policy issues with respect to these barriers will be increasingly important in the future. The benefits of sound economic analysis of current technical trade barriers and the consideration of pertinent policy options will therefore increase as well.

References

Ahl, A.S., and J.A. Acree (1993). "Implications of Regionalization and Risk Assessment for Developing Countries," R*evue Élev. Méd. vét. Pays trop*., 46 (1-2): 19-22.

Akerlof, G.A. (1970). "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, 84(August): 488-500.

Anderson, Kym (1992). "A Standard Welfare Analysis of Policies Affecting Trade and the Environment," Chapter 2 in *The Greening of World Trade Issues*, Kym Anderson and Richard Blackhurst (eds.), Harvester Wheatsheaf, London.

Animal and Plant Health Inspection Service (1996). "APHIS Proposes a Regionalization Strategy," USDA/APHIS/International Services, *Trade Support Team Newsletter*, May.

Antle, John (1996). "Efficient Food Safety Regulation in the Food Manufacturing Sector," *American Journal of Agricultural Economics*, 78 (5): 1242-1247.

Antle, John (1995). *Choice and Efficiency in Food Safety Policy*, American Enterprise Institute Press, Washington, DC.

Bhagwati, Jagdish (1984). "The Generalized Theory of Distortions and Welfare," Chapter 12 in *International Trade: Selected Readings*, Jagdish Bhagwati (ed.), MIT Press, Cambridge.

Bredahl, Maury, and Kenneth W. Forsythe (1989). "Harmonizing Phytosanitary and Sanitary Regulations," *The World Economy*, 12 (2): 189-206.

Bredahl, Maury, and Lokman Zaibet (1995). "Adoption of ISO 9000 Standards in the United Kingdom Food Sector," *Complete European Trade Digest*, February.

Camerer, Colin, and Howard Kunreuther (1989). "Decision Processes for Low Probability Events: Policy Implications," *Journal of Policy Analysis and Management*, 8 (4): 565-592.

Carman, Hoy, and Roberta Cook (1996). "An Assessment of Potential Economic Impacts of Mexican Avocado Imports on the Californian Industry," unpublished paper, Department of Agricultural Economics, University of California, Davis.

Caswell, Julie, and Eliza Mojduszka (1996). "Using Informational Labeling to Influence the Market for Quality in Food Products," *American Journal of Agricultural Economics*, 78 (5): 1248-1253.

Ervin, David (1997). "Agriculture, Trade and the Environment: Anticipating the Policy Challenges." Report Prepared for the Joint Working Party of the Committee for Agriculture and the Environment Policy Committee, Organization for Economic Cooperation and Development, Paris.

Esty, Daniel (1994). *Greening the GATT: Trade, Environment, and the Future*, Institute for International Economics, Washington, DC.

Evangelou, P., P. Kemere, and C. Miller (1993). "Potential Economic Impacts of an Avocado Weevil Infestation in California," unpublished paper, Animal and Plant Health Inspection Service, U. S. Dept. Agr., August.

Federal Register (1997). "Importation of Animals and Animal Products Final Rule," Docket No. 94-106-9, Government Printing Office, 62 (208): 55999-56026, October 28.

Farber, Daniel, and Robert Hudec (1996). "GATT Legal Restraints on Domestic Environmental Regulations," Chapter 2 in *Fair Trade and Harmonization: Prerequisites for Free Trade?* Vol. 2: Legal Analysis, Jagdish Bhagwati and Robert Hudec (eds.), MIT Press, Cambridge, pp. 59-94.

Firko, Michael (1995). "Importation of Avocado Fruit (Persea americana) from Mexico, Supplemental Pest Risk Assessment," unpublished report, Biological Assessment and Taxonomic Support, Plant Protection and Quarantine, Animal and Plant Health Inspection Service, U.S. Dept. Agr., May.

Forsythe, Kenneth, and Maury Bredahl (1991). "Effects of Animal Health Regulations on Market Access for Exports of Livestock Products," *Journal of Agribusiness*, 9 (2): 41-51.

Garoyan, Leon (1995). "Proposed Rule for the Importation of Fresh Hass Avocado Fruit Grown in Michoacan, Mexico," unpublished report prepared for the California Avocado Commission by Management Research Associates, Davis, California, August.

General Agreement on Tariffs and Trade (1994). *The Results of the Uruguay Round of Multilateral Trade Negotiations: The Legal Texts*, Geneva.

General Agreement on Tariffs and Trade (1995). *Analytic Index: Guide to GATT Law and Practice*, Sixth Edition, Geneva.

Hillman, Jimmye S. (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), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 1-32.

Hoekman, Bernard, and Michael Leidy (1993). "Environmental Policy Formation in a Trading Economy: A Public Choice Perspective," Chapter 11 in *The Greening of World Trade Issues*, Kym Anderson and Richard Blackhurst (eds.), Harvester Wheatsheaf, London.

Hooker, Neal, and Julie A. Caswell (1995). "Regulatory Targets and Regimes for Food Safety: A Comparison of North American and European Approaches," paper presented at the NE-165 Conference, Washington, DC, June.

Huber, Peter (1986). "The Bhopalization of American Tort Law," in *Hazards: Technology and Fairness*, National Academy of Engineering, National Academy Press, Washington, DC, pp. 89-110.

Hudec, Robert (1996). "GATT Legal Restraints on the Use of Trade Measures against Foreign Environmental Practices," Chapter 3 in *Fair Trade and Harmonization: Prerequisites for Free Trade?* Vol. 2: Legal Analysis, Jagdish Bhagwati and Robert Hudec (eds.), MIT Press, Cambridge, pp. 95-174.

James, Sallie, and Kym Anderson (1998). "On the Need for More Economic Assessment of Quarantine/SPS Policies," Seminar Paper 98-02, Centre for International Economic Studies, University of Adelaide, February.

Josling, Tim (1994). "Towards a Measure of the Impact of Environmental Regulations on Trade," unpublished paper, Stanford University, December.

Kinsey, Jean (1993). "GATT and the Economics of Food Safety," *Food Policy*, 18:2, 163-176.

Kopp, Raymond, Alan Krupnick, and Michael Toman (1997). "Cost-Benefit Analysis and Regulatory Reform: An Assessment of the Science and the Art," Discussion Paper 97-19, Resources for the Future, Washington, DC, January.

Kramer, Carol S. (1989). "Food Safety and International Trade: The U.S.-EC Meat and Hormone Controversies," in *The Political Economy of U.S. Agriculture*, Carol S. Kramer (ed.), National Center for Food and Agricultural Policy, Resources for the Future, Washington, DC.

Krissoff, Barry, Linda Calvin, and Denice Gray (1997), "Barriers to Trade in Global Apple Markets," *Fruit and Tree Nuts Situation and Outlook*, FTS-280, Econ. Res. Serv., U.S. Dept. Agr., August.

Krissoff, Barry, Nicole Ballenger, John Dunmore, and Denice Gray (1996). *Exploring Linkages Among Agriculture, Trade, and the Environment: Issues for the Next Century*, Econ. Res. Serv., U.S. Dept. Agr., Agricultural Economic Report No. 738, May.

MacDonald, James, and Stephen Crutchfield (1996). "Modeling the Costs of Food Safety Regulation," *American Journal of Agricultural Economics*, 78 (5): 1285-1290.

MacLaren, Donald (1997). "Uncertainty Aversion and Technical Barriers to Trade: An Australian Example," in *Understanding Technical Barriers to Agricultural Trade*, Proceedings of a Conference of the International Agricultural Trade Research Consortium (IATRC), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 255-283.

Mahè, Louis-Pascal (1997). "Environment and Quality Standards in the WTO: New Protectionism in Agricultural Trade? A European Perspective," *European Review of Agricultural Economics*, 24: 480-503.

May, Peter (1991). "Addressing Public Risks: Federal Earthquake Policy Design," *Journal of Policy Analysis and Management*, 10 (2): 263-285.

McDorman, Ted (1991). "The GATT Consistency of U.S. Fish Import Embargoes to Stop Driftnet Fishing and Save Whales, Dolphins and Turtles," *George Washington Journal of International Law and Economics*, 24: 477-525.

Ndayisenga, Fidele, and Jean Kinsey (1994). "The Structure of Nontariff Trade Measures on Agricultural Products in High-Income Countries," *Agribusiness*, 10 (4): 275-292.

Nyrop, Jan (1995). "A Critique of the Risk Management Analysis for Importation of Avocados from Mexico," unpublished report prepared for the Florida Avocado and Lime Committee, Ithaca, NY, August.

Orden, David, and Eduardo Romano (1996). "The Avocado Dispute and Other Technical Barriers to Agricultural Trade under NAFTA," paper presented to the conference "NAFTA and Agriculture: Is the Experiment Working?" San Antonio, TX, November.

Organization for Economic Cooperation and Development (1997). "Regulatory Reform and the Agro-Food Sector," in *OECD Report on Regulatory Reform*, Vol. 1, Sectoral Studies, October.

Organization for Economic Cooperation and Development (1998). "Regulatory Reform and International Standardisation," *Report of the Working Party of the Trade Committee*, TD/TC/WT(98)36/APP/REV1, September.

Paarlberg, Philip, and John Lee (1998). "Import Restrictions in the Presence of a Health Risk: An Illustration Using FMD," *American Journal of Agricultural Economics*, 80 (1), February.

Powell, Mark (1997). "Science in Sanitary and Phytosanitary Dispute Resolution," Discussion Paper 97-50, Resources for the Future, Washington, DC.

Randall, Alan (1993). "The Problem of Market Failure," Chapter 9 in *Economics of the Environment*, Robert Dorfman and Nancy Dorfman (eds.), W.W. Norton (3rd edition), New York.

Roberts, Donna (1997). "USDA Lifts Import Ban on Mexican Avocados," *Agricultural Outlook*, AO-241, Econ. Res. Serv., U.S. Dept. Agr., June, pp. 17-21.

Roberts, Donna (1998a). "Preliminary Assessment of the Effects of the WTO Agreement on Sanitary and Phytosanitary Trade Regulation," *Journal of International Economic Law*, December: 377-405.

Roberts, Donna (1998b). "The WTO SPS Agreement: Overview and Implications for Animal Health and Animal Product Import Decision Making," paper presented at the USDA Workshop on Use of Economic Analysis In Evaluating Animal and Animal Product Import Requests, Riverdale, MD, March 24-25.

Roberts, Donna, and David Orden (1997). "Determinants of Technical Barriers to Trade: The Case of U.S. Phytosanitary Restrictions on Mexican Avocados, 1972-1995," in *Understanding Technical Barriers to Agricultural Trade*, Proceedings of a Conference of the International Agricultural Trade Research Consortium (IATRC), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 117-160.

Roberts, Donna, and Kate DeRemer (1997). *An Overview of Technical Barriers to U.S. Agricultural Exports, Economic Research Service*, Econ. Res. Serv., U.S. Dept. Agr., Staff Paper AGES-9705, March.

Roessler, Frieder (1996). "Diverging Domestic Policies and Multilateral Trade Integration," Chapter 1 in *Fair Trade and Harmonization: Prerequisites for Free Trade?* Vol. 2: Legal Analysis, Jagdish Bhagwati and Robert Hudec (eds.) MIT Press, Cambridge, pp. 21-56.

Romano, Eduardo and David Orden (1997). "The Political Economy of U.S. Import Restrictions on Nursery Stock and Ornamental Plants in Growing Media," in *Understanding Technical Barriers to Agricultural Trade*, Proceedings of a Conference of the International Agricultural Trade Research Consortium (IATRC), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 99-115.

Secretariat of the World Trade Organization (1996). "Understanding the World Trade Organization Agreement on Sanitary and Phytosanitary Measures," Geneva.

Simberloff, D., and M. Alexander (1994). "Biological Stressors," Chapter 6 in *Ecological Risk Assessment Issue Papers*, EPA/630R-94/009, U.S. Environmental Protection Agency, Washington, DC.

Stanton, Gretchen (1997). "Implications of the WTO Agreement on Sanitary and Phytosanitary Measures," in *Understanding Technical Barriers to Agricultural Trade*, Proceedings of a Conference of the International Agricultural Trade Research Consortium (IATRC), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 75-78.

Sumner, Daniel, and Hyunok 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), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 273-283.

Sykes, Alan O. (1995). *Product Standards for Internationally Integrated Goods Markets*, The Brookings Institution, Washington, DC.

Thiermann, Alex (1997). "Implementation of the WTO's Agreement on Sanitary and Phytosanitary Measures: The U.S. Perspective," in *Understanding Technical Barriers to Agricultural Trade*, Proceedings of a Conference of the International Agricultural Trade Research Consortium (IATRC), David Orden and Donna Roberts (eds.), IATRC: St. Paul, MN, January, pp. 63-69.

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

Thompson, Paul (1996). "Food Labels and the Ethics of Consent," *Choices*, First Quarter: 11- 13.

Thornsbury, Suzanne, Donna Roberts, Kate DeRemer, and David Orden (1997). "A First Step in Understanding Technical Barriers to Agricultural Trade," presented at the XXIII International Conference of Agricultural Economists, Sacramento, California, August, and forthcoming in *IAAE Occasional Papers*, No. 8.

United States Department of Agriculture (1996). "Guidelines for Preparing Risk Assessments and Preparing Cost-Benefit Analyses," Appendix C, Departmental Regulation on Regulatory Decisionmaking, DR 1512-1, [http:/www.aphis.usda.gov/ppd/region/dr1512.html].

van Ravenswaay, Eileen, and John Hoehn (1996). "The Theoretical Benefits of Food Safety Policies: A Total Economic Value Framework," *American Journal of Agricultural Economics*, 78 (5): 1291-1296.

Viscusi, W., J. Vernon, and J. Harrington, Jr. (1995). *Economics of Regulation and Antitrust*, Second Edition, MIT Press, Cambridge.

World Bank (1997). *Bioengineering of Crops*, Report of the World Bank Panel on Transgenic Crops, Environmentally and Socially Sustainable Development Studies and Monographs Series No. 23, Washington, DC, October.

World Trade Organization (1997). "EC Measures Concerning Meat and Meat Products (Hormones)," Complaint by the United States, Report of the Panel. WT/DS26/R/USA, August 18, Geneva.

World Trade Organization (1998). "EC Measures Concerning Meat and Meat Products (Hormones)," Complaint by the United States, Report of the Appellate Body. WT/DS48/AB/R, January 16, Geneva.