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
Packaging standards
Information remedies
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.

Information 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 to, 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 that 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	Compatibility
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 longstanding 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 measures 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 equipment. Some product incompatibilities may in fact enhance welfare if they emerge from the

[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	Commercial animal and plant health protection	Protection of natural environment from HNIS[1]
Import bans			
• Total bans	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 bans	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 standards	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 standards	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 standards	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 require 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

development of superior technology that leads to 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

[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.

and complex. One useful two-dimensional classification 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).