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A Review of Methods for Quantifying the Trade Effects of Standards in the Agri-Food Sector

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A REVIEW OF METHODS FOR QUANTIFYNG THE TRADE EFFECTS OF STANDARDS IN THE AGRI-FOOD SECTOR

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ABSTRACT

This paper evaluates the different approaches to quantifying the trade impact of standards in the agri-food sector. The approaches discussed fall into two broad categories: *ex post* empirical estimation and *ex ante* simulation. Recent developments on the impact of standards on market segmentation are also examined. Since both the level and design of a standard are important determinants of its impact, the most suitable choice of quantification strategy will depends on the characteristics of the standard itself. For example, *ex ante* simulation techniques are more appropriate when measuring the impact of complex standards regimes. On the other hand, *ex post* empirical estimation is preferable when the level of the standard is more important than its design.

Keywords: quantification of non tariff measures, standards, TBT, SPS measures, tariff equivalents, supply and demand shifts, frequency and coverage measures, agri-food sector, market segmentation.

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Executive Summary

With the world-wide reduction in tariffs under the auspices of the GATT/WTO, standards and, more generally, non-tariff measures (NTMs) have assumed greater importance in world agri-food trade. This trend also reflects growing concerns over product quality and consumer health and safety. There are non-trivial compliance costs associated with standards. Consequently, such measures have the potential to restrict trade by effectively protecting local producers from foreign competition. A greater understanding of the trade and welfare effects of standards is of utmost importance.

This study reviews existing standards and, where appropriate, NTM quantification strategies focusing on government mandated product and process standards in the agri-food sector. This information is then used to ascertain which quantification methods are most suitable for measuring the impact of different types of standards. Quantifying the impact of standards is a difficult exercise. Experts have yet to agree on a preferred quantification strategy. This is mainly because standards tend to be complex and their design can vary significantly. In addition, the required data is often not readily available.

Product standard quantification techniques can be broadly grouped into two categories. *Ex-post* approaches such as gravity-based econometric models tend to estimate the observed impact of standards. On the other hand, *ex ante* methods such as simulations involving the calculation of tariff equivalents are usually employed to predict the impact of standards regimes whose effects are, as yet, unobserved.

If the focus of analysis is on the trade impact of a standard then *ex post* quantification methods tend to be most suitable. Moreover, while frequency and coverage measures can give some guidance as to the potential trade impact of a standard, econometric estimation is required to estimate its magnitude. On the other hand, when the welfare effects of a standard are an issue, especially its distributive impact between consumers and producers, then it is necessary to explicitly model how consumers and producers react to standards-induced price changes. *Ex ante* simulation techniques are likely to represent the most suitable quantification approach in such cases.

Both the level and design of a standard are important determinants of its impact. Since the level of a standard is usually related to the product's content-attributes, the level effect can generally be adequately measured by estimation. For more complex standards regimes, especially those related to a product's process attributes, simulation methods are preferable since they permit explicit modelling of the standard's design.

Until recently, the market segmentation effect of standards has been largely neglected. Simulation models which seek to account for product differentiation within a given industry as well as consumer preferences over such heterogeneity are promising. Ex post empirical approaches are less useful in such cases as the data employed implicitly assumes homogeneity within a given product category.

Introduction

1. Successive rounds of global trade liberalisation have substantially reduced tariff barriers to trade. At the same time, NTMs such as quotas and technical regulations have become increasingly prevalent.

This paper investigates the different methods that can be used to measure the impact of one type of NTM – government mandated product and process standards – on trade in the agri-food sector.[1]

2. Standards specify a level of quality or attainment. They are defined by product characteristics (including the nature of the production process employed) and, as such, are typically a feature of differentiated product markets. Products that are vertically differentiated by some measurable characteristic of quality or attainment can be objectively ranked against a standard defined over this characteristic. For example, agri-food products can be rated with respect to their process-attributes (e.g. organically produced) or their content-attributes (e.g. the level of pesticide residuals they contain).[2] Standards may also be defined using (horizontal) product characteristics that are not objectively measurable; colour, taste or country-of-origin, for example.[3] Regarding processed agri-food commodities, now "the most important type of agricultural commodities traded internationally" (Sarker and Surry, 2006), the degree of product differentiation in agri-food trade is significant. Product standards, therefore, have come to play an increasingly important role in this sector.

3. Under World Trade Organisation (WTO) rules, product standards may either take the form of mandatory technical regulations (henceforth, referred to as "mandatory standards") with which producers are obliged to comply, or voluntary standards. Generally, technical regulations are dealt with under the Technical Barriers to Trade (TBT) Agreement of the WTO or, if they are imposed to protect human, animal or plant health, under the Sanitary and Phytosanitary (SPS) Agreement.[4] Consistent with WTO terminology, this paper focuses on mandatory product standards, including both content-attribute and process-attribute standards, as imposed by governments or their mandated institutions.

4. While standards can facilitate trade by, for example, reducing informational asymmetries between consumers and producers, they can also restrict trade in two main ways. First, trade will be eliminated in those product varieties that consumers demand but which do not satisfy the standard. More generally, mandatory standards represent an additional cost of production in the form of non-trivial compliance costs.[5] At the margin, therefore, standards may, whether or not by design, effectively shelter local producers from foreign competition. This protective effect can be exacerbated if standards are implemented, intentionally or otherwise, in an origin-specific manner; for example, in a way that favours the production methods of a particular country or region.[6]

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[1] In practice, agri-food standards are set both by governments and the private sector. While private standards are very important in the global food chain (Henson and Reardon, 2005), this paper concentrates purely on government-defined standards. This is because the motivation for public and private standards can be quite different and involve significantly divergent quantification strategies. While public standards are usually justified on social welfare grounds (e.g. consumer health and safety), private standards are typically driven by strategic considerations at the firm level, product differentiation in the pursuit of market share, for example. The difference between government and private standards is explored further in **Box 1**. OECD (2006a) provides an extensive discussion of private standards. Some case studies of private standards in developing countries are discussed in OECD (2006b). A comprehensive analysis of the interactions between private and public standards can be found in OECD (2007a).

[2] Henceforth, the term "product standards" will be taken to incorporate both "content-attribute standards" and "process-attribute standards". Product and process standards are discussed in detail in **Box 2**.

[3] Country-of-origin labelling requirements, common in the agri-food sector, are an example of a mandatory standard based on horizontal product characteristics.

[4] Note that only the SPS agreement explicitly refers to international standard setting bodies such as CODEX, the International Plant Protection Convention (IPPC) and the World Organisation for Animal Health (OIE).

[5] Issues of measurement of compliance costs are discussed in **Box 3**.

[6] An overview of the economic rationale for standards is given in Appendix 1.

5. Since exporters must comply with the (mandatory) standards of importing countries in order to gain market access, the requirement that a product satisfy different national standards increases the cost of doing business internationally. Note, however, that a foreign producer's willingness to comply with mandatory standards is a necessary but not sufficient condition for market entry. A firm may be willing and able to meet a particular market's required standard yet prefer, *ceteris paribus*, to minimise production costs by supplying more leniently regulated markets. Hence, the impact of a particular standard on trade depends on how this and related standards are designed and enforced in *all* markets world-wide.

6. Product standards may either be country-specific or harmonised (i.e. shared among a number of countries). Many governments and international standards bodies encourage harmonisation of product standards, including in the agri-food sector. Both the SPS and TBT agreements promote harmonisation and presume that when governments adopt or base their technical regulations on international (i.e. harmonised) standards, these do not constitute a barrier to trade. Harmonisation aims to promote trade by reducing product adaptation costs for producers, establishing consumer trust by standardising product quality and reducing search costs for consumers (Moenius, 2006). On the other hand, harmonisation reduces the varieties available and may force consumers to purchase a variety that they consider to be inferior. Therefore, while producers save on adaptation costs, they also lose any differentiation they may have had under a system of country-specific standards. In short, as Moenius (2004, 2006) demonstrate, the harmonisation of standards may not necessarily promote trade.

7. Evidence from surveys suggests that standards can, in fact, act as significant barriers to trade. Business surveys in OECD and non-OECD countries indicate that standards are a major concern for exporters in developing and developed countries alike (Fliess, 2005). A recent survey by Wilson and Otsuki (2004a) suggests that small and medium-sized firms in developing and transition economies can find the need to comply with the import standards of developed countries particularly burdensome.[7] Note, however, that this conclusion is by no means unanimous. There is also evidence that standards may help to upgrade agribusiness and reduce poverty in developing countries (Minten, Randrianarison and Swinnen, 2006).

Box 1: Government and private standards in the agri-food sector

Both governments and the private sector set standards for agri-food products. While government standards usually reflect social welfare concerns, private standards are typically motivated by strategic considerations at the firm level – product differentiation in the pursuit of market share, for example. Nevertheless, private standards may be in the interests of both producers and consumers especially if the latter demand products of a certain quality.

Government standards imply the existence of domestic or international legislation specifying the standard (WTO, 2005). They are set by law and hence typically mandatory. In contrast, private standards and their implementation, including conformity assessment, are the responsibility of the private sector. Private standards are thus defined as voluntary but can become quasi-mandatory if producers wish to gain access to a market in which the private standard applies to a large share of the market. Particularly in developing countries, producers and processors of agri-food products have increasingly faced strong pressure to comply with the private standards of supermarkets and retailers who dominate the global agri-food market with large market share (Henson and Reardon, 2005).

In setting standards, particularly those that impact on a firm's production process, governments typically seek expert (technological) advice from producers. In fact, some process standards that were originally developed for use by a given industry, have since been adopted by government for more widespread use. Examples include the Hazard Analysis Critical Control Point (HACCP) system that was originally developed by the agri-food industry, as well as the standards developed by the International Standardisation Organisation (ISO).

[7] Wilson and Otsuki (2004a) survey firms from a wide range of industries from raw and processed food to industrial equipment and textiles.

Private standards incorporate those governmental standards that are obligatory for producers. While private standards in the agri-food sector are based on government standards, they may also exceed governmental requirements. This particularly relates to requirements in the production process. On the one hand, private standards initiatives use tighter processing requirements that help producers differentiate their products and charge higher prices. On the other hand, private standards initiatives insist on management systems beyond governmental requirements so as to better control quality. This is because recalls and food contamination scares can damage the reputation of an entire industry. The BSE crisis, for example, harmed consumer confidence in the safety of beef products leading to a large decline in beef consumption in Europe.

8. Measuring the impact of standards presents some formidable challenges. Standards can be designed and implemented in a variety of different ways, each of which has important implications for their impact. These challenges are reflected in the literature in two main ways. First, many existing studies have tended to undertake specific case studies whose results are not easily generalised. Second, no unifying methodology exists by which to estimate the impact of heterogeneous standards.

9. Data availability presents another major source of difficulty. Estimation of the impact of a particular standard may require data on, *inter alia*, price differences between domestic and foreign-produced goods or the value placed by consumers on the product characteristics subject to the standard. Accurate data of this sort is often not readily available, compromising the estimation exercise.

10. The literature reviewed here primarily measures the impact of standards on trade flows and on welfare. Overwhelmingly, the welfare effects considered arise from changes in: (i) consumer and producer behaviour in response to standards-induced price changes and (ii) the number of varieties of goods produced and consumed as a result of the implementation of the standards. *Note, however, that while these effects are important, they do not adequately capture the costs and benefits of standards and, more generally, NTMs*. In particular, the benefits of standards arising from a reduction in the incidence of negative externalities is usually underestimated or ignored altogether.

11. This paper does not address methods of risk assessment associated with benefit cost analysis. Risk assessments, particularly prevalent in studies considering the effects of environmental and health regulation, are worthy of a separate study. The frequent use of benefit-cost analysis in environmental decisions for example, particularly in the United States, suggest that such analysis could be used more widely to distinguish those standards that restrict trade but address a market failure, from those that have net negative welfare impacts. The main limitations of this approach are the large levels of uncertainty which surround the size of risks and their economic consequences (Beghin and Bureau, 2001). In the case of some SPS measures, for example, it is necessary to assess the probability of a spread of a disease from a pest, and its associated costs (see for example Peterson and Orden (2006)). It may also be necessary to value the loss of human life – a highly controversial exercise. In short, therefore, many of the issues associated with risk assessment and benefit-cost analysis have been judged to lie beyond the scope of the current paper.

12. This paper reviews the different methods that have been employed to quantify the impact of standards.[8] It investigates the applicability of these methodologies to quantify different types of standards and offers an assessment of considerations when matching quantification strategy with standard type. Throughout, the primary focus is on the agri-food sector although much of the discussion which follows is equally relevant for other sectors. This review is concerned primarily with the impact of standards on trade and, as covered in the literature, welfare, generally defined as changes in prices, quantities and varieties of products produced and consumed. The trade effects of standards, and these narrowly-defined welfare

[8] NTM quantification methods have also been reviewed by Bora, Kuwahara and Laird (2002) and OECD (2006c).

effects, and only one part of the total effect of standards. A broader project is underway within the OECD Trade and Agriculture Directorate to attempt to assess the impacts of standards and other NTMs in the agri-food sector more widely.[9] The present paper represents a methodological contribution to quantifying a sub-set of the effects of standards, those that impact trade.

13. The paper proceeds as follows. **Section 2** describes the different approaches used to quantify the trade and welfare impacts of standards in the agri-food sector. **Section 3** analyses which quantification methods are most suitable for measuring the impact of different types of standards. **Section 4** concludes.

Box 2: Product and process standards in the agri-food sector

In the agri-food sector, product standards typically prescribe maximum levels of pesticide and herbicide residues, drugs or additives as well as maximum permitted levels of possible contaminants; or, alternatively, minimum levels, such as fat content, etc. They may even ban certain substances. Packaging requirements can also be considered as product standards since they either directly relate to product characteristics or add value (freshness, for example) to the products themselves. Standards may also take the form of labelling requirements that provide consumers and processors with information about product characteristics such as ingredients of food products (WTO, 2005).

Process-attribute standards in the agri-food sector may prescribe permitted inputs or specify the handling and storage requirements for agri-food products and their inputs. Such standards may, for example, require the separation of intermediate and final products that contain genetically modified organisms (GMOs) from those that do not. Hygiene, sanitary and pest control requirements which directly affect the safety of agri-food products are other examples of product-related process standards.

Some process standards, such as environmental process standards, are non-product related. They influence production conditions but do not necessarily affect the physical characteristics of the products themselves. Examples of such process standards include quality management systems such as the Hazard Analysis Critical Control Point (HACCP), the ISO 9000 series or requirements by Good Agricultural Practice (GAP) which define preferred production processes rather than explicitly stipulating product characteristics.

Table 1 provides an overview of some of the different product and process standards applied in the agri-food sector.

Table 1: Product and process standards in the agri-food sector

Type	Target	Examples
Product standards	Maximum level/ban Minimum levels	Pesticide/herbicide residue, drug residues, additives and contaminants Fat, protein content,
	Packaging	Size, material, treatment of material
	Grading/classification	Wheat classes, meat classes, fruit classes
	Labelling	Label of ingredients; other labels
Process standards	Product-related	Requirements for inputs (GMO, hormones)
		Handling/storage requirements
		Hygiene and sanitary requirements
		Pest control measures
	Non product-related	Labour conditions
		Animal welfare
		Environmentally friendly/organic production
		Traceability
		Quality management/assurance systems (HACCP, ISO, GAP)

[9] See OECD (2007b) for the project proposal.

2. Quantifying the trade effects of standards

14. Standards have an ambiguous impact on international trade and welfare. On the one hand, they may facilitate trade by providing product information to consumers and contribute to the achievement of the imposing country's social and technical objectives. On the other hand, they may be restrictive and so hamper international trade, especially if they discriminate against foreign producers.[10] Moreover, standards vary across countries reflecting international differences in consumer and producer preferences and perceptions risk attitudes. This section evaluates the methodologies that have been used to model and quantify the impact of standards in the agri-food sector.[11]

15. Broadly speaking, the impact of standards can be quantified *ex post* and *ex ante*. *Ex post* analyses tend to attribute *observed* changes in trade to the imposition or redesign of standards, while controlling for other factors that may simultaneously have an impact on trade flow. Such analyses typically estimate econometric models of the relationship between standards and trade or construct frequency and coverage measures of standards based on historical trade data. This review examines the frequency and coverage approach as well as two families of econometric models: the gravity model and models of individual firm export decisions.

16. In contrast, *ex ante* analyses are generally employed to predict the likely impact of a regulatory change before it is introduced. This usually involves simulating a partial or general equilibrium model to determine how individual consumers and producers will respond to the price changes arising from a change to the regulatory environment. *Ex ante* quantification strategies discussed in this section include: the calculation of tariff equivalents, measurement of demand and supply shifts and the analysis of standards-induced market segmentation.[12] By adding-up the behavioural responses of all economic agents, it is possible to obtain the aggregate impact on trade of a given change in regulation.[13] However, the focus on individual behaviour also makes it possible to decompose the aggregate impact of standards into welfare effects on individual economic agents. That is, one can analyse the distributional impact of a regulatory change. This is typically not possible in *ex post* (i.e. econometric) analyses which, for the most part, can only measure the aggregate impact of regulation on trade.

2.1 Frequency and coverage measures of standards

17. Frequency measures count the number of regulations or the proportion of products (or tariff lines) that are subject to standards within a given product classification. Coverage measures calculate the volume or value of imported goods subject to standards and are usually expressed as a percentage of total imports

[10] Fischer and Serra (2000) argue that a minimum standard may be considered to excessively restrict trade "when it exceeds what a [social] planner would impose if all producers were local." While attractive in theory, this definition is difficult to implement in practice; the counterfactual – all producers are local firms – is usually not observed. Nevertheless, James and Anderson (1998) have shown that, in practice, standards may be used to protect local production from foreign competition. After all, as Fischer and Serra (2000) point out, in cases where a country adopts a minimum standard that exceeds the level accepted elsewhere, exporters face a choice. They can either reconfigure production systems in order to produce *all output* at the higher standard, or they can decide not to supply the market subject to the more stringent standard. Adopting the former strategy involves a significant fixed (implementation) cost which is only likely to be worthwhile if the stringent market is large relative to alternative markets.

[11] Environmental standards represent a significant area of study and in some cases serve as models for measuring the effects of regulation. This paper does not directly consider this large body of literature.

[12] For a summary of the literature that utilises these approaches to quantify standards, see Appendix 2.

[13] Aggregation across individual economic agents is a non-trivial exercise and typically can only be justified in the presence of quite restrictive assumptions about the nature of consumer and producer payoff functions.

in that product category or tariff line. While such comparisons shed some light on the *potential* trade impact of standards, they do not explicitly quantify it.

18. One attraction of frequency and coverage measures is their simplicity. Their main drawback, however, is the assumption that the greater the number of restrictions and the broader their application, the larger the likely restrictive impact on trade. In fact, standards are complex and impact different products in different ways. Standards related to health and food safety, for example, may have a significant impact on the behaviour of consumers and producers. Other standards may have little effect if consumers do not ascribe sufficient value to the product characteristics over which they are defined. There is little agreement in the literature on how to weight the importance of different standards in calculating an aggregate measure of their impact on trade. Moreover, as already discussed, standards, unlike most quantitative trade barriers, may encourage trade rather than restrict it by improving information flow to consumers. A simple aggregation does not account for the potential benefits of standards.

19. There are a number of other difficulties associated with implementing frequency and coverage measures. First, documents stipulating standards and other regulatory requirements may differ in information content and contain requirements relating to more than one standard. Hence, statistics based on the number of pages of national regulations are unlikely to provide a clear measure of the extent of regulation. Second, the quantity of regulation reveals little about the degree of enforcement of legislated standards. Without effective enforcement, standards are unlikely to meaningfully influence economic behaviour. A third difficulty relates to the calculation of the import coverage index. Deardorff and Stern (1997) argue that, for NTMs in general, this should be calculated using the total value or volume of imports once NTMs are removed. In practice, however, this information cannot be observed. Hence, the observed (and NTM-biased) value or volume of imports is typically used. In short, frequency and coverage measures are of limited use. Analysis of intended function, design, implementation and enforcement are at least as important in determining a standard's likely impact on trade (WTO, 2005).

20. Notwithstanding the above problems, data on the frequency and coverage of standards are the most widely used and readily available source of data on standards. These data can be readily obtained from a number of sources including individual industries or governments. Some of this data has been consolidated into multi-country databases such as PERINORM which covers standards in 23 developed and developing countries.[14] The Trade Restrictiveness Index used by the International Monetary Fund (IMF) and the World Bank is also constructed using frequency and coverage measures.[15] Under the WTO SPS and TBT agreements, member countries are encouraged to voluntarily report their import-relevant NTMs, including standards. All notifications to the WTO are recorded in the Trade Analysis and Information System (TRAINS) database of the United Nations Conference on Trade and Development (UNCTAD) by notifying country, product (HS code), and type of measure. Standards fall under the TRAINS category of technical measures. Currently the TRAINS database is the most comprehensive source of information about standards. By classifying standards in the same way as tariffs, by HS product code, the TRAINS database ensures that standards and trade data are classified consistently by all reporting countries. For independent researchers, this facilitates the matching process between particular standards and the product categories on which they are likely to have an impact.

[14] Note that PERINORM has limited coverage of agri-food products. Furthermore, it does not contain the full text of regulations, simply an abstract.

[15] For more detail on the theoretical underpinnings of the trade restrictiveness index, see for example Anderson, Bannister and Neary (1995) and Anderson and Neary (2003).

21. The main deficiency of the TRAINS data source is incomplete reporting.[16] Over one third of WTO members, particularly developing countries, do not report their standards. Note also that under the SPS and TBT agreements, only *changes* to existing measures have to be reported. Hence, measures that have existed for a long time but which have never been altered do not appear in the TRAINS database. Finally, TRAINS suffers from the fact that existing information on standards, and NTMs more generally, tends to be outdated.[17]

22. An additional and potentially rich source of data relating to standards is the documentation that records WTO complaint and dispute proceedings. Reflecting their wider use, standards are increasingly the subject of trade complaints. While concerns relating to SPS and TBT standards and regulations are typically dealt with by the SPS and TBT Committee of the WTO as complaints or "specific trade concerns" (STCs), more severe disagreements can be brought before the WTO dispute settlement body. OECD (2002) notes that 105 STCs were discussed by the WTO's SPS committee in the period 1995-2001. Similarly, OECD (2003) reports that a total of 63 STCs were considered by the WTO's TBT committee during the same time.

23. Few studies systematically apply frequency and import coverage measures to identify the potential trade impact of standards. Fontagné, von Kirchbach and Mimouni (2005) use NTM (including standards) notification data from the TRAINS database to calculate the import coverage index – the ratio of notifying country imports to total world imports – for groups of NTMs applied for different reasons.[18] NTMs applied for human health reasons potentially affect 24 percent of world trade. In order of declining import coverage index value, NTMs applied for animal health, plant health, human safety, wildlife and environmental reasons follow.

24. Fontagné, von Kirchbach and Mimouni (2005) also calculate the import coverage index for different types of environmentally-related NTMs. While product standards are the most widely used environmentally-related NTM, affecting trade in the most number of items, their import coverage index is lowest (17 percent). On the other hand, less frequently employed NTMs such as authorisation and technical measures related to testing, inspection and quarantine requirements potentially impact on 18 percent and 20 percent respectively of world trade in these products.

25. While the import coverage index sheds light on the potential trade impact of standards, and NTMs more generally, it reveals little about whether these standards are motivated by legitimate quality concerns or merely a desire to protect local producers. If many countries impose a similar standard, however, this may indicate a consensus on the risks associated with a particular product. Widely imposed standards are less likely to reflect protectionist intent. Fontagné, von Kirchbach and Mimouni (2005) calculate the import coverage index for NTMs of varying popularity. NTMs notified by five or less countries cover 16 percent of world agri-food trade: approximately 20 products. This is significantly higher than the import coverage index for the entire range of products (6 percent) suggesting that these NTMs may be designed to protect local agri-food producers.

[16] See OECD (2006c) for a detailed discussion of the TRAINS database including some of its deficiencies. Note that UNCTAD is seeking to improve the quality of the TRAINS database. The Eminent Persons Group on NTBs has produced an exhaustive classification of NTMs and has started collecting information on existing NTMs in a subset of countries.

[17] Data in TRAINS exist for NTMs such as standards through 2001, for those countries that have reported them. From 2002 onward, only data relating to anti-dumping measures have been recorded in TRAINS.

[18] For all studies, data, model specification and estimation details are presented in **Appendix 2**.

2.2 Ex post econometric estimation

26. Econometric models are often used to quantify the trade impact of standards and other NTMs. These usually take the form of gravity models in which bilateral trade is fundamentally explained by the distance between trade partners as well as their size. More recent approaches have sought to model the impact of standards on firms export decisions.

2.2.1 Gravity-based models

27. Gravity models exploit panel data to regress bilateral trade values (exports or imports) on a variety of explanatory variables including the GDPs of trade partners, the distance between them as well as some quantitative measure of standards.[19] The coefficient on the standards regressor quantifies its impact on bilateral trade.[20] Reflecting the literature's lack of agreement on the best way to measure standards, gravity model analyses employ a number of different approaches. Some studies try to capture the stringency of standards by incorporating frequency and coverage measures or explicit standards requirements such as maximum residue levels into the regression model. As discussed in the previous section, however, such measures can often involve an unsatisfactory trade-off between accuracy and simplicity. If no appropriate measure for a particular standard exists, dummy variables are often used instead to indicate whether or not a standard exists (e.g. Cao and Johnson, 2006 and Chevassus-Lozza et al., 2005). Such dummy variables provide little information on the extent of the standards at issue.[21] The choice of standards measure ultimately depends on data availability, -- the extent of commodity and country coverage and the types of products analysed.

28. When calculating the impact of standards on trade, implementation and enforcement matter. Countries implement and enforce standards differently, in part, because governments differ markedly in their institutional capacity to enforce legislated standards (Kim and Reinert, 2006). These country differences are (crudely) accounted for in gravity estimation by the inclusion of country fixed effects.

29. The stringency of standards can also be measured using either "input-oriented" or "output-oriented" measures (van Beers and van den Bergh, 1997). These measures have been adopted from the literature on environmental regulation, an area where much analytical work on standards has been undertaken. Input-oriented measures quantify efforts devoted to the achievement of a given standard, investments in pollution abatement and control, for example, or public expenditure on research and development into environmentally friendly technologies. Output-oriented measures, on the other hand, quantify the direct impact of regulation. They may include *inter alia* the results of laboratory testing of agri-food ingredients or the incidence of recalls or border detentions due to unsatisfactory compliance.

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[19] Tariffs and other trade policies are often omitted in gravity models of trade in part because detailed and reliable data is difficult to obtain. Country-specific fixed effects are usually employed to correct for the influence of trade policy, and all other country-specific factors, on bilateral trade. Notable exceptions in the NTM literature include Fontagné, Mimouni and Pasteels (2005) and Disdier, Fontagné, and Mimouni (2007) who explicitly account for trade policies and market access.

[20] Anderson and van Wincoop (2003) provide a theoretical foundation for the gravity model arguing for the inclusion of individual importing and exporting country fixed effect variables which capture the extent to which countries are resistant to trade with other countries. In the standards literature, this approach is employed by Disdier, Fontagné and Mimouni (2007). Chevassus-Lozza et al. (2005) seek to correct for so-called multilateral resistance by explicitly including prices in the gravity equation.

[21] Nevertheless, inclusion of such dummy variables might mitigate econometric problems such as estimation biases arising from omitted variables. The coefficients associated with such variables can also provide a useful initial estimate of the mean difference in trade due to the presence of standards.

30. Typical of the gravity specification, endogeneity is a significant problem regardless of the measure of standards used.[22] The direction of causality between trade and standards is unclear. For example, more trade may lead to higher national income resulting in consumer demand for tighter food quality standards. In theory, instrumental variable estimation can be used to mitigate endogeneity. In practice, however, finding suitable instruments – variables which explain the existence of the standard while at the same time not influencing bilateral trade in any way – is difficult.

[22] For a useful discussion of other model specification issues which arise in gravity models see, for example, Silva and Tenreyro (2006) and Baldwin (2006).

Box 3: Measuring the costs of complying with standards

The costs to firms of complying with standards can be measured using surveys, calculated or estimated. These approaches are based on detailed firm-level information. Compliance costs can also be measured using price-based methods which impute costs from price differences between compliant and non-compliant products.

Compliance costs add to a firm's usual production costs. They may arise because producers must change their production processes in order to satisfy the requirements of the standard. Complying with standards may reduce output and, hence, a producer's ability to exploit economies of scale; average production costs will rise. This is particularly the case when producers are faced with inconsistent standard requirements in different countries. Meeting the requirements of a standard involves opportunity costs for any investment undertaken. Any changes to production processes are also accompanied by non-trivial costs associated with risk and uncertainty. Measuring these additional costs is difficult and they are therefore often excluded.

Another difficulty is that compliance costs may differ amongst producers. The magnitude of compliance costs is likely to depend on firm level factors such as size, resources and technology applied. For example, results of a survey by OECD (1999) report that small firms in the dairy sector incur comparatively higher costs of complying with standards than large enterprises. For small firms, compliance costs may also represent a larger share of production costs. The different firm level factors influencing compliance costs have to be accounted for when measuring compliance costs.

Gravity model estimation using frequency and coverage measures

31. Gravity model analyses that use frequency and coverage measures of standards usually cover a wide range of products and subsume standards and technical regulations under the broad category of NTMs. Estimation results concentrate on the direction of the trade impact, that is, whether standards are trade-restricting or trade-promoting.

32. One recent study to adopt this approach is Moenius (2004) who examines the trade effect of country specific standards and bilaterally shared standards in 12 OECD countries over the period 1985-1995.[23] The panel data set covers 471 industries including the agri-food sector. He estimates a gravity model in which the value of bilateral trade is regressed on the number of bilaterally-shared and country-specific standards in the exporting and importing country.

33. Aggregating across industries, Moenius (2004) finds that trade significantly increases with the number of bilaterally shared standards. Country-specific (i.e. non-shared) standards implemented by the importing or exporting country are also trade-promoting on average. The latter result runs contrary to the commonly held belief that importer-specific standards imply additional adaptation costs and, hence, should hamper trade. Exporter-specific standards, meanwhile, are generally associated with trade promotion because they raise the comparative advantage of an industry. At the industry level, the only variation to the aggregate results is that importer-specific standards have the expected negative trade effect in non-manufacturing sectors such as agriculture. In manufacturing industries, however, the positive impact of importer-specific standards on trade is confirmed.

34. The intuition for these results is that importer standards provide information not just about product requirements but also consumer preferences in import markets. Thus, compliance costs associated

[23] Moenius (2006) analyses the trade effects of harmonised standards that are imposed by the EU as a group.

with importer standards may be more than offset by reduced information costs. Since agri-food products are relatively homogeneous, information requirements are comparatively low. Hence, lower information costs arising from importer standards are unlikely to be sufficient to compensate producers for compliance costs. It is not surprising, therefore, that importer standards tend to negatively impact agri-food trade.

35. Other studies that employ frequency and coverage measures within a gravity model framework include Fontagné, Mimouni and Pasteels (2005) and Disdier, Fontagné, and Mimouni (2007). Both studies correct for bilateral market access using information extracted from the Market Access Map (MAcMap). Unlike Moenius, therefore, these studies decompose the impact of trade barriers into distinct tariff and NTM effects. Both studies adopt a frequency index to measure the impact of NTMs on trade. These indices are constructed using the share of products within a particular product category for which the importing country has reported at least one SPS or TBT barrier. Information regarding the incidence and frequency of NTMs is extracted from the TRAINS database.

36. Fontagné, Mimouni and Pasteels (2005) collect data on 61 product groups, including agri-food products, and classify these as "sensitive products" (at least 40 countries have notified NTMs to the WTO), "suspicious products" (fewer than 11 notifying countries) and "remaining products" (11-39 notifying countries). The final category comprises a large share of processed agri-food products. In order to correct for the different levels of development of importing countries, they differentiate between least developed countries (LDCs), developing countries (DCs) and OECD countries.

37. Fontagné, Mimouni and Pasteels confirm the findings of Moenius (2004): NTMs, including standards, have a negative impact on agri-food trade but not on trade in other products. While no significant trade effects exist for "suspicious products", negative trade effects are observed for pork meat, cut flowers, vegetables and wheat/pastry in the group of "sensitive products" as well as for a variety of processed agri-food products (e.g. chocolate, beverages) in the group of "remaining products". Over the entire product range, LDCs, DCs and OECD countries seem to be equally affected. However, OECD agri-food exporters tend to benefit from NTMs, at the expense of exporters from DCs and LDCs. The authors also find that tariffs matter more than NTMs, particularly for agri-food products on which comparatively high tariffs are levied.

38. Disdier, Fontagné, and Mimouni (2007) restrict their analysis to the trade effect of standards and other NTMs on 690 agri-food products (HS 6-digit level). Their data covers bilateral trade between importing OECD countries and 114 exporting countries (OECD and others) in 2004, excluding intra-EU trade. As well as a frequency index, they use two alternative approaches to measure NTMs: (i) a dummy variable that records whether the importing country has notified at least one NTM and (ii) ad-valorem tariff equivalent measures of NTMs which use import demand elasticities to impute the price impact of NTMs.[24] For all three measures they find that the NTMs imposed by OECD countries have a negative impact on agri-food trade and affect trade more than other trade policy measures such as tariffs. The tariff equivalent shows the smallest effect.

39. Next, Disdier, Fontagné, and Mimouni differentiate between exports originating from LDC, DC and OECD countries and use the tariff equivalent as a measure for NTMs. They find that a 1 percent (tariff equivalent) increase in the restrictiveness of NTMs increases agri-food exports from OECD countries by about 0.16 percent but reduce exports from LDCs and DCs by approximately 0.23 percent. For the sub-sample of EU imports, NTMs no longer influence OECD exports positively. NTMs imposed by the EU reduce exports from other OECD countries by 0.14 percent and those from LDCs and DCs by 0.37 percent.

[24] See Kee et al. (2004) for details.

40. Finally, Disdier, Fontagné, and Mimouni analyse the effect of NTMs on trade in individual agri-food products. They estimate that NTMs have a negative influence on trade in cut flowers, processed food products (e.g. beverages) and meat, but a strong positive influence on trade in cereals, wool and albuminoids/starch.

Gravity model estimation using maximum residue levels

41. Many studies employ maximum residue levels to measure the stringency of standards within a gravity-type modeling framework.[25] These studies tend to focus on specific cases of standards for particular products and countries. Wilson and Otsuki (2004b) and Otsuki, Wilson and Sewadeh (2001a, b) analyse the trade impact of maximum residue levels for aflatoxin, a toxic fungus that typically contaminates cereals, spices and nuts. Wilson and Otsuki (2004c) analyse maximum residual levels relating to chlorpyrifos, a pesticide used in banana production to kill ants, mites and cockroaches. Wilson, Otsuki and Majumdsar (2003) analyse residue regulations on tetracycline, a widely used antibiotic to promote animal health and growth. Wilson and Otsuki (2004b) and Otsuki, Wilson and Sewadeh (2001a, b) examine the trade effect of aflatoxin standards in groundnuts and other agricultural products (vegetables, fruits and cereals). All three studies show that imports are greater when the importing country imposes less stringent aflatoxin standards on foreign products. Otsuki, Wilson and Sewadeh (2001b) also find an increasing impact of aflatoxin standards on groundnuts over time. They conclude that the rigour of standards enforcement at the border has increased.

42. The estimated coefficients of the effects of aflatoxin standards on trade are used to predict changes in trade flows resulting from changes in the maximum permitted levels of aflatoxin. Changes in trade flows are predicted under different levels of harmonization, e.g. worldwide harmonization towards Codex standards for aflatoxin (9 parts per billion) or towards the lower maximum level of aflatoxin allowed in the EU (2 parts per billion).[26] These are then compared to the status quo of maximum aflatoxin levels in 1995. If the maximum level of aflatoxin was equal to that permitted within the EU, for example, Otsuki, Wilson and Sewadeh (2001a) approximate a total loss of 400 million US dollars in cereals, fruits and nuts exports from African countries. In contrast, trade in these products would increase by almost 700 million US dollars if the EU imposed less stringent aflatoxin standards than those prescribed by Codex.

43. Similarly, Wilson, Otsuki and Majumdsar (2003) analyse the effect of standards for tetracycline residues on beef trade. Independent of the various maximum residue levels of tetracycline, they consider that standards imposed by importing countries restrict trade only if the importer standard is stricter than the standard prevailing in the exporting countries. In order to account for exporter standards exceeding the standards requirements of importing countries, they introduce an additional dummy variable. Results show that regardless of the exporter standards, the standards of tetracycline imposed by the importing countries have the same negative trade impact on beef trade.

2.2.2 Other econometric approaches

44. In addition to gravity models, other approaches are based on recent insights into the link between trade costs, export quality and variety (Hummels and Skiba, 2004) and firm heterogeneity (Melitz, 2003). These approaches tend to evaluate standards from the point of view of a firm deciding whether or not to export to a particular market (and, therefore, comply with its standards). If standards differ across

[25] Metha and Nambiar (2005) define an index of maximum residue levels over a number of contaminants.

[26] The Codex Alimentarius refers to food standards, guidelines and codes of practice recommended under the Joint FAO/WHO Food Standards Programme. Codex standards are negotiated internationally, providing a benchmark for government and private standards. The Codex aims to protect consumer health and promote the international coordination of agri-food standards, thereby facilitating agri-food trade.

importing countries, producers must satisfy several different and, perhaps, inconsistent import regulations. The additional production costs this implies impact on a firm's export decision.

45. Chen, Otsuki and Wilson (2006) econometrically estimate the trade effect of standards from the point of view of individual exporters. Their empirical analysis relies on firm level data on standards provided by the World Bank Technical Barrier to Trade Survey. The database contains information of 619 firms in 25 industries including the agri-food sector in 17 developing and transition countries. Since the main export destinations of the 619 firms are the EU, US, Canada, Japan and Australia, the authors focus on the import requirements imposed by these countries.

46. Chen et al. (2006) investigate how, for individual firms, the share of exports in total sales is influenced by: the existence of standards, whether a testing procedure is employed, inspection time, labelling requirements and the ease with which exporters can access information about the standard. Correcting for firm characteristics and bilateral trade policies (e.g. regional trade agreements), either of which might influence a firm's export decision, it is shown that exporter access to information has the greatest impact reducing the average firm's export share by 18 percent. Exporting firms subjected to testing procedures and lengthy inspections export, respectively, 9 percent and 5 percent less than other firms. Moreover, access to information about standards requirements is relatively more important for exporters of manufactures than agri-food products. In contrast, testing procedures and lengthy inspections have a stronger negative impact on the export share of agri-food producers. Finally, standards and labelling requirements have an insignificant impact on firm exports – increased production costs for producers are offset by lower information costs for consumers.

2.2.3 Econometric estimation – outstanding issues

47. A paucity of data has constrained the econometric analysis of the trade effects of standards. Panel data incorporating information on standards are difficult to obtain. Existing studies, therefore, have mostly relied on cross-section data. That is, existing work tends to only capture variation across products, not variation within products over time. Ideally, estimation should capture both forms of variation. Moenius (2004, 2006) tries to do this using a ten-year panel which includes frequency data on standards. Metha and Nambiar (2005) account for changing maximum residue levels over only four years.

48. In most empirical work, the impact of standards on trade is determined at a point in time. The dynamic response of producers to changes in standards is not modelled. For example, an exporter's ability to adjust to regulatory changes over time, or decisions to cease exporting as a result of increased compliance costs, is not estimated. This is largely a reflection of the lack of time series data on standards.

49. Satisfying the requirements of a standard involves both fixed and variable compliance costs (Chen, Otsuki and Wilson, 2006) that influence a producer's decision about whether or not to export to a particular market. Differences in production structure mean that some firms can more easily comply with standards than others. Moreover, the fixed costs of compliance imply that producers can exploit economies of scale in standards compliance, expanding their exports over time even after the introduction of stricter regulation.[27] This may mitigate and eventually reverse any negative relationship between standards and trade. By neglecting dynamics, therefore, existing work tends to overestimate the negative trade impact of standards on trade in agri-food products.

50. Standards can hamper trade but may at the same time be beneficial for consumers and/or society as a whole. These welfare effects of standards are not taken into account in econometric models. One reason is that the data generally do not capture the underlying motivation of standards. Another reason

[27] See **Box 3** for a discussion of measurement of compliance costs.

relates to the structure of the estimated regression models which, as a rule, do not differentiate between supply and demand responses to standards in either the exporting or importing country. The potential welfare impact of standards on consumers and producers is, therefore, indeterminate.

2.3 Standards as tariff equivalents

51. All NTMs restrict imports either directly by prohibition (as with a quota, for example) or indirectly by raising the transactions costs of trade. *Ceteris paribus*, this raises domestic prices in the importing country relative to world prices creating a price "wedge" similar to that which arises when an import tariff is imposed. One way to measure the impact of a standard, therefore, is to calculate the size of this price wedge. Correcting for other possible reasons (i.e. unrelated to the NTM) for this price difference, such as transport and distribution costs or perceived quality differences, it may be possible to determine the "equivalent" (*ad valorem* or specific) tariff rate that reproduces both the restricted import level and the higher domestic price induced by the standard.[28] Apart from providing an intuitive (i.e. price-based) measure of the trade impact of a standard, tariff equivalents also facilitate comparison of heterogeneous standards imposed by different countries.[29] Under perfect competition, there exists an equivalent tariff for every quota. This is the theoretical motivation for the tariff equivalents approach to quantifying the impact of NTMs such as standards. It has been proven, however, that this premise breaks down under imperfect competition (Bhagwati, 1965; Harris, 1985; Krishna, 1989) or when firms can select both the quantity and quality of output (Alchian and Allen, 1964; Hummels and Skiba, 2004).[30] That is, a tariff rate may not exist that reproduces both the higher domestic price and the lower import level induced by the quota.

52. While perfect competition may approximate the market structure of some agri-food industries, the existence of standards strongly suggests that producers are in a position to select the quality, not just the quantity, they produce. In agri-food markets characterised by significant product differentiation (e.g. processed foods), therefore, calculating tariff equivalents for standards may prove difficult.

53. The notion of a tariff equivalent is illustrated in Figure 2 for a simple two-country model in which the importing country can influence world prices. The free trade equilibrium occurs where the excess supply curve, *ES*, of the exporting country and the excess demand curve, *ED*, of the importing country intersect; quantity Q_1 is traded at price P_1. If the importing country imposes a standard that results in compliance costs, *c*, for foreign producers, the *ES* curve shifts upwards from ES_1 to $ES_2 = ES_1 + c$. The compliance costs constitute a price wedge between domestic and foreign prices P_2^d and P_2^f respectively. The tariff-equivalent of this standard is the (specific) tariff $P_2^d - P_2^f$ which results in a quantity trade of Q_2.[31] Note that the elasticities of demand and supply influence the size of the tariff equivalent. Moreover, Deardorff and Stern (1998) argue that the correct measure of the tariff equivalent is, in fact, $P_2^d - P_1$. However, P_1, the price in the absence of the standard, is typically not observed.

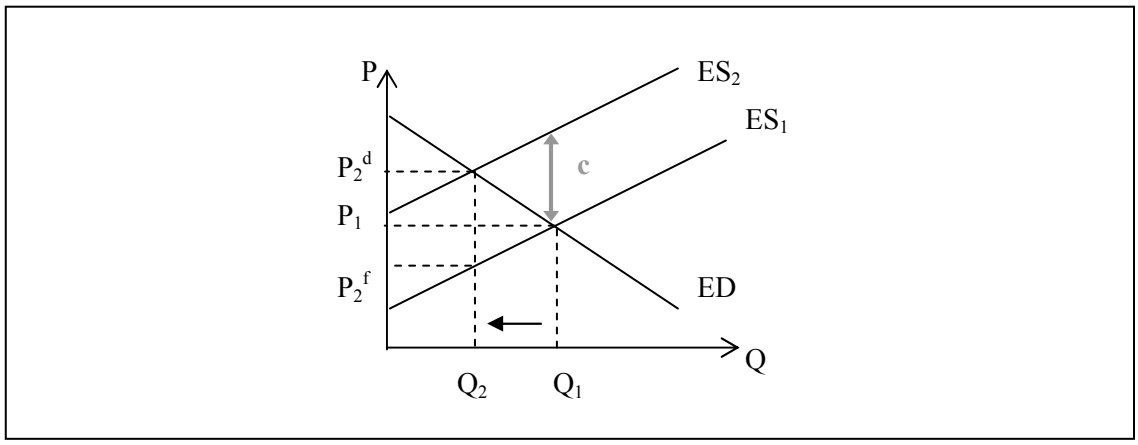
[28] The magnitude of the tariff equivalent reflects the compliance costs of the standard and can be obtained by price-based measurement methods, e.g. the handicraft price gap method.

[29] Tariff equivalent calculations typically assume that standards are imposed only on foreign products. This implies either that domestic firms already meet the standard or that the regulator is unable to enforce standards domestically while being able to control them at the border.

[30] In the case of imperfect competition, this occurs because, by restricting imports, the quota "shelters" domestic firms from foreign competition – domestic prices are higher than they would be under a tariff associated with an identical import level. When firms can choose quality as well as quantity, tariff equivalence can break down because a quota encourages consumers to demand, and producers to produce, higher-quality varieties.

[31] The ad valorem tariff equivalent can be written as $(1+t)\, P_2^f = P_2^d$ or, equivalently, $t = (P_2^d / P_2^f) - 1$.

Figure 2: Quantifying the trade effect of standards by tariff equivalents



54. This analysis demonstrates that, abstracting from informational and quality benefits as well as implementation and enforcement costs, standards induce price changes similar to those of tariffs. A small country suffers a dead-weight loss from the imposition of standards because domestic prices rise, imports are curtailed and world prices do not change. This dead-weight loss is greater than under an equivalent tariff because standards generally do not raise revenue for the government. A large country, on the other hand, can gain from the imposition of standards. By raising domestic prices, domestic (and world) demand fall; a large country's standards can shift the terms-of-trade in its favour. This can be seen in Figure 2 where the world price falls from P_1 under free trade to P_2^f after standards are introduced.[32] Finally, note that as OECD (2006c) argues, standards and NTMs more generally can be applied at different stages of the supply chain. Hence, they may, for example, be expressed as excise tax and export subsidy equivalents rather than simply tariff equivalents. Moreover, a single product may be subject to multiple standards in its journey from the producer to the final consumer. The calculation of a single tariff equivalent captures the aggregate impact of all these applied standards. The "handicraft" price-wedge method discussed by OECD (2006c) allows the impact of NTMs such as standards to be calculated by comparing the price of a chosen product at each stage of its production process. The individual impacts of these standards should add up to the aggregate tariff equivalent.

Calculating tariff equivalents: the case of US apple exports to Japan

55. In order to prevent transmission of fire blight – a bacterial disease that affects apple trees – a number of countries have imposed SPS standards that comprise a buffer zone, special treatment of at-risk horticultural products and regular inspections. In this section, we discuss how a number of studies have sought to calculate tariff equivalents on SPS measures applied by Japan to US apple imports.[33]

56. Krissoff, Calvin and Gray (1997) quantify the trade effects of SPS standards on fire blight by simulating the removal of SPS requirements on exports of US apples to Japan, South Korea and Mexico. To do this, they obtain estimates of *ad valorem* tariff equivalents for the SPS requirements within a partial equilibrium model. They show that these standards considerably restricted US apple exports in 1994/95 and 1995/96. If all importing countries lifted their SPS regulations relating to fire blight, the value of US

[32] Ganslandt and Markusen (2001) show, therefore, that small countries cannot generally win a "standards war". Being small, they cannot influence the terms of trade in their favour

[33] For an overview of the studies discussed in this section, see **Appendix 2**.

apple exports would have increased by 23 percent in 1994/95 and 14 percent in 1995/96; an increase of $97 and $53 million respectively.

57. Calvin and Krissoff (1998) attempt to capture the trade impact of standards by taking into account the possibility of an infestation of fire blight in the US Using a partial equilibrium model, they focus on US apple exports to Japan during 1994-1997. They calculate the tariff equivalent of SPS requirements to be 27 percent. The removal of these regulations leads to a short run increase in apple imports from the US of approximately $40 million which represents about 9 percent of 1996/97 US apple production.[34] The long run impact of eliminating the SPS requirements is more pronounced, amounting to approximately $150 million or 35 percent of total 1996/97 US apple production.

58. Yue, Begin and Jensen (2006) identify four potential sources for differences in domestic and foreign prices: tariffs, NTMs, quality differences and marketing costs. They develop a methodology for apportioning observed price differences among these four sources. A partial equilibrium model is defined and simulated in which consumer preferences are defined over domestically-produced and imported apples. Domestic (here, Japanese) consumers are assumed to have an inherent preference for home-produced apples. The consumption of these, therefore, is weighted more heavily in the utility function of domestic consumers. The simulation model is parameterised using estimates of this weight and the elasticity of substitution between local and foreign apples. Two scenarios are examined: one where fire blight is not transmitted to Japan and one where it is.

59. For different degrees of domestic preference and values for the elasticity of substitution, Yue, Begin and Jensen (2006) calculate the *ad valorem* tariff equivalent for the SPS requirements for US apples. As the degree of domestic preference falls due to, say, smaller quality differences between US and Japanese apples, the tariff equivalent rises. Intuitively, US apple exports become less sensitive to Japanese SPS requirements as Japanese consumer tastes become more biased towards local production. On the other hand, as the elasticity of substitution falls, the tariff equivalent rises. This is because, as preferences become more inelastic, consumers maintain purchases of their preferred apple regardless of changes in the relative price of local and imported produce.

60. For the year 2000, elimination of SPS requirements, assuming that fire blight is not transmitted, results in an increase in the value of US apple exports into Japan of between $1.8 million and $60 million depending on the degree of domestic preference and the elasticity of substitution between US and Japanese apples. As the degree of domestic preference declines, eliminating SPS measures raises the value of US imports by more (the tariff equivalent was higher). Similarly, as the elasticity of substitution declines, removing SPS measures also encourages US exports to rise further (again, the tariff equivalent rises).

61. In concluding this discussion, it should be emphasised that the estimation of tariff equivalents is problematic when standards are prohibitive. This is because, in such cases, bilateral trade flows are not observed. Using Wales and Woodland's (1983) approach to estimating corner solutions in consumer choice, Yue and Beghin (2008) calculate the tariff equivalent of prohibitive Australian SPS regulations applied to New Zealand apples. They estimate the foregone value of annual bilateral trade in apples at up to US$40 million.

2.4 Modelling the impact of standards by supply and demand shifts

62. As discussed in the previous section, the main reason for calculating a tariff equivalent is to measure the trade, not welfare, impact of an NTM. Consequently, when calculating tariff equivalents, standards tend to be represented as pure trade costs. Any impact on the demand and supply curves of

[34] Demand and supply elasticities are assumed to be lower in the short run than the long run.

exporting and importing countries, arising from the imposition of the standard, is not explicitly modelled as part of the tariff equivalent calculation. In fact, standards do influence production decisions at the firm level. Moreover, such regulation tends to raise product quality and reduce asymmetric information. It is reasonable, therefore, to expect changes in the nature of consumer demand and producer supply. This section analyses how the implementation of a standards regime can influence the welfare of consumers and producers in the importing and exporting country.

63. Compliance with standards can influence production in a number of ways. First, in satisfying regulatory requirements, firms invariably incur additional production costs (e.g. labelling, testing, certification etc.). Second, firms may be compelled to adopt new production techniques for environmental or health and safety reasons. Standards can alter input requirements; implementing the Hazard Analysis Critical Control Point (HACCP) system, for example, involves substantial additional labour for documenting the production process in detail. On the other hand, adherence to standards may reduce a firm's marginal costs of production by encouraging it to upgrade its facilities. In short, standards have the potential to impact firm supply curves in both importing and exporting countries. They may lead a firm to increase or decrease quantity supplied at any given price (i.e. shift the firm's supply curve to the right or left).

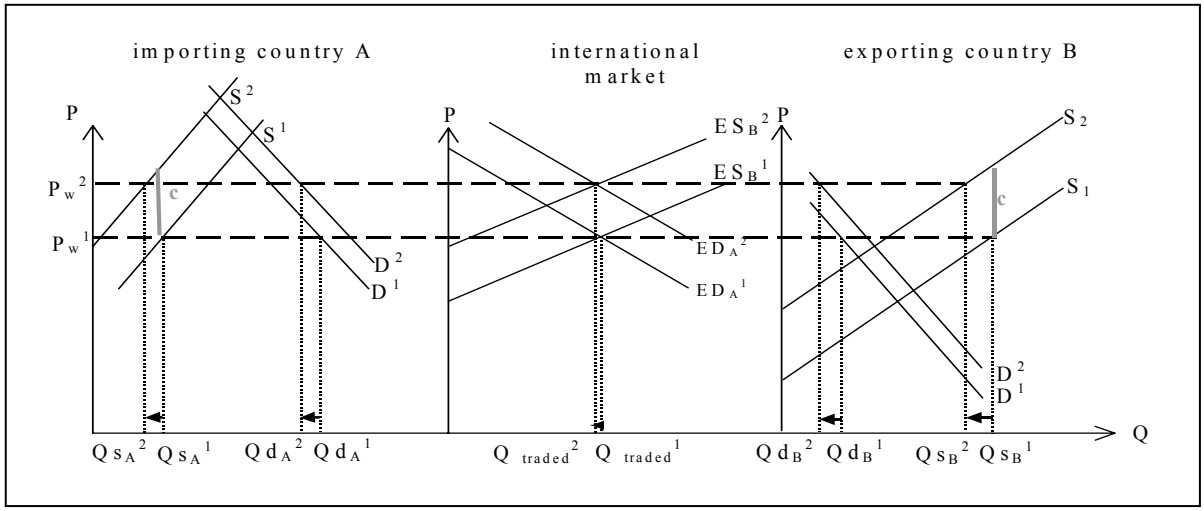
64. Compliance with standards also alters the nature of consumer demand. As already discussed, standards are motivated, in part at least, by a desire to improve product quality and the distribution of information between buyers and sellers. To the extent that the introduction of a standards regime achieves these goals, consumers should be willing *ex post* to consume more at any given price than they were *ex ante*. Equivalently, if consumers gain greater utility from consuming high-quality (i.e. compliant) products, they will be willing to pay higher prices for these. The introduction of standards, therefore, is likely to shift consumer demand curves (usually to the right). The likely magnitude of this shift is difficult to model as it requires the explicit inclusion of quality into the specification of consumer preferences. One simplistic approach would involve the inclusion of an exogenous quality parameter in consumer preferences which ensures that consuming a certain amount of one (high-quality) good provides a greater utility benefit than the consumption of an identical amount of another (low-quality) product. Ideally, however, product quality should be determined endogenously. The Dixit-Stiglitz approach to modelling consumer demand for product variety can provide the basis for modelling consumers' demand for products of different quality.

65. Figure 3 illustrates the possible impact of standards on supply and demand in a world with one importing country (A) and one exporting country (B). Under free trade the world price is P_w^1. Country A imports $Q^d_A{}^1 - Q^s_A{}^1$. Country B exports $Q^s_B{}^1 - Q^d_B{}^1$. Now say that Country A introduces a standard to which both domestic products and imports must adhere. The supply curves in Country A and Country B shift upwards by the cost of compliance.[35] At the same time, the demand curve shifts right in the importing country as consumers are now willing to pay more for certified products.

66. In Figure 3, the magnitude of the supply shift exceeds that of the demand shift in each country. The imposition of standards leads Country A's excess demand curve and Country B's excess supply curve to shift upwards from ED_A^1 to ED_A^2 and from ES_B^1 to ES_B^2 respectively. As the costs of production increase "globally", the world price also rises; quantities demanded in both countries decrease. The increase in world price is, *ceteris paribus*, larger than it would be if only the supply curve were to shift.

[35] For simplicity of exposition assume that producers in both countries face the same compliance costs.

Figure 3: Standards as shifting demand, world market



67. The preceding analysis gives rise to three important conclusions regarding the quantification of standards and, more generally, NTMs. First, the calculation of tariff equivalents is entirely consistent with an approach that explicitly models the impact of standards on demand and supply. (Note that it is possible to impute the tariff equivalent for Country A's standard regime from Figure 3). Second, shifts in the excess supply and excess demand curves of trading countries are explicitly decomposed into supply and demand shifts at the level of individual firms and consumers in each country.[36] Contrary to how the tariff equivalents approach is typically applied, the central focus of demand and supply shift analysis is to undertake an explicit welfare analysis of standards. Third, an attractive feature of this approach is its versatility. It can be used to model discriminatory and non-discriminatory standards alike (the supply curve only shifts in the targeted country).

68. Supply and demand shift models allow for more complete modelling of the effects of standards. Standards defined over a product's process-attributes can be explicitly modelled via their impact on an individual firm's production function. Standards defined over a product's content-attributes can be explicitly modelled via their impact on an individual consumer's utility function. The demand and supply approach also permits the analysis of standards which address externalities of production and consumption that have national consequences. For example, standards that aim to reduce local environmental pollution would only shift upwards the supply curve of firms in the regulating country.

69. Despite the advantages of explicit demand and supply analysis, some drawbacks remain. Merely shifting demand and supply curves is problematic because it does not allow for the possibility that standards alter the elasticities of demand and supply. Moreover, a standard may change the extent to which products are complementary to, or substitutes for, one another. The demand and supply analysis described in this section also implicitly assumes that all units of a product are homogeneous. That is, it cannot capture changes in the mixture of product varieties consumed and produced. Shifting supply curves also implies that the mandated standard impacts on the producing firm's entire output. In fact, exporters are

[36] Changes in the slopes of the demand and supply curves may also change if compliance alters supply and demand elasticities. The adoption of a more efficient production technique may permit a firm to more readily vary production in response to changes in price. If a standard increases average product quality, it may give consumers the confidence to consume not only more, but also more readily, at each price.

usually only required to satisfy the standard with respect to those units of output slated for export. However, in practice they often change their production processes used for their entire output.

70. Lusk and Anderson (2003) apply supply and demand shift analysis to determine the welfare impact of standards. They investigate the impact of country-of-origin labeling (COOL) on meat producers and consumers by simulating a (partial) equilibrium displacement model that links consumption in the beef, pork and poultry industries. The poultry market is included because it is exempt from COOL requirements. Meat production is assumed to involve farm and marketing inputs. Lusk and Anderson (2003) assume that the only impact of COOL is to shift the demand and supply curves of each industry. The own-price and cross-price elasticities of demand are exogenously fixed. The production elasticities of substitution between farm and marketing inputs, as well as the own-price supply elasticities of each type of meat production are also calibrated to exogenous data sources.

71. The main contribution of Lusk and Anderson (2003) is to show that the welfare impacts of COOL will vary significantly depending on how the standard is implemented. In particular, if implementation costs are concentrated on marketers, consumers will suffer a disproportionately large welfare decline (as prices rise), while meat producers will be only slightly impacted. On the other hand, if COOL is implemented in such a way that increased costs are borne mostly by producers, both meat producers and consumers will suffer a significant negative welfare impact (higher costs for producers and higher prices for consumers). Not surprisingly, poultry producers (who are exempt from COOL) will almost certainly benefit as consumers respond to higher beef and pork prices by consuming poultry instead.

72. Peterson and Orden (2006) model supply and demand shifts arising from changes to the SPS standards regime applied to the import of Mexican Haas avocados into the US. This study demonstrates the power of the demand and supply shift approach in two ways. First, it shows how this approach can deal with multiple and quite complicated changes in standards regimes. Second, it demonstrates that this approach can be used to calculate welfare impacts, not just on the importing country applying the standards, but also on foreign producers.

73. In the case of Mexican avocado imports into the US, a virtual total import ban was replaced by seasonal and geographic constraints which were progressively relaxed between 1993 and 2004. In 1993, these constraints were augmented with a system of risk management production procedures with which Mexican avocado producers had to comply in order to export to the US. By 1997, while avocadoes were permitted entry to 19 US states, they could only be imported during February-March each year. In 2001, imports of Mexican avocados were permitted into a further 12 states and the seasonal restriction was relaxed to allow imports between October and April each year. In 2004, all geographic and seasonal constraints were effectively removed with only the compliance procedures on Mexican producers maintained.

74. Using a static partial equilibrium model, Peterson and Orden consider three possible standards regimes and estimate the welfare impact of each. The net welfare gain to the US arising from the 2004 reform is calculated at $72 million – the result of US consumers facing lower prices and consuming more. In addition, compliance costs for Mexican producers are estimated to decline by half as a result of the opening up of the US market. While they must still demonstrate compliance with certain risk management production procedures, their per-unit compliance costs are lower overall as a result of their increased exports to the US.

75. If the removal of geographic and seasonal constraints is accompanied by the removal of those compliance procedures on Mexican producers relating to fruit-fly infestations, then US welfare improves by *an additional* $1.7 million. This is because compliance costs for Mexican producers fall by an estimated

20%, allowing them to export more to the US at a lower price. While US consumers gain from this, US producers face an increased (100 times greater) risk of pest infestation.

76. Finally, Peterson and Orden (2006) consider the case where, in addition to the removal of geographic and seasonal constraints, all risk management production procedures in Mexico are also eliminated. The net welfare outcome for the US in this case depends on the assumed level of risk of pest infestation. A high level of risk can lead to a lower net welfare gain to the US of up to $16 million compared to the other scenarios considered. Assuming an average level of risk, however, the net welfare gain to the US will be greater than $80 million. Increased consumer benefits (low prices, higher import volumes) outweigh the increased costs faced by US producers in the face of an increased risk of pest infestation (producer surplus declines by $5.2 million).

77. Studies by Yue, Beghin and Jensen (2006) and Calvin and Krissoff (1998) on US apple exports to Japan demonstrate how estimates of the tariff equivalent can be combined with demand and supply shift analysis to obtain estimates of the welfare impact of standards. Yue, Beghin and Jensen (2006) find that if fire blight is not transmitted the removal of SPS requirements results in higher Japanese welfare irrespective of the degree of domestic preference or the elasticity of substitution. The lost producer surplus from lower domestic prices is more than offset by the increase in consumer surplus resulting from lower domestic apple prices and higher imports. Moreover, as the degree of home bias in consumption and the elasticity of substitution decrease, Japan gains more. In the case where fire blight is transmitted, Japan suffers a net welfare loss from the elimination of regulation on apple imports. This reflects the production loss due to the disease which swamps any welfare gains arising from the removal of the SPS requirements.

78. Calvin and Krissoff (1998) find that eliminating SPS requirements on apple imports leaves Japanese producers worse off as imports increase; producer surplus declines by about 30 percent. In total, however, the net welfare impact on Japan is positive since consumers gain relatively more and tariff revenue increases with imports.[37] They also account for a potential import of fire blight into Japan. In the absence of SPS requirements, a local outbreak of fire blight reduces Japanese apple production. The supply curve for Japanese apples shifts upwards and imports rise. Depending on the magnitude of the production decrease, the net welfare change from removing the Japanese SPS requirements need not to be positive. In particular, a 26 percent reduction of Japanese apple production would exactly offset any gains from trade that arise from the elimination of SPS requirements.

2.5 The impact of standards on market segmentation

79. The demand and supply shift approach described in the previous section implicitly assumes that standards raise the quality of all products to the required level – non-compliant products are not offered for sale. Even with mandatory technical regulations or standards, however, products are unlikely to be homogeneous. In the case of minimum standards, for example, producers may seek to differentiate their products from those of their competitors by meeting an even more stringent standard than required by regulation. If standards take the form of labelling requirements, products of different quality are explicitly permitted to be offered for sale side-by-side.

80. Product heterogeneity in the presence of standards is important for a number of reasons. First, the introduction of a standard may alter economic behaviour, providing consumers and producers with a choice over product quality which may not have existed previously. This additional dimension of consumer and producer choice must be modeled. Second, accurate welfare analysis is problematic because the

[37] Note that US apple imports into Japan are subject to a tariff in addition to the SPS standards described here. The tariff equivalent calculated by Calvin and Krissoff (1998) relates to the SPS standards only. To obtain the total tariff burden on U.S apple producers, the actual tariff must be added to the calculated tariff equivalent.

introduction of a standard (a mandatory labeling requirement for example) fundamentally changes the nature of market equilibrium. Regulation may transform a perfectly competitive, homogeneous good market *ex ante*, into an imperfectly competitive, differentiated products market *ex post*. In this way, welfare is defined over different product sets *ex ante* and *ex post*. These sets are likely to only partially intersect (if, indeed, they do at all).

81. A third reason why product heterogeneity is important in the presence of standards is that elasticities of demand and supply, particularly cross-price elasticities, become important. In other words, the introduction of standards can also influence the *composition* of demand and supply. Provided compliance can be independently verified, standards can alter consumption elasticities of substitution (and, hence, cross-price elasticities) between compliant and non-compliant products. If standards are origin-specific, they can alter the degree of substitutability between imported and locally-produced goods.

82. Alchian and Allen (1964) demonstrate that any per-unit transaction cost (a standard, for example) can affect the composition of demand and supply. They construct a model in which firms choose both the quality and quantity of their output and consumers demand variety. It is found that per-unit transactions costs may encourage firms to produce higher-quality output. This occurs because the additional cost, by constraining the producer's profit maximising output choice, effectively imposes an additional production cost upon them. To recoup this cost, firms produce higher-quality (and, therefore, higher-priced) varieties. Standards may also encourage consumers to switch their demand to higher-quality varieties that represent better value (i.e. have a lower price-per-unit-quality). Hummels and Skiba (2004) extend this theoretical result to a trade context and test it empirically. They find that increasing transport costs results in firms exporting higher quality goods. This implies that other increases in costs of export, like compliance costs with regulation in importing countries, are also likely to result in the export of higher quality goods. On the other hand, a rise in import tariffs reduces the quality of products exported.

83. Baller (2006) employs Melitz's (2003) heterogeneous firm approach to investigate the impact on trade of TBT liberalisation. In this study, TBT liberalisation takes the form of harmonisation and mutual recognition agreements (MRAs) for testing procedures in the telecoms and medical devices industries. While this work is not focussed on the agri-food sector, it is included here to demonstrate how the heterogeneous firm technique can be applied to explain the impact of standards in the most recent literature.

84. The Melitz (2003) model helps explain why many pairs of countries do not trade at all, while the volume of trade among other pairs varies considerably. Melitz points out that the volume of trade is determined both by the volume of exports of individual firms (the so-called "intensive margin") and the number of firms actually exporting (the "extensive margin"). If firms have different productivities but face the same set-up costs associated with producing a new variety, only some of them – the most productive – will produce at all. Further, if firms face market entry costs, such as costs associated with complying with foreign standards, only the most productive firms will be willing to produce for export.

85. Employing a two-stage gravity model estimation procedure, Baller (2006) finds that MRAs have a positive impact on a firm's decision about whether or not to export as well as on its decision about how much to export. The evidence for harmonisation is less clear – the impact of harmonisation on trade in telecoms equipment and medical devices is often insignificant and of variable sign. These results seem to suggest that standards and associated testing procedures represent mostly a fixed rather than variable cost for OECD firms.

86. The industries studies by Baller (2006) are characterised by very large fixed costs. To the extent that agri-food industries are characterised by a relatively greater variable cost component, we might expect

that MRAs will have a smaller impact on agri-food firms' decisions to export but a larger impact on their decisions about how much to export.

3. Matching quantification strategy to standard type

87. All standards have an impact on trade between countries and on the welfare of economic agents within countries. Hence, the choice of measurement strategy depends on (i) whether the analytical focus is on the trade or welfare impact of the standard and (ii) data availability. In **Section 2** it was argued that methods for quantifying the impact of standards can be grouped into two broad categories: *ex post* econometric analyses that estimate the impact of standards on trade and *ex ante* simulations that determine the impact of standards on consumer and producer welfare. This section evaluates the quantification strategies discussed in **Section 2** in order to determine which is the most appropriate for modelling the impact of different types of standards. The most suitable quantification technique is the one which, given the analytical focus, yields the most accurate measure of a standard's impact.

88. If the focus of analysis is on a standard's trade impact, then the most direct approach to quantification involves estimating an *ex post* econometric model of bilateral trade (usually, but not necessarily, a gravity model). Such a model can be augmented with data measuring the stringency of the standard; frequency and coverage measures or explicit standards requirements such as maximum residue levels are commonly used. The availability of highly disaggregated, high-volume bilateral trade data improves the accuracy of estimation and should, in part, help to mitigate inevitable model misspecification.

89. If the focus of analysis is on the (indirectly observable) welfare effects of a standard, then one must explicitly model consumer and producer choice. This usually involves simulating an *ex ante* partial or general equilibrium model involving one or more countries and industries. The nature of firm production and consumer preferences are explicitly modelled. Parameters such as the own and cross-price elasticities of demand and supply are calibrated to existing empirical work. An estimate of the "tariff equivalent" of the standard may also be included. The results of such simulations are typically sensitive to changes in assumed parameter values and functional forms. Nevertheless, they facilitate analysis of how consumers react to changes in equilibrium prices induced by the imposition of a standard. It is, therefore, the comparative statics of these models, rather than the equilibrium values of endogenous variables, which are of most value to the policymaker.[38] Note that, in this context, an *ex post* analysis of how economic agents respond to changes in prices is usually impractical. Accurate historical price data for individual products is difficult to collect on an international basis.

90. Two features of a standard drive its impact on trade and welfare: its level and its design. The level of a standard measures the *degree* of regulation and provides a direct measure of its likely impact. The design of a standard provides an indirect measure of its likely impact by indicating which economic agents are likely to alter their behaviour in response to the standard and how they are likely to alter it. For simple standards defined over a product's content-attributes, maximum residue levels for example, the level of the standard is likely to largely determine its impact. In such cases, this impact can be estimated by using frequency and coverage measures alone or, preferably, in conjunction with *ex post* econometric models of bilateral trade. For more complex standards, such as those defined over a product's process-attributes, the design may be as important as the level, if not more so. This is because such standards impact directly on a firm's production process. The standard's design, therefore, influences the firm's response. To measure the impact of such complex standards, the design of the standard should ideally be explicitly modelled. *Ex ante* simulation methods such as those discussed in **Section 2** are most suited to this task.

[38] Comparative statics refers to the change in the equilibrium value of an endogenous variable that arises when a shock to an exogenous model parameter instigates a shift to a new equilibrium.

91. Discriminatory standards that are applied on an origin-specific basis alter relative prices potentially distorting consumption and production decisions. For example, standards applied to units imported from a particular country may encourage consumers to instead demand cheaper units produced elsewhere. Producers seeking to avoid the costs of compliance may locate their firms in countries whose exports are not subject to the standard. While an *ex post* empirical analysis can estimate the impact of a discriminatory standard on trade patterns and volumes, *ex ante* simulation is required to show how the costs and benefits of regulation are distributed among consumers and producers in different countries.

92. Since non-discriminatory standards apply equally to all products regardless of origin, the (relative) prices at which international trade takes place may not change significantly; the impact on trade patterns will be minimal. If such cases, *ex post* analyses of trade data may conclude that non-discriminatory standards have an insignificant impact. Nevertheless, the introduction of such standards can have significant welfare implications for consumers and producers in affected countries. In particular, the increase in quality implied by the introduction of the standard may (or may not) be sufficient to compensate agents for the compliance costs of the standard. *Ex ante* simulation analyses are best suited to address such welfare issues which depend upon the nature of consumer preferences and the extent to which increased production costs associated with the standard can be passed on to consumers. The latter is a function of the degree of competition among producers as well as the elasticity of demand.

93. The degree of heterogeneity in product markets should also influence the choice of standard quantification technique. The bilateral trade data used to estimate the impact of standards on trade typically does not account for heterogeneity within product categories. The greater the degree of product differentiation that characterises a given industry, therefore, the less accurate *ex post* empirical analyses using bilateral trade data are likely to be. Moreover, as the degree of product heterogeneity increases, the role of consumer preferences over different product varieties assumes greater importance in welfare analysis. *Ex ante* simulation analyses which incorporate calibrated estimates of own and cross-price demand and supply elasticities are uniquely suited to determining the welfare impact of standards applied to monopolistically competitive industries. Simulation models which explicitly model the market segmentation effects of standards are also useful in this context as they can assist in measuring any costs or benefits of product variety which accrue to consumers.

4. Summary and concluding remarks

94. This paper has discussed the different methods that have been used to quantify the impact of product standards on trade and welfare. Attention was focused on government mandated standards (i.e. technical regulations) applied in the food and agriculture sectors. These regulations are usually defined over the content and/or process attributes of products. While standards may be restrictive, they can also facilitate trade by revealing information about product quality to consumers.

95. Standards are motivated by two basic economic goals. First, they can be used to encourage trade in products which confer positive externalities on society. On the other hand, they can also be employed to discourage production and consumption of products which have negative externalities. Second, standards serve to overcome the asymmetric and incomplete information problems that plague most product markets. In such cases, standards often take the form of minimum or labelling requirements. Whatever their stated motivation, however, standards can, whether intentionally or otherwise, also be used as instruments of protection.

96. There are two broad methodologies available for quantifying the impact of standards. *Ex post* analyses tend to estimate econometric models which relate the degree of regulation to the value of bilateral trade between countries or to an individual firm's export decision. The degree of regulation is often captured by frequency or coverage measures of standards. *Ex ante* analyses tend to explicitly model how

firms and consumers alter their behaviour in response to price changes induced by the introduction or removal of standards. While simulation analyses primarily measure the impact of standards on trade, empirical studies are generally more concerned with their impact on the welfare of consumers and producers in different countries.

97. In determining which quantification strategy is most suited to measuring the impact of a particular standard, three issues need to be considered: (i) Is the standard likely to have a significant impact on trade and/or welfare? (ii) What are the characteristics of the standard? Is it the level of the standard or its design that is likely to drive its impact? (iii) What are the characteristics of the product subject to the standard? In particular, what is the degree of product heterogeneity?

98. In spite of their widespread adoption, the measurement methods discussed in this paper have many problems. Both the simulation and estimation approaches suffer from misspecification issues and a paucity of data. It is difficult to accurately specify firm production functions and consumer utility functions used in simulated welfare analyses. Similarly, reduced-form econometric models of bilateral trade invariably suffer from missing variables and incorrect functional form. Given that results are typically very sensitive to such assumptions, extensive sensitivity analysis is necessary regardless of the methodology adopted.

99. While some of the problems plaguing the standards literature are not easily surmountable –lack of data, inaccurate measures of welfare – existing analyses of the impact of standards could be improved in a number of ways. First, the role of political economy concerns in the design of standards and, more generally, NTMs has yet to be fully exploited. One recent exception is Anderson, Damania and Jackson (2004) who investigate the role of lobbying in genetically modified food standards.

100. Despite a plethora of work which seeks to measure the impact of standards, the literature still lacks an objective, practical method for determining whether or not a given standard is motivated by quality or risk concerns or merely protectionist intent. Moreover, the measurement of welfare in existing work typically focuses on changes in consumer and producer behaviour resulting from standards-induced price changes, or changes in the number of product varieties consumed and produced. This provides an incomplete picture of the welfare impact of standards. Detailed cost-benefit analysis could capture more fully effects such as the benefits of improved health and safety outcomes for consumers.

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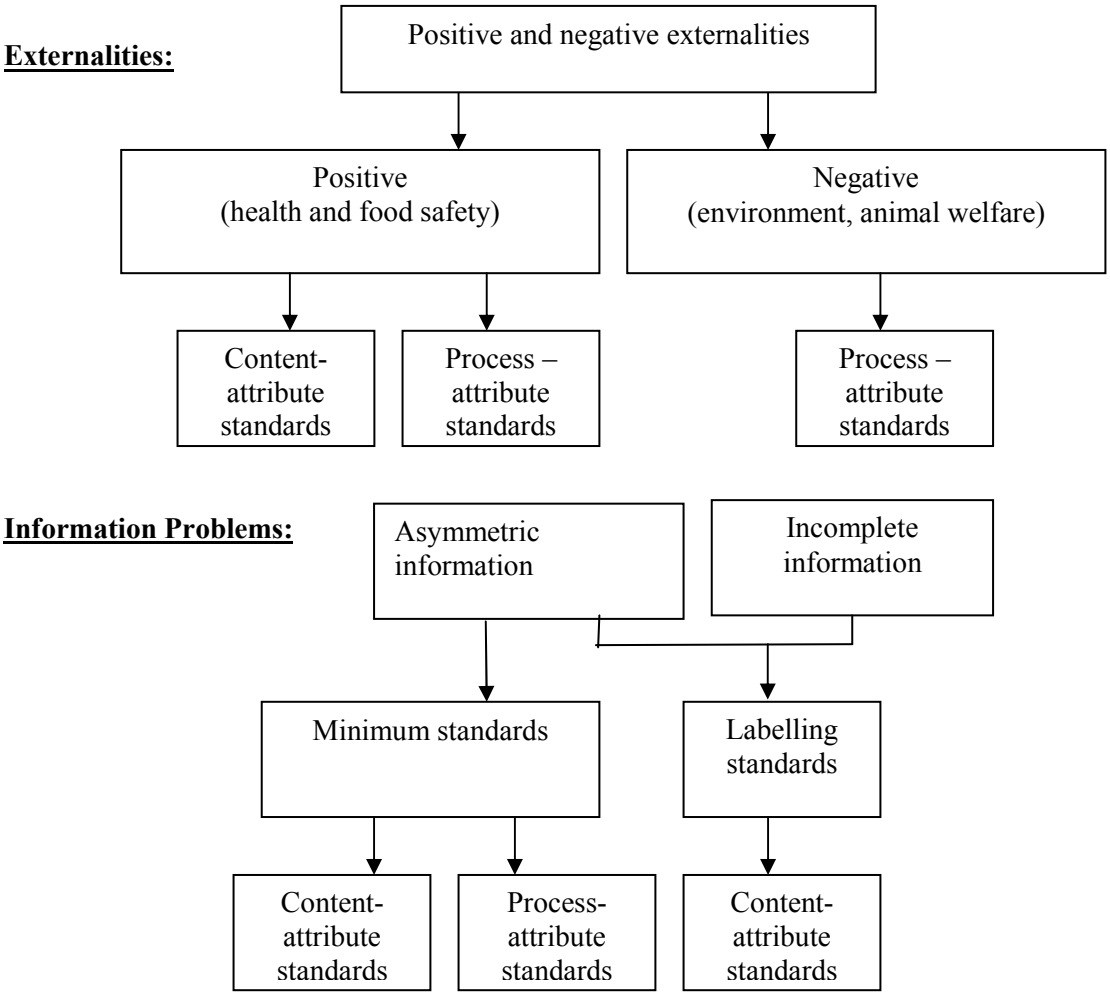
APPENDIX 1: THE ECONOMIC RATIONALE FOR MANDATORY STANDARDS

101. Product markets characterised by externalities in production or consumption or by information problems affecting buyers and sellers, may not provide the quality, quantity or variety of products desired by consumers. Such market failure can be corrected with the implementation of a standards regime which permits the compliance status of producers to be independently verified. This section investigates the links between these sources of market failure and the application of different types of standards. These links are summarised in Figure A.1.

Figure A.1. Rationales for mandatory agri-food standards and types of standards applied



1.1 Standards addressing externalities

102. Externalities arise when economic agents directly involved in a market transaction impose a cost (negative externality) or benefit (positive externality) on agents that are not directly involved in the transaction. Typically, agents acting in their own self-interest fail to account for the unintended consequences of their actions. This may result in outcomes that are sub-optimal from the point of view of society as a whole. For example, agri-food producers may fail to account for the pollution cost of their production decisions – a negative externality. Excessive production and pollution may result. On the other hand, production may yield a wider benefit, such as technological spillovers into unrelated industries, for which producers are not adequately compensated. Firms may respond by under-investing in productive capacity or research and development. In short, the externalities rationale for imposing mandatory technical regulations or standards reflects the need for a mechanism which ensures the adequate provision of public goods, such as a clean and healthy environment.

103. This welfare cost of externalities can be mitigated through the introduction of mandatory standards including content and process-attribute standards which oblige agents to internalise any externalities which occur due to self-interested decision-making. For example, firms may be required to invest in upgrading their production processes in order to ensure they meet hygiene requirements for the preparation of food. Alternatively, producers may be required to alter the chemical composition of a product in the interests of consumer health and safety. In either case, the role of the standard is to ensure that, as far as possible, all direct and indirect costs (benefits) arising from production are borne by (accrue to) the producers themselves.

104. In the agri-food sector negative externalities typically arise from the production process. Hence, standards aimed at mitigating negative externalities tend to be based on a product's process-attributes. For instance, government may regulate emission levels (e.g. maximum application of pesticide per acre) or stipulate requirements for animal production (e.g. space per livestock unit). Positive externalities in the agri-food sector arise from the consumption of healthy and safe products which may relate either to the production process or the characteristics of the products themselves. Consequently, standards designed to manage positive externalities may be process-attribute or content-attribute based. Typically, the benefits accruing to society from the widespread consumption of healthy and safe products tend to exceed the compensation typically received for producing them. Without an adequate return, producers have little incentive to undertake the investment required to deliver such products to market.

105. In the agri-food sector, the over-riding focus of government-mandated standards is on reducing consumer health risks. However, such standards can be difficult to implement effectively if health problems associated with consumption only become apparent with a significant time lag or if, more generally, legal liability is difficult to prove. The agri-food sector, therefore, poses particular problems for the enforcement of standards.

Standards addressing information problems

106. Product characteristics are often not observable to consumers. This means that: (i) producers invariably know more about a product than consumers – asymmetric information – and (ii) consumers tend to have little or no information about the quality of the products they buy – incomplete information. Producers can use this information advantage to behave opportunistically to the detriment of consumers. For example, the seller may falsely claim that a product is of high quality, causing the uninformed consumer to overpay for a product of ultimately inferior quality. In order to overcome these information problems governments set minimum quality standards and labelling requirements.

Asymmetric information

107. Akerlof's (1970) seminal analysis of the "market for lemons" demonstrates that information asymmetries between consumers and producers may result in "adverse selection" – the exclusive provision of low quality products. Consumers react to their informational disadvantage by assuming that all units offered for sale are of an identical, average quality and worth an identical, average price. Producers, therefore, refrain from selling units of higher-than-average quality for which the average price paid by consumers is too low. In the extreme case, producers may only produce goods of the lowest possible quality even if consumers desire high-quality products and are prepared to pay a fair price for them.

108. Adverse selection can be mitigated if consumers obtain inexpensive access to the same product information available to producers. Producers of high-quality products have an incentive to signal the quality of their output using guarantees or warranties. Such mechanisms ensure that consumers pay more for high-quality products without burdening them with excessive information search costs. Mandatory standards play a similar role, signalling to consumers that products available for sale are of some minimum acceptable quality without requiring them to invest excessively in expensive information search. A large number of government-mandated minimum quality standards, usually based on a product's content-attributes, apply in the agri-food sector.

Incomplete information

109. In some markets, product characteristics may not be perfectly visible to a consumer prior to purchase. Rather, consumers may only experience certain product attributes post-consumption. The shelf life of food, for example, constitutes one such experience characteristic. Alternatively, some product attributes may be revealed either imperfectly or not at all even after consumption. Agri-food products tend to have many such credence characteristics including health and nutrition, pesticide residue or a firm's production practices. Indeed, most elements of agri-food product quality can be classified as credence characteristics.

110. Incomplete information about product characteristics may lead to inefficient market outcomes as consumers remain uninformed about the true value of the product at the time of purchase. Repeat purchasing largely solves the incomplete information problem as it relates to experience characteristics. However, such reputation effects cannot be relied upon to overcome a lack of consumer information with respect to credence characteristics. The consumer remains as ignorant after consumption as they were before. Of course, it may be possible (though most likely prohibitively costly) for consumers to obtain information about credence characteristics from other sources.

111. Voluntary labelling may also fail to address the incomplete information problem arising from a product's credence characteristics. As noted earlier, a standard will be effective if the compliance status of producers can be independently verified. Credence characteristics, by definition, cannot be verified by consumers even after purchase. Therefore, in order to provide consumers with information about product quality, an independent third party, usually a government, may require mandatory product labelling that transforms experience and credence characteristics into searchable characteristics. Such labels typically relate to a product's content-attributes.

112. For agri-food products, governmental labelling regimes provide consumers with information about ingredients (e.g. traces of ingredients, additives), nutritional values (e.g. calories), and the ideal use-by date. Other labels reveal the production method employed (e.g. labels for conventional, free range and organic egg production) or the location of production (country-of-origin labels). While such labels are most relevant for consumers who buy non-processed and processed agri-food products for direct consumption,

other governmental labelling standards provide processors and consumers with information based on official classifications and grading regimes (e.g. wheat and meat classes).

113. Government-mandated labelling reduces information search costs for consumers thereby facilitating market transactions. Furthermore, it provides reliable information about product quality to consumers who are consequently better able to judge the true value of different product varieties. In this context, ingredient labels play a particularly important role in helping consumers avoid products that may be harmful to their health (e.g. traces of nuts to which consumers may have allergic reactions).

114. In addition to mandatory labelling, governments may also establish voluntary labelling regimes. Voluntary labels are issued to products generated by specific production methods (e.g. organic production) or under specific conditions in a particular region (i.e. geographic indication). These production processes typically exceed the obligatory minimum requirements. Thus voluntary government labels signal a relatively high or special quality level, allowing producers to use their compliance as a means to obtain greater pricing power.

Appendix 2: Studies quantifying the trade effect of standards

Table A2.1: Studies using econometric estimation

AUTHORS	Country and commodity coverage	Type of standard	Model characteristic and data	Main findings
Baller (2006)	Countries: All OECD countries and 22 top manufactured export non-OECD countries. Products: Telecommunication equipment and medical devices.	TBT liberalisation in the form of harmonisation and mutual recognition agreements (MRAs) for testing procedures.	Two-stage estimation structure. Stage 1: a probit gravity equation yielding a proxy for the fraction of firms which decide to export. Stage 2: A standard bilateral trade gravity equation in which the fitted values from stage 1 are used to correct for heterogeneity bias. Dependent variable (stage 1): probability of at least some trade between a given country pair. Dependent variable (stage 2): bilateral trade value. Explanatory variables (stage 1): typical gravity model explanatory variables and dummy variables for two membership, existence of a bilateral MRA and standards harmonisation. Explanatory variables (stage 2): identical explanatory variables as stage 1 *except* for WTO membership dummy. This assumes that WTO membership only affects the fixed costs (i.e. not the variable costs) of exporting.	MRAs positively impact on the decision whether or not to export as well as on its decision about how much to export. The evidence for harmonisation is ambiguous. Impact of harmonisation on trade in telecoms equipment and medical devices is often insignificant and of variable sign.

Chevassus-Lozza et al. (2005)	Countries: Exporting countries: 8 new EU member states of Middle and Eastern Europe (CEECs) Importing countries: 15 old EU member states (EU15) Commodities: agri-food products	SPS standards, quality standards and import certificates Import standards/ requirements	2 stage Heckmann model with country and products specific fixed effects linear-log specification Data information for standards: dummy variables (0/1) for SPS standards, quality standards and import certificates Dependent variable: export share relative to total exports (volume) for 1999 and 2003 Explanatory variables: total imports of importing country j (M_j), total world trade, distance in terms of transport costs (d_{ij}), dummy variables for common boarder (B_{ij}), tariffs (t_{ij}), bilateral competitiveness index (fob prices/cif prices) (phi_{ij}), global competitiveness index (weighted average of export price/world market price) (phi_i), 3 dummy variables (0/1) for SPS standards, quality standards and import certificates (NTB_{ij}).	First stage (probit) Estimated coefficients 1999 (2003): SPS standards: -0.32 (-0.27) Food quality standards: -0.09 (-0.1) import certificates: -0.22 (-0.25) Second stage Estimated coefficients 1999 (2003): SPS standards: -0.63 (-0.25) Food quality standards: -0.31 (-0.07) import certificates: -0.28 (-0.51) Standards and import certificates negatively affect trade between the new and old EU members. In the second stage, the estimate coefficients indicate their impact on trade volume.

Chen, Otsuki and Wilson (2006)	Countries: 619 exporting firms in 17 developing and transition countries, importing countries: EU, USA, Canada, Japan and Australia Commodities: 25 industries including agri-food sector	Standards, testing procedure, inspection time, labelling requirement and information inquiry difficulty	Regression model with country and industry fixed effects, estimation method: generalized linear model Data information for standards: Firm level data on standards and compliance costs by the World Bank Technical Barrier to Trade Survey (Wilson and Otsuki, 2004a) Dependent variable: Firm's export share relative to total sales Explanatory variables: - Firm characteristics such as ownership structure, firm age, size and productivity in terms of employment and inputs - Labour costs - dummy variables for standards, testing procedure, labelling requirement and information inquiry difficulty	Testing procedure, inspection time and information inquiry difficulties have a negative impact on firm exports. Estimated coefficients: standards: not significant testing procedure: -0.09 inspection time: -0.03 labelling requirement: not significant information inquiry difficulty: -0.18

Cao and Johnson (2006)	Countries: Exporting country: New Zealand and 9 major importing countries (Australia, Canada, China, EU countries, Japan, Korea and the US) Commodities: Meat (beef and mutton/lamb)	HACCP domestic standards	Gravity model, linear-log specification OLS estimator Data information for NTMs/standards: Dummy variable for HACCP mandatory in New Zealand since 1999/2000 Dependent variable: 1994-2003 volume of exports from New Zealand (i) to importing country j (X_{ij}) Explanatory variables: GDP per capita (GDP_i , GDP_j), geographical distance ($DIST_{ij}$), population (POP_i, POP_j), dummy variables for tariff rate quota agreements ($QUOTA_{ij}$) and HACCP ($HACCP_i$), exchange rate (ER_{ij}), FOB price (PR_{ij}) and production in importing country ($PROD_j$).	HACCP has a significantly positive effect on meat exports from New Zealand. Since beef producers adopted HACCP before mandatory requirement, the effect on beef exports (estimated coefficient: 0.06) is considerably smaller than for mutton/lamb (0.29).

Disdier, Fontagné and Minimouni (2007)	Countries: importing OECD countries, 183 exporting countries, (EU countries are included but intra-EU trade is not considered) Commodities: 690 agri-food products, for which between 2 and 40 OECD countries notified NTMs.	SPS and TBT measures including standards in OECD countries	Gravity with fixed effects for each exporting and importing country (multiresistance term) and sector specific fixed effects, linear-log specification Data information for NTMs/standards: notification by at least one OECD importing country, frequency indices (share of notifications within product category) (TRAINS) and trade restrictiveness index by Kee et al. (2006) matched with the notifications in the TRAINS database (NTB_{ij}) Dependent variable: 2004 trade volume from exporting OECD country i to importing country j (X_{ij}) Explanatory variables: absolute difference between GDP per capita ($DiffGDP_{ij}$), geographical distance ($DIST_{ij}$), dummy variables for common boarder ($CBORD_{ij}$), language ($LANG_{ij}$) and colonial ties (COL_{ij}), and trade agreements (DTA_{ij}), bilateral market access (TAR_{ij}) and alternatively used to cover NTMs/standards: a) dummy variable (0/1) for notification by at least one country, b) frequency index and c) trade restrictiveness index (NTB_{ij}).	NTMs including standards have a negative trade effect on agri-food trade. Estimated coefficients: a) dummy variable for at least one notification: -0.18 b) frequency index: -0.22 c) trade restrictiveness index: -0.10 NTMs restrict trade more than market access by other trade policy measures (estimated coefficient: -0.08) With differentiation between LDCs, DCs and OECD countries, NTMs have a positive effect on OECD exports (0.16) and a negative one on LDCs and DCs exports (-0.23). Focusing on sub-sample of EU member states as importing countries: NTMs imposed by EU have a negative trade effect on exports from OECD countries (-0.14) and LDCs and DCs (-0.37). Negative trade effect on cut flowers, processed food products (e.g. beverages) Positive trade effect on cereals, wool and albuminoids/starch.

Fontagné, Mimouni and Pasteels (2005)	Countries: 114 exporting countries, 61 importing country (excluding EU) Commodities: 61 product groups arranged in the following product categories: - "sensitive products": at least 40 countries notifying the presence of NTMs to the WTO, - "suspicious products": less than 11 notifying countries and - "remaining products": 11-39 notifying countries.	Environmental-related measures (NTMs) including standards and technical regulations	Gravity with fixed effects per exporter and importer (multiresistance terms) linear-log specification Estimation method: random-effect Tobit left censoring Data information for standards: Frequency index up to 2001 (share of notifications by importer within product category) (MRM_j) (TRAINS) Dependent variable: 2000-2001 volume of bilateral trade (X_{ij}) Explanatory variables: absolute difference between GDP ($DiffGDP_{ij}$) population density (POP_{ij}), informational infrastructure ($TELE_{ij}$), geographical distance ($DIST_{ij}$), dummy variables for common boarder ($BORDER_{ij}$), culture ($CULTURE_{ij}$), location ($TRANSIT_{ij}$) and trade agreements (DTA_{ij}), bilateral market access ($TARIFF_{ij}$), share of notifications by importer within product category (MRM_j) weighted by dummy for development status of exporter (LDC_i, DC_i and $OECD_i$),	Positive trade effect for "sensitive products": medicaments (DC, OECD), chemicals for retail sale, concentrated milk and maize (LDC). Negative trade effect for "sensitive products": pork (DC, OECD), cut flowers, vegetables (DC and LDC), wheat and pastry (DC) and for "remaining products": processed food and beverages (LDC, DC). No statistically significant effect for "sensitive products": bovine meat and live animals, fishery, food preparations, cheese, tomatoes, soy and rice and for all "suspicious products". Different country groups (LDC, DC and OECD) are equally affected, except for processed food and beverages: LDC and DC more affected. Market access by other trade policy measures restricts trade more than environmental-related measures.

Metha and Nambiar (2005)	Countries: Exporting country: India Importing countries: Australia, France, Germany, Japan, Netherlands, UK and US Commodities: 4 processed agri-food products (shrimps, mushrooms, mango and poultry)	Maximum residual levels (62 substances) Import standards	Gravity model, linear-log specification OLS estimator Data information for standards: Index for maximum residual level (SPS index) related to Codex standards in 2000, index varies across importing country and over time. Dependent variable: 2000-2003 value of export from India (i) to importing countries j (US$) Explanatory variables: GDP in India (GDP_i), population (POP_i and POP_j), geographical distance ($DIST_{ij}$), imports from India to j (IMP_{ij}), index for maximum residual levels (SPS_i).	Indian exports are impeded by stricter residual levels as recommended by Codex. Estimated coefficient of SPS index:: -0.01 NB: Estimation results seem to be biased since IMP_{ij} are used as an explanatory variable. Furthermore estimated coefficient of GDP is negative. R^2: 0.3
Moenius (2006)	Countries: 14 countries: 8 EU member countries, 6 non EU member countries including Australia, Japan, Norway, Switzerland, Turkey and the United States Commodities: 80 agri-food products	Bilaterally shared standards and country specific standards in the importing and exporting country, i.e. importer and exporter standards.	"Collapsed gravity model" with country, industry and year fixed effects, linear-log specification Data information for standards: number of standards from PERINORM database varying over time (Moenius, 1999) Dependent variable: 1980-1995 imports of importing country i from exporting country j (US$) Explanatory variables: number of bilaterally shared standards (SST_{ij}), number of country specific importer and exporter standards ($CSTI_{ij}$ and $CSTE_{ij}$), dummy variable for EU member or not	Importer standards within the EU promote EU trade and hamper trade with countries outside the EU. Exporter standards within the EU have little trade promoting effect, while exporter standards in countries outside the EU have strong effect on trade with the EU. Shared (harmonised) standards within the EU have a strong positive effect on trade with countries outside the EU, but this effect decreases over time. Harmonisation reduces agri-food trade within the EU due to reduced variety.

Moenius (2004)	Countries: 12 OECD countries Commodities: 471 products including agri-food products (4-digit SITC)	Bilaterally shared standards and country specific standards in the importing and exporting country, i.e. country specific importer and exporter standards.	"Collapsed gravity model" with country-pair, industry and year fixed effects, linear-log specification Data information for standards: number of standards from PERINORM database varying over time (Moenius, 1999) Dependent variable: 1985-1995 value of imports of importing country i from exporting country j (US$) Explanatory variables: number of bilaterally shared standards (SST_{ij}), number of country specific importer and exporter standards ($CSTI_{ij}$ and $CSTE_{ij}$), industry specific time trend	10 % increase in the number of bilaterally shared standards increases trade by 2.7%. 10% increase in the number of country specific importer (exporter) standards increases trade by 1.9% (2.0%). Introducing an industry specific time trend reduces the trade promoting effect of standards significantly. With data pooled according to industry, shared and importer standards hamper trade in agri-food products and promote trade in manufacturing products. Exporter standards are always trade promoting.
Otsuki, Wilson and Sewadeh (2001a)	Countries: 9 exporting African countries, 15 importing EU countries Commodities: Groundnuts from African countries to the EU (STIC-2 digit level)	EU aflatoxin standards (MRL) import standards	Gravity with country specific fixed effects linear-log specification Data information of standards: Max. aflatoxin levels in 1995 (FAO, 1995) Dependent variable: 1988-1998 value of exports from African to EU countries (US$) Explanatory variables: Real GDP/capita (GDP), geographical distance (DIST), dummy variable for colonial ties, different maximum level of aflatoxin required by EU countries (STAN), dummy variable for time/years	EU aflatoxin standards reduce the value of African exports. Estimated coefficients: - cereals: 1.052 - fruit, vegetable and nuts: 0.44 Adjusted R^2: cereals: 0.257 and fruit, vegetable and nuts: 0.664 With more detailed data disaggregation, estimated coefficients: cereals: 1.052, coconuts and cashew nuts: 0.74, groundnuts: 1.295 and dried fruit: 0.77.

Otsuki, Wilson and Sewadeh (2001b)	Countries: 9 exporting African countries, 15 importing EU countries (including Switzerland) Commodities: Groundnuts: edible groundnuts, groundnuts for oilseed and groundnut oil	EU aflatoxin standards (MRL) import standards	Gravity model fixed effect for exporting countries, linear-log specification Data information of standards: Max. aflatoxin levels in 1995 (FAO, 1995) Dependent variable: 1989-1998 volume of exports from African to EU countries Explanatory variables: Real GDP/capita (GDP), geographical distance (DIST), dummy variable for colonial ties, different maximum level of aflatoxin required by EU countries (STAN), average rain fall in African countries (RAIN) and dummy variable for time/years.	EU aflatoxin standards reduce African exports in groundnuts. Estimated coefficients: - edible groundnuts: 1.107 - groundnuts for oilseed: 0.2 - groundnut oil: 1.065 Throughout time period, the trade impact for edible groundnuts and groundnuts for oilseed becomes greater, the opposite holds for groundnut oil.
Wilson and Otsuki (2004b)	Countries: 31 exporting countries (21 developing countries) and 15 importing countries (4 developing countries) Commodities: cereal, dried fruit, nuts	Aflatoxin standards (MRL) import standards	Gravity with country specific fixed effects for each commodity, linear-log specification Data information of standards: Max. aflatoxin levels in 1995 (FAO, 1995) Dependent variable: 1995-1998 value of bilateral trade flows (US$) Explanatory variables: Real GDP/capita (GDP), geographical distance (DIST), different maximum level of Aflatoxin required by importing countries (STAN), dummy variable for colonial ties and for free trade area (EU, ASEAN, NAFTA, Mercosur), dummy variable for time/years.	Aflatoxin standards in importing countries reduce the value of African exports in groundnuts. Estimated coefficients: - cereals: 1.12 - dried fruits 0.34 - nuts: 0.09 Adjusted R^2: cereals: 0.56, dried fruits: 0.52 and nuts: 0.55

Wilson and Otsuki (2004c)	Countries: 11 importing countries (6 EU countries treated as one country, Canada, Japan, New Zealand, Switzerland and the US), 21 exporting countries (10 Central and Latin American countries, 2 Caribbean , 4 African and 5 Asian countries) Commodity: banana	Chlorpyrifos standards (MRL) import standards	Gravity with country specific fixed effects, linear-log specification Data information of standards: maximum residual limits of chlorpyrifos (Ministry of Agriculture New Zealand) Dependent variable: 1997-1999 value of bilateral trade flows (US$) Explanatory variables: Real GDP/capita (GDP), population (POP), geographical distance (DIST), different maximum residual limits required by importing countries (MLR), applied ad valorem tariff rate (TARIFF), dummies for EU tariff-rate quota arrangements, dummy variable for colonial ties and for regional trade agreements (RTA), dummy variable for time/years.	10% decrease in the maximum allowed level of chlorpyrifos decreases trade value by 16.3%. Adjusted R^2: 0.71

Wilson, Otsuki and Majumdsar (2003)	Countries: 16 exporting countries (developing and developed countries) and 6 importing countries (developed countries) Commodities: beef	Tetracycline standards (MRL) import standards	Gravity with country specific fixed effects linear-log specification Data information of standards: different maximum level of tetracycline residuals required by importing countries (Department of Agriculture, Fisheries and Forestry Australia, AFFA, 2002) Dependent variable: 1995-2000 value of trade from exporting to importing country (US$) Explanatory variables: Real GDP/capita (GDP), population (POP), geographical distance (DIST), dummy variable for colonial ties (COL) and trade agreements (APEC, NAFTA), different maximum residue limit of tetracycline required by importing countries (VST), dummy variable for EU ban on hormone beef and for the outbreak of BSE and FMD, dummy variable for time (years). Additional dummy for standard in exporting country exceeding importer standard.	10% lower residual level –tighter standard- decreases trade value in beef by 5.9%. Model with additional dummy variable for standards in exporting country exceeding importer standards: no difference in effect. Adjusted R^2: 0.74 (model with additional dummy: 0.56).

Table A2.2: Studies quantifying the trade effect of standards by simulation models

AUTHORS	Country and commodity coverage	Type of standard	Model characteristic and data	Scenarios/main findings
Calvin and Krisoff (1998)	Countries: US and Japan Commodity: apples	SPS measures for US apple exports: process standards and inspection.	Static PE models assumed supply and demand elasticities in importing countries (ε^s and ε^d), small country assumption Modelling approach of standards: **ad valorem tariff equivalent** obtained by price wedge method: comparison of CIF prices of US apples and whole sale prices in Japan approximated by FOB price + insurance cost + transport cost.	Baseline Scenario: average SPS tariff equivalent of 27% in 1994-1997 Scenario 1: short run: ε^s =0.1, elimination of SPS tariff equivalent Scenario 2: long run: ε^s =1, elimination of SPS tariff equivalent, without infestation of fire blight in Japan Scenario 3: long run: ε^s =1, elimination of SPS tariff equivalent, with infestation of fire blight in Japan (supply shift) Trade effects: Scenario 1: Apple imports to Japan increase by US$ 39 million (9% of 1996/97 US apple production). Scenario 2: Due to the greater suppliers' response apple imports to Japan increase by US$ 150 million (35% of 1996/97 US apple production). Welfare effects: In scenario 1 and 2, welfare of Japanese producers falls by up to 30% while Japanese consumers gain. In total, net welfare in Japan is positive when the SPS requirements are removed. In scenario 3, the gains from trade without SPS requirements are offset if Japanese production decreases by 26% due to an infestation of fire blight in Japan.

Krisoff, Calvin and Gray (1997)	Countries: US, Japan, South Korea and Mexico Commodity: apples	SPS measure for US apple exports: process standards and inspection	static PE model, assumed supply and demand elasticities in importing countries (ε^s and ε^d), since $\varepsilon^s = 0.1$ short run analysis only, small country assumption Modelling approach of standards: **ad valorem tariff equivalent** for 1994/1995 and 1995/1996, obtained by price wedge method: comparison of CIF prices of US apples and whole sale prices in respective importing countries (US FOB price + insurance and transport costs).	Baseline Scenario: average SPS tariff equivalents in 1994/1995 (1995/1996) for US apple exports to Japan 58 (24), South Korea 4 (0) and Mexico 20 (13). Scenario 1: elimination of SPS tariff equivalents in the respective importing countries. Depending on the tariff equivalent, the removal of the SPS requirements leads to a more or less pronounced increase in US apple exports. In total, US apple exports increase by US$ 97 (US$ 53) million, i.e. 23% (14%) of the value of US apple exports in the two years.
Nogueira and Chouinard (2006)	Countries: US, China and India Commodity: apples	SPS measures imposed on US apple exports	Static PE model estimated import demand elasticities for US apples in China and India by accounting for SPS measures small country assumption Modelling approach of standards: **ad valorem tariff equivalent**, assumed	Baseline Scenario: SPS tariff equivalent for China:50% and India:30%. Scenario 1: reduced SPS tariff equivalent for US apple exports in China (-20%) and in India (+20%). US exports to China increase by 21%, while those to India decrease by 0.8%. The great difference in simulation results depend on the different elasticities of import demand.

Peterson and Orden (2006)	Countries: US, Mexico Commodity: avocados	SPS standards imposed on Mexican Avocado exports	Comparative static PE Modelling approach of standards: Compliance costs for Mexican producers and exporter by **supply shift** Data information for standards: Control costs and losses in the case of infestation for US, risk of infestation	Baseline Scenario: risk of fruit fly and avocado pests zero since seasonal and geographic restrictions in place in the US as well as compliance measures in Mexico. Scenario 1: US geographic and seasonal restrictions eliminated, but compliance systems in Mexico remain in place. Assumed probability of fruit fly infestation = 0.0000025. Scenario 2: elimination of: US geographic and seasonal restrictions, fruit fly monitoring of Mexican orchards and quarantine requirements during harvests and packaging in Mexico. Assumed probability of pest infestation = 0.00055. Scenario 3: in addition to the elimination of all US geographic and seasonal restrictions, all compliance measures in Mexico removed. Various probabilities of pest infestation assumed. Trade effects (assuming average pest risk probabilities): Scenario 1: Annual avocado exports from Mexico increase by 250%. Scenario 2: Annual Mexican exports increase by a further 1% over Scenario 1. Scenario 3: Annual Mexican exports increase by 5.5% compared to Scenario 1. Welfare effects (assuming average pest-risk probabilities): In scenario 1 total US welfare increases by $72 million compared to the benchmark case. In scenario 2, US welfare increases by a further $2 million. In scenario 3, US welfare increases by a further $8 million compared to the benchmark scenario. (Note: trade and welfare results also provided for higher-than-average risk.)

Yue, Beghin and Jensen (2006)	Countries: US and Japan Commodity: apples		static PE model, assumed supply elasticities in Japan (ε^s) and CES demand specification with estimated quality parameter (α =0.64) and elasticity of substitution between Japanese and US apples demand (σ = 7.12). Modelling approach of standards: ad valorem tariff equivalent derived by accounting for quality differences and consumer preferences for domestic apples in Japan (product heterogeneity and home preference)	Baseline Scenario: SPS tariff equivalent of 60%, in 2000. Scenario 1: long run: ε^s =1, elimination of SPS tariff equivalent Scenario 2:, long run: ε^s =1 elimination of SPS tariff equivalent with outbreak of fire blight disease i.e. assumed 20% decrease of apple production in Japan (supply shift). Trade effects: Scenario 1: for σ = 7.12 and α =0.64, the import value increases by US$ 1.81 million; for α<0.64 increase by up to US$ 60.5 million. As α and σ decreases, Japan imports of US apples increase. Welfare effects: Scenario 1: As α and σ decreases, net welfare in Japan increases; positive net welfare change; Scenario 2: negative net welfare; loss in producer surplus is not offset by the gains from the removal of the SPS standards.