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Disentangling the Demand-enhancing Effect and Trade-cost Effect of Technical Measures in Agricultural Trade among OECD countries

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Disentangling the Demand-enhancing Effect and Trade-cost Effect of Technical Measures in Agricultural Trade among OECD countries[♦]

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Abstract: Domestic technical measures such as SPS and TBTs can enhance import demand via information disclosure and quality improvement, or hamper foreign export supply via imposing sizeable compliance costs, or both. The traditional gravity equation model estimates the net effect of these measures on international trade with a loss of useful inference on separate effects. We stipulate a generalized gravity equation model to disentangle the two effects. We apply the augmented approach to agricultural trade among OECD countries in 2004. We find that technical measures in agriculture often jointly enhance import demand and hinder export supply with the net effect of promoting the propensity to trade. Further disaggregated data analysis reveals heterogeneity across sectors in terms of net effects of technical measures, despite common demand-enhancing and supply-hindering effects. These measures in the net decrease the probability of intra-OECD trade in dairy products, whereas they increase that of intra-OECD trade in cereal preparations.

Keywords: sanitary and phytosanitary, SPS, technical measures, NTM, TBT, standards, gravity equation, protectionism, OECD.

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The Agreements on the Application of Sanitary and Phytosanitary (SPS) Measures and Technical Barriers to Trade (TBT) of the World Trade Organization (WTO) took effect in 1995. They allow WTO member countries to apply SPS and TBT measures to protect domestic human health, animal and plant health, and the environment. However, concerns that these measures create trade frictions and serve protectionist motives have been brought up frequently. For instance, the Philippines, in a complaint to the WTO in 2002, claimed that Australia's SPS measures on fresh fruit and vegetables had hurt its exporters unnecessarily. In 2010, Indonesia filed a WTO dispute against the United States (DS406) for imposing restrictions on cigarette additives thus affecting the production and sale of Indonesian clove cigarettes. In general, the implications of technical measures¹ on market access and welfare are more complex than traditional tax-based trade barriers measures, such as tariffs and countervailing duties, primarily because they often address market imperfections (asymmetric information, externalities). They tend to affect consumers' information set and behavior as well as producers' behavior. Thus they cannot be easily translated into a simple tax or price equivalent. Their welfare effects are fundamentally different as well. The presumption that the removal of technical measures is welfare-improving is not grounded in any economic theory, unlike for the removal of a trade tax by a small country.

From the perspective of exporters, the additional cost of complying with a stringent standard abroad could be high. Those compliance costs may include the fixed costs of upgrading the equipments and/or practice codes, gaining certificates, altering marketing strategies, etc. In addition, inspection procedures at custom points add to the variable cost of exporting. As a result, the compliance costs could significantly decrease export volumes, and drive small exporting firms out of a foreign market. This is the trade-cost effect, or the supply-inhibiting effect of technical measures, which corresponds to the conventional "standards as barriers" argument in the international development literature on market access (Otsuki, Wilson, and Sewadeh 2001a).

On the other hand, a technical measure may enhance the demand for imports if the measure is informative (Thilmany and Barrett 1997). In the latter case, the measure signals a higher quality of the permitted imports via information disclosure such as trade marks, labeling requirements, and detailed description of certain attributes or restricting toxic residues. The quality improvement enhances consumers' demand for imports, as well as contributes to consumers' long-run health benefits (Marette and Beghin 2010). This is the demand-enhancing effect, or the quality improvement effect of technical measures, corresponding to the "standards as catalyst" argument in the SPS/TBT debate. (The "standards as catalyst" argument also includes the claim that stringent foreign standards could trigger exporters to upgrade their supply chain, to access higher quality markets opportunities in the long-run, e.g., Jaffee and Henson 2005). Therefore, a technical measure can affect trade volumes and/or the propensity to trade in either direction: a tighter standard promotes trade if its demand-enhancing effect dominates its trade-cost effect; it impedes trade if its demand-enhancing effect falls short of the trade cost effect. The analytical ambiguity of the impact of technical measures on international trade calls for a more careful empirical quantification and identification of the trade effects of these measures, a task we pursue in this investigation.

Gravity equation models are widely used to estimate bilateral trade flows and their determinants such as the attributes of trading countries (such as GDP, total production) and various trade cost terms (such as tariffs, distance, colonial ties, and preferential trade agreements), including certain technical measures imposed by the importing countries. The existing results accumulated so far on trade effects of technical measures are mixed. The estimated net effects of technical measures vary across products, country groups, and to some extent estimation methods with net trade effects spanning from significantly negative to significantly positive (Li and Beghin 2010). For example, Otsuki, Wilson, and Sewadeh (2001a) predicted that 2002 EU harmonization

of aflatoxin residue standards would reduce groundnut exports from Africa. This prediction could not be confirmed by Xiong and Beghin (2011) in an ex-post panel analysis. Jaffee and Masakure (2005) report that Kenyan fresh vegetable exporters benefited from the proliferation of food safety standards in Europe by successfully updating their supply chains. Anders and Caswell (2009) find that Hazard Analysis Critical Control Points (HACCP) reduces American's seafood imports from large exporting countries. Disdier, Fontagné, and Mimouni (2008) show that agricultural exporters from the South are more likely to be hurt by rising TBTs and technical measures than their competitors from the OECD countries but that they measure can enhance trade in some sectors among OECD partners, while hindering trade or having no net trade effects in other sectors. Disentangling the separate impacts of technical measures on import demand and export supply would allow a cogent rationalization of these various outcomes. However, studies toward the identification of the two effects are rare to date. (As a case study on Japanese cut flowers, Yue and Lan (2009) show that estimates of the trade effect of SPS are biased when the induced quality changes are not considered).

We undertake to separately identify these supply and demand effects. This is a useful pursuit. First, the disentanglement of consumers' and producers' responses to an informative standard helps determine if the standard is driven by public awareness or potential protectionism. (Fugazza and Maur (2008) demonstrate the importance of modeling both the demand and supply-shift effects of technical measures in policy analysis using CGE models). In case consumers are found to be insensitive to the quality improvement induced by a higher standard, the new policy should be subject to further scrutiny for possible protectionism. For instance, the absence of direct demand-enhancing effect could also be consistent with policies addressing long-term deleterious health or environmental effects valued by society but overlooked by consumers of the good affected by the technical measure (e.g., Peterson and Orden 2008).

Second, the disentangled approach provides grounds for better policy recommendation both for domestic consumers and development assistance to exporters in the South, potentially handicapped by technical measures. For example, the fairly common finding of negligible net trade effect of technical measures (e.g., Xiong and Beghin 2011) may dissimulate a potential demand-enhancing effect beneficial to consumers and mostly offset by exporters' inability to comply with the measures. The latter could lead to international assistance programs to exporters in the South.

Moreover, the disentanglement of the effects of SPS measures on consumers and producers makes possible the welfare evaluation of a policy change. Disdier and Marette (2010) use an analytical framework to link the mercantilist aspects and welfare aspects of non-tariff measures and find that although antibiotic residue limits reduce crustaceans imports in US, EU, Canada, and Japan, they boost both domestic and international welfare. Therefore, a proper disentangling strategy would allow exploring how a change in SPS policies affects different agents in international trade. Identifying the two separate effects could also lead to better policy design by the social planner, especially in presence of externalities associated with trade. An optimum measure can be designed with proper knowledge of its impact on consumers.

We propose an econometric approach to disentangle the demand-enhancing effect and the trade-cost effect of any standard and apply the model to examine the impact of technical measures on agricultural trade among OECD countries in 2004. The two effects can be told apart based on two simple but essential facts. First, the maximum of the domestic standards and the foreign standards affects consumers' demand for imports: the domestic standards serve as the quality signal if the home country adopts stricter regulations than the exporting country; the foreign standards serve as the quality signal if higher standards are applied abroad. However, the difference in standards between the trading countries influences the trade costs of exporting firms: a firm already meeting a stringent regulation in its home market can meet the standards in the

country of destination easily or at no additional cost. For instance, seafood exporters from Canada are arguably better equipped to meet U.S. HACCP regulations than seafood exporters from Thailand because HACCP procedures are common in Canada.

We apply the model to investigate agricultural trade among OECD countries in 2004 and significantly refine the findings of Disdier, Fontagné, and Mimouni (2008). Technical measures facilitate intra-OECD agricultural trade, for those measures enhance consumers' demand for imports more than they handicap exporters' supply of exports. In a further disaggregated analysis of technical measures imposed on vegetable preparations primarily targeting mycotoxins, we find that these measures tend to in the net to induce additional intra-OECD trade in vegetable products. In contrast, technical measures affecting dairy products tend to decrease the trade among OECD countries in their net effect. Demand enhancing effects are found in both of these sectors.

In what follows, we provide a conceptual model leading to a specification disentangling the two effects of technical measures. Then we apply the model to empirically examine the impact of technical measures on agricultural trade among OECD countries in 2004. Section 4 concludes the analysis and discusses possible extensions.

The modeling approach

Our analytical framework characterizes the separate impact of technical measures on the demand for imports and the supply of exports. In equilibrium, a generalized gravity equation model emerges and provides a specification to be estimated which preserves the identification of the separate impacts on domestic consumers and foreign exporters. Welfare implications are also discussed.

The import demand

The goods available in the economy are differentiated by sectors and by country of origins

(Armington 1969). For example, “Japanese apples” and “New Zealand apples” are two distinct goods in the composite sector “apples.” There are S sectors. There are I countries trading or potentially trading with one another. Country j has N_j identical consumers deriving utility from market consumption and long-run health (or the environment). The implementation of a standard affects both utility channels. The standard affects individual consumption level by conveying a quality signal to consumers. In addition, there might be certain long-run health benefits (individual and collective ones) associated with the standard but overlooked by individual consumers. For example, standards restricting antibiotic use in food provide quality enhancements perceived by consumers and collective health benefits from reduced antibiotic resistance likely to be external considerations for many individuals (Beghin and Marette 2009; Disdier and Marette 2010). Similar external environmental effects are often linked to the volume of trade, such as invasions by exotic pests.

To accommodate the above features, we use the Constant Elasticity of Substitution (CES) preferences to characterize consumers’ utility derived with market consumption and we assume that the health or environmental benefit is additively separable from the market consumption utility. Specifically, the representative consumer in country j solves the following optimization problem:

$$(1a) \quad \max_{q_{sij}} U_j = \left[\sum_s \sum_i (\delta_{sij} q_{sij})^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} - \sum_i \sum_s \kappa(\delta_{sij}) Q_{sij}$$

$$(1b) \quad s.t. \quad \sum_s \sum_i P_{sij} q_{sij} = y_j,$$

where δ_{sij} is the quality preference parameter of the representative consumer in country j for good s produced by country i ; q_{sij} is the consumer’s quantity demanded for good s produced by the country i ; $\kappa(\cdot)$ is a decreasing function mapping the quality of the good to the per-unit

hazard associated with the import; Q_{sij} , exogenous to individual consumers, is country j 's aggregate demand for good s sourced in country i ; ε is the constant elasticity of substitution; P_{sij} is the price of good s produced in country i and sold in country j ; y_j is the per-capital income in country j . Solving the representative consumer's problem (1) yields the following individual demand:

$$(2) \quad q_{sij}^d = \frac{\delta_{sij}^{\varepsilon-1} P_{sij}^{-\varepsilon}}{\Pi_j} y_j,$$

where $\Pi_j = \sum_s \sum_i \delta_{sij}^{\varepsilon-1} P_{sij}^{1-\varepsilon}$ is the consumer price index in country j . Note that the long-run health benefit doesn't affect the solution at all since the external effect is assumed separable for tractability. Country j 's aggregate demand for good s produced by the country i , in value terms, is then

$$(3) \quad V_{sij}^d \equiv P_{sij} \cdot Q_{sij}^d = P_{sij} \cdot N_j \cdot q_{sij}^d = \frac{\delta_{sij}^{\varepsilon-1} P_{sij}^{1-\varepsilon}}{\Pi_j} y_j N_j = \frac{\delta_{sij}^{\varepsilon-1} P_{sij}^{1-\varepsilon}}{\Pi_j} Y_j,$$

where Y_j is country j 's national income. Note that the above import demand is positively related to the income level and the consumers' quality evaluation of the good, but negatively related to the price of the good as long as $\varepsilon > 1$.

The information disclosed by the technical measures, among many factors, can alter consumers' quality evaluation of the concerned good. We parameterize δ_{sij} as

$$(4) \quad \delta_{sij} = \delta_{s0} \exp(\beta \max\{SPS_{si}, SPS_{sj}\}),$$

where δ_{s0} is consumers' preference for good s in absence of technical regulations;² β , is a non-negative parameter to be estimated that captures the degree to which consumers respond to the technical information disclosure; SPS_{si} and SPS_{sj} are the stringency of technical measures

imposed on sector s in country i and j . Hence, the term $\exp(\beta \max\{SPS_{si}, SPS_{sj}\})$ characterizes the demand-enhancing effect, or the quality improvement effect of technical measures. Notably, Equation (4) assumes full compliance of all firms: a firm must meet its domestic standards in the first place, and it has to improve the quality of its exports to meet the foreign standards if selling to a destination where stricter standards apply. In the latter case, consumers in the destination country care about the higher domestic quality signal. However, if a foreign firm has a quality exceeding the importing country's quality requirement, then consumers in the latter country react to the stricter quality requirements adopted by the exporting country.³

The export supply

We assume a representative producer for each sector in each country. The products sold by this representative producer at different destinations are imperfect substitutes because the producer has to further modify the products to meet the local quality requirements in each destination country (re-packaging, re-labeling, etc). For example, U.S. apples to be sold in Japan are not exactly the same as U.S apples consumed domestically (Calvin, Krissoff, and Foster 2008). We further assume the representative producer of good s in country i is endowed with a production capacity Q_{si} and a Constant Elasticity of Transformation (CET) technology (Geraci and Prewo 1982; Bergstrand 1985). The CET technology allows the exporter to transform products prepared for different destinations. The problem for the representative producer is to decide which countries to export to and how much to export to each foreign market. Let Ω_{si} be the set of destinations the representative producer of good s in country i decides to serve.⁴ The producer solves the following problem

$$(5a) \quad \max_{\{Q_{sij}\}_{j \in \Omega_{si}}} \sum_{j \in \Omega_{si}} P_{sij} Q_{sij}$$

$$(5b) \quad s.t. \quad \left[\sum_{j \in \Omega_i} (\tau_{sij} Q_{sij})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} = Q_{si},$$

where $\eta < 0$ is the CET between exports prepared for different destinations (a large η in absolute value corresponds to easy transformation); $\tau_{sij} > 1$ is the “iceberg melting” trade cost term: τ_{sij} units of good s have to be shipped out of country i in order for one unit to arrive in country j .

The solution to (5) yields the following export supply functions in value terms:

$$(6) \quad V_{sij}^s \equiv P_{sij} \cdot Q_{sij}^s = \frac{Q_{si} \tau_{sij}^{\eta-1}}{\Psi_{si} P_{sij}^{\eta-1}},$$

where $\Psi_{si} = \left[\sum_{j \in \Omega_{si}} \tau_{sij}^{\eta-1} P_{sij}^{1-\eta} \right]^{\frac{\eta}{\eta-1}}$ is the producer price index for sector s in country i reflecting the cost of exporting to all possible destinations. Equation (6) suggests that the supply of exports is positively related to the production capacity of the exporting country and the price of the goods, but negatively related to trade cost terms.

With the empirical investigation in mind, and as standard practice in gravity equation models, we parameterize τ_{sij} as

$$(7) \quad \tau_{sij} = (1 + tar_{sij})(1 + dist_{ij})^{b_d} \exp(-b_p NTB_{sj}) \exp(-b_b Bord_{ij}) \\ \cdot \exp(-b_c Col_{ij}) \exp(\gamma \max\{SPS_{sj} - SPS_{si}, 0\}),$$

where tar_{sij} is the bilateral tariff rates in sector s ; $dist_{ij}$ is the distance between country i and j ; NTB_{sj} represents the protectionist non tariff barrier (other than technical measures) imposed in sector s by country j ; ⁵ $Bord_{ij}$ is a common border dummy variable that equals one if the trading partners share a common border; Col_{ij} is a colonial dummy variable that equals one if the two countries had a colonial relationship in history; γ , b_d , b_b , b_c , all presumably positive, are parameters to be estimated.

The new source of trade cost in (7) is $\max\{SPS_{sj} - SPS_{si}, 0\}$, which characterizes the trade cost due to the difference in technical measures between trading countries. The trade cost term implies that exporting firms have to overcome additional costs (e.g., expenditure on additional equipments to improve quality, further processing, obtaining necessary certificates, etc.) if selling to a destination where a stricter standard applies relative to their home country's standard. Czubala, Shepherd, and Wilson (2007) find that the harmonized or shared standards are less trade-impeding and sometimes trade-promoting. Our formulation of the trade cost effect accommodates such harmonized or shared standards ($SPS_{sj} = SPS_{si}$). For instance, intra-EU trade is presumably less impeded or even promoted by EU's technical measures because of their harmonization within the community.

The equilibrium

In equilibrium, the import demand equals the export supply in each sector and for each country pair. By imposing the market clear condition, $V_{sij}^d = V_{sij}^s$, we can solve for the equilibrium trade value, V_{sij} , and the equilibrium price, P_{sij} , in sector s for the exporting country i and the importing country j . Specifically, solving (3) and (6) yields

$$(8a) \quad P_{sij} = \left(\frac{Y_j}{\Pi_j}\right)^{\frac{1}{\varepsilon-\eta}} \left(\frac{\Psi_{si}}{Q_{si}}\right)^{\frac{1}{\varepsilon-\eta}} \delta_{sij}^{\frac{\varepsilon-1}{\varepsilon-\eta}} \tau_{sij}^{\frac{1-\eta}{\varepsilon-\eta}},$$

$$(8b) \quad V_{sij} = \left(\frac{Y_j}{\Pi_j}\right)^{\frac{1-\eta}{\varepsilon-\eta}} \left(\frac{Q_{si}}{\Psi_{si}}\right)^{\frac{\varepsilon-1}{\varepsilon-\eta}} \left(\frac{\delta_{sij}}{\tau_{sij}}\right)^{\frac{(\varepsilon-1)(1-\eta)}{\varepsilon-\eta}}.$$

It can be noted from (8a) that the equilibrium price is increasing in the importing country's income level, Y_j , the quality of the imports, δ_{sij} , and the trade cost between the two countries, τ_{sij} ; but it is decreasing in the exporting country's total supply capacity, Q_{si} . Equation (8b) shows that the

bilateral trade flow (in value) is increasing in the importing country's income level, Y_j , the exporting country's capacity, Q_{si} , and the quality of the imports, δ_{sij} ; but it is decreasing in the trade cost between the two countries, τ_{sij} . Substituting (4) and (7) into (8b), and taking logarithms lead to following characterization of equilibrium bilateral trade flows

$$(9) \quad \ln(V_{sij}) = \phi Y_j - \phi \Pi_j + (1 - \phi) Q_{si} - (1 - \phi) \Psi_{si} - \theta \ln(1 + \tau_{sij}) - \theta b_p NTB_{sj} - \theta b_d \ln(1 + dist_{ij}) \\ + \theta b_b Bord_{ij} + \theta b_c Col_{ij} - \theta \gamma \max\{SPS_{sj} - SPS_{si}, 0\} + \theta \beta \max\{SPS_{sj}, SPS_{si}\},$$

where $\phi = (1 - \eta)/(\varepsilon - \eta)$ and $\theta = (\varepsilon - 1)(1 - \eta)/(\varepsilon - \eta)$.

Equation (9) forms a generalized gravity equation model in which the demand-enhancing effect and the trade cost effect of SPS measures are identified separately. The most stringent set of standards between exporting and importing countries affects consumers' valuation of the concerned good by signaling the highest quality between the two. On the other hand, stringency differentials between the trading partners influence trade costs and export supply: a firm already meeting stringent home regulations can meet the standards in the destination country at negligible additional cost. The proposed model makes explicit how underlying demand and supply components of bilateral trade react to technical measures. Meanwhile, the model retains the parsimony and spirit of the gravity equation approach.

Besides noting the disentangling the two effects of SPS/TBT measures, our specification leads to several remarks. First, the inclusion of tariffs as a determinant of trade remains essential to identify the model structure as in many gravity applications. Equation (9) shows that the trade effects of all other trade costs combine the price effect of tariffs (parameter θ) to their specific impacts on unit cost of each other trade cost as shown in equation (7). Secondly, the estimated trade effects of technical measures may suffer from omitted variable bias if the technical measures adopted by the exporting countries are ignored. Equation (9) shows that trade flows are

independent of the standards applied by the country of origin, SPS_{si} , if and only if $SPS_{si} = 0$, that is, the exporting country has no technical measures of its own. Last, the recovered elasticities of substitution in traditional gravity equation models analyzing technical measures should be interpreted with caution. The elasticity recovered here, $\theta = (\varepsilon - 1)(1 - \eta)/(\varepsilon - \eta)$, includes both CES and CET parameters and provides information on consumers' taste patterns, as well as exporters' ability to transform products across destinations.

At last, we discuss some of the welfare implications of a new standard on good s by the importing country, specifically on its consumers' and foreign exporters' welfare. To characterize the welfare effect for domestic consumers, we substitute (2) and (8a) into (1a) to get the indirect utility function for country j as follows:

$$(10) \quad W_j = A_j \left(\sum_i \sum_s B_{si} \delta_{sij}^\theta \tau_{sij}^{-\theta} \right)^{\frac{\varepsilon}{\varepsilon-1}} - A_j \sum_i \sum_s B_{si} \kappa(\delta_{sij}) \delta_{sij}^{-\eta(1-\phi)} \tau_{sij}^{-\varepsilon\phi},$$

where $A_j = \left(\frac{Y_j}{\Pi_j} \right)^{\frac{\eta}{\varepsilon-\eta}}$ and $B_{si} = \left(\frac{Q_{si}}{\Psi_{si}} \right)^{\frac{\varepsilon}{\varepsilon-\eta}}$. The first term on the right hand side of (10) captures in

the surplus associated with market consumption, while the second term characterizes the consumers' welfare implications on long-run health or other external effect.⁶ For simplicity sake, we assume for a moment that the new standard adopted by country j only affects exporter i . (All other trading partners already have the same or the equivalent standards in place). The first term in (10) captures the consumer surplus effects. The quality improvement associated with the new regulation increases δ_{sij} , which benefits domestic consumers and increases their willingness to pay for q_{sij} . On the other hand, trade cost rises with the new stringency faced by the exporter; the price of the good increases and welfare is reduced. Consequently, the net effect on the consumer surplus from consuming good s is presumably ambiguous. Secondly, the negative external effect shown in the second term of (10) is reduced via lower morbidity or reduced

invasion rates $\kappa(\delta_{ij})$, although trade expansion could exacerbate these external effects.

The total welfare effect on the consumer is presumably ambiguous and is unlikely to be just determined by effect on the volume of trade as often assumed in gravity analyses of NTMs. The quantification of the demand-enhancing effect and the impact on potential externalities is essential: the more information standards convey to consumers, and/or the more scientific evidence underlies the regulations, the weaker the presumption of sheer protectionism and welfare losses.

Country j 's new regulation affects foreign exporters' profits. By assumption, exporters from country i face additional cost to continue selling in country j . By substituting (6) and (8a) into (5a), we derive the following profit function for the representative exporter i in sector s :

$$(11) \quad \pi_{si} = \sum_{j \in \Omega_{si}} V_{sij}^s = B_{si}^{\frac{\varepsilon}{\varepsilon-1}} \sum_{j \in \Omega_{si}} A_j^{\frac{1-\eta}{\varepsilon-1}} \delta_{sij}^\theta \tau_{sij}^{-\theta}.$$

It can be noted from (11) that the profit is increasing in the perceived quality of the imports, δ_{sij} , in country j but decreasing in the trade costs, τ_{sij} to meet the new standard. Hence, the importing country's new regulation has two direct offsetting effects on the profit of foreign exporters (higher willingness to pay in the importing country but higher trade cost to sell there). The relative size of these effects determines the direct impact of the new standard on profits.⁷

In summary, from the above discussion of equations (10) and (11), it is clear that technical measures and their stringency have complicate welfare implications requiring the disentanglement of their separate effects on import demand and export supply as also emphasized by Disdier and Marette (2010), and Beghin et al. (2011).

An empirical application

In this section, we apply the proposed model to examine the impact of technical measures on agricultural and food trade among OECD member countries using data for the year 2004. The data come from Disdier, Fontagné, and Mimouni (2008) and COMTRADE. As in Disdier, Fontagné, and Mimouni (2008), we run a regression based on pooled data for all sectors and then separate regressions based on sectoral data with a detailed investigation of trade in dairy and cereal preparations. The dataset is rich but unfortunately is a pure cross-section without time variation. This constraint means that we can only identify the effects of variables that are not co-linear in absence of time variation in the data. Accordingly, we re-write (9) as

$$(12) \quad \ln(V_{sij}) = -\theta \ln(1 + tar_{sij}) - \theta b_p NTB_{sj} - \theta b_d \ln(1 + dist_{ij}) + \theta b_b Bord_{ij} + \theta b_c Col_{ij} \\ - \theta \gamma \max\{SPS_{sj} - SPS_{si}, 0\} + \theta \beta \max\{SPS_{sj}, SPS_{si}\} + fe_j + fe_{si},$$

where fe_j is the fixed effect, or the multilateral resistance term (Anderson and van Wincoop 2003) of the importing country j ; fe_{si} is the fixed effect in sector s in the exporting country i . Note that importers' fixed effects absorb the impact of the price indexes, Π_j and incomes Y_j , in the importing countries; and that sector-specific exporters' fixed effects subsume the impact of the price indexes, Ψ_{si} , and the production capacity, Q_{sit} , in the exporting countries. Admittedly, the lack of time variation in the across-sectional analysis prevents us from identifying ε and η separately but we can still identify the separate shifts resulting from demand enhancing effects and export supply cost effects of technical measures affecting trade.

Data and empirical strategy

The data set largely draws upon Disdier, Fontagné, and Mimouni (2008). Information on non tariff measures (NTMs) in 2004 is retrieved from the Trade Analysis Information System (TRAINS). Various measures imposed by the importing countries are recorded at each HS-6 product level. According to the United Nations Conference on Trade and Development

(UNCTAD), a NTM measure can be sorted into the following seven categories: (a) para-tariff measures, (b) price control measures, (c) finance measures, (d) automatic licensing measures, (e) quantity control measures, (f) monopolistic measures, and (g) technical measures. Among the seven categories, (a) (b) (e) and (f) are protectionist by design as they decrease allocative efficiency, so we pool these four categories together and call them “protectionist NTBs.” Category (g) contains the technical measures we are interested in. We restrict our attention to intra-OECD trade because notifications by non-OECD countries are often not up to date and incomplete. One would estimate the impact of notification behavior rather than the impact of actually implemented policies if including NTMs notifications by non-OECD countries.

The intra-OECD agricultural trade and tariff data are collected from the “Base pour l’Analyse du Commerce International” (BACI), of Centre d’Etudes Prospectives et d’Informations Internationales (CEPII), and augmented with COMTRADE-WITS. They are aggregated at the HS-4 level. Within each HS-4 category and for each country, a *frequency index* proxy-ing the stringency of technical measures is constructed as the total number of “technical measure” notifications within that HS-4 category over the total number of HS-6 level products within that HS-4 category. For example, New Zealand issued a total of 80 technical measures (measures applied to different HS-6 products are considered distinct even if the requirements are the same) under the HS-4 category “fruits, nuts and other edible parts of plants” in 2004. This particular HS-4 category contains 12 HS-6 products. Hence, New Zealand’s frequency index of technical measures applied to “fruits, nuts and other edible parts of plants” is 6.67. A frequency index representing the intensity of the use of protectionist NTBs (other than the technical measures) is constructed in a similar manner. Other trade cost terms, including bilateral distance, common border dummy variable, common language dummy variable, and colonial tie dummy variable, are sourced from CEPII.⁸

Our estimation strategy is to rely on the Heckman sample selection model. The Heckman sample selection model has three empirical advantages. First of all, it accounts for countries' self-selection to not export by including a selection equation. This selection could be caused by the inability to overcome certain fixed costs of trade. Thus, the Heckman sample selection model is in line with the micro-foundation of gravity equation models as proposed by Helpman, Melitz, and Rubinstein (2008) and addresses the problem with frequent zero outcomes. (Another estimator capable of accommodating zeros numerically is the Poisson Pseudo Maximum Likelihood (PPML) estimator advocated by Silva and Tenreyro 2006. However, Martin and Pham (2008) show that PPML can lead to biased estimates when zeros are frequent). Second, the Heckman sample selection model allows exploring both the intensive and the extensive margins to trade. Technical measures can either affect exporter's trade volumes via increasing the variable cost of exporting, or their propensity to trade via adding to the fixed cost of trade, or both. It is worthwhile to investigate both margins and determine how the technical measures affect the related industry. Lastly, the Heckman sample selection model corrects for the sample selection bias inherent in traditional Least-Square estimators. Specifically, the Heckman sample selection model, based on (12), is

$$(13a) \quad \ln(V_{sij} | V_{sij} > 0) = -\theta \ln(1 + tar_{sij}) - \theta_b \ln(1 + dist_{ij}) + \theta_p NTB_{sj} + \theta_b Bord_{ij} + \theta_c Col_{ij} \\ - \theta \gamma \max\{SPS_{sj} - SPS_{si}, 0\} + \theta \beta \max\{SPS_{sj}, SPS_{si}\} + fe_j + fe_{si} + \varepsilon_{sij},$$

$$(13b) \quad V_{sij}^* = -\theta^* \ln(1 + tar_{sij}) - \theta^* b_d^* \ln(1 + dist_{ij}) + \theta^* b_p^* NTB_{sj} + \theta^* b_b^* Bord_{ij} + \theta^* b_c^* Col_{ij} + \theta^* b_l^* Lang_{ij} \\ - \theta^* \gamma^* \max\{SPS_{sj} - SPS_{si}, 0\} + \theta^* \beta^* \max\{SPS_{sj}, SPS_{si}\} + fe_j^* + fe_{si}^* + \nu_{sij},$$

where $V_{sij} > 0$ if and only if $V_{sij}^* > 0$. Equation (13a) is the outcome equation that explains the trade volume conditional on trade taking place. If the sample selection bias is present, the idiosyncratic term is correlated with covariates in (13a). Equation (13b) is essentially a Probit model in which the outcome is one if two countries trade with each other, and zero otherwise.

We can estimate (13a) and (13b) jointly either via the maximum likelihood approach, assuming that the idiosyncratic terms are bivariate normal with correlation ρ , or via a two-step procedure.⁹ For identification purpose, the Heckman sample selection mode often uses an exclusion restriction. A variable in the selection equation is excluded from the outcome equation. In our context, a variable that affects the fixed cost of trade but not the variable cost of trade would qualify. However, it is often difficult to find such a variable. Helpman, Melitz, and Rubinstein (2008) use “days and procedures needed to start a business” for this purpose, but they also use the common religion dummy variable as an alternative due to the limit data on the above-mentioned variable. We choose the common language dummy variable as the exclude variable in our application.¹⁰

In the next subsection, we first examine the impact of technical measures on intra-OECD agricultural trade in general. To this end, we pool different agricultural sectors together and fit the Heckman sample selection model (13a)-(13b). We then analyze each sector (at HS-2 level) separately to see how different products have been affected by technical measure.

Results discussion

The estimation results for the intra-OECD agricultural trade in 2004 are reported in table 1. We first discuss the estimates in the outcome equation to see how different factors determine the trade volumes conditional on countries trading with one another, and then we turn to the estimates in the selection equation to explore what affects the propensity to trade. As shown in the second column of table 1, the technical measures adopted by OECD countries enhance consumers’ demand for imports significantly, suggesting that the OECD technical measures do serve as quality signals to which consumers respond. This finding contradicts the claim that pure protectionist motives drive these measures. The trade cost effect of OECD technical measures turns out negative and statistically significant, indicating that technical measures adversely affect

OECD exporters via increasing variable costs of exports. To gauge the net effect of technical measures, we test the hypothesis that sum of the demand-enhancing effect and the trade-cost effect is zero. The associated F-statistic fails to reject the hypothesis, which implies that the volumes of trade between OECD countries are not severely affected by technical measures because the two effects almost cancel out. Other trade cost terms have the expected signs and magnitudes as typically found in a gravity equation analysis. Specifically, tariffs, other NTBs, and geographic distance are found to impede trade; countries with a common border or a historical colonial tie tend to trade more.

The selection equation is shown in the last column of table 1, technical measures as quality signals increase the propensity of OECD consumers to purchase agricultural products from other OECD countries, as evidenced by a positive and statistically significant demand-enhancing effect. The trade cost effect, on the other hand, decreases exporter's propensity to export, suggesting that the technical measures significantly add to the fixed costs of export.

[Table 1 about here]

The above finding has important implications for small exporters, or firms that are just productive enough to overcome the fixed cost of trade (Melitz 2003; Chaney 2008). The proliferation of technical measures places another hurdle for small firms to jump, which could drive them out of foreign markets although results show that higher willingness to pay is generated by the technical measures.

In terms of other trade determinants, tariffs and distance are shown to hinder trade; a common border, a colonial tie in history, or a common language fosters trade new partnership. The protectionist NTBs are shown to be positively correlated with trade propensity, which is unexpected given the presumption of real trade impediment.¹¹ The significance of the Inverse

Mills Ratio confirms the importance of accounting for the selection process and the propensity to open new trade.

To shed more light on the trade effects of technical measures, we compute the extensive margins to trade, the intensive margins to trade, and the overall marginal effects (see Appendix for the derivation). The extensive margin to trade refers to the changes in the propensity to trade as its determinants change. In the Heckman sample selection model, the extensive margin corresponds to the marginal effect in the selection equation (13b). The intensive margin to trade, on the other hand, describes how trade volumes between existing trading partners respond to changes in underlying determinants. The intensive margin of a trade determinant corresponds to its direct effect, captured by its coefficient in outcome equation (13a), as well as its indirect effect through the sample correction term. The overall marginal effects can then be calculated as the sums of these two margins.

[Table 2 about here]

Table 2 summarizes the extensive and intensive margins of technical measures on intra-OECD agricultural trade in 2004. As shown in the first row in table 2, technical measures appear to serve as quality signals and enhance OECD consumer's quantity demanded as well as the propensity to import from other OECD countries. The second row in table 2 suggests that technical regulations increase both the variable cost and the fixed cost faced by OECD exporters. Noticeably, the magnitude of the extensive margin is comparable to that of the intensive margin, for either effect. To gauge the net effect on both margins, we consider a simple case in which the importing country imposes a new technical measure while the exporting country doesn't. The net effect of this new regulation can be computed as the sum of the demand-enhancing effect and the trade-cost effect. As shown in the third row in table 2, the net effect is positive but not

statistically significant on the intensive margin, which suggests that the bilateral trade volume would be barely affected by the new regulation although both supply and demand shift and welfare will be affected. However, the net effect is negative and statistically significant on the extensive margin, which indicates that the new measure is likely to create new trade partnership among OECD members. In other words, the technical measures enhance consumers' demand for imports more than they handicap exporters' supply of exports. These results substantially refine the previous findings of Disdier, Fontagné, and Mimouni (2008) who found that SPS/TBT measures on agricultural commodities imposed by OECD countries had decreased exports from non-OECD countries but slightly promoted intra-OECD trade (although not statistically significant).

Next, we turn to regressions for specific sectors at HS-2 level. A glance at the frequency index of technical measures suggests that the following twelve agricultural sectors are regulated in OECD countries: dairy products (HS-04); live trees, cut flowers (HS-06); edible fruits, nuts (HS-08), coffee, tea, spices (HS-09); cereals (HS-10); milling products (HS-11); meat, fish preparations (HS-16); cereal preparations (HS-19); vegetable preparations (HS-20); edible preparations (HS-21); and beverages, spirits (HS-22). We fit the Heckman sample selection model with each subsample and report in table 3 the simple counts of different demand-enhancing effects and the trade-cost effects. The results on the demand-enhancing effects suggest that the role of technical measures as quality signals increases the chance of intra-OECD trade in eight out of the twelve intensively regulated sectors. Moreover, the volume of trade in three sectors would increase as result of the quality improvement if firms were not affected by the regulations. On the other hand, the estimates of the trade-cost effects indicate that technical measures significantly add to the variable costs of trade in three sectors, and the fixed costs of trade in three sectors. We find positive trade-cost effects on the extensive margin for two sectors,

which was surprising. One possible explanation is that the country-specific notifications of technical measures do not capture certain harmonization or mutually recognition of standards, which presumably reduces compliance cost considerably.

[Table 3 about here]

Now we focus on two particular sectors, dairy products (HS-04) and cereal preparations (HS-19), in which both consumers and producers in OECD are found to be sensitive to technical measures. SPS/TBT issues in dairy products involve the use of Bst, a genetically engineered growth hormone that increases milk production, a dispute over mandatory pasteurization of cheese, and labeling of yogurts among others (Bureau and Doussin 1999). The technical regulations toward cereal preparations evolve around the Maximum Residue Limits (MRLs) on mycotoxin residues that result from poor farm practice in high temperature and high humidity environments. In 2002, EU harmonized their MRLs on mycotoxins in several sectors, including cereal and vegetable preparations. Compared to the international standards (Codex Alimentarius), EU's harmonized regulation is more stringent in terms of both allowable level and sampling methods, which triggered concerns about the potential trade loss borne by exporters (Otsuki, Wilson, and Sewadeh 2001b). The econometric results for the two sectors are reported in table 4 and the implied marginal effects of regressors in table 5.

[Table 4 about here]

[Table 5 about here]

We first discuss the results for dairy products. As shown in table 4, both the demand-enhancing effect and the trade-cost effect bear the expected signs and turn out statistically significant. In terms of the magnitude, table 5 suggests that the technical measures on dairy

products depress the supply of exports more than they enhance consumer's demand via information disclosure and quality improvement. In fact, if an OECD importer adopts a new regulation while the trading partner doesn't, the new measure would reduce the likelihood of trade between the two countries, as the net effect on the extensive margin is negative and statistically significant. The above results suggest that although OECD consumers in general place a premium on the dairy products of higher quality, but the compliance costs borne by producers prevent them from adopting new technologies and capturing some of these markets.

Regarding cereal preparations, table 4 shows that both OECD consumers and producers seem to respond to technical regulations, with the demand-enhancing effect dominating the trade-cost effect in magnitude. Table 5 further confirms that agents on both sides of the market are affected by the technical measures, and that a new regulation is likely to increase the chance of intra-OECD trade in cereal preparations. The trade-promoting attribute of technical regulations in cereal products reflect several facts. OECD consumers are visibly concerned about mycotoxin contamination in food stuff and they are willing to pay a sizable premium for high-quality cereal products. For OECD exporters who are able to conform to these costly regulations, trade expands. Not captured here but documented elsewhere is the fact that non-OECD exporters have difficulty meeting these standards (Disdier, Fontagné, and Mimouni 2008; Otsuki, Wilson, and Sewadeh 2001b) inducing some changes in sourcing these products from new OECD suppliers meeting the stricter standards.

The estimates of other trade determinants, in both sectors, are in line with a typical gravity equation analysis. Tariffs are found to be trade-impeding; the farther apart two countries are, the less the bilateral trade there is; a shared border and a common language between trading partners facilitate trade; NTBs other than technical regulations do not significantly affect the intra-OECD trade in dairy products and cereal preparations.

Robustness and specification checks

In this subsection, we conduct several robustness checks for our empirical application. One concern about the Heckman sample selection model is that it requires a variable in the selection equation to be excluded from the outcome equation. To see to the influence of the choice of excluded variable on results, we re-estimate the models when the colonial tie dummy variable is excluded. The associated results are almost identical to those reported in table 2 through 5.¹²

Another criticism toward the use of the Heckman sample selection model is that the estimates can be biased if trade flow exhibits heteroskedasticity. One remedy to the problem is to use the PPML approach proposed by Silva and Tenreyro (2006), in which the gravity equation is estimated in its multiplicative form instead of the logarithmically linear form and robust standard errors are used to accommodate heteroskedasticity. However, as Pham and Marin (2008) show, the PPML approach ignores the limited dependency of the trade flow and fails to explain the absence of trade. A variant to the PPML approach is the Zero-Inflated Poisson Pseudo Maximum Likelihood (ZIPPMML) estimator which improves upon the standard PPML approach by accounting for the excessive zeros (Burger, van Oort, and Linders 2009). One disadvantage with the ZIPPMML approach is that the estimates vary as to the unit of the dependent variable varies.¹³ Nevertheless, we conduct the ZIPPMML regressions and compare the results to those delivered by the Heckman models. In the augmented regressions, the demand-enhancing effects and the trade-cost effects found are qualitatively similar except that the trade-cost effect becomes positive in the pooled regression.¹⁴ The technical measures are shown to promote intra-OECD agricultural trade overall.

Conclusions

In this article, we propose a generalized gravity equation model in which the demand-enhancing effect and the trade cost effect of technical measures can be disentangled. The approach allows examining whether technical measures affects international trade, if any, through shifting consumers' demand curve via quality information disclosure, or shifting exporters' supply curve via imposing compliance costs, or both. An application of the approach to the intra-OECD agricultural trade in 2004 suggests that technical measures foster trade within OECD because these measures enhance consumers' demand for imports more than they hamper exporters' supply of exports. Although we do not investigate North-South trade, our findings are relevant to the debate on "standards as barrier to or catalyst for trade." We find that the willingness to pay of consumers in OECD countries increases with stricter regulation affecting quality of food. Hence, these standards do create new market opportunities for exporters. We do not say anything on how exporters in the South succeed or fail to capture these markets. Nevertheless, the allegation that these technical measures are mostly driven by protectionism is invalid.

More disaggregated analysis reveals that technical regulations on dairy products affect both consumers and producers in OECD, with trade-cost effect slightly dominating the demand-enhancing effect. On the other hand, technical measures on cereal preparations are shown to promote intra-OECD trade in the net because the enhancement of demand for high-quality cereal products outweighs the decrease of supply due to the associated compliance costs.

A promising extension would be to compile a panel data set and investigate the welfare effects of changes in technical measures. The time variation would allow the identification of all structural parameters in the proposed model and facilitate the computation of domestic and international welfares. Furthermore, one could also explicitly consider additive external effects on human/animal health and the environment based on currently available scientific evidence, which allows predicting the welfare implications of technical measures in the long-run.

¹ Throughout the article, we use technical measures, SPS measures, and quality standards interchangeably.

² All other factors affecting consumers' quality perception or evaluation are subsumed in δ_{s0} .

³ Consumers are assumed to be cognizant of both domestic and foreign quality signals implied by the measures. This is consistent with a label stating that quality exceeds the standard in the destination market.

⁴ For the purpose of tractability, we do not explicitly model the endogenous choice of Ω_{st} . However, in the empirical part, we partially account for countries' decision to export or not by using the Heckman sample selection model. Interested readers are referred to Helpman, Melitz, and Rubinstein (2008) for a detailed characterization of firms' exporting behavior.

⁵ These protectionist non-tariff barriers differ from the technical measures or SPS measures in that they do not constitute quality signals thus presumably impede trade by suppressing the supply of exports. See further discussion in Section 3.

⁶ We leave out the impact of domestic standards on domestic producers. Presumably, the effect can be either positive, if the domestic producers successfully comply with the regulations, or negative, if the associated compliance costs turn out significant.

⁷ Additionally, the new standard affects exporters' profitability in other destinations by altering the relative prices across foreign markets. We abstract from such indirect trade diversion effect in our discussion.

⁸ Some tariff and trade data are missing in Disdier, Fontagné and Mimouni (2008). We complement the data with COMTRADE. Nevertheless, the bilateral tariff series is still incomplete. We drop those observations with missing tariffs. As a robustness check, we replace with missing tariffs with the sample averages at importer level. The results are qualitatively unchanged.

⁹ In the next subsection, we report the results from the two-step procedure because the high dimensionality makes the convergence of the full likelihood function difficult.

¹⁰ For robustness check, we re-estimate the model with the colonial tie dummy variable excluded. The results are barely affected. See the next subsection for detail.

¹¹ However, the overall marginal effect of protectionist NTBs, with both the extensive margin and the intensive margin taken into account, can be shown to impede trade.

¹² The econometric results are available from authors upon request.

¹³ Both the selection and the outcome processes can generate zeros in the ZIPPMML model. Hence, more zeros are attributed to the selection process when trade data are recoded say in dollars as opposed to in millions of dollars.

¹⁴ The econometric results are available from authors upon request.

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Table 1: Model results for intra-OECD agricultural trade, 2004

Variable	Trade	Selection
	Equation	Equation
Quality	0.140***	0.123***
$\theta\beta$	(0.036)	(0.010)
Trade Cost	-0.166***	-0.099***
$-\theta\gamma$	(0.044)	(0.013)
Tariff	-0.988***	-0.363***
$-\theta$	(0.086)	(0.026)
Distance	-1.288***	-0.604***
$-\theta b_d$	(0.033)	(0.009)
Border	0.911***	0.460***
θb_b	(0.043)	(0.022)
Colony	0.040	0.073**
θb_c	(0.051)	(0.024)
Language	N.A.	0.150***
θb_l		(0.020)
Protectionist	-0.205***	0.034*
NTBs	(0.053)	(0.019)
θb_p		

Table 1 (continued) : Model results for intra-OECD agricultural trade, 2004

Protectionist	-0.077	0.040
EU NTBs	(0.127)	(0.037)
θb_{p-EU}^a		
Inverse		0.726***
Mills Ratio ^b	(0.075)	

Note: a. The protectionist NTBs adopted by the EU can have different trade effects than those imposed by other OECD countries because intra-EU trade is not subject to EU's NTBs. To capture this potential difference, we allow the response to EU's NTBs to be different. b. The Inverse Mills Ratio is the additional regressor in the trade equation that corrects for the sample selection bias. The significance of the Inverse Mills Ratio confirms the suitability of the Heckman sample selection model. Standard errors are in parenthesis. *, **, and *** denote significance level at 0.1, 0.05, and 0.01 respectively.

Table 2: Marginal effects of technical measures on intra-OECD agricultural trade, 2004

	Intensive margin	Extensive margin
Demand-enhancing effect	0.140*** (0.036)	0.142*** (0.012)
Trade-cost effect	-0.166*** (0.044)	-0.113*** (0.015)
P value of χ^2 -stat for	0.303	0.001
H ₀ : zero net effect		

Note: Standard errors are in parenthesis. *, **, and *** denote significance level at 0.1, 0.05, and 0.01.

Table 3: Summary of sectoral analysis of the effects of technical measures on intra-OECD agricultural trade, 2004

	Intensive margin	Extensive margin
Demand-enhancing effect	Positive & stat. significant: 3 Null: 9 Negative & stat. significant: 0	Positive & stat. significant: 8 Null: 4 Negative & stat. significant: 0
Trade-cost effect	Positive & stat. significant: 0 Null: 9 Negative & stat. significant: 3	Positive & stat. significant: 2 Null: 7 Negative & stat. significant: 3

Note: Positive & stat. significant refers to positive and statistically significant at 10% level or lower; Negative & stat. significant refers to negative and statistically significant at 10% level or lower; Null refers to statistically insignificant at 10% level.

Table 4: Model results for intra-OECD trade in dairy products and vegetable preparations, 2004

Dairy products	Trade Equation	Inflation Equation	Cereal preparation	Trade Equation	Inflation Equation
Quality	0.763***	0.144***	Quality	0.973***	1.003***
$\theta\beta$	(0.185)	(0.049)	$\theta\beta$	(0.180)	(0.050)
Trade Cost	-0.848***	-0.205***	Trade Cost	-0.748***	-0.447***
$-\theta\gamma$	(0.216)	(0.057)	$-\theta\gamma$	(0.217)	(0.076)
Tariff	-0.480*	-0.221***	Tariff	-0.861	-0.598
$-\theta$	(0.264)	(0.076)	$-\theta$	(0.930)	(0.372)
Distance	-1.150***	-0.641***	Distance	-1.477***	-0.642***
$-\theta b_d$	(0.177)	(0.042)	$-\theta b_d$	(0.153)	(0.066)
Border	1.300***	0.407***	Border	0.959***	0.166
θb_b	(0.197)	(0.106)	θb_b	(0.238)	(0.171)
Colony	-0.109	0.050	Colony	-0.073	0.326*
θb_c	(0.254)	(0.110)	θb_c	(0.269)	(0.190)
Language	N.A.	0.258***	Language	N.A.	0.359**
θb_l		(0.096)	θb_l		(0.145)
Protectionist	0.270	-0.073	Protectionist	0.014	-0.509*
NTBs	(0.501)	(0.078)	NTBs	(0.755)	(0.296)
θb_p			θb_p		

Table 4 (continued): Model results for intra-OECD trade in dairy products and vegetable preparations, 2004

Inverse	0.718	Inverse	0.212
Mills Ratio	(0.390)	Mills Ratio	(0.359)

Note: Inverse Mills Ratio is defined as in table 1. Standard errors are in parenthesis. *, **, and *** denote significance level at 0.1, 0.05, and 0.01 respectively.

Table 5: Marginal effects on intra-OECD trade in vegetable preparations, 2004

Dairy products	Intensive	Extensive
	Margin	Margin
Demand-enhancing Effect	0.763***	0.163***
	(0.185)	(0.057)
Trade-cost Effect	-0.848***	-0.232***
	(0.216)	(0.065)
P value of χ^2 -stat for	0.417	0.025
H ₀ : zero net effect		
Cereal preparations	Intensive	Extensive
	Margin	Margin
Demand-enhancing Effect	0.973***	0.779***
	(0.180)	(0.046)
Trade-cost Effect	-0.748***	-0.347***
	(0.217)	(0.061)
P value of χ^2 -stat for	0.260	0.000
H ₀ : zero net effect		

Note: Delta-method standard errors are in parenthesis. *, **, and *** denote significance level at 0.1, 0.05, and 0.01 respectively.

Appendix (on the derivation of intensive margins, extensive margins, and unconditional marginal effects in the Heckman sample selection model)

In general, the selection equation determining firms' self-selection to export is specified as

$$(A1) \quad \Pr(Y > 0) = \Phi(X\gamma).$$

The outcome equation generating the trade flows conditional on trade taking place is specified as

$$(A2) \quad E(\ln Y | Y > 0) = \sum_k x_k \beta_k + \eta IMR,$$

Let $z = x' \cdot \hat{\gamma}$ be the linear prediction from the selection equation; $IMR = \phi(\hat{z})/\Phi(\hat{z})$ is the Inverse Mill's Ratio as in Heckman (1979), which corrects for the sample selection bias.

Applying the rules of conditional expectations, we have

$$E(Y) = E(Y | Y > 0) \cdot \Pr(Y > 0) + E(Y | Y = 0) \cdot \Pr(Y = 0) = E(Y | Y > 0) \cdot \Pr(Y > 0).$$

Taking the logarithm of the above equation, and then taking the derivative with respect to an exogenous variable, x_k for instance, we have

$$(A3) \quad \frac{\partial \ln E(Y)}{\partial x_k} = \frac{\partial \ln E(Y | Y > 0)}{\partial x_k} + \frac{\partial \ln \Pr(Y > 0)}{\partial x_k}.$$

The above equation states that the overall marginal effect can be decomposed into an *intensive*

margin $\frac{\partial \ln E(Y | Y > 0)}{\partial x_k}$, that is, the intensification of existing trade flows, and an *extensive*

margin $\frac{\partial \ln \Pr(Y > 0)}{\partial x_k}$, that is, the creation of new trade. Note that the extensive margin can be

readily computed from the estimates in the selection equations.

As Hoffman and Kassouf (2005) shows, $\frac{\partial \ln E(Y | Y > 0)}{\partial x_k} = \frac{\partial E(\ln Y | Y > 0)}{\partial x_k}$ holds under some

regular conditions.¹⁴ Therefore, the intensive margin can be computed as

$$(A4) \quad \frac{\partial \ln E(Y | Y > 0)}{\partial x_k} = \frac{\partial E(\ln Y | Y > 0)}{\partial x_k} = \hat{\beta}_k + \left(\frac{\phi'(z)}{\Phi(z)} - IMR^2 \right) \eta \hat{\gamma}_k,$$

where $\phi'(z) = -\frac{z}{\sqrt{2\pi}} \exp(-0.5z^2)$ is the derivative of the standard normal density function. The

above equation states that a trade determinant affects the trade level both directly and indirectly.