An Analysis of the Trade Impact of Food Safety Standards using the Generalized Gravity Model

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Technical Regulations and Standards

- Technical Regulations

  A specification contained in a document which **lays down the characteristics of a product** such as dimension, labelling, packaging, level of quality, conformity assessment procedures etc., which compliance is **mandatory**. This term also covers production methods and processes.

- Standards

  The same as above except that compliance may be **voluntary or mandatory**. (in the case of food safety standards, they are generally mandatory.)

Technical Regulations – Examples

- For food products:

  Sanitary and Phytosanitary (SPS) standards

  Food safety and animal and plant health standards

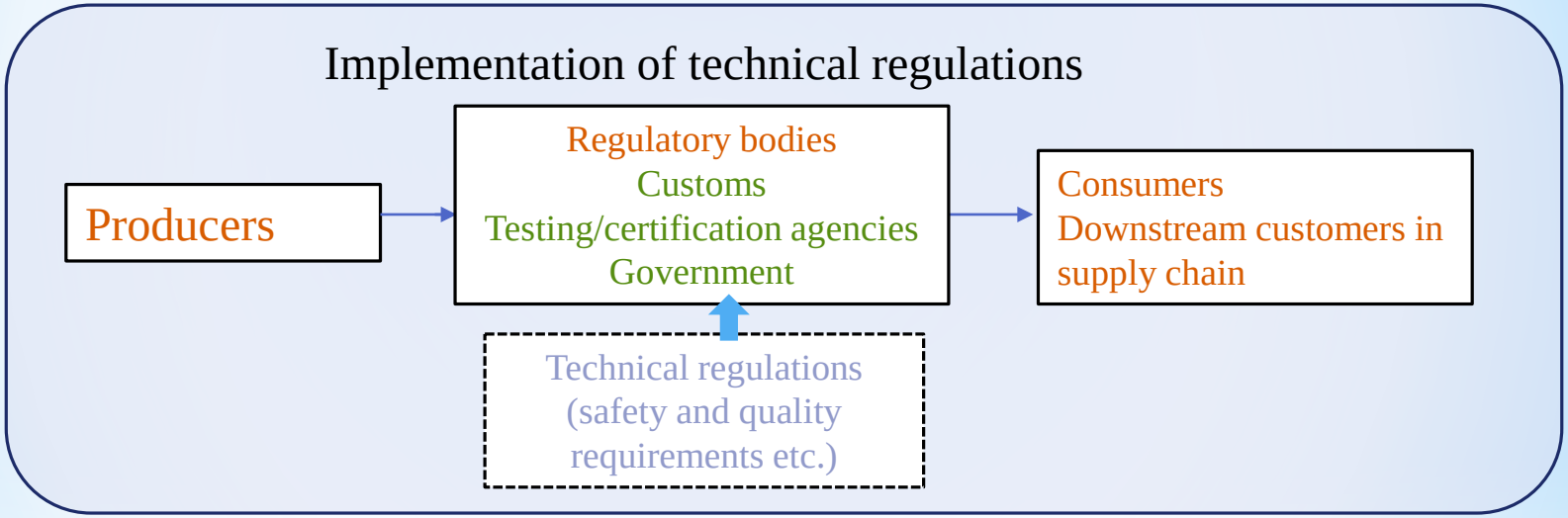
  e.g. Pesticide residue standards

- For general product categories (food and manufactured products):

  Technical barriers to trade (TBT) (mainly for traded goods)

  e.g. Product-related environmental regulations, consumer safety standards, etc.

Technical Regulations and Producers/Consumers



- In the case of imports, imported products are subject to border inspection, and the products not meeting the standards result in rejection.
- In the case of domestic products, products are subject to testing and inspection, or required certification.

TBT and SPS Agreements

- Technical regulations may reduce the exposure of consumer to health/environmental risks, but it also may constitute barriers to trade by imposing the compliance cost on producers

- WTO's TBT and SPS Agreements stipulate appropriate use of standards and technical regulations in international trade

WTO Disputes Related to SPS Standards

Case	Complaint by	Year	Reason of regulation	Category
Australia's quarentine practises	Philippines	1998		SPS
Egypt's ban on canned tuna with GM soybean oil	Thailand	2000	Allergenicity, gene transfer, outcrossing	SPS,TBT
EU standards on pesticide and antibiotic residue in honey	Cuba	2002	Increase of antibiotic-resistent bacteria	SPS

Costs and Benefits of Technical Regulations

- Costs

  Compliance cost – Product re-designing & testing/labeling

  Scale diseconomy – Designing/testing for multiple markets

- Benefits

  Ensuring consumer safety

  Correction of market failures caused by consumption externality, information asymmetry and network (in)compatibility

Empirical Evidence of the Impact of Standards

- Cereals, dried fruits and nuts – Otsuki, Wilson and Sewadeh (2001)
- Pesticide residue standards and export

  Bananas (pesticide standards) – Wilson and Otsuki (2004)

  Pear (pesticide standards) – Drogue and De Maria (2011)

  Plant products in general – Winchester et al. (2012), Ferro, Wilson and Otsuki (2014)
- Veterinary drug residue standards and export

  Beef (antibiotics standards) – Wilson, Otsuki and Majumdar (2003)

Results from Cross-Country Studies on Using Gravity Models

- The majority found negative effect of tightening food safety standards

- Suggesting the presence of trade-off between trade and consumer health

Empirical Methodologies to Estimate the Impact of Standards

- Cross-country studies
  - Gravity model – link between trade and standards
  - Computable General Equilibrium (CGE) model – link between trade and standards
- Market-level studies
  - Demand-supply analysis, Demand (System) analysis, etc. – Impact of standards on particular market(s)
- Micro-level studies
  - Firm-level - export/cost function, entry/exit analysis
  - Consumer-level – contingent valuation method
    conjoint analysis
- Scientific assessment
  - Scientific assessment of health risk of hazards (toxic substances, bacteria, pesticide /drug residues)

Generalized Gravity Model

- **Limitation of** the traditional gravity models is that it is not suitable to identify the demand and supply effects of standards because it lacks structure.
- Need for estimation models capturing both demand and supply effects.
- Xiong and Beghin (2014) proposed the generalized gravity model to include structural parameters of the demand and supply sides.
- Xiong and Beghin found positive **demand-enhancing effect** and negative **trade cost (supply) effect** of pesticide residue standards.

Research Objectives

- To identify the **demand-enhancing** and **trade cost (supply) effects** of MRL standards of veterinary drug residues on the global meat product trade using the Xiong and Beghin's (2014) **generalized gravity model**.

  Meat products of interest include beef, pork and chicken.

Theoretical Foundation

General equilibrium model as a theoretical foundation for the generalized gravity model

Consumer

The representative consumer in country *j* with CES preferences maximizes its utility:

$$\max_{Q^d_{sij}} U_j = \left[\sum_s \sum_i (\delta_{sj} Q^d_{sij})^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \qquad (1)$$

$$s.t. \sum_s \sum_i P_{sij} Q^d_{sig} = Y_j$$

where δ_{sj} is the consumer's perceived quality of good *s*; Q^d_{sig} is the consumer's quality demanded for good *s* produced by 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 national income of country *j*.

Theoretical Foundation

The solution to the problem leads to country *j*'s import demand (in values) for good s originated from country *i*;

$$V_{sig}^{d} \equiv P_{sij} \cdot Q_{sij}^{d} = \delta_{sj}^{\varepsilon-1} P_{sij}^{1-\varepsilon} / \Pi_j Y_j \qquad (2)$$

where $\Pi_j = \sum_s \sum_i \delta_{sj}^{\varepsilon-1} P_{sij}^{1-\varepsilon}$ is the consumer price index in country *j*.

In particular, δ_{sj} is parameterized as

$$\delta_{sj} = \delta_{so} \exp(\beta MRL_{sj}) \qquad (3)$$

where δ_{s0} is the consumer's quality perception for good *s* in absence of MRL regulation, MRL_{sj} is the stringency index of MRLs for sector *s* in country *j*, with larger index representing more stringent MRLs. β is the parameter to be estimated that captures **demand-enhancement effect** of standards.

Theoretical Foundation

Producer

There is a representative producer for each sector in each country, whose problem is to decide which markets to target and how much to sell in each destination, which is characterized as:

$$\max_{\{Q^s_{sij}\}_{j\in\Omega_{si}}} \sum_{j\in\Omega_{si}} P_{sij}Q^s_{sij} \quad \text{s.t.} \quad \left[\sum_{j\in\Omega_{si}} (\tau_{sij}Q^s_{sij})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} = Q_{si} \qquad (4)$$

where Q^s_{sij} is country *i*'s quantity of good *s* supplied to country *j*, $\eta<0$ is the elasticity of transformation, $\tau_{sij}>1$ is the "ice-berg melting" trade cost term.

Theoretical Foundation

The solution to the producer's problem gives values as

$$V_{sij}^{s} \equiv P_{sij} \cdot Q_{sij}^{s} = \frac{Q_{si}\tau_{sij}^{\eta-1}}{\Psi_{si}P_{sij}^{\eta-1}} \tag{5}$$

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.

Theoretical Foundation

Trade cost τ_{sij} is parameterized as:

$$\tau_{sij} = (1+Tar_{sij})(1+Dist_{ij})^{b_d} \exp(-b_p Lang_{ij}) \exp(-b_b Bord_{ij}) \cdot \exp(-b_c Col_{ij}) \exp(-b_r Rel_{ij}) \exp(\gamma \max\{MRL_{sj} - MRL_{si}, 0\}) \quad (6)$$

where Tar_{sij} is country *j*'s tariff rate imposed on good *s* form country *i*, $Dist_{ij}$ is the distance between country *i* and *j*, $Lang_{ij}$ is the common language dummy, $Bord_{ij}$ is the common border dummy, Col_{ij} is the colonial dummy, Rel_{ij} is the proportion of two populations that speak a common language.

Theoretical Foundation

$\max\{MRL_{sj} - MRL_{si}, 0\}$ is the difference in MRLs between *i* and *j*. Thus, γ represents **trade-cost effect** of standards.

The new source of trade cost is the difference in MRLs between trading partners. Exporters from countries with $MRL_{sj} > MRL_{si}$ $MRL_{sj} < MRL_{si}$ have to overcome additional costs to reach the stringent limits required by the importing country while those with are less likely to experience trade disruption from MRLs variation.

Theoretical Foundation

The equilibrium

The equilibrium is given by

$$P_{sij} = \left(\frac{Y_j}{\Pi_j}\right)^{\frac{1}{\varepsilon-\eta}} \left(\frac{\Psi_{si}}{Q_{si}}\right)^{\frac{1}{\varepsilon-\eta}} \delta_{sj}^{\frac{\varepsilon-1}{\varepsilon-\eta}} \tau_{sij}^{\frac{1-\eta}{\varepsilon-\eta}} \qquad (7a)$$

and

$$V_{sij} = \left(\frac{Y_j}{\Pi_j}\right)^{\frac{1-\eta}{\varepsilon-\eta}} \left(\frac{Q_{si}}{\Psi_{si}}\right)^{\frac{\varepsilon-1}{\varepsilon-\eta}} \left(\frac{\delta_{sj}}{\tau_{sij}}\right)^{\frac{(\varepsilon-1)(1-\eta)}{\varepsilon-\eta}} \qquad (7b)$$

The first equation suggests the equilibrium price is increasing in Y_j, δ_{sj}, τ_{sij} but decreasing in Q_{si}.

The second equation suggest the bilateral trade value is increasing Y_j, Q_{si}, δ_{sj} but decreasing in τ_{sij}.

Theoretical Foundation

Generalized gravity model

Substituting (3) and (6) into (7b) will give the following generalized gravity model.

$$\begin{aligned}\ln(V_{sij}) &= \varphi Y_j - \varphi\Pi_j + (1-\varphi)Q_{si} - (1-\varphi)\Psi_{si} - \theta\ln(1+Tar_{sij}) \\ &+\theta b_p Lang_{ij} - \theta b_d(1+Dist_{ij}) + \theta b_b Bord_{ij} + \theta b_c Col_{ij} + \theta b_r Rel_{ij} \\ &-\theta\gamma\max\left\{MRL_{sj} - MRL_{si}, 0\right\} + \theta\beta MRL_{sj}\end{aligned} \tag{8}$$

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

Estimation Model

The estimated equation which simplifies the previous equation is given by

$$\ln(T_{sijt}) = \mathbf{X_{ijt}\beta} + \gamma \max\{MRL_{sjt} - MRL_{sit}, 0\} + \delta MRL_{sjt} + fe_{it} + fe_{jt} + fe_s + \varepsilon_{sijt}$$

Here γ gives the trade cost effect whose sign is expected to be negative. δ gives the demand-enhancing effect whose sign is expected to be positive.

Data

Period: 2012-2016

Products: beef, pork and chicken in HS 6 digit.

Data sources:

- Bilateral trade – UN COMTRADE data
- Distance, language, etc. – CEPII
- RTA – RTA list of the WTO
- MRL (maximum residue limit) – Global MRL

Data

MRL index for veterinary drug is constructed based on Li and Beghin (2012)

$$MRL_{jk} = \frac{1}{N_{(k)}} \sum_{n_{(k)}=1}^{N_{(k)}} \exp\left(\frac{MRL_{codex,kn_{(k)}} - MRL_{jkn_{(k)}}}{MRL_{codex,kn_{(k)}}}\right)$$

where $MRL_{jkn_{(k)}}$ is the MRL adopted by country *j*, for product *k*, and targeting veterinary drug $n_{(k)}$; $MRL_{codex,kn_{(k)}}$ is the MRL recommended by Codex for the same product – veterinary drug combination; and $N_{(k)}$ is the total number of applicable to product *k*.

Descriptive Statistics

	# ofObs.	Mean	Std. Dev.	Min	Max
$\text{Trade Value}_{sijt}$ (in thousand US$)	64,472	6.606	41.025	0.000001	1648.678
$\ln(\text{Trade Value}_{sijt} + 1)$	413,488	0.102	0.490	0	7.408
$\text{Total Export}_{sit}$ (in thousand US$)	413,488	70.444	275.651	0.000001	4450.733
$\ln(\text{Total Export}_{sit})$	413,488	0.113	3.860	-13.816	8.401
Distance_{ij} (km)	413,488	6779.529	4740.932	59.617	19772.340
$\ln(\text{Distance}_{ij})$	413,488	8.429	1.043	4.088	9.892
$\text{Language Dummy}_{ij}$	413,488	0.117	0.322	0	1
Colony Dummy_{ij}	413,488	0.0651	0.247	0	1
$\text{Contingency Dummy}_{ij}$	413,488	0.0353	0.185	0	1
RTA Dummy_{ijt}	413,488	0.533	0.499	0	1
MRL_{sjt}	413,488	1.123	0.212	0.379	1.586
$\max\{\text{MRL}_{sjt} - \text{MRL}_{sit}, 0\}$	413,488	0.0534	0.132	0	0.905

Estimation Schemes

- We use OLS and PPML (Poisson pseudo-maximum likelihood) to estimate the generalized gravity model.
- PPML is used to accommodate the presence of zero trade values (Santos Silva and Tenreyro (2006)).

Estimation Results

	All countries		High-income importer	
	OLS	PPML	OLS	PPML
$\ln(\text{Total Export}_{sit})$	0.0297***	0.903***	0.0404***	0.939***
$\ln(\text{Distance}_{ij})$	-0.0532***	-0.571***	-0.0805***	-0.447***
$\text{Language Dummy}_{ij}$	0.0299***	0.304***	0.0212***	0.411***
$\text{Colonial Dummy}_{ij}$	-0.104***	-0.171***	-0.129***	-0.160*
$\text{Contingency Dummy}_{ij}$	0.526***	0.826***	0.580***	0.951***
RTA Dummy_{ijt}	0.0677***	0.280***	0.127***	0.522***
Demand shifter (δ)	0.187***	0.290	0.109***	0.0589
Trade cost shifter (γ)	-0.273***	-2.260***	-0.237***	-2.752***
Observations	413,488	64,472	138,154	30,349
R^2 (pseudo R^2)	0.199	0.485	0.242	0.523

Main Results

- **Demand-enhancing effect** (δ) is found to be **positive** (significant in OLS and not significant in PPML).
- **Trade cost effect** (γ) is found to be **negative**.
- Largely, the results remain unchanged when we limit to importers to high-income countries.
- This implies that the negative sign of the trade cost effect is consistent with expectation.
- Even though we admit that the (positive) demand-enhancing effect is present, the trade cost effect overweighs the demand effect in the case of meat product trade.

Implications

- Although the net effect of MRL standards is negative as is found in the most previous studies, we are able to avoid bias from mixing up the supply and demand effects.
- If the demand-enhancing effect is considered to be present, more stringent MRL can be said to attract consumers.

Findings of Other Studies in Progress

- Market-level study of veterinary drug standards and Japanese demand of poultry imports: Japanese consumers are likely to shift to the imports from the previously looser standard when the Japanese standard is tightened (because safety is guaranteed by the border regulation).
- Consumer-level study of veterinary drug standards and Japanese consumer's willingness to pay (WTP): Japanese consumer's WTP for antibiotic residue standards (assurance of safety) is 170% of the unit price (150% WTP for radioactive safety).

Overall Summary

- Food safety standards may impose significant cost on exporting countries, but can be, at least partially, rewarded by higher demand (quantity and/or price) for safer food products.
- Food safety regulations should be designed to balance producer's profit and consumer's health.
- Also, developing country suppliers should grasp the opportunity to penetrate into developed country markets by investing to ensure safety.