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March 2016

Abstract

This paper explores the potential usefulness of an AGE model with the Melitz-type trade specification to assess economic effects of technical regulations, taking the case of the EU ELV/RoHS directives as an example. Simulation experiments reveal that: (1) raising the fixed exporting cost to make sales in the EU market brings results that exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions/countries expand while the domestic trade in the EU shrinks when the importer's preference for variety (PfV) is not strong; (2) if the PfV is not strong, policy changes that may bring reduction in the number of firms enable survived producers with high productivity to expand production to be large-scale mass producers fully enjoying the fruit of economies of scale; and (3) When the strength of the importer's PfV is changed from zero to unity, there is the value that totally changes simulation results and their interpretations.

Keywords: applied general equilibrium; non-tariff barriers; preference for variety

JEL classification: C68, D58, F12, L11

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Kazuhiko OYAMADA†

March 25, 2016

Abstract

This paper explores the potential usefulness of an applied general equilibrium model with the Melitz-type trade specification to assess economic effects of technical regulations, taking the case of the European Union (EU) End-of-Life Vehicles/Restriction of Hazardous Substances (ELV/RoHS) directives as an example. Simulation experiments reveal that: (1) raising the fixed exporting cost to make sales in the EU market brings interesting results that exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions/countries expand while the domestic trade in the EU shrinks when the importer's preference for variety (PfV) is not strong as Ardelean (2006) suggests; (2) if the PfV is not strong, policy changes that may bring reduction in the number of firms enable survived producers with high productivity to expand production to be large-scale mass producers fully enjoying the fruit of economies of scale; and (3) When the strength of the importer's PfV is changed from zero to unity, there is the value that totally changes simulation results and their interpretations.

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1. Introduction

Modeling non-tariff barriers (NTBs) has long been a challenge for builders of applied general equilibrium (AGE) models, since NTBs are not straightforwardly connectable to economic variables included in a model unlike taxes or tariffs, in addition to the fact that information on NTBs is not easy to collect, sort out complication, or quantitatively measure. Non-tariff measures are introduced in order not only to protect local industries, but also to regulate the domestic market. In consequence, NTBs may generate different kinds of economic effects, i.e., protection effects as well as supply- and demand-shifting effects (Fugazza and Maur (2008)). Protection effects may be generated by measures which restrict trade raising cost. Supply-shifting effects may be caused by regulations which specify and affect production processes, such that prevent the sales of hazardous products and create standards to increase compatibility and interoperability. Demand-shifting effects may be brought by rules which affect consumers' behaviors, such that obligate to provide certain information related to the sold commodity.

Protection effects can be assessed by two different approaches. One approach uses ad-valorem equivalent (AVE) estimates of NTBs based on the difference between the world price and the domestic price in the importing or exporting country, which has been adopted by previous AGE analyses, such as Andriamananjara, Ferrantino and Tsigas (2003) and Fugazza and Maur (2008). Another one focuses on the additional cost of production that firms have to bear in order to export to a specific market. This kind of cost is considered by the seminal work of Melitz (2003) where within-industry resource allocation among heterogeneous firms plays an important role. The purpose of this study is to show the usefulness of an AGE model with the Melitz-type trade specification to assess economic effects of technical regulations, taking the case of the European Union (EU) End-of-Life Vehicles/Restriction of Hazardous Substances (ELV/RoHS) directives as an example. We also explore cases when demand-shifting effects incur, changing the importer's preference for variety (PfV), to show some points need to be paid attention.

Ardelean (2006) explored how strong the PfV is, and found that consumer’s PfV is around 40 percent lower than the one assumed in the Krugman’s model. In this paper, we clarify some of the behavioral characteristics of a sample AGE model with the Melitz-type trade specification changing the strength of PfV. Simulation experiments reveal that: (1) raising the fixed exporting cost to make sales in the EU market brings reasonable results that exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions shrink while the domestic trade in the member countries of the EU expands when the importer's PfV is strong as assumed in the theoretical model by Melitz (2003); (2) those who are better off when the importer's PfV is strong are the regions/countries successful in expanding domestic trade, intra-regional trade, or inter-regional trade with a non-EU region/country replacing the shrunk exports to the EU; (3) raising the fixed exporting cost to make sales in the EU market brings interesting results that exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions expand while the domestic trade in the member countries of the EU shrinks when the importer's PfV is not strong as Ardelean (2006) suggests; (4) if the PfV is not strong, policy changes that may bring reduction in the number of firms enable survived producers with high productivity to expand production to be large-scale mass producers fully enjoying the fruit of economies of scale; and (5) When the value of the strength of the importer's PfV is changed from zero to unity, there is the value that totally changes simulation results and their interpretations.

The reminder of this paper is organized as follows. Section 2 illustrates the sample AGE model with the Melitz-type trade specification, which becomes the base of the analysis. In Section 3, we perform simulations with the model which is extended to include an explicit parameter to control the strength of PfV, and verify the results. Then, Section 4 concludes this paper.

2. The Model

In this section, we overview the sample AGE model with the Melitz-type trade specification used in this study. The global economy consists of six regions/countries indexed r (source) and s (destination), which are linked through trade flows: (r01) the EU; (r02) the United States of America (USA); (r03) Japan; (r04) China; (r05) ASEAN; and (r06) rest of the world (ROW). Commodities and activities respectively indexed i and j are categorized into five kinds: (i01) the primary industries; (i02) services; (i03) motor vehicles and parts; (i04) electronic equipment; and (i05) other manufacturing. Sectors i03 through i05 are assumed to be imperfectly competitive with increasing returns to scale (IRTS), while the other two are characterized by constant returns to scale (CRTS). Sector i01 uses a sector specific factor, such as land and natural resources, in addition to capital, labor, and intermediate goods in its production process. Sector i02 provides a fraction of its output as the inter-regional transportation supply.

An important feature of the model is that firms in the manufacturing sector are divided into two segments that respectively take charge of production and sales. In the production process, the production segment of firms collectively determines sector-wide input levels of intermediate goods and primary factors, and the output volume, based on CRTS technologies. Then, the product is wholesaled to the sales segment. The sales segment consists of many dealers/merchants, those who have market power to determine the sales price of the commodity in local markets. The scale economy enters here.

2.1 Production

Composite Commodity for Intermediate Input: First, the unified production segment of firms in sector j in region r determines input levels of commodity i for intermediate use X_{ijr} to minimize cost subject to a constant-elasticity-of-substitution (CES) technology. The problem can be expressed as

$$\min \quad \sum_i p_{ir} X_{ijr}$$

$$\text{s.t.} \quad \tilde{X}_{jr} = \theta_{jr}^X \left\{ \sum_i \alpha_{ijr}^X X_{ijr}^{\left(\sigma_j^X - 1\right)/\sigma_j^X} \right\}^{\sigma_j^X/\left(\sigma_j^X - 1\right)} \quad \perp p_{jr}^X, \qquad (1)$$

where

p_{ir} is the market price of commodity i in region r, inclusive of export duty/subsidy, transportation margin, and import tariff,

p_{jr}^X is price index for the composite commodity for intermediate input by sector j in region r,

$\tilde{X}_{jr}$ is quantity of composite commodity for intermediate input by sector j in region r,

σ_j^X is the elasticity of substitution between commodities,

α_{ijr}^X is the share parameter that reflects requirements of commodity i to form $\tilde{X}_{jr}$, and

θ_{jr}^X is the scaling factor of the measuring units.[1]

The perpendicular symbol ' $\perp$ ' 'shows the corresponding relationship between variable and an equation. The first order condition (FOC) for optimization is

[1] This parameter is needed to pass the replication test, which verifies whether an AGE model can reproduce the state captured by the benchmark data when there is no policy change (the reference run). For example, consider the case in which a data set that includes expenditures for two kinds of commodities, 1 and 1, and total expenditure 2. If we assume a Cobb-Douglas type function to aggregate these two commodities to make a composite good, we need to equate 2 with $1^{0.5} \cdot 1^{0.5}$. In this example, the scaling factor $\theta = 2$ is required to satisfy $2 = \theta \cdot 1^{0.5} \cdot 1^{0.5}$.

$$p_{ir} = \alpha_{ijr}^{X} p_{jr}^{X} \left(\theta_{jr}^{X}\right)^{\left(\sigma_j^X - 1\right)/\sigma_j^X} \left(\frac{\tilde{X}_{jr}}{X_{ijr}}\right)^{1/\sigma_j^X} \qquad \perp X_{ijr}. \quad (2)$$

Value-Added: The unified production segment of firms in sector j in region r also determines input levels of primary factor V_{ajr} to minimize cost subject to a CES technology. Three kinds of the primary factor, capital, labor, and the one specific to the primary industries, are indexed a. The problem can be expressed as

$$\min \quad \sum_a \sum_j w_{ar} V_{ajr}$$

$$\text{s.t.} \quad Y_{jr} = \theta_{jr}^{Y} \left\{ \sum_a \alpha_{ajr}^{Y} V_{ajr}^{\left(\sigma_j^Y - 1\right)/\sigma_j^Y} \right\}^{\sigma_j^Y/\left(\sigma_j^Y - 1\right)} \qquad \perp p_{jr}^{Y}, \quad (3)$$

where

w_{ar} is rental rate of the primary factor a in region r,
p_{jr}^{Y} is price index for value-added by sector j in region r,
Y_{jr} is value-added by sector j in region r,
σ_j^Y is the elasticity of substitution between the primary factors,
α_{ajr}^{Y} is the share parameter that reflects requirements of the primary factor a in production, and
θ_{jr}^{Y} is the scaling factor.

The FOC for optimization is

$$w_{ar} = \alpha_{ajr}^{Y} p_{jr}^{Y} \left(\theta_{jr}^{Y}\right)^{\left(\sigma_j^Y - 1\right)/\sigma_j^Y} \left(\frac{Y_{jr}}{V_{ajr}}\right)^{1/\sigma_j^Y} \qquad \perp V_{ajr}. \quad (4)$$

Gross Output: Finally, the unified production segment of firms in sector j in region r determine input levels of composite input factors Y_{jr} (value-added) and $\tilde{X}_{jr}$ (composite intermediate commodity) to minimize cost subject to a CES technology. The problem can be expressed as

$$\min \quad p_{jr}^{Y} Y_{jr} + p_{jr}^{X} \tilde{X}_{jr}$$

$$\text{s.t.} \quad Z_{jr} = \theta_{jr}^{Z} \left\{ \alpha_{jr}^{Z} Y_{jr}^{\left(\sigma_j^Z - 1\right)/\sigma_j^Z} + \left(1 - \alpha_{jr}^{Z}\right) \tilde{X}_{jr}^{\left(\sigma_j^Z - 1\right)/\sigma_j^Z} \right\}^{\sigma_j^Z/\left(\sigma_j^Z - 1\right)}$$

$$\perp p_{jr}^{Z}, \quad (5)$$

where

p_{jr}^{Z} is the price index for gross output by sector j in region r,
Z_{jr} is gross output by sector j in region r,

σ_j^Z is the elasticity of substitution between composite input factors,

α_{jr}^Z is the share parameter that reflects requirements of value-added Y_{jr} to produce Z_{jr}, and

θ_{jr}^Z is the scaling factor.

The FOC for optimization is

$$p_r^Y = \frac{1}{1+\tau_{jr}^Z} \alpha_{jr}^Z p_{jr}^Z \left(\theta_{jr}^Z\right)^{\left(\sigma_j^Z - 1\right)/\sigma_j^Z} \left(\frac{Z_{jr}}{Y_{jr}}\right)^{1/\sigma_j^Z} \quad \perp Y_{jr}, \quad (6)$$

and

$$p_{jr}^X = \frac{1}{1+\tau_{jr}^Z} \left(1 - \alpha_{jr}^Z\right) p_{jr}^Z \left(\theta_{jr}^Z\right)^{\left(\sigma_j^Z - 1\right)/\sigma_j^Z} \left(\frac{Z_{jr}}{\tilde{X}_{jr}}\right)^{1/\sigma_j^Z} \quad \perp \tilde{X}_{jr}, \quad (7)$$

where τ_{jr}^Z is the rate of indirect taxes on production.

2.2 Inter-regional Trade: The Melitz-type Trade Module

The inter-regional links between gross outputs in source regions and absorptions in destinations are represented by the Melitz-type trade module based on Balistreri and Rutherford (2012), and Dixon, Jerie, and Rimmer (2015). The equations that form our Melitz-type trade module are summarized as follows:[2]

$$\sum_j X_{ijs} + C_{is} = \theta_{is}^T \begin{Bmatrix} (1 - \sum_r \alpha_{irs}^T) N_{is}{}^{(\beta_{is} + \sigma_i^T - 1)/\sigma_i^T} D_{is}^{(\sigma_i^T - 1)/\sigma_i^T} \\ + \sum_r \alpha_{irs}^T (E_{irs} N_{ir})^{(\beta_{is} + \sigma_i^T - 1)/\sigma_i^T} Q_{irs}^{(\sigma_i^T - 1)/\sigma_i^T} \end{Bmatrix}^{\sigma_i^T/(\sigma_i^T - 1)} \quad \perp p_{is}; \quad (8)$$

$$p_{is}^D = (1 - \sum_r \alpha_{irs}^T)(\theta_{is}^T)^{(\sigma_i^T - 1)/\sigma_i^T} N_{is}{}^{(\beta_{is} - 1)/\sigma_i^T} p_{is} \left(\frac{\sum_j X_{ijs} + C_{is}}{D_{is}}\right)^{1/\sigma_i^T} \quad \perp D_{is}; \quad (9)$$

$$(1 + \tau_{irs}^M)(1 + \tau_{irs}^T)(1 + \tau_{irs}^E) p_{irs}^Q = \alpha_{irs}^T (\theta_{is}^T)^{(\sigma_i^T - 1)/\sigma_i^T} (E_{irs} N_{ir})^{(\beta_{is} - 1)/\sigma_i^T} p_{is} \left(\frac{\sum_j X_{ijs} + C_{is}}{Q_{irs}}\right)^{1/\sigma_i^T} \quad \perp Q_{irs}; \quad (10)$$

$$p_{ir}^D = \left(\frac{1}{1+\eta_i}\right) p_{ir}^W \quad \perp p_{ir}^D; \quad (11)$$

$$p_{irs}^Q = \left(\frac{1}{1+\eta_i}\right) \frac{p_{ir}^W}{\varphi_{irs}} \quad \perp p_{irs}^Q; \quad (12)$$

$$N_{ir} D_{ir} + \sum_s E_{irs} N_{ir} \frac{Q_{irs}}{\varphi_{irs}} + \Omega_r = Z_{ir} - N_{ir} H_{ir} - \sum_s E_{irs} N_{ir} F_{irs}$$

[2] The deriving process of these seven equations is explained in Oyamada (2014).

$$\perp p_{ir}^{W}; \quad (13)$$

$$E_{irs} = \left(\frac{\gamma_i}{\gamma_i - \sigma_i^T + 1}\right)^{\gamma_i/(\sigma_i^T - 1)} \varphi_{irs}{}^{-\gamma_i} \qquad \perp E_{irs}; \quad (14)$$

$$\varphi_{irs} = \frac{\gamma_i - \sigma_i^T + 1}{\gamma_i(\sigma_i^T - 1)}\left(\frac{Q_{irs}}{F_{irs}}\right) \qquad \perp \varphi_{irs}; \quad (15)$$

and

$$p_{ir}^{w}(H_{ir} + \textstyle\sum_s E_{irs} F_{irs}) = -\eta_i\left(p_{ir}^{D} D_{ir} + \textstyle\sum_s E_{irs} p_{irs}^{Q} Q_{irs}\right) \qquad \perp N_{ir}, \quad (16)$$

where

C_{is} is the final demand for commodity i in region s,

D_{is} is the domestic (intra-national) trade flow of commodity i sold in region s,

Q_{irs} is the inter- and intra-regional (not intra-national but inter-national) trade flow of commodity i sold by exporting firms in region r to region s,

p_{is}^{D} is the differentiated sales price for domestic market s,

p_{irs}^{Q} is the differentiated sales price for inter-regional market s sold by firms in region r excluding the transportation margin and the import tariff,

p_{ir}^{W} is the wholesale price of the products,

$E_{irs} \in (0,1)$ is the proportion of exporting firms in region r that sell products to region s,

φ_{irs} is the average productivity of exporting firms,

N_{ir} is the number of firms entered in region r,

F_{irs} is the fixed exporting cost as measured in units of gross output (composite input) and necessary to make sales on the r-s link,

H_{ir} is the fixed entry cost as measured in units of gross output (composite input) and necessary to establish a firm in region r,

$\beta_{is} \in [0,1]$ is the strength of importer's PfV,

$\sigma_i^T > 1$ is the elasticity of substitution between the varieties from various sources,

α_{irs}^T is the weight parameter that reflects the preference of region s for the region of origin r,

θ_{is}^T is the scaling factor,

η_i is related to the elasticity of substitution σ^T such that $\eta_i \equiv -1/\sigma_i^T$,

γ_i is a shape parameter related to productivity such that $\gamma_i > \sigma_i^T - 1$,[3]

τ_{irs}^E is the rate of export duty/subsidy,

[3] For details, see Balistreri and Rutherford (2012).

τ_{irs}^{T} is the rate of transportation margin,

τ_{irs}^{M} is the import tariff rate, and

Ω_r is inter-regional transportation supply defined with a regional share parameter ω_r as

$$\Omega_r \equiv \frac{\omega_r}{p_{"i02"r}^{W}} \sum_{i'} \sum_{r'} \sum_{s} \tau_{i'r's}^{T} \left(1 + \tau_{i'r's}^{E}\right) E_{i'r's} N_{i'r'} p_{i'r's}^{Q} Q_{i'r's}.$$

Ω_r is included in Equation (13) if and only if i is the services sector (i02). Furthermore, the second and the third terms in the right-hand side of Equation (13) enter if and only if i is the manufacturing sectors (i03, i04, and i05). Similarly, η_i and φ_{irs} enter Equations (11) and (12) only when i is the manufacturing sectors. Equations (14) through (16) are only for the manufacturing sectors.

2.3 Final Demand

Composite Commodity for Final Consumption: Similar to the case of intermediate inputs, the representative consumer in region s determines demand levels of commodity i for final demand C_{ir} to minimize cost subject to a Cobb-Douglas aggregator.[4] The problem can be expressed as

$$\min \quad \sum_i p_{ir} C_{ir}$$

$$\text{s.t.} \quad \tilde{C}_r = \theta_r^C \prod_i C_{ir}^{\alpha_{ir}^C} \qquad \perp p_r^C, \quad (17)$$

where

p_r^C is price index for the composite commodity for final demand in region r;

$\tilde{C}_r$ is quantity of composite commodity for final demand in region r;

α_{ir}^C is the share parameter that reflects requirements of commodity i to form $\tilde{C}_r$; and

θ_r^C is the scaling factor.

The FOC for optimization is

$$p_{ir} = \alpha_{ir}^C p_r^C \left(\frac{\tilde{C}_r}{C_{ir}}\right) \qquad \perp C_{ir}. \quad (18)$$

Welfare: Then, the representative consumer in region s maximizes the level of composite final demand $\tilde{C}_r$, which represents his/her welfare level, subject to a budget constraint,

[4] Final demand C_{ir} includes fixed capital formation to keep the model simple in this study.

given as the total of factor income and tax revenue transferred from the regional authority. In this setting, we presume that the current account remains imbalanced at the same position given by the benchmark data for simplicity.[5] This problem can be expressed as follows:

$$\max \quad \tilde{C}_r$$
$$\text{s.t.} \quad p_r^C \tilde{C}_r = \sum_a \sum_j w_{ar} V_{ajr} + T_r + \bar{S}_r^F \qquad \perp \lambda_r, \qquad (19)$$

where

λ_r is the total change of composite consumption given a unit increase of income;

$\bar{S}_r^F$ is foreign savings by region r, which is given exogenously; and

T_r is the tax revenue, defined as

$$T_r \equiv \sum_j \left\{ \begin{array}{c} \frac{\tau_{jr}^Z}{1+\tau_{jr}^Z} p_{jr}^W Z_{jr} \\ + \sum_s \tau_{irs}^E E_{irs} N_{ir} p_{irs}^Q Q_{irs} \\ + \sum_s \tau_{isr}^M (1+\tau_{isr}^T)(1+\tau_{isr}^E) E_{isr} N_{is} p_{isr}^Q Q_{isr} \end{array} \right\}.$$

Note that $E_{irs}N_{ir}$ is set to unity when i is not the manufacturing sector, since the primary industries and services sectors are assumed to be perfectly competitive so that the Armington-type specification is applied. The FOC for optimization is

$$\lambda_r p_r^C = 1 \qquad \perp \tilde{C}_r. \qquad (20)$$

2.4 Other Items

Factor Market: The factor market clearing conditions are

$$\sum_j V_{ajr} = \bar{V}_{ar} \qquad \perp w_{ar}, \quad (21)$$

where $\bar{V}_{ar}$ is the exogenously given factor endowment.

A Dual Relation: Finally, a relation between p_{jr}^Z (price index for gross output) and p_{jr}^W (wholesale price) is added:

$$p_{jr}^Z = p_{jr}^W \qquad \perp Z_{jr}. \quad (22)$$

The system of a six-region, five-sector AGE model that includes the Melitz-type trade module is described by 22 equations consist of (1) through (22). Because of the *Walras' Law*, one of the market clearing conditions automatically holds. In this regard, for

[5] The level of position (foreign savings) is valued by the price of numéraire commodity. Foreign savings $\bar{S}_r^F$ is defined by the total value of imports at CIF (cost, insurance, and freight) prices minus the total value of exports at FOB (free-on-board) prices that includes inter-regional transportation supply. In the present model, net factor income from abroad does not exist.

example, we drop Equation (13) with respect to the primary industries (i01) in the EU (r01), exogenously setting the corresponding p_{ir}^{W} to unity. This implies we treat the primary products made in the EU as the numéraire commodity.

2.5 Data and Parameterization

In the implementation process of an AGE model, we need to match the theoretical features of the model with benchmark data. There are two possible approaches as Hertel (2009) has shown. One approach is to assume the existence of unobserved (iceberg) trade costs to fill the gap between the observed and calculated trade flows given as a solution by an AGE model with a symmetric preference for varieties among exporters in the replication test. This approach requires re-estimation of the transportation margins based on a certain assumption. The second approach is to include preference weights to capture differentiation among regions, such as home bias, as in the Armington-type specifications.

Zhai (2008) and Balistreri, Hillberry, and Rutherford (2011) have taken the former approach. Zhai (2008) derived the unobserved transportation margins on the international trade flows by assuming that domestic trade incurs no iceberg trade costs.[6] Balistreri, Hillberry, and Rutherford (2011) econometrically estimated the whole set of parameters by using a nonlinear structural estimation procedure. On the other hand, Balistreri and Rutherford (2012) and Dixon, Jerie, and Rimmer (2015) have referred to the possibilities of the latter approach. Balistreri and Rutherford (2012) have explained a part of the calibration procedures in both approaches. To pursue a more labor-saving and simpler way by making full use of the information that we are familiar with or have relatively easy access to, we take the latter approach by assuming the non-existence of unobserved trade costs.

The most important point is that changes in varieties are fully assessed in the importer's demand aggregator in many studies. Ardelean (2006) explored how strong the PfV is, and found that importer's PfV is around 40 percent lower than the one assumed in the Krugman's model. Therefore, we compare simulation results obtained with both strong and relatively weak PfV in the following section. As we saw previously, we introduced an additional parameter (β_{is}) that assessed the influence of PfV. At $\beta_{is} = 0$, Equation (8) is equivalent to the Armington-type and an importer s places no value on additional varieties. At $\beta_s = 1$, the setting is consistent with the assumption in the theoretical models by

[6] Careful consideration is required to apply this assumption when one is going to handle regions instead of countries. Assuming that intra-regional trade does not incur iceberg costs, no matter the distances between the countries grouped in the same region, might be unrealistic in some cases.

Krugman (1980) and Melitz (2003), with which an importer s fully enjoys variety increase. An important point here is that the CES weights $\alpha_{irs}^{T}(E_{irs}N_{ir})^{(\beta_{is}+\sigma_i^T-1)/\sigma_i^T}$ are now endogenous when $\beta_{is} > 0$. One of the problems of the Armington-type specification pointed out in previous studies is that the CES weights are fixed and do not change in the long-run. Contrary, the present model can manage the case an importer endogenously changes his/her valuation of the commodity based on certain changes in the economic environment.

The model is calibrated to the Global Trade Analysis Project (GTAP) 8.1 database[7] for 2007 along with additional information on the shape parameter related to productivity (γ_i). The original 129 countries/regions and 57 commodities/activities are respectively aggregated to six and five. The regions consist of the EU (r01); the USA (r02); Japan (r03); China (r04); ASEAN (r05); and ROW (r06).[8] The five sectors are the primary industries (i01), services (i02), motor vehicles and parts (i03); electronic equipment (i04); and other manufacturing (i05). As noted previously, the manufacturing sectors (i03 through i05) are assumed to be imperfectly competitive with IRTS, while the other two are characterized by CRTS. The primary industries sector (i01) uses a sector specific factor, such as land and natural resources, in addition to capital, labor, and intermediate goods in its production process. The services sector (i03) provides a fraction of its output as the inter-regional transportation supply.

Estimates for γ_i can be found in several empirical studies, such as Melitz and Redding (2013), Balistreri, Hillberry, and Rutherford (2011), and Bernard, Redding, and Schott (2007). Based on their findings, we set γ_i to 5.0. All of the other parameters except PfV (β_{is}) can be calibrated since the choices of initial values of the number of entered firms (N_{ir}) and the proportion of exporting firms (E_{irs}) or levels of fixed costs (H_{ir} and F_{irs}) will not affect simulation results as long as we evaluate effects in terms of deviations (percentage changes) from the initial levels of endogenous variables.[9] Therefore, fixed costs can be derived setting N_{ir} to be unity, and E_{irs} to be any preferred levels between zero and unity. The calibration step is similar to the ones adopted in traditional AGE models.

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[7] For details, see Hertel (1997).

[8] The EU consists of the following 28 countries: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Bulgaria, Croatia, and Romania. The ASEAN includes: Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, the Philippines, Singapore, Thailand, Viet Nam, and the Rest of Southeast Asia.

[9] For detailed explanations, see Oyamada (2014).

3. Experiments

In this section, we report on the results of simulation experiments performed using the six-region, five-sector AGE model with the Melitz-type trade module introduced in the previous section. Taking the case of the EU ELV/RoHS directives as an example, we will show the usefulness and limitations to include the Melitz-type trade specification in assessments of economic effects of NTBs.

3.1 Scenario and Policy Modeling

The simulation experiments are categorized into two types. In the first type, we examine the effects of changing the fixed exporting cost (F_{irs}) necessary to make sales on the r-s link in two cases when importer's PfV is strong ($\beta_{is} = 1$) and relatively weak as Ardelean (2006) suggests ($\beta_{is} = 0.5$). In the second type, we examine how the results obtained in the first type change when the importer's PfV (β_{is}) take different values from zero to unity. While we focus on the effects of changing F_{irs} on economic variables in the former type, the effects of changing β_{is} is focused in the latter.

The EU ELV and RoHS directives are basically expressed as the permanent increase of the fixed exporting cost (F_{irs}) necessary to make sales on the EU market ($s = \mathrm{r01}$) corresponding to motor vehicles and parts ($i = \mathrm{i03}$) and electronic equipment ($i = \mathrm{i04}$), respectively. Since we may not measure the volumes of the cost increases by introducing ELV/RoHS, F_{irs} corresponding to $i = \mathrm{i03}$ or $i = \mathrm{i04}$, as well as $s = \mathrm{r01}$, is simply expanded by 50%, 100%, and 200%. In addition, it is uncertain how much the introduction of ELV/RoHS increases the cost for the trade within the EU compared to the one for the imports from outside the EU. Therefore, we consider three cases: (1) when the fixed exporting cost (F_{irs}) for the intra-EU trade ($r = s = \mathrm{r01}$) is kept unchanged from its initial level; (2) when the cost is increased to the extent as the ones for the imports from outside; and (3) when the fixed entry cost (H_{ir}) in the EU, instead of the fixed exporting cost (F_{irs}) for the intra-EU trade, is increased by 5%, 10%, and 20%. The reason why the changing volumes are ten times smaller than the case of the fixed exporting cost (F_{irs}) is because the impact by changing H_{ir} is much stronger than the one by F_{irs}.

When we change the value of importer's PfV (β_{is}) from zero to unity, the model is re-calibrated for every values of β_{is} to purify the effects of ELV/RoHS and make it comparable to each other. If we change the value of β_{is} after the model is calibrated, the modification itself alters the economic environment and affects the state of the global economy (an equilibrium), even when no policy change takes place. The effects of changing the value of β_{is} should be clearly distinguished and split from those of policy changes, and swept out from the experiments.

3.2 Effects of EU RoHS/ELV Directives when PfV Is Strong

Let us start with examining the effects of ELV/RoHS on selected economic variables in the case when importer's PfV is strong ($\beta_{is} = 1$). Table 1 shows the effects of 200% increase of the fixed exporting cost (F_{irs}) necessary to make sales on the EU market ($s = \mathrm{r01}$) respectively on the value of exports to the EU, on the price of exports to the EU, on the value of domestic flows within the EU, on the price of domestic flows within the EU, on the proportion of the firms exporting to the EU, on the average productivity of the firms exporting to the EU, and on the total variety exported to the EU related to the focused sector, i.e., motor vehicles and parts (i03) in the case of ELV and electronic equipment (i04) in the case of RoHS. The effects are measured as deviations (percentage changes) from the base case given by the benchmark data set built on the GTAP 8.1 database. The sings +++, ++, +, -, --, and --- implies the volume of effect is greater than 20%, 10% to 20%, 0% to 10%, -10% to 0%, -20% to -10%, and less than -20%, respectively. The signs out of parentheses are the average of the non-EU regions/countries, while the ones in the parentheses correspond to the EU. In Scenario "ELV", F_{irs} corresponding to Sector i03 increases. Similarly, in Scenario "RoHS", F_{irs} corresponding to Sector i04 increases. Since Scenario ELV/RoHS, which implies simultaneous implementation of ELV and RoHS, includes both Sectors i03 and i04, the signs are shown in the manner i03/i04. Finally, Cases "U", "I", and "D" imply the cases when the fixed exporting cost (F_{irs}) for the intra-EU trade is kept unchanged from its initial level, when the cost is increased to the extent as the ones for the imports from outside, and when the fixed entry cost (H_{ir}) in the EU, instead of the fixed exporting cost (F_{irs}) for the intra-EU trade, is increased by 5%, 10%, and 20%, respectively. Because the signs do not change in the cases when the fixed exporting cost is increased by 50% and 100%, only the case for 200% (20% for H_{ir}) increase is shown in Table 1.

At the outset, we focus on the cases when the fixed exporting cost (F_{irs}) for the intra-EU trade is kept unchanged or increased (Cases U and I). If we look at the non-EU countries, which are shown outside the parentheses, it is clear that the exports to the EU decrease regardless of the cases ELV and RoHS. Another important point is that smaller proportions of highly productive firms operate. If we look at the EU members, which are shown inside the parentheses, we will find the following three points. First, domestic productions expand to cover the decreased imports from outside the EU. Second, smaller proportion of highly productive firms operates, similar to the non-EU firms. Third, if we focus on the case when fixed exporting cost is kept unchanged, which is shown with “U”, the intra-EU trade also expands. In the background, entry of firms in the EU increases so that the total variety also increases. As a result, welfare level of the EU members improves when F_{irs} for the intra-EU trade is kept unchanged. Contrary, welfare level of the EU members worsens in the case when F_{irs} for the intra-EU trade is increased, which is shown with “I”, since the number of entered firms in the EU decreases. These effects can be referred to as the protection effects.

Next, let us turn to focus on the case when the fixed entry cost (H_{ir}) in the EU is increased by 20% instead of F_{irs} (Case D). If we look at the non-EU countries, exports to the EU tend to increase because of the reduced entry of firms in the EU. In this case, smaller number of highly productive firms operates, and the firm-level exports expand. It implies that large-scale firms dominate. If we look at the EU members, we will find domestic productions shrink because of the less entry. On the other hand, proportion of exporting firms increases because of the fixed exporting costs are kept unchanged. Then, large-scale firms lead expansion of the intra-EU trade in the case of RoHS.

One interesting point observed throughout Cases U, I, and D, is that the proportion of the firms exporting to the EU totally synchronizes with the price of exports to the EU. In addition, the average productivity of the firms exporting to the EU shows just the opposite signs of those items. Because of the expanded fixed exporting cost, only the firms who have relatively high productivity, and are able to cover the cost, may survive. Higher productivity enables firms to produce with cheaper prices. It is the source of high competitiveness.

As mentioned above, the effects of ELV/RoHS on the welfare level of the EU members reflect the changes in total variety. Table 2 shows the changes in regional welfare levels for the entire scenario when importer’s PfV is strong ($\beta_{is} = 1$). Those who are better off are the regions/countries successful in expanding domestic trade, intra-regional trade, or inter-regional trade with a non-EU region/country replacing the shrunk exports to the EU. An interesting point is that the USA (r02) is worse off in all of the ELV/RoHS combinations when the fixed exporting cost for the intra-EU trade is increased (Case I), while Japan (r03) is always worse off when the cost is kept unchanged (Case U). A possible story for the USA is that the productions of commodities exported to the EU use relatively large amount of the

US made intermediates. For Japan, the commodities traded within the EU might be rivalries of the Japanese products.

When the USA (r02) is worse off, China (r04) and ASEAN (r05) tend to suffer negative impact. It suggests that the two Asian regions/countries supply sub-components for the US products. Since this tendency is relatively weak for China, we infer ASEAN has stronger/weaker relationships with USA/Japan compared to China.

Another interesting point is that all of the non-EU regions/countries are worse off in Scenario RoHS when the fixed exporting cost for the intra-EU trade is kept unchanged (Case U). In this case, the number of entered firms substantially increases in the EU because of the unchanged fixed exporting and entry costs so that both the intra-EU trade and the domestic sales in the EU substitute the imports from outside.

Finally, note that ELV and RoHS have effects in the same direction. The case of simultaneous implementation of ELV/RoHS shows the results mixed of the cases ELV and RoHS are independently implemented.

3.3 Effects of EU RoHS/ELV Directives when PfV Is Not Strong

Let us move to the effects of ELV/RoHS in the case when importer's PfV is not so strong ($\beta_{is} = 0.5$). Table 3 shows the effects of 200% increase of the fixed exporting cost (F_{irs}) necessary to make sales on the EU market ($s = \mathrm{r01}$) on the selected variables we saw previously. In Case D, the fixed entry cost (H_{ir}) in the EU is increased by 20% instead of F_{irs} for the intra-EU trade.

From Table 3, we may find two points. First, if we look at the non-EU countries, exports to the EU expand in all cases. Second, if we look at the EU members, results related to the trade-flows are reversed from the previous case when we assume strong PfV in Cases U and I. These results are brought by the importer's PfV. If the PfV is not strong, there might be a room to increase volumes of productions/dealings per firm to keep welfare to a certain level even if the number of exporting firms reduces. It is clear if we look at Case I, in which welfare level of the EU members improves in spite of the fact that total variety decreases. In this kind of situation, large-scale firms that have high productivity can play important roles. When the number of firms reduces, the sector-wide consumption of resources to pay fixed costs can be saved so that a firm may expand its production and suppress its output price fully enjoying the fruit of economies of scale. Therefore, consumers may be better off by the relatively cheap mass-products. By the relatively cheap commodities imported from outside the EU, the domestic trade within the EU is crowded out and the price of domestic products depreciates.

In accordance with the previous story, the proportion of the firms exporting to the EU as well as the total variety tends to reduce. On the other hand, welfare levels of the EU in Cases U and I tend to be better in spite of the fact that the total variety reduces. Because of the balanced preference for both variety and the volume of consumption, the welfare level can be kept by the expanded imports produced by large-scale firms. In Case D, increase in fixed entry cost drastically spoils the competitiveness of firms in the EU members. It is reflected to the prices of domestic and imported EU-made products in the EU countries. Then, reduced entry of firms in the EU brings lower welfare level to the EU members.

Table 4 shows the changes in regional welfare levels for the entire scenario when importer's PfV is relatively weak ($\beta_{is} = 0.5$). Although the changes are not so large, increases in the fixed exporting cost brought by the ELV/RoHS directives tend to improve welfare levels of all regions/countries except for the EU members when ELV is implemented in Case U, and in the all combinations of ELV/RoHS when Case D applies. In these cases, the firms in the EU exporting to other EU members may not enjoy the fruit of economies of scale saving the payment for the fixed costs.

3.4 Effects of Changing Strength of the Importer's PfV

As we have seen, the effects of the permanent increase of the fixed exporting cost necessary to make sales on the EU market corresponding to motor vehicles and parts (i03) and electronic equipment (i04) totally change under different assumptions on the importer's PfV (β_{is}). The almost totally opposite results may look embarrassing for many people those who are concerned with policy-makings. Hence, it is worth examining the effects of changing β_{is}.

Figure 1 captures the Hicksian equivalent variations in billions US dollars when the value of β_{is} is changed from zero to unity for the case in which the fixed exporting cost necessary to make sales on the EU market corresponding to Sectors i03 and i04 is raised 50%. This scenario represents the simultaneous implementation of the ELV and RoHS when the fixed exporting cost for the intra-EU trade is increased along within the imports from outside the EU (Case I). It is clear that the welfare level of the EU monotonically decreases from 57.453 to -43.391 billion US dollars. Compared to the EU, the welfare changes in other regions/countries are negligible. The most important point is that the welfare effects for the EU turns from positive to negative around $\beta_{is} = 0.7$. This suggests that empirical estimations of β_{is} play important roles in assessments of ELV/RoHS directives if one is planning to evaluate those policies utilizing a model with the Melitz-type trade specification.

5. Concluding Remarks

Modeling NTBs has long been a challenge for builders of AGE models, since NTBs are not straightforwardly connectable to economic variables included in a model unlike taxes or tariffs, in addition to the fact that information on NTBs is not easy to collect, sort out complication, or quantitatively measure. This paper explored the potential usefulness of an AGE model with the Melitz-type trade specification to assess economic effects of technical regulations, taking the case of the EU ELV/RoHS directives as an example. With the special focus on the strength of the importer's PfV, the key findings can be summarized as follows.

1. When the importer's PfV is strong as assumed in the theoretical model by Melitz (2003), raising the fixed exporting cost to make sales in the EU market brings reductions in exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions/countries while the domestic and intra-regional trade in the EU expands to cover the decreased imports, in the cases when the fixed exporting cost for the intra-EU trade is kept unchanged or increased.

2. If the fixed entry cost in the EU increases instead of the fixed exporting cost for the intra-EU trade when the importer's PfV is strong, exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions/countries expand because of the reduced entry of firms in the EU, even though the fixed exporting cost to make sales in the EU market is raised.

3. Those who are better off when the importer's PfV is strong are the regions/countries successful in expanding domestic trade, intra-regional trade, or inter-regional trade with a non-EU region/country replacing the shrunk exports to the EU.

4. When the importer's PfV is not strong as Ardelean (2006) suggests, raising the

fixed exporting cost to make sales in the EU market brings interesting results that exports of the targeted commodities (motor vehicles and parts for ELV and electronic equipment for RoHS) to the EU from outside regions expand while the domestic trade in the member countries of the EU shrinks.

5. If the PfV is not strong, policy changes that may bring reduction in the number of firms enable survived producers with high productivity to expand production to be large-scale mass producers fully enjoying the fruit of economies of scale. As a result, consumers may be better off by the relatively cheap mass products.

6. When the strength of the importer's PfV (β_{is}) is changed from zero to unity, the welfare effects for the EU turns from positive to negative around $\beta_{is} = 0.7$. This value is the dividing ridge over which simulations results and their interpretations totally differ.

If we regard the productivity growth to cover the fixed exporting cost as a kind of cost-effective innovation, applying a model with the Melitz-type trade specification to analyses on the EU ELV/RoHS directives may provide insights on the questions related to the potential innovation induced by environmental policies with economic instruments studied by Mazzanti and Zoboli (2006) and Crotty and Smith (2006). Our results (the cells corresponding to "Productivity of Firms Exporting to EU" and "Case D" in Tables 1 and 3) suggest that the ELV/RoHS directives may discourage innovation in the EU members while the innovation outside the EU would be promoted, if the fixed entry cost in the EU increases instead of the fixed exporting cost for the intra-EU trade.

Furthermore, the model can be applied to assess greening of supply chain or evaluations of environmental product standards, such as those studied by Koh, Gunasekaran, and Tseng (2012), Tong, Shi, and Zhou (2912), and Ishikawa and Okubo (2011), if one introduces an environment-related index into the model.

On the other hand, simulation results and their interpretations may totally differ depending on the assumed level of the importer's PfV (β_{is}). When the importer's PfV is strong, firms tend to respond to demand expansion by increasing the number of firms and to reduction by shrinking their production/dealings per firm, while they respond to demand expansion by increasing their production/dealings per firm and to reduction by decreasing the number of firms when the PfV is weak. Since this study presents the very first step to approach to model NTBs, many efforts are needed to make it of practical use. Our findings suggest that empirical estimations of the strength of the importer's PfV play important roles in assessments of ELV/RoHS directives if one is planning to evaluate those policies utilizing a model with the Melitz-type trade specification.

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Table 1. Effects of ELV/RoHS on Selected Economic Variables when Importer's PfV Is Strong ($\beta_{is} = 1$)

Scenario	Type	Exports to EU	Price of Exports to EU	EU Domestic	Price of EU Domestic
ELV 200%	HU	− − − (+ +)	− − − (−)	(+ +)	(−)
	HI	− (− −)	− − − (− − −)	(+ +)	(+)
	HD	+ (−)	− − (+)	(−)	(+)
RoHS 200%	HU	− − − (+ + +)	− − − (−)	(+ + +)	(−)
	HI	− − (− −)	− − − (− − −)	(+ + +)	(+)
	HD	+ (+)	− − (+)	(−)	(+)
ELV/RoHS 200%	HU	− − −/− − − (+ +/+ + +)	− − −/− − − (−/−)	(+ +/+ + +)	(−/−)
	HI	−/− − (− −/− −)	− − −/− − − (− − −/− − −)	(+ +/+ + +)	(+/+)
	HD	+/− (−/−)	− −/− − (+/+)	(−/−)	(+/+)

Scenario	Type	Proportion of Firms Exporting to EU	Productivity of Firms Exporting to EU	Total Variety	Welfare Level of EU (%)
ELV 200%	HU	− − − (−)	+ + + (+)	− − − (+ +)	(+ +)
	HI	− − − (− − −)	+ + + (+ + +)	− − − (− − −)	(− − −)
	HD	− − − (+ + +)	+ + + (−)	− − − (−)	(− − −)
RoHS 200%	HU	− − − (−)	+ + + (+)	− − − (+ + +)	(+)
	HI	− − − (− − −)	+ + + (+ + +)	− − − (− − −)	(− − −)
	HD	− − − (+ + +)	+ + + (−)	− − − (−)	(− − −)
ELV/RoHS 200%	HU	− − −/− − − (−/−)	+ + +/+ + + (+/+)	− − −/− − − (+ +/+ + +)	(+ + +)
	HI	− − −/− − − (− − −/− − −)	+ + +/+ + + (+ + +/+ + +)	− − −/− − − (− − −/− − −)	(− − −)
	HD	− − −/− − − (+ + +/+ + +)	+ + +/+ + + (−/−)	− − −/− − − (−/−)	(− − −)

Note 1: +++ (0.20 ~), ++ (0.10 ~ 0.20), + (0.00 ~ 0.10), - (-0.10 ~ 0.00), -- (-0.20 ~ -0.10), and --- (~ -0.20).

Note 2: "Welfare Level of EU" is in percentage.

Note 3: Non-EU (EU) and i03/i04.

Note 4: The signs for non-EU are the averages of non-EU regions.

Table 2. Welfare Effects of ELV/RoHS ($\beta_{is} = 1$)

HU

	r01	r02	r03	r04	r05	r06
ELV 50%	0.071522	0.108144	-0.004602	0.028104	0.042944	-0.173671
ELV 100%	0.115180	0.172119	-0.008046	0.046045	0.076134	-0.276160
ELV 200%	0.173919	0.257083	-0.014024	0.073024	0.133986	-0.411098
RoHS 50%	0.011051	-0.078959	-0.010049	-0.024726	-0.010639	-0.034228
RoHS 100%	0.015932	-0.125320	-0.015706	-0.039153	-0.014069	-0.050385
RoHS 200%	0.020264	-0.180301	-0.022171	-0.057115	-0.016055	-0.065831
ELV/RoHS 50%	0.085157	0.032661	-0.014965	0.009106	0.033075	-0.214358
ELV/RoHS 100%	0.139122	0.058741	-0.024945	0.023253	0.068599	-0.347002
ELV/RoHS 200%	0.232650	0.140231	-0.043348	0.071699	0.186105	-0.574910

HI

	r01	r02	r03	r04	r05	r06
ELV 50%	-0.166013	-0.017743	0.003021	0.000157	-0.003065	0.023312
ELV 100%	-0.270631	-0.021979	0.004698	0.002109	-0.002321	0.027023
ELV 200%	-0.402091	-0.019505	0.006663	0.006578	0.001126	0.019188
RoHS 50%	-0.104838	-0.010862	0.001052	0.001258	0.002118	-0.001812
RoHS 100%	-0.173596	-0.021705	0.001293	0.000949	0.002970	-0.004640
RoHS 200%	-0.262835	-0.040507	0.001059	-0.000868	0.003413	-0.010290
ELV/RoHS 50%	-0.270613	-0.028379	0.004077	0.001399	-0.000875	0.021358
ELV/RoHS 100%	-0.443569	-0.043063	0.006009	0.003020	0.000795	0.022002
ELV/RoHS 200%	-0.663355	-0.058543	0.007776	0.005743	0.004710	0.007946

HD

	r01	r02	r03	r04	r05	r06
ELV 50%	-0.152819	-0.031171	0.004258	-0.002095	-0.010852	0.038164
ELV 100%	-0.299434	-0.070571	0.00776	-0.006801	-0.02029	0.092743
ELV 200%	-0.563591	-0.147702	0.012535	-0.017614	-0.03124	0.205517
RoHS 50%	-0.09143	-0.007022	0.001783	0.000573	-0.007655	-0.00804
RoHS 100%	-0.179332	0.002959	0.005499	0.006636	-0.010004	-0.006061
RoHS 200%	-0.342136	0.036756	0.01397	0.023927	-0.004155	0.01101
ELV/RoHS 50%	-0.24442	-0.037995	0.006115	-0.001535	-0.018647	0.030508
ELV/RoHS 100%	-0.479185	-0.066908	0.013429	0.000368	-0.030612	0.087314
ELV/RoHS 200%	-0.905849	-0.108546	0.026726	0.010666	-0.036532	0.215362

Table 3. Effects of ELV/RoHS on Selected Economic Variables when Importer's PfV Is Not Strong ($\beta_{is} = 0.5$)

Scenario	Type	Exports to EU	Price of Exports to EU	EU Domestic	Price of EU Domestic
ELV 200%	LU	++ (−)	−− (−)	(−)	(−)
	LI	+ (+)	−− (−−)	(−−)	(−)
	LD	+++ (−)	−− (+)	(−)	(+)
RoHS 200%	LU	++ (−−)	−− (−)	(−−)	(−)
	LI	+ (+)	−− (−−)	(−−)	(−)
	LD	++ +(−−−)	−− (+)	(−−)	(+)
ELV/RoHS 200%	LU	++/++ (−/−)	−−/−− (−/−)	(−/−−)	(−/−)
	LI	+/+ (+/+)	−−/−− (−−/−−)	(−−/−−)	(−/−)
	LD	+++/+++ (−/−−)	−−/−− (+/+)	(−/−−)	(+/+)

Scenario	Type	Proportion of Firms Exporting to EU	Productivity of Firms Exporting to EU	Total Variety	Welfare Level of EU (%)
ELV 200%	LU	−−− (−)	+++ (+)	−−− (−)	(−)
	LI	−−− (−−−)	+++ (+++)	−−− (−−−)	(+++)
	LD	−−− (++)	++ (−)	−−− (−)	(−−−)
RoHS 200%	LU	−−− (−)	+++ (+)	−−− (−)	(+)
	LI	−−− (−−−)	+++ (+++)	−−− (−−−)	(++)
	LD	−−− (++)	+++ (−)	−−− (−−−)	(−−)
ELV/RoHS 200%	LU	−−−/−−− (−/−)	+++/+++ (+/+)	−−−/−−− (−/−)	(+)
	LI	−−−/−−− (−−−/−−−)	+++/+++ (+++/+++)	−−−/−−− (−−−/−−−)	(+++)
	LD	−−−/−−− (++/++)	++/+++ (−/−)	−−−/−−− (−/−−)	(−−−)

Note 1: +++ (0.20 ~), ++ (0.10 ~ 0.20), + (0.00 ~ 0.10), - (-0.10 ~ 0.00), -- (-0.20 ~ -0.10), and --- (~ -20).

Note 2: "Welfare Level of EU" is in percentage.

Note 3: Non-EU (EU) and i03/i04.

Note 4: The signs for non-EU are the averages of non-EU regions.

Table 4. Welfare Effects of ELV/RoHS ($\beta_{is} = 0.5$)

LU

	r01	r02	r03	r04	r05	r06
ELV 50%	-0.001723	0.000205	0.019363	0.002544	0.015543	0.008210
ELV 100%	-0.002926	0.000351	0.033805	0.004444	0.027136	0.014322
ELV 200%	-0.004575	0.000557	0.055189	0.007264	0.044300	0.023355
RoHS 50%	0.010586	0.001011	0.005701	0.049562	0.043188	0.007923
RoHS 100%	0.018948	0.001732	0.009777	0.085146	0.074098	0.013598
RoHS 200%	0.032023	0.002751	0.015545	0.135715	0.117884	0.021644
ELV/RoHS 50%	0.008851	0.001219	0.024980	0.052062	0.058638	0.016112
ELV/RoHS 100%	0.015982	0.002093	0.043331	0.089466	0.100958	0.027860
ELV/RoHS 200%	0.027328	0.003338	0.070088	0.142679	0.161490	0.044849

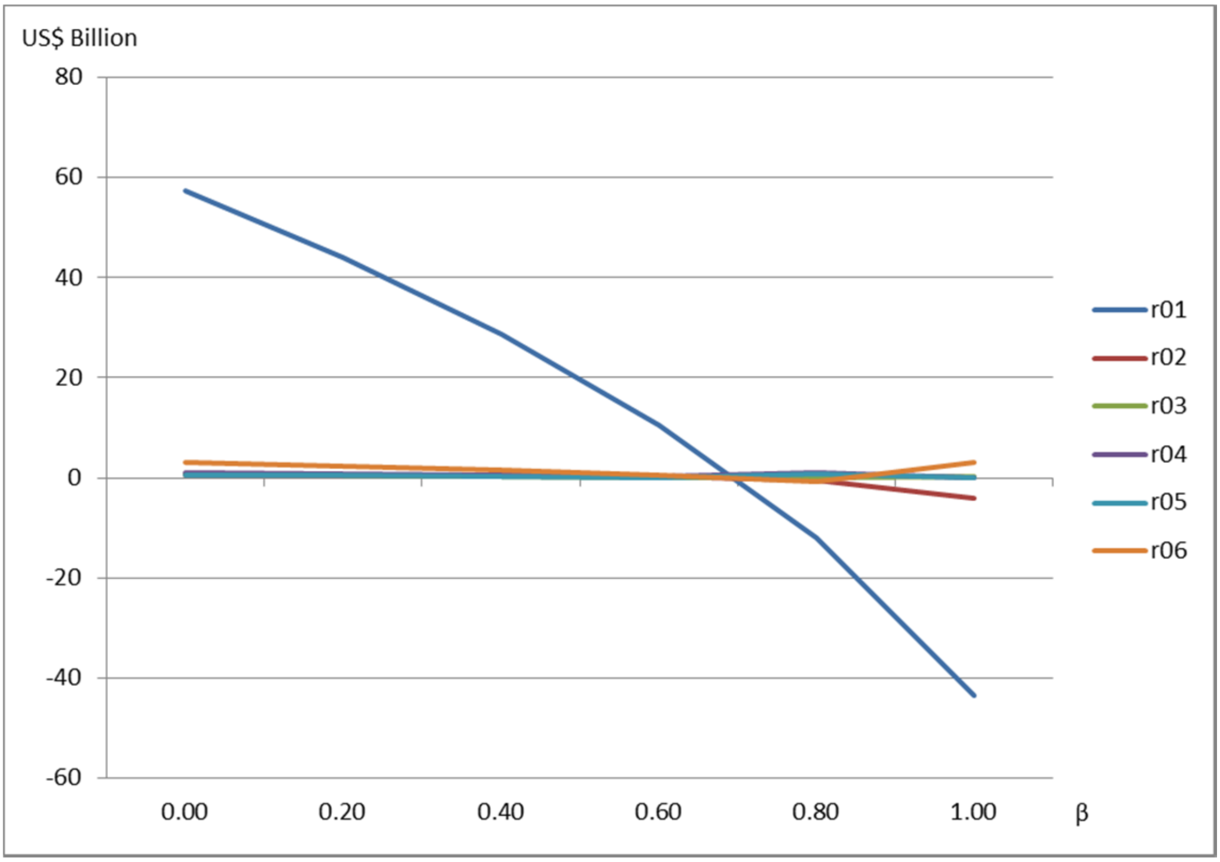
LI

	r01	r02	r03	r04	r05	r06
ELV 50%	0.074900	0.000929	0.003947	0.000501	0.002456	0.003663
ELV 100%	0.130083	0.001617	0.006405	0.000819	0.003898	0.006190
ELV 200%	0.210779	0.002628	0.009355	0.001207	0.005475	0.009640
RoHS 50%	0.050276	0.001235	0.001262	0.015680	0.013237	0.003186
RoHS 100%	0.087116	0.002118	0.002043	0.025950	0.021867	0.005331
RoHS 200%	0.140677	0.003374	0.002975	0.039175	0.032922	0.008187
ELV/RoHS 50%	0.125219	0.002164	0.005198	0.016186	0.015688	0.006849
ELV/RoHS 100%	0.217328	0.003737	0.008418	0.026780	0.025747	0.011520
ELV/RoHS 200%	0.351789	0.006010	0.012260	0.040413	0.038354	0.017827

LD

	r01	r02	r03	r04	r05	r06
ELV 50%	-0.080958	-0.002098	0.039387	0.00428	0.033529	0.010438
ELV 100%	-0.157014	-0.00405	0.073949	0.008074	0.063083	0.01944
ELV 200%	-0.296813	-0.007531	0.134991	0.014952	0.115443	0.035546
RoHS 50%	-0.029997	0.000272	0.010848	0.085334	0.072823	0.011188
RoHS 100%	-0.058448	0.000326	0.019783	0.155391	0.132258	0.020191
RoHS 200%	-0.109889	0.000184	0.034398	0.270027	0.229006	0.034769
ELV/RoHS 50%	-0.111132	-0.001824	0.050015	0.089458	0.106104	0.021546
ELV/RoHS 100%	-0.216113	-0.003718	0.093005	0.162999	0.194561	0.039368
ELV/RoHS 200%	-0.40897	-0.007326	0.1672	0.283854	0.342324	0.069552

Figure 1. Hicksian Equivalent Variations (US$ Billion) with Different Values of β_{is}



Note 1: Fixed exporting cost necessary to make sales on the EU (r02) market corresponding to i03 and i04 are raised 50% (ELV/ROHS).

Note 2: Fixed exporting cost for the intra-EU trade is increased along within the imports from outside the EU (Case I).