Behavioral Characteristics of Applied General Equilibrium Models with an Armington-Krugman-Melitz Encompassing Module[*]

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Abstract

This paper explore how simulation results change with different choice of trade specification, and the strength of preference for traded variety by economic agent differs, utilizing two types of three-region, three-sector AGE model that includes the Armington-Krugman-Melitz Encompassing module based on Dixon and Rimmer (2012). Simulation experiments reveal that: (1) the Melitz-type specification does not always enhance effectiveness of a certain policy change more than the one obtained with the Krugman-type, especially when economic agents' preference for traded variety is not so strong; (2) there are likely to be points where the volumes of effects obtained with the Melitz-type exceed the ones with the Krugman-type; and (3) the preference of the producers, those who are in the sectors that exhibit increasing returns to scale, for traded variety might be the engine of explosive effects as suggested by Fujita, *et al.* (2000).

Keywords: applied general equilibrium; monopolistic competition; firm heterogeneity; love of variety.

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1. Introduction

Because the global economy has become increasingly interdependent, thousands of applied general equilibrium (AGE) analyses have been conducted to evaluate regional trade agreements and economic partnership arrangements, and a number of model builders have attempted to incorporate theoretical information on intra-industry trade to account for economies of scale and imperfect competition. In conventional AGE models, the so-called "Armington assumption" has been widely adopted to handle cross-hauling, which is often observed in real data, between developed economies that have similar technologies and factor endowments.[1] Because this can be regarded to be an *ad hoc* approach and can cause awkward simulation results from its tendency to underestimate efficiency gains, some models such as those of Francois and Roland-Holst (1997), Francois (1998), and Roson (2006) have introduced theoretical illustrations of product differentiation in their analytical models as presented in the pioneering work of Krugman.

Krugman (1980) focused on two sources of efficiency gains that result from reducing trade barriers: cost reductions brought by economies of scale and increased variety obtained through additional imports. In the steady advance of new trade theory that followed, one of the most successful extensions of his work was made by Melitz (2003). Melitz appended another source of efficiency gains, namely, the reallocation of resources that result from endogenous productivity growth among heterogeneous firms. In the AGE research community, Zhai (2008) introduced a Melitz-type specification to an AGE model as an alternative to the Armington approach. Then, Balistreri and Rutherford (2012) prepared a comprehensive guide to the treatment of the three approaches of Armington, Krugman, and Melitz. Finally, Dixon and Rimmer (2012) developed a generalized supermodel that includes these three types of model as special cases. The supermodel, which is called the "Armington-Krugman-Melitz encompassing (AKME) model," replaces the inter-regional trade aspect of a multi-regional AGE model that links gross output in a source region with absorption in a destination.[2]

In such situations, Arkolakis, *et al*. (2012) has shown possibilities that a class of heterogeneous and homogeneous firm models may yield the same level of welfare gains from trade if those models have the same domestic trade share. In response to their argument, Melitz and Redding (2013) have noted that the elasticity of substitution takes different values in different specification in the Arkolakis and his colleagues' "macro"

[1] Armington (1969).
[2] When discussing the AKME, we use the term "module" instead of "model."

approach. In the “micro” approach, which has been taken by Melitz and Rodding (2013), the models retain the same values for behavioral parameters, and then the heterogeneous firm model may generate larger welfare gains from reductions in trade costs. The purpose of this paper is to show the strength of the love of variety (LoV) may play a role in the midst of those two extreme cases, taking the “micro” approach in calibrating an AKME module by assuming that the same value applies to the elasticity of substitution among varieties in every specification.[3]

Ardelean (2006) explored how strong the love of variety (LoV) is, and found that consumer’s LoV 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 an AKME module changing the strength of LoV. Simulation experiments reveal that: (1) the Melitz-type specification does not always enhance effectiveness of a certain policy change more than the one obtained with the Krugman-type, especially when LoV is not so strong; (2) there are likely to be points where the volumes of effects obtained with the Melitz-type exceed the ones with the Krugman-type; and (3) the preference of the producers, those who are in the sectors that exhibit increasing returns to scale (IRTS), for traded variety might be the engine of explosive effects as suggested by Fujita, *et al.* (2000:242).

The reminder of this paper is organized as follows. Section 2 illustrates a sample AGE model with an AKME module, 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 LoV, and verify the results. A further extension to make the model to be a “sourcing-by-agent” type is applied in Section 4 to identify whose LoV matters most. Then, Section 5 presents the paper’s conclusions.

2. The Basic Model

In this section, we review details of the basic AGE model with an AKME module used in this study. The global economy consists of three regions indexed r (source) and s (destination), which are linked through trade flows. Commodities and activities respectively indexed i and j are categorized into three kinds: the primary industries, manufacturing,

[3] The “macro” approach is followed by Dixon and his colleagues’ latest research, which verifies whether the Melitz model can be regarded as an Armington-type with a high substitution elasticity. Their preliminary answer is “Yes.”

and services sectors. The manufacturing sector is assumed to be imperfectly competitive with IRTS, while the other two are characterized by constant returns to scale (CRTS). The primary industries sector 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 provides a fraction of its output as the inter-regional shipping supply. The manufacturing sector is imperfectly competitive when the Melitz- or the Krugman-type specification is adopted, while the other two sectors stay perfectly competitive at all times.

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

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

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

where

p_{ir}^M 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.[4]

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

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

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

[4] 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 $2 = \theta \cdot 1^{0.5} \cdot 1^{0.5}$.

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

$$\text{s.t.} \quad Z_{jr} = \theta_{jr}^{Z} \left\{ \alpha_{jr}^{Z} Y_{jr}^{\left(\sigma_j^Z - 1\right)/\sigma_j^Z} + \left(1 - \alpha_{jr}^{Z}\right) \tilde{X}_{jr}^{\left(\sigma_j^Z - 1\right)/\sigma_j^Z} \right\}^{\sigma_j^Z / \left(\sigma_j^Z - 1\right)} \quad \perp p_{jr}^{Z}, \quad (5)$$

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 AKME Module

The inter-regional links between gross outputs in source regions and absorptions in destinations are represented by an AKME module based on the supermodel proposed by Dixon and Rimmer (2012), which includes the Armington, Krugman, and Melitz models as special cases. Although their original model is characterized by the dual approach, we use the primal approach to evaluate the model from a different angle. Furthermore, every effort has been made to clearly represent the counterpart relationships between the quantity and price variables in the equations. Hence, manipulations that may make the counterpart relationships unclear, such as substitution to derive a demand function, are avoided as much as possible, which leaves the FOCs as they are.

The equations that form our AKME module are summarized as follows:[5]

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

$$\sum_j X_{ijs} + C_{is} = \theta_{is}^T \left\{ \sum_r \delta_{irs}^T \widetilde{N}_{rs} Q_{irs}^{(\sigma_i^T - 1)/\sigma_i^T} \right\}^{\sigma_i^T/(\sigma_i^T - 1)} \qquad \perp p_{is}^M; \quad (8)$$

$$(1 + \tau_{irs}^M)(1 + \tau_{irs}^T)(1 + \tau_{irs}^E) p_{irs}$$

$$= \delta_{irs}^T (\theta_{is}^T)^{(\sigma_i^T - 1)/\sigma_i^T} p_{is}^M \left(\frac{\sum_j X_{ijs} + C_{is}}{Q_{irs}} \right)^{1/\sigma_i^T} \qquad \perp Q_{irs}; \quad (9)$$

$$p_{irs} = \left(\frac{1}{1+\eta} \right) \frac{p_{ir}^W}{\varphi_{rs}} \qquad \perp p_{irs}; \quad (10)$$

$$\sum_s \widetilde{N}_{rs} \frac{Q_{irs}}{\varphi_{rs}} + \Omega_r = Z_{ir} - \sum_s \widetilde{N}_{rs} F_{rs} - N_r H_r \qquad \perp p_{ir}^W; \quad (11)$$

$$G_{rs} = 1 - \left(\frac{\gamma}{\gamma - \sigma_i^T + 1} \right)^{\gamma/(\sigma_i^T - 1)} \varphi_{rs}{}^{-\gamma} \qquad \perp G_{rs}; \quad (12)$$

$$\varphi_{rs} = \left(\frac{\gamma}{\gamma - \sigma_i^T + 1} \right)^{1/(\sigma_i^T - 1)} \frac{(-\eta)^{1/(1 - \sigma_i^T)}}{1+\eta} \left(\frac{p_{ir}^w}{p_{irs}} \right)^{\sigma_i^T/(\sigma_i^T - 1)} \left(\frac{F_{rs}}{Q_{irs}} \right)^{1/(\sigma_i^T - 1)}$$

$$\perp \varphi_{rs}; \quad (13)$$

and

$$p_{ir}^w \left(\sum_s \widetilde{N}_{rs} F_{rs} + N_r H_r \right) = -\eta \sum_s p_{irs} \widetilde{N}_{rs} Q_{irs} \qquad \perp N_r, \quad (14)$$

where

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

Q_{irs} is the average trade flow of commodity i sold by active firm in region r to region s,

p_{irs} is the differentiated sales price for market s sold by firm in region r excluding the transportation margin and the import tariff,

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

$G_{rs} \in (0,1)$ is the proportion of registered but inactive firms in region r that sell products to region s,

φ_{rs} is the average productivity of active firms,

N_r is the number of firms registered in region r.

$\widetilde{N}_{rs}$ is the number of active firms that operate in region r and sell products on the r-s link,

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

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

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

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

θ^T_{is} is the scaling factor,

η is related to the elasticity of substitution σ^T such that $\eta \equiv -1/\sigma^T_i$,

γ is a shape parameter related to productivity such that $\gamma > \sigma^T_i - 1$,[6]

τ^E_{irs} is the rate of export duty/subsidy,

τ^T_{irs} is the rate of transportation margin,

τ^M_{irs} is the import tariff rate, and

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

$$\Omega_r \equiv \frac{\omega_r}{p^W_{ir}} \sum_{i'} \sum_{r'} \sum_s \tau^T_{i'r's} \left(1 + \tau^E_{i'r's}\right) p_{i'r's} \widetilde{N}_{r's} Q_{i'r's}.$$

Ω_r is included in Equation (11) if and only if i is the services sector. Furthermore, the second and the third terms in the right-hand side of Equation (11) enter if and only if i is the manufacturing sector when we assume the Melitz- and the Krugman-type specifications. Similarly, η and φ_{rs} enter Equation (10) only when i is the manufacturing sector. Equations (12) and (13) do not appear in either a Krugman- or Armington-type specification. Equation (14) is also dropped from an Armington–type specification.

Then, the module switches the Melitz-, Krugman-, and Armington-type specifications by applying different parameter settings as follows.

Melitz-type Specification: In the Melitz-type specification, the following two settings apply, in addition to (8) through (14):

$$\eta = -\frac{1}{\sigma^T_i};$$

and

$$\widetilde{N}_{rs} = (1 - G_{rs}) N_r.$$

Krugman-type Specification: In the Krugman-type specification, the following four relations apply, in addition to (8) through (11) and (14):

$$F_{rs} = 0;$$

$$\eta = -\frac{1}{\sigma^T_i};$$

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

$\varphi_{rs} = 1$;
and
$\tilde{N}_{rs} = N_r \qquad (\because G_{rs} = 0)$.

Armington-type Specification: In the Armington-type specification, the following four relations apply, in addition to (8) through (11):

$F_{rs} = H_r = 0$;
$\eta = 0$;
$\varphi_{rs} = 1$;
and
$\tilde{N}_{rs} = N_r = 1 \quad (\because G_{rs} = 0)$.

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.[7] The problem can be expressed as

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

$$\text{s.t.} \quad \tilde{C}_r = \theta_r^C \prod_i C_{ir}^{\alpha_{ir}^C} \qquad \perp p_r^C, \quad (15)$$

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

$$p_{ir}^M = \alpha_{ir}^C p_r^C \left(\frac{\tilde{C}_r}{C_{ir}}\right) \qquad \perp C_{ir}. \quad (16)$$

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,

[7] 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.[8] This problem can be expressed as follows:

$$\max \quad \tilde{C}_r$$
$$\text{s.t.} \quad p_r^C \tilde{C}_r = \sum_a \sum_j w_{ar} V_{ajr} + T_r + \bar{S}_r^F \qquad \perp \lambda_r, \qquad (17)$$

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

$$T_r \equiv \sum_j \left\{ \begin{array}{c} \frac{\tau_{jr}^Z}{1+\tau_{jr}^Z} p_{jr}^W Z_{jr} \\ + \sum_s \tau_{irs}^E \, p_{irs} \widetilde{N}_{rs} Q_{irs} \\ + \sum_s \tau_{isr}^M \, (1+\tau_{isr}^T)(1+\tau_{isr}^E) p_{isr} \widetilde{N}_{rs} Q_{isr} \end{array} \right\}.$$

Note that $\widetilde{N}_{rs}$ 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

$$\lambda_r p_r^C = 1 \qquad \perp \tilde{C}_r. \qquad (18)$$

2.4 Others

Factor Market: The factor market clearing conditions are

$$\sum_j V_{ajr} = \bar{V}_{ar} \qquad \perp w_{ar}, \quad (19)$$

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:

$$p_{jr}^Z = p_{jr}^W \qquad \perp Z_{jr}. \quad (20)$$

The system of a three-region, three-sector AGE model that includes the AKME module based on Dixon and Rimmer (2012) is described by 20 equations consist of (1) through (20). Since Walras' Law holds, one of the market clearing conditions automatically

[8] 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 shipping supply. In the present model, net factor income from abroad does not exist.

holds. In this regard, for example, we drop (11) with respect to the primary industries in the third region, exogenously setting the corresponding p_{ir}^{W} to unity. This implies we treat the primary products made in the third region as the numéraire commodity.

3. Experiments A

In this section, we report on some results of simulations performed with the three-region, three-sector AGE model with the AKME module introduced in the previous section. Before we begin, it is necessary to match the theory, on which the analytical model is based, with the given benchmark data to parameterize the model. Let us start by making some choices that characterize the model.

3.1 Matching Theory with Data

Although the trade specification by Armington (1969) assumed that varieties are differentiated by region of origin, the monopolistic competition models presented by Krugman (1980) and Melitz (2003) assume that an importer assesses variety expansion regardless of its source. As Ardelean (2006) has noted, these imply that an Armington-type specification eliminates the variety expansion channel of larger exporters, which fixes the number of varieties so that an exporter grows only through the intensive margin, and the Krugman- and Melitz-types predict that the rate of variety expansion is proportional to the growth in the volume of exports so that an exporter grows only through the extensive margin.[9]

In the implementation process of an AGE model, we need to match the theoretical features shown above 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.

[9] There has been a discussion on the relationship between the number of export varieties, volume of export quantities, and total value of exports. For instance, Hummels and Klenow (2005) found that the number of export varieties explains only 60 percent of the difference in export values across regions.

Zhai (2008) and Balistreri, *et al*. (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.[10] Balistreri, *et al*. (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, *et al*. (2013) have referred to the possibilities of the latter approach.[11] 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. It also is the same in the studies by Arkolakis, *et al*. (2012) and Melitz and Redding (2013), which address a debate over the welfare gains generated by a class of heterogeneous and homogeneous firm models. If the models are calibrated to the same domestic trade share and reduced-form trade elasticity, which is called the "macro" approach by Melitz and Redding (2013), the same level of welfare gains from trade is obtained. If the models retain the same values for behavioral parameters, which is called the "micro" approach, the heterogeneous firm model may generate larger welfare gains from reductions in trade costs. Concerning the elasticity of substitution among varieties, the strength of importer's LoV may play a role to connect these two extreme cases. Ardelean (2006) explored how strong the LoV is, and found that importer's LoV is around 40 percent lower than the one assumed in the Krugman's model.

Based on the study done by Ardelean (2006), we introduce an additional parameter that assesses the influence of LoV. At the same time, we would like to suggest we clearly distinguish two different kinds of viewpoint: (a) to what extent, total import values including changes in varieties are differentiated with respect to the region of origin; and (b) to what extent, the influence of LoV is accounted for in an importer's demand formation.[12] Then, δ_{irs}^{T} in Equations (8) and (9) can be defined as

[10] 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.

[11] Although the discussion is limited to a Krugman-type, Francois and Roland-Holst (1997) and Francois (1998) took the latter approach.

[12] While Ardelean (2006) has shed lights on the intensity of LoV, the import demand still remains symmetric across regions. With such formulation, the model may not reproduce the state given by the benchmark data in the reference run, especially when the Armington-type is the case. A way to calibrate a model to manage the symmetric preference, setting α_{irs}^{T} to unity, in a case of the Krugman- or Melitz-type is explained later.

$$\delta_{irs}^{T} \equiv \alpha_{irs}^{T} \widetilde{N}_{rs}^{(\beta_s - 1)/\sigma_i^T}, \tag{21}$$

where

α_{irs}^{T} is the demand share parameter which corresponds to the viewpoint (a); and

$\beta_s \in [0,1]$ is the importer's LoV which corresponds to the viewpoint (b).

β has suffix s because variety expansion in certain kind of commodity might be differentiated by importers.

Substituting (21) into Equation (8), the CES demand aggregator for imported products from region r is rewritten to

$$\sum_j X_{ijs} + C_{is} = \theta_{is}^{T} \left\{ \sum_r \alpha_{irs}^{T} \widetilde{N}_{rs}^{(\beta_s + \sigma_i^T - 1)/\sigma_i^T} Q_{irs}^{(\sigma_i^T - 1)/\sigma_i^T} \right\}^{\sigma_i^T/(\sigma_i^T - 1)}. \tag{22}$$

Since the volumes of basic preference weights α_{irs}^{T} are adjusted in the calibration process by the scaling factor θ_{is}^{T} to pass the replication test, we assume $\sum_r \alpha_{irs}^{T} = 1$.

At $\beta_s = 0$, Equation (22) is equivalent to the Armington-type and an importer s places no value on additional varieties. At $\beta_s = 1$, (22) is consistent with the setting in the theoretical models by Krugman (1980) and Melitz (2003), with which an importer s fully enjoys variety increase. An important point here is that the CES weights $\alpha_{irs}^{T} \widetilde{N}_{rs}^{(\beta_s + \sigma_i^T - 1)/\sigma_i^T}$ are now endogenous when $\beta_s > 0$. 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 Krugman- and Melitz-types can manage the case an importer endogenously changes his/her valuation of the commodity based on certain changes in the economic environment.

3.2 Data and Parameterization of the Model

The model is calibrated to the Global Trade Analysis Project (GTAP) 8.1 database[13] for 2007 along with additional information on the shape parameter related to productivity (γ) for the Melitz-type specification.[14] The original 129 countries/regions and 57 commodities/activities are respectively aggregated to three. The regions consist of the Asia-Pacific (r01), the North and South Americas (r02), and the European Union and the Rest of the World (r03). The three sectors are the primary industries (i01), manufacturing

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

[14] The choice of number of firms or level of fixed costs will not affect simulation results. Thus, initial levels for two types of number of firms, N_r and G_{rs}, or parameter values for two types of fixed costs, H_r and F_{rs}, can be set freely to any preferred value. For detailed explanations, see Oyamada (2014).

(i02), and services (i03). As noted previously, the manufacturing sector (i02) is 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 shipping supply.

Estimates for γ can be found in several empirical studies, such as Melitz and Redding (2013), Balistreri, *et al*. (2011), and Bernard, *et al*. (2007). Based on their findings, we set γ to 5.0. The details of the benchmark data set are summarized in Appendix. The calibration step is similar to the ones adopted in traditional AGE models.

3.3 Simulations

The simulation experiments in this section, that reveal some of the behavioral characteristics of the model, are categorized into two types. In the first type, we examine the effects of trade liberalization on the regional welfare levels switching the three kinds of trade specification based on the Armington, Krugman, and Melitz models. In the second type, we examine how the results obtained by the first type change when the importer's LoV (β_s) take different values from zero to unity.

Trade liberalization is expressed as the permanent removal of trade barriers, such as export duty/subsidy and import tariff, levied on the trade flows of manufactured products (i02). First, we consider three kinds of trade liberalization scenario: [Scenario I] intra-regional free trade agreement (FTA) in the Asia-Pacific region (r01); [Scenario II] intra-regional FTA in the North and South Americas (r02); and [Scenario III] intra- and inter-regional FTA among the Asia-Pacific (r01) and the North and South Americas (r02). In this type of experiment, the values of the importer's LoV (β_s) for three regions are all set to 0.5, when the Krugman- and Melitz-types are applied.[15]

Next, the values of the importer's LoV (β_s) for the Asia-Pacific (r01) and the North and South Americas (r02) are respectively changed from zero to unity, while the value for the European Union and the Rest of the World (r03) remains constant, fixed to 0.5. The step width of the value changes for r01 and r02 is set to 0.05. It implies that we have 21 values of β_s between zero and unity for one region. Thus, we underwent 441 (21×21) different simulations for each of three scenarios. Note that the model is re-calibrated for every values

[15] When the Armington-type specification is utilized, β_s for all regions are set to zero by definition.

of β_s to purify the effects of trade liberalization and make it comparable to each other. If we change the value of β_s 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 trade liberalization takes place. The effects of changing the value of β_s should be clearly distinguished and split from those of trade liberalization, and swept out from the experiments.

3.3.1 Welfare Effects of Trade Liberalization under Alternative Trade Specifications

Let us start with examining the effects of trade liberalization on the regional welfare levels switching the three kinds of trade specification respectively based on the Armington, Krugman, and Melitz models. As noted above, the following three kinds of trade liberalization scenario are considered: [Scenario I] intra-regional FTA in the Asia-Pacific region (r01); [Scenario II] intra-regional FTA in the North and South Americas (r02); and [Scenario III] intra- and inter-regional FTA among r01 and r02. The values of the importer's LoV (β_s) for three regions are all fixed to 0.5 when the Melitz- and Krugman-type specifications apply.

Table 1 shows the Hicksian equivalent variations (EV) in billions U.S. dollars when the Asia-Pacific region (r01) fully liberalizes trade in manufactured products (i02) within the region (Scenario I). It is expressed by setting $\tau^M_{"i02""r01""r01"} = \tau^E_{"i02""r01""r01"} = 0$ in the model. The intra-regional trade liberalization concerning i02 in r01 may bring large welfare gains only to r01, and has negative effects on the welfare levels of outsiders. When the Melitz- and Krugman-type specifications apply, the welfare gains of r01 are more than ten times greater than the case of the Armington-type. It is the expansion effects brought by endogenous changes of the CES weights in the demand aggregator for imported products. Even when β_s is fixed to 0.5, the expansion effects become this large.

While the trade diversion effects for r02 is larger than the ones for r03 when the Armington-type apply, the relation is reversed in the cases of the Melitz- and Krugman-types and the loss of r03 turns to be much large than r02. For this, trade patterns in the base case as well as the preference on the source region of a commodity are playing roles. Once r01 liberalizes the intra-regional trade, expansion effects through an increase of the preference weight for the domestic products accrue. Thus, both r02 and r03 lose opportunities to trade with r01, and as a result, those regions increase trade with each other. The import values of i02 by r02 at the cost, freight, and insurance (CIF) prices in the base case are 898 billion and 572 billion U.S. dollars from r01 and r03, respectively, and the imports by r03 are 1015 billion and 457 billion from r01 and r02, respectively. Assuming that r02 and r03 respectively lose trade opportunities with r01 at the same level, r03 loses more favorable opportunities (the value of α_{irs}^{T} is larger) with r01 and has to increase trade with more unfavorable partner r02 (the value of α_{irs}^{T} is smaller), compared to r02. This is the reason why the loss of r03 is greater than the one of r02.

In a similar manner, Table 2 shows EV in billions U.S. dollars when the North and South Americas (r02) fully liberalizes trade in i02 within the region (Scenario II). As in the previous scenario, this case is expressed by setting $\tau^{M}_{"i02""r02""r02"} = \tau^{E}_{"i02""r02""r02"} = 0$ in the model. In this scenario, the welfare gains of r02 are much smaller than the previous scenario in all of the trade specifications. In addition, levels of the expansion effects in the Melitz- and Krugman-types also are shrinking. It is because, the initial import tariff rate levied on the intra-regional trade of i02 is lower in r02 (0.170%) than in r01 (0.679%). Elimination of a larger distortion may bring greater welfare effects.

Table 3 is for the case when r01 and r02 settle intra- and inter-regional FTA (Scenario III). It is expressed by setting $\tau^{M}_{"i02""r01""r01"} = \tau^{M}_{"i02""r02""r02"} = \tau^{M}_{"i02""r01""r02"} = \tau^{M}_{"i02""r02""r01"} = \tau^{E}_{"i02""r01""r01"} = \tau^{E}_{"i02""r02""r02"} = \tau^{E}_{"i02""r01""r02"} = \tau^{E}_{"i02""r02""r01"} = 0$. In this case, r03 who is excluded from the FTA becomes the sole loser, while the member regions of the FTA are better off.

Similar to the first scenario, the welfare gains of r01 in the cases of the Melitz- and Krugman-type specifications become more than ten times greater than the one obtained in the Armington-type. On the other hand, the expansion effects brought by endogenous changes of the preference weights are not so large for r02. However, if we focus on the inter-regional part of the trade liberalization, the gains of r02 are much greater than the ones of r01. From the second scenario, the welfare gains of r02 become 2.5 times larger, while the gains of r01 are 1.5 times larger than the ones in the first scenario. Especially, when the Armington-type specification applies, the gains of r02 exceed those of r01. In this meaning, inter-regional trade liberalization between r01 and r02 is more favorable for r02.

Let us start verifying the case of the Armington-type first. The initial import tariff rate levied by r01 on the i02 commodities produced in r02 is 4.078%, and the one by r02 on the r01 products is 3.651%. When those barriers are abolished, we expect the increase of exports by r02 is greater than that by r01. Then, recall that the current account is assumed to remain imbalanced at the same position given by the benchmark data in the simulations. To increase exports, the volumes of imports have to be expanded. In addition, other kinds of commodity, i01 and i03, also are traded. The combinations of such effects determine the final state of terms of trade, and as a result, the gains of r02 exceed the ones of r01.

Why is this relation reversed when the Melitz- and Krugman-types apply? Previously, we saw that the initial import tariff rates levied on the intra-regional trade of i02 in r01 and r02 are 0.679% and 0.170%, respectively. Since the effects from liberalizing intra-regional trade might be stronger in r01 than in r02, there is a possibility that the expansion effects brought by increases of the preference weight for domestic products cancel those for the r02 products out in r01. Again, the preference weight α_{irs}^{T} plays an important role. In many cases, the proportion of intra-regional trade that includes domestic trade is larger than those of inter-regional trade. Then, it is likely that economic agents in every region may place more importance for domestic and intra-regional trade than inter-regional trade. Hence, the expansion effects accrued in the models with imperfect competition become stronger to intra-regional trade, and suppress the welfare gains of r02 observed in the Armington-type specification.

Finally, let us see the differences brought by changing trade specifications. Generally speaking, the introduction of imperfect competition into the manufacturing sector (i02) largely inflates gains by the participants of FTAs, while decreases gains or increases losses by the outsiders, as expected. For r01 in Scenarios I and III, the gains become more than ten times larger than the one obtained with the Armington-type. On the other hand, notice that the Krugman-type specification tends to provide larger gains for the members of FTAs than the Melitz-type, unexpectedly, except r02 in Scenario II. The reason why these happen can be found in the setting of the strength of LoV (β_s). Hence, we forward to see the effects of changing the values of β_s on these simulations results.

3.3.2 Effects of Changing the Strength of LoV on the Simulation Results

In this experiment, we will see how the results obtained previously, assuming the Melitz- and Krugman-type trade specifications, change with different values of the importer's LoV (β_s) for the manufactured products (i02), given for the Asia-Pacific (r01) and the North and South Americas (r02). The values of β_s for the two regions are respectively changed from zero to unity, with the step width of 0.05, while the value for the European Union and the Rest of the World (r03) is fixed to 0.5.[16] As noted above, the model is re-calibrated for every values of β_s to eliminate the effects of changing the value of β_s, which may

[16] Note that the results obtained setting $\beta_s = 0$ for both r01 and r02 differ from the ones obtained assuming the Armington-type trade specification, which are shown in the bottom rows of Tables 1 through 3, because in the former case the value of β_s for r03 is 0.5 while the corresponding value is zero in the latter case.

permeate in the effects of trade liberalization if we change it after the model is calibrated. Hence, we have 441 independent models for each of three scenarios. Since the three dimensional figures that includes all the 441 cases look too much complicated, we present, in this section, two dimensional figures that capture changes in the regional welfare when the values of β_s for both r01 and r02 simultaneously shift from zero to unity.

Figures 1 through 3 depict the effects of changing the value of β_s on the regional welfare levels with the Melitz- and Krugman-type specifications. Three figures respectively correspond to the three trade liberalization scenarios: [Figure 1] intra-regional FTA in the Asia-Pacific region (r01); [Figure 2] intra-regional FTA in the North and South Americas (r02); and [Figure 3] intra- and inter-regional FTA among r01and r02. In each set, three figures from the top to the bottom capture the effects for r01 through r03. It can be regarded that the picture on the top of Figure 1 (let us call it Figure 1T), the one in the middle of Figure 2 (3M), and the ones on the top and middle of Figure 3 (3T and 3M), are showing the effects when the corresponding region is liberalizing trade. On the other hand, the rest of the pictures, the ones in the middle and bottom of Figure 1 (1M and 1B), the ones on the top and bottom of Figure 2 (2T and 2B), and the one on the bottom of Figure 3 (3B), are all corresponding to the cases when the captured region is excluded from the FTAs.

From Figures 1T, 2M, 3T, and 3M, it can be said that stronger LoV improves the welfare levels of the regions that settle free trade. On the other hand, the regions outside a FTA tend to be worse off. One exception is found in Figure 1M. When LoV is weak, the intra-regional FTA in r01 has trade creation effects, which bring positive spillovers to r02. This might be related to the discussion we made previously on the welfare gains of r02 in Scenario III when the Armington-type specification applies. As the strength of LoV becomes weaker, the expansion effects brought by changes of CES weights vanish. Then, the trade creation effects, which the intra-regional FTA in r01 basically has, are getting obvious.

Another characteristic shown in the figures is that the welfare effects tend to be inflated as the value of β_s gets larger and closer to unity. For instance, the difference between the welfare levels that correspond to $\beta_s = 0$ and $\beta_s = 1$ are more than fifteen times for r01 in Scenario I (Figure 1T) and about ten times for r02 in Scenario II (Figure 2M), respectively. The negative impacts to the regions excluded from a FTA also magnify. One interesting point is that there are reversals in the welfare effects respectively obtained with the Melitz- and Krugman-type specifications. When LoV is weak, the effects obtained with the Krugman-type tend to be larger, while the effects with the Melitz-type exceed those with the Krugman-type when LoV is strong. Recall the question why the

Krugman-type specification tends to provide larger gains for the members of FTAs than the Melitz-type as shown in Tables 1 through 3, which we placed in the last part of the previous subsection. The answer is here.

From Figures 1 through 3, the following behavioral characteristics are found: (i) when the values of β_s for r01 and r02 are small and close to zero, effects (deviations from the initial values) obtained with the Melitz-type specification tend to be smaller than the one with the Krugman-type except the case for r02 in Figure 1; (ii) when the values of β_s for r01 and r02 are large and close to unity, effects with the Melitz-type tend to be much larger than the one with the Krugman-type except the case for r02 in Figure 3; and (iii) since the non-linearity is stronger in the model with the Melitz-type in many cases, the Melitz-type specification may not always enhance effectiveness of a certain policy change more than the one obtained with the Krugman-type, especially when the importer's LoV is not so strong. There are likely to be points, around $\beta_s = 0.5$, where the volumes of effects obtained with the Melitz-type exceed the ones with the Krugman-type. What fill the differences between the results obtained with the Melitz- and the Krugman-type specifications are the effects on the reallocation of resources resulting from endogenous productivity growth among heterogeneous firms that enters the Melitz-type model. Thus, we need further researches on the strength of the importer's LoV.

4. Experiments B

In the three-region three-sector AGE model with the AKME module, which is utilized in the previous section, trade flows from source regions are aggregated at the border, and then, the composite commodity i is sold on a local market, as expressed by Equation (8). In this section, we extend the model from the "sourcing-at-border (SaB)" type to be a "sourcing-by-agent (SbA)" type, and verify effects of changing the strength of LoV by economic agent, i.e. the unified producers in every sector and the representative consumer, to identify whose LoV matters most. In a SbA-type model, trade flows from source regions are sold on a local market first, and then every economic agent aggregates the commodities to be a i-th composite with his/her own preference for traded variety. In this case, β has suffix j in addition to s.

4.1 Extending the Model from a "Sourcing-at-Border" Type to be a "Sourcing-by-Agent" Type

To extend the previously introduced SaB-type model to be a SbA-type, Equation (22) is divided into two respectively related to X_{ijs} and C_{is}:

$$X_{ijs} = \theta_{ijs}^{X}\left\{\sum_{r}\alpha_{ijrs}^{X}\widetilde{N}_{rs}^{\left(\beta_{js}^{X}+\sigma_{i}^{T}-1\right)/\sigma_{i}^{T}}\left(Q_{ijrs}^{X}\right)^{\left(\sigma_{i}^{T}-1\right)/\sigma_{i}^{T}}\right\}^{\sigma_{i}^{T}/\left(\sigma_{i}^{T}-1\right)} \perp p_{ijs}^{MX}; \quad (23)$$

and

$$C_{is} = \theta_{is}^{C}\left\{\sum_{r}\alpha_{irs}^{C}\widetilde{N}_{rs}^{\left(\beta_{s}^{C}+\sigma_{i}^{T}-1\right)/\sigma_{i}^{T}}\left(Q_{irs}^{C}\right)^{\left(\sigma_{i}^{T}-1\right)/\sigma_{i}^{T}}\right\}^{\sigma_{i}^{T}/\left(\sigma_{i}^{T}-1\right)} \perp p_{is}^{MC}, \quad (24)$$

where

Q_{ijrs}^{X} is the average trade flow of commodity i sold by active firm in region r to the producer j in region s,

Q_{irs}^{C} is the average trade flow of commodity i sold by active firm in region r to the representative consumer in region s,

p_{ijs}^{MX} is the market price of commodity i sold to the producer j in region s, inclusive of export duty/subsidy, transportation margin, and import tariff,

p_{is}^{MC} is the market price of commodity i sold to the representative consumer in region s, inclusive of export duty/subsidy, transportation margin, and import tariff,

α_{ijrs}^{X} is the demand share parameter that reflects the preference of the producer j in region s for the commodity i produced in region r,

α_{irs}^{C} is the demand share parameter that reflects the preference of the representative consumer in region s for the commodity i produced in region r,

$\beta_{js}^{X} \in [0,1]$ is the LoV by the producer j in region s,

$\beta_{s}^{C} \in [0,1]$ is the LoV by the representative consumer in region s, and

θ_{ijs}^{X} and θ_{ij}^{C} are the scaling factors.

Then, Equation (9) also is divided into two as follows:

$$\left(1+\tau_{ijrs}^{MX}\right)\left(1+\tau_{ijrs}^{TX}\right)\left(1+\tau_{ijrs}^{EX}\right)p_{irs} = \alpha_{ijrs}^{X}\left(\theta_{ijs}^{X}\right)^{\left(\sigma_{i}^{T}-1\right)/\sigma_{i}^{T}}\widetilde{N}_{rs}^{\left(\beta_{js}^{X}-1\right)/\sigma_{i}^{T}}p_{ijs}^{MX}\left(\frac{X_{ijs}}{Q_{ijrs}^{X}}\right)^{1/\sigma_{i}^{T}} \perp Q_{ijrs}^{X}; \quad (25)$$

and

$$\left(1+\tau_{irs}^{MC}\right)\left(1+\tau_{irs}^{TC}\right)\left(1+\tau_{irs}^{EC}\right)p_{irs} = \alpha_{irs}^{C}\left(\theta_{is}^{C}\right)^{\left(\sigma_{i}^{T}-1\right)/\sigma_{i}^{T}}\widetilde{N}_{rs}^{\left(\beta_{s}^{C}-1\right)/\sigma_{i}^{T}}p_{is}^{MC}\left(\frac{C_{is}}{Q_{irs}^{C}}\right)^{1/\sigma_{i}^{T}} \perp Q_{irs}^{C}, \quad (26)$$

where

τ_{ijrs}^{EX} and τ_{irs}^{EC} are the rates of export duty/subsidy,

τ_{ijrs}^{TX} and τ_{irs}^{TC} are the rates of transportation margin, and

τ_{ijrs}^{MX} and τ_{irs}^{MC} are the import tariff rates.

Finally, small modifications are added to Equations (11), (13), and (14):

$$\sum_s \tilde{N}_{rs} \frac{\sum_j Q_{ijrs}^X + Q_{irs}^C}{\varphi_{rs}} + \Omega_r = Z_{ir} - \sum_s \tilde{N}_{rs} F_{rs} - N_r H_r \qquad \perp p_{ir}^W; \quad (27)$$

$$\varphi_{rs} = \left(\frac{\gamma}{\gamma - \sigma_i^T + 1}\right)^{1/(\sigma_i^T - 1)} \frac{(-\eta)^{1/(1-\sigma_i^T)}}{1+\eta} \left(\frac{p_{ir}^w}{p_{irs}}\right)^{\sigma_i^T/(\sigma_i^T - 1)} \left(\frac{F_{rs}}{\sum_j Q_{ijrs}^X + Q_{irs}^C}\right)^{1/(\sigma_i^T - 1)} \qquad \perp \varphi_{rs}; \quad (28)$$

and

$$p_{ir}^w\left(\sum_s \tilde{N}_{rs} F_{rs} + N_r H_r\right) = -\eta \sum_s p_{irs} \tilde{N}_{rs}\left(\sum_j Q_{ijrs}^X + Q_{irs}^C\right) \quad \perp N_r. \quad (29)$$

To calibrate a SbA-type model, a global input-output (I-O) table has been compiled based on the GTAP 8.1 database for 2007.[17] Neither additional information nor re-balancing is required. The import matrices for national I-O tables, "*VIFM*", "*VIPM*", and "*VIGM*", are chopped utilizing the proportions with respect to the source region derived from the trade flows at CIF prices inclusive of transportation margin and import tariff, "*VIMS*". Then, the I-O tables for domestic products, "*VDFM*", "*VDPM*", and "*VDGM*" are added to the intra-regional part of the extended import matrices. In this case, the rates of transportation margin and import tariff with respect to the intra-regional trade differ among production sectors and final demand. The global I-O used in this study is shown in Appendix.

4.2 Simulations

The experiments in this section simulate the same scenarios considered in the previous section. Trade liberalization is expressed as the permanent removal of trade barriers, such as export duty/subsidy and import tariff, levied on the trade flows of manufactured products (i02). The scenarios are [Scenario I] intra-regional free trade agreement (FTA) in the Asia-Pacific region (r01), [Scenario II] intra-regional FTA in the North and South Americas (r02), and [Scenario III] intra- and inter-regional FTA among the Asia-Pacific (r01) and the North and South Americas (r02). Then, the values of the economic agents' LoV (β_{js}^X and β_s^C) for the Asia-Pacific (r01) and the North and South Americas (r02) are respectively

[17] For the development of GTAP-based multi-region, I-O tables, Walmsley, *et al*. (2013) provides useful information.

changed from zero to unity, while the value for the European Union and the Rest of the World (r03) remains constant, fixed to 0.5, as in the previous case.

Figures 4 through 6 depict the effects of changing the value of β_s^C, which corresponds to the LoV of the representative consumer in r01 and r02, on the regional welfare levels with the Melitz- and Krugman-type specifications. In these cases, non-linearity of the effects with the Melitz-type is lost, and volumes of the impacts are suppressed. In addition, differences between Melitz- and Krugman-type specifications shown in Figures 4T and 5M are quite small. In these cases, the effects on the reallocation of resources resulting from endogenous productivity growth among heterogeneous firms are not working very much. Finally, one may notice that the positive effects with the Melitz-type observed in Figure 6M is now smaller than those with the Krugman-type when the values of β_s^C is large. This is reflected in the previously verified Figure 3M, in which the reversal in the welfare effects did not happen. Let us compare these results with the ones changing β_{js}^X, which corresponds to the LoV of the unified producers in r01 and r02.

Figures 7 through 9 show the effects of changing the value of β_{js}^X. The figures are much similar to the ones we checked in the previous section, while volumes of the effects are slightly suppressed. It is because the volumes of intermediate demand for commodity i02 are respectively 298.23%, 149.24%, and 159.04% of final demand respectively in r01 through r03. This time, the effects of the intra- and inter-regional FTA among r01 and r02 on the welfare level of r02 with the Melitz-type exceed the effects with the Krugman-type when LoV is strong (Figure 9M).

Whose LoV matters most? Figures 10 through 12, 13 through 15, and 16 through 18 respectively show the effects of changing the value of $\beta_{"i01"s}^X$, $\beta_{"i02"s}^X$, and $\beta_{"i03"s}^X$ for r01 and r02 from zero to unity on the regional welfare levels. The LoV of the unified producers in sector i01 does not matter very much, and the effect reversals also are not observed. The reason might be found in the shares of intermediate demand for commodity i02 by sector i01, which are 3.39%, 3.57%, and 3.82% in regions r01, r02, and r03. The most influential agent is the unified producers in sector i02. Figures 13 through 15 respectively look very similar to Figures 7 through 9, which resemble Figures 1 through 3. The shares of intermediate demand for commodity i03 by sector i02 are 69.31%, 56.50%, and 59.30% in regions r01, r02, and r03. The effects of changing the strength of LoV corresponding to the unified producers in sector i03, whose shares in total intermediate demand for commodity i02 are 27.30%, 39.92%, and 36.89% respectively in regions r01, r02, and r03, are just similar to the ones corresponding to the representative consumers' LoV, which are captured by Figures 4 through 6.

A point is that the effects of changing the strength of LoV corresponding to the unified producers in sectors i01 and i03, and the representative consumer do not show strong non-linearity. While we need further investigation, efficiency gains from the reallocation of resources resulting from endogenous productivity growth among heterogeneous firms, which are featured in the Melitz model, might be boosted through the intermediate inputs by the IRTS sector. It is the forward linkage suggested by Fujita, *et al.* (2000:242) based on their analysis using a model with intermediate goods.

By the simulations with a SbA-type AGE model with AKME module, the following behavioral characteristics are found: (iv) based on the demand shares in local markets, the volumes of the expansion effects brought by endogenous changes of the preference weights on welfare gains from trade liberalization are determined; (v) efficiency gains from the reallocation of resources resulting from endogenous productivity growth among heterogeneous firms, which are featured in the Melitz model, are not obvious when the preference for traded variety is not so strong; and (vi) the preference of the producers, those who are in the IRTS sector, for variety might be the engine of explosive effects because it creates the forward linkage suggested by Fujita, *et al.* (2000:242).

5. Concluding Remarks

Comparing simulation results obtained by AGE models based on the intra-industry trade specifications presented by Armington (1969), Krugman (1980), and Melitz (2003) may have considerable importance in evaluating trade-related economic policies today. This paper explored how simulation results change with different choice of trade specification, and the strength of preference for traded variety by economic agent differs. Simulations with the two types of three-region, three-sector AGE model that includes the AKME module based on Dixon and Rimmer (2012) revealed some of the behavioral characteristics of the model. With the special focus on the strength of the importer's preference for traded variety, the key findings can be summarized as follows:

1. The introduction of imperfect competition into the manufacturing sector (i02) largely inflates the effects of trade liberalization. Stronger preference for traded variety may contribute to further expansions of the effects;

2. The Melitz-type trade specification may not always enhance effectiveness of a

certain policy change more than the one obtained with the Krugman-type, especially when the importer's preference for traded variety is not so strong. There are likely to be points where the volumes of effects obtained with the Melitz-type exceed the ones with the Krugman-type;

3. Based on the demand shares in local markets, the volumes of the expansion effects brought by endogenous changes of the preference weights on welfare gains from trade liberalization are determined;

4. Efficiency gains from the reallocation of resources resulting from endogenous productivity growth among heterogeneous firms, which are featured in the Melitz model, are not substantial when the preference for traded variety is not so strong; and

5. The preference of producers, those who are in the IRTS sector, for traded variety might be the engine of explosive effects as suggested by Fujita, *et al.* (2000:242).

We believe further researches on the strength of economic agents' preference for traded variety enrich the discussions among trade models, and bridge the two extreme cases presented by Arkolakis, *et al*. (2012) and Melitz and Redding (2013). Our next goal is to develop an extension module in the GEMPACK (General Equilibrium Modeling PACKage)[18] format for the GTAP models to make comprehensive trade analysis more accessible.

[18] Harrison and Paerson (1996).

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Table 1. Hicksian Equivalent Variations (US$ Billion) - Intra-regional FTA in r01

	r01	r02	r03
Melitz	65.150 (0.532%)	-0.188 (0.001%)	-7.855 (-0.036%)
Krugman	65.178 (0.532%)	-0.412 (0.002%)	-7.897 (-0.037%)
Armington	6.478 (0.053%)	-0.961 (0.005%)	-0.525 (-0.002%)

Note: $\beta_s = 0.5$ for all s.

Table 2. Hicksian Equivalent Variations (US$ Billion) - Intra-regional FTA in r02

	r01	r02	r03
Melitz	-2.012 (-0.016%)	10.346 (0.053%)	-1.776 (-0.008%)
Krugman	-2.027 (-0.017%)	10.317 (0.053%)	-1.769 (-0.008%)
Armington	-0.019 (-0.008%)	2.270 (0.012%)	-0.586 (-0.003%)

Note: $\beta_s = 0.5$ for all s.

Table 3. Hicksian Equivalent Variations (US$ Billion) - Intra- and Inter-regional FTA among r01 and r02

	r01	r02	r03
Melitz	99.587 (0.813%)	25.178 (0.129%)	-18.099 (-0.084%)
Krugman	99.605 (0.813%)	25.972 (0.133%)	-18.312 (-0.085%)
Armington	9.825 (0.080%)	17.115 (0.088%)	-4.050 (-0.019%)

Note: $\beta_s = 0.5$ for all s.

Figure 1. Change in Welfare (%) - Intra-regional FTA in r01 (All Agents)

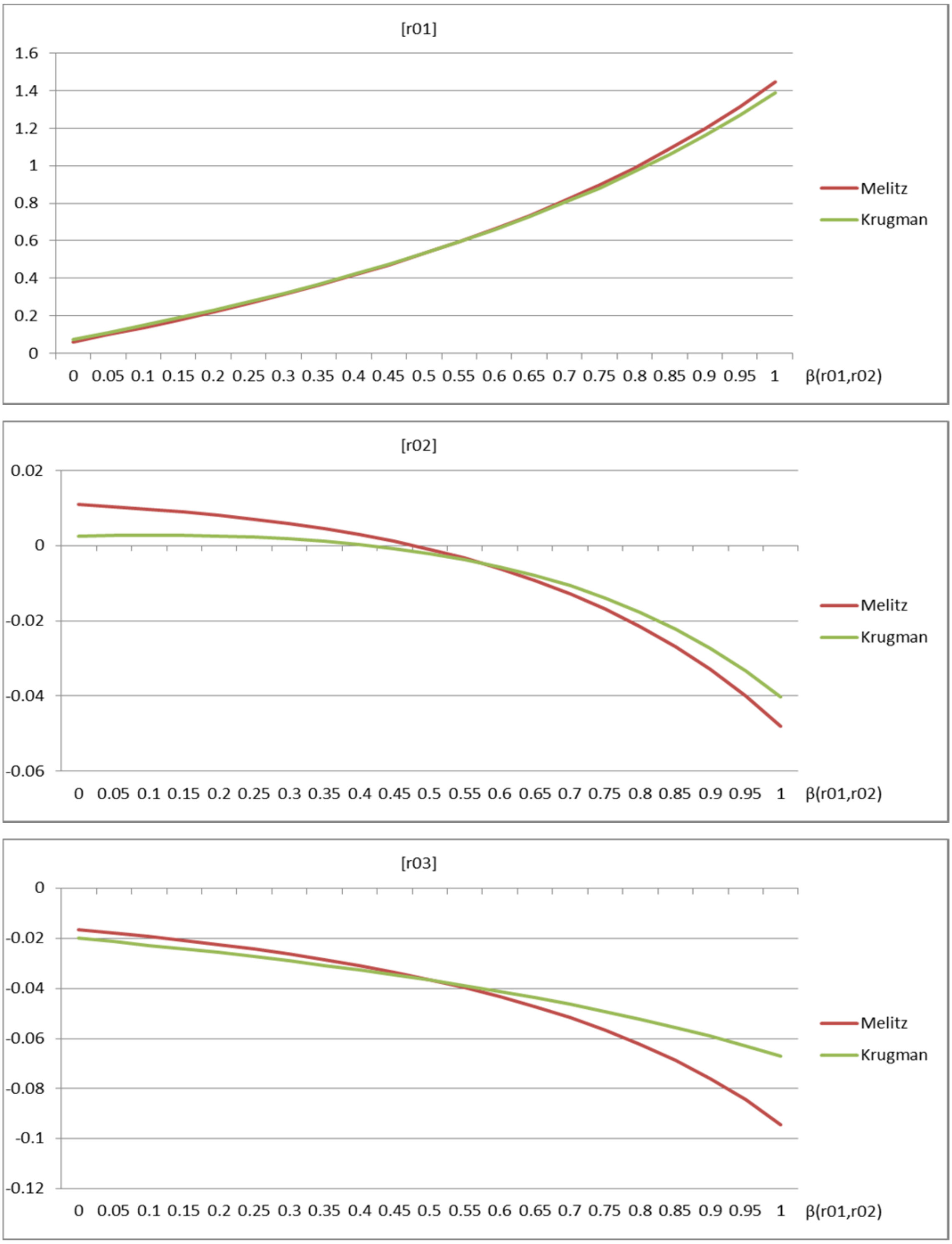


Figure 2. Change in Welfare (%) - Intra-regional FTA in r02 (All Agents)

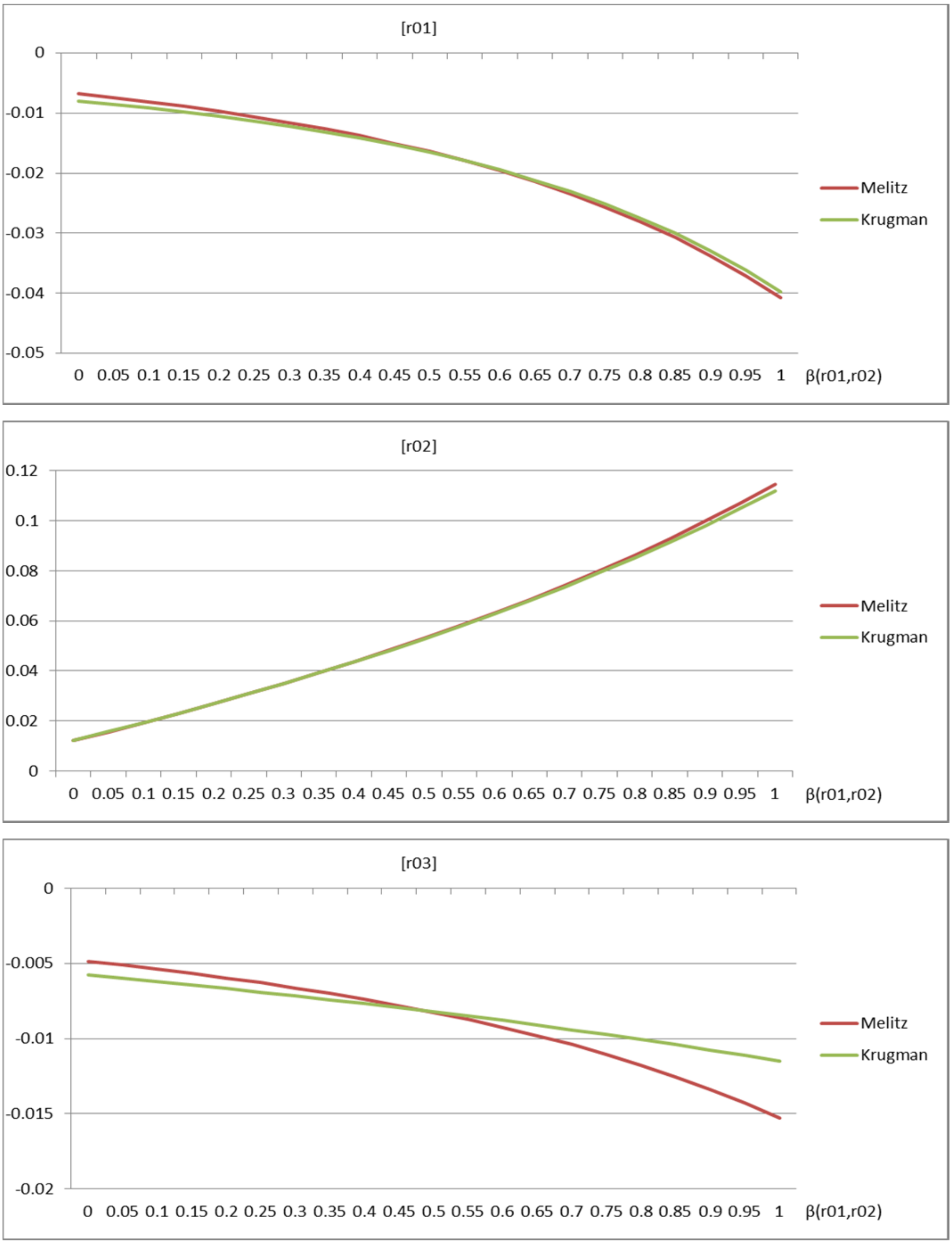


Figure 3. Change in Welfare (%) - Intra- and Inter-regional FTA among r01 and r02 (All Agents)

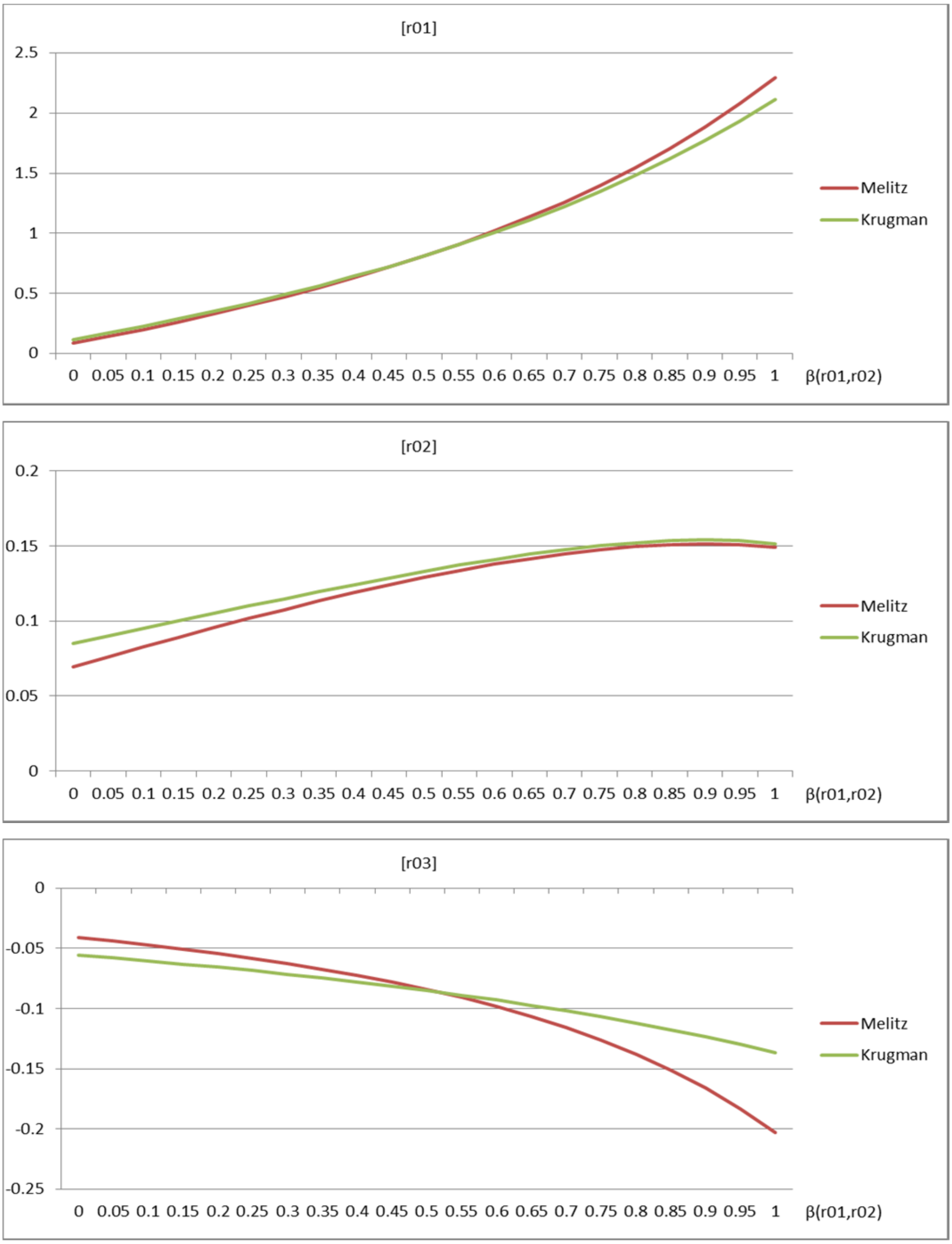


Figure 4. Change in Welfare (%) - Intra-regional FTA in r01 (Final Demand)

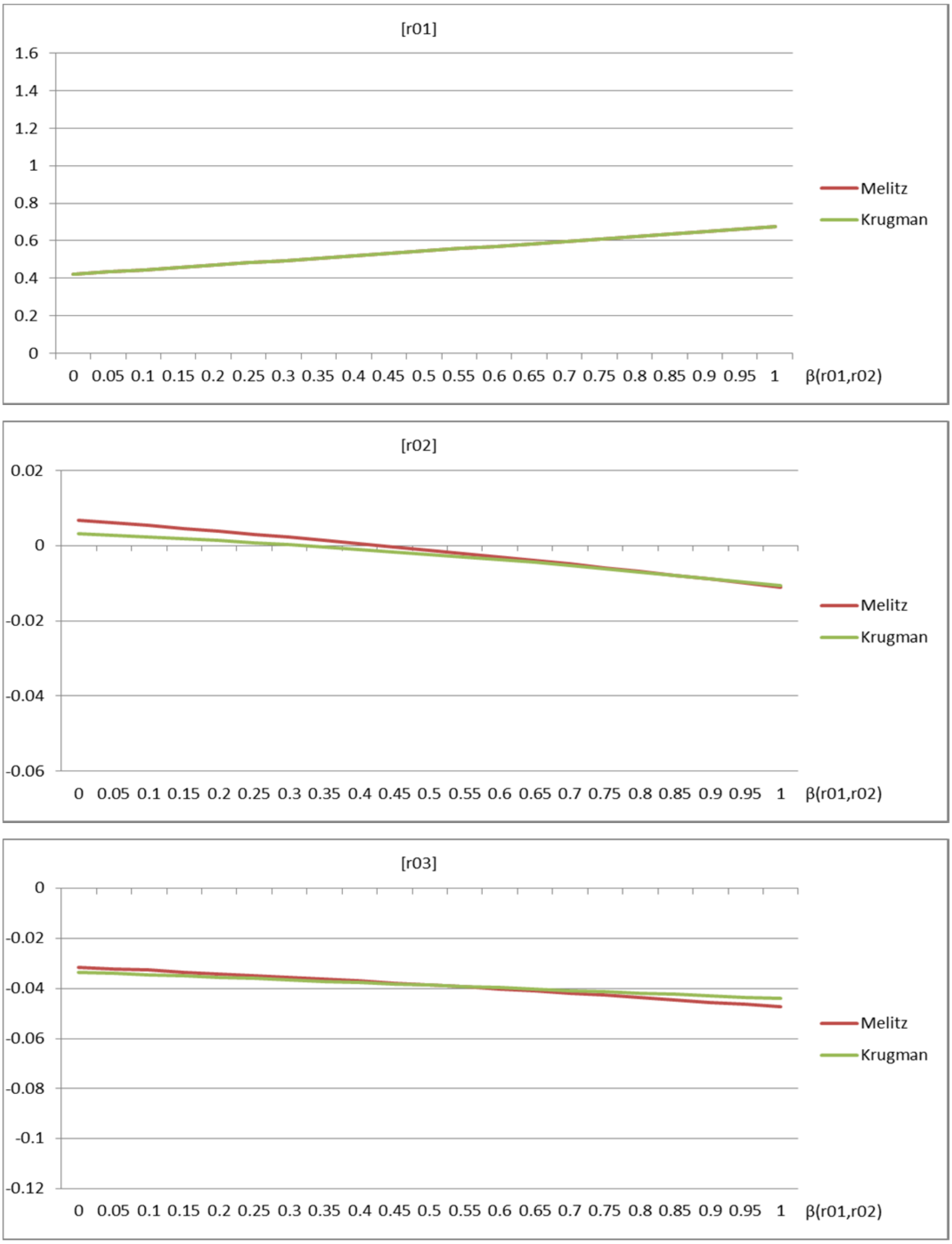


Figure 5. Change in Welfare (%) - Intra-regional FTA in r02 (Final Demand)

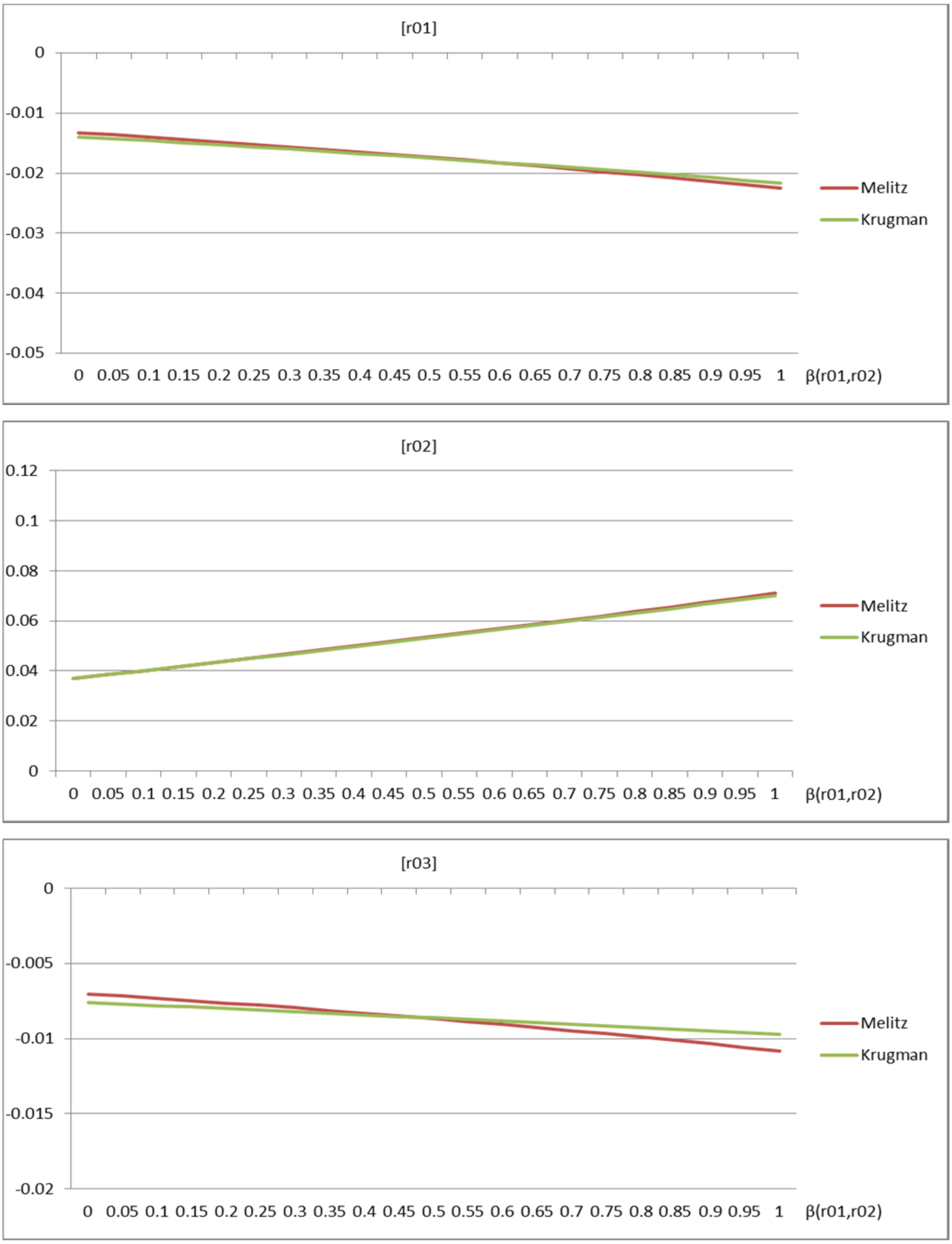


Figure 6. Change in Welfare (%) - Intra- and Inter-regional FTA among r01 and r02 (Final Demand)

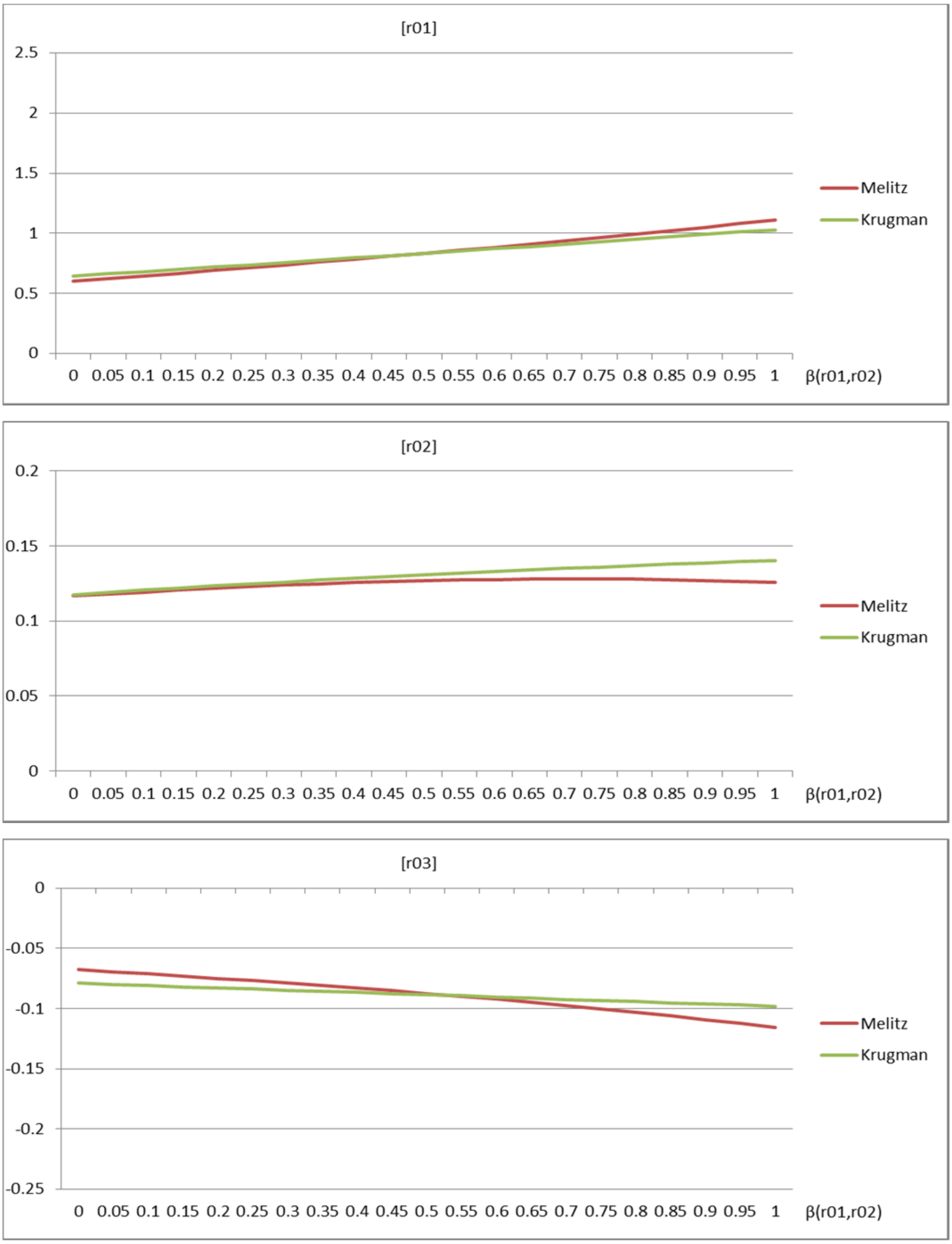


Figure 7. Change in Welfare (%) - Intra-regional FTA in r01 (All Intermediate)

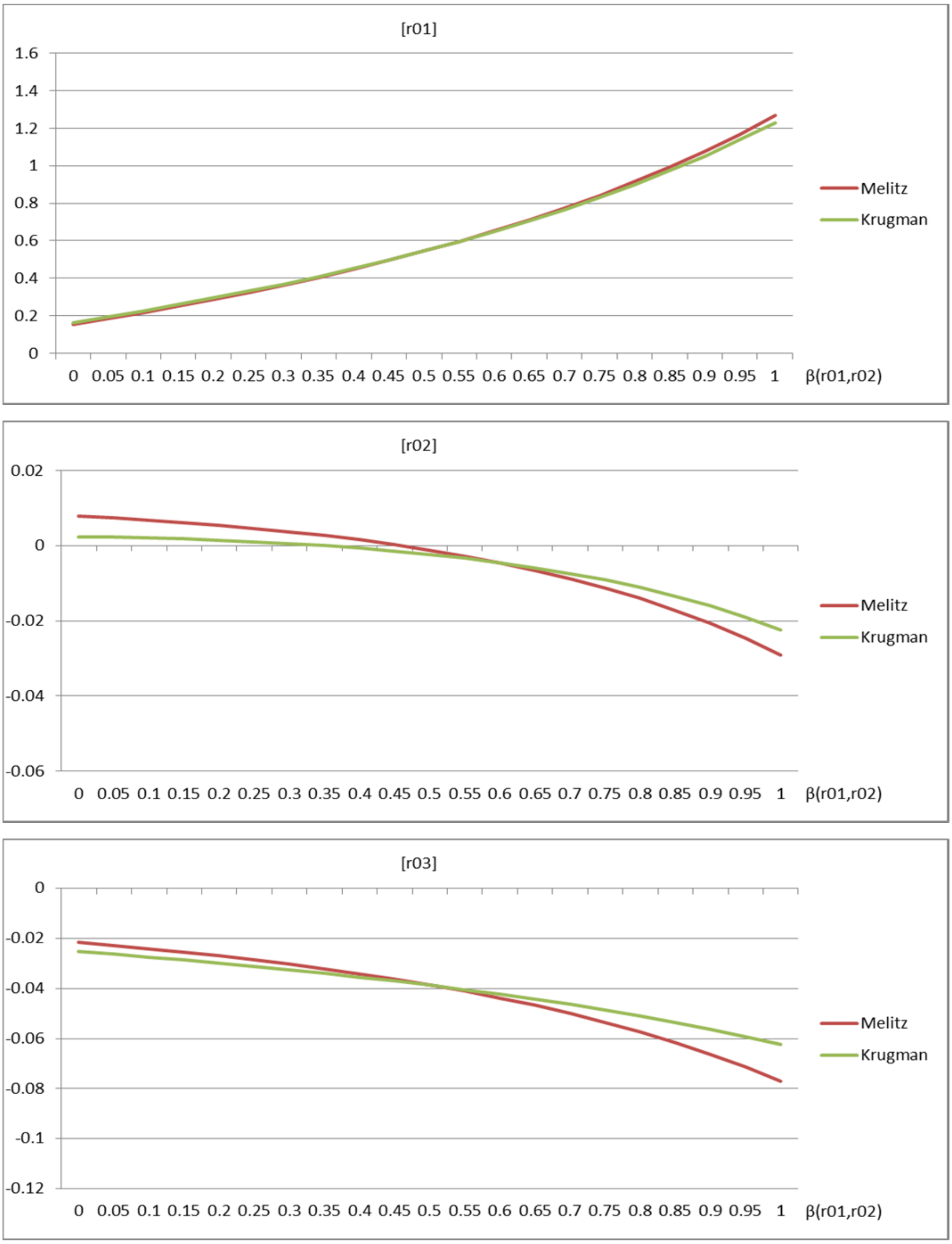


Figure 8. Change in Welfare (%) - Intra-regional FTA in r02 (All Intermediate)

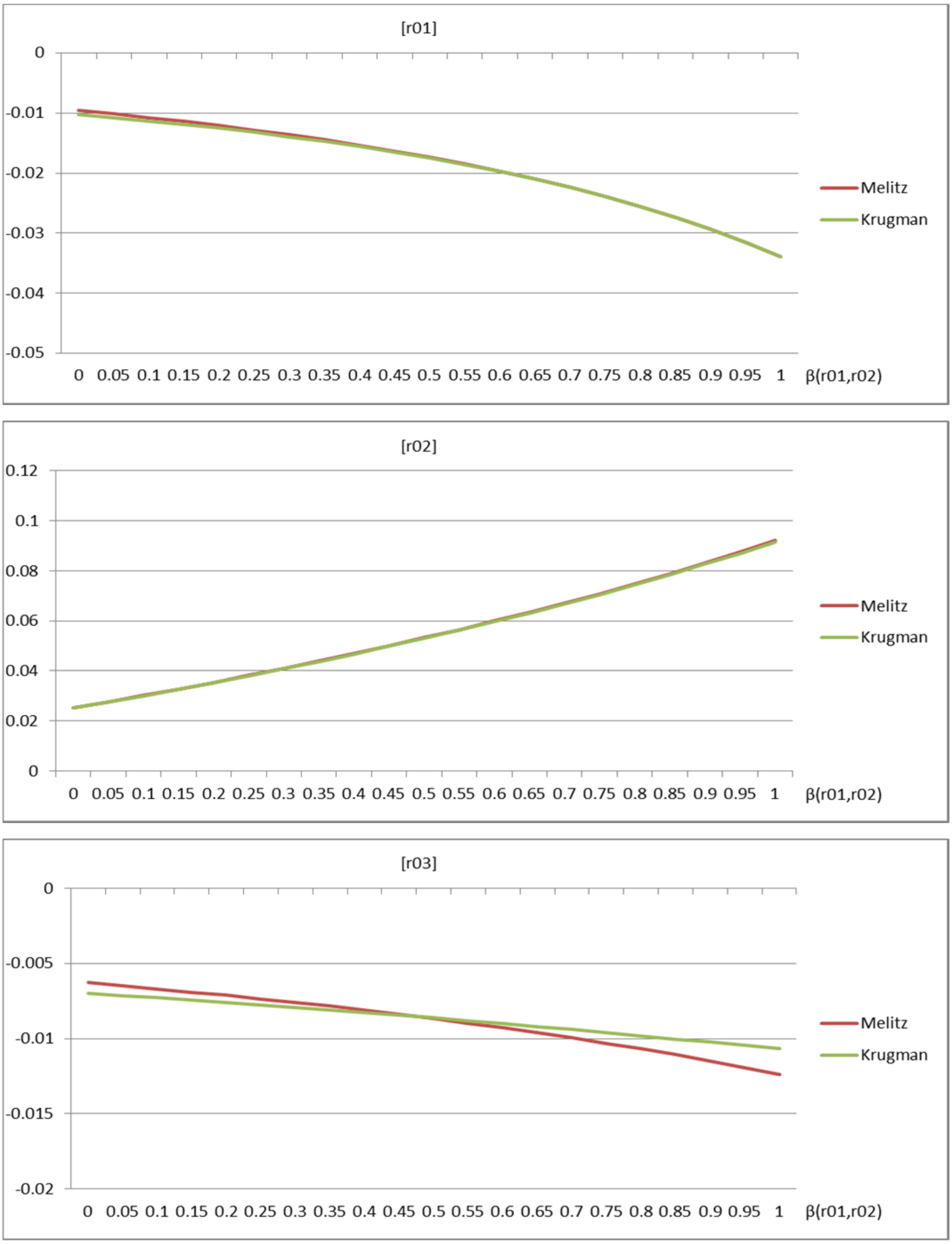


Figure 9. Change in Welfare (%) - Intra- and Inter-regional FTA among r01 and r02 (All Intermediate)

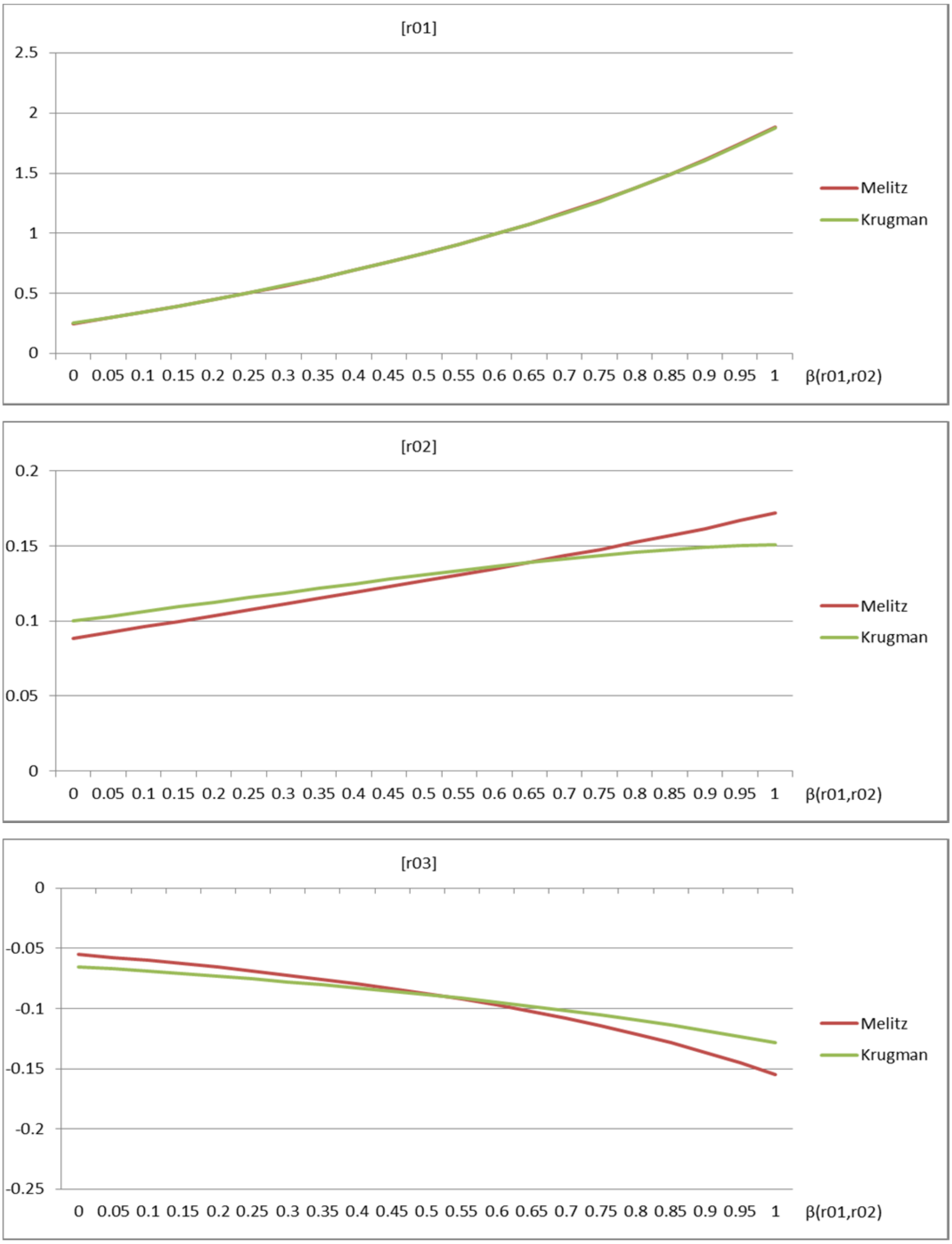


Figure 10. Change in Welfare (%) - Intra-regional FTA in r01 (Intermediate i01)

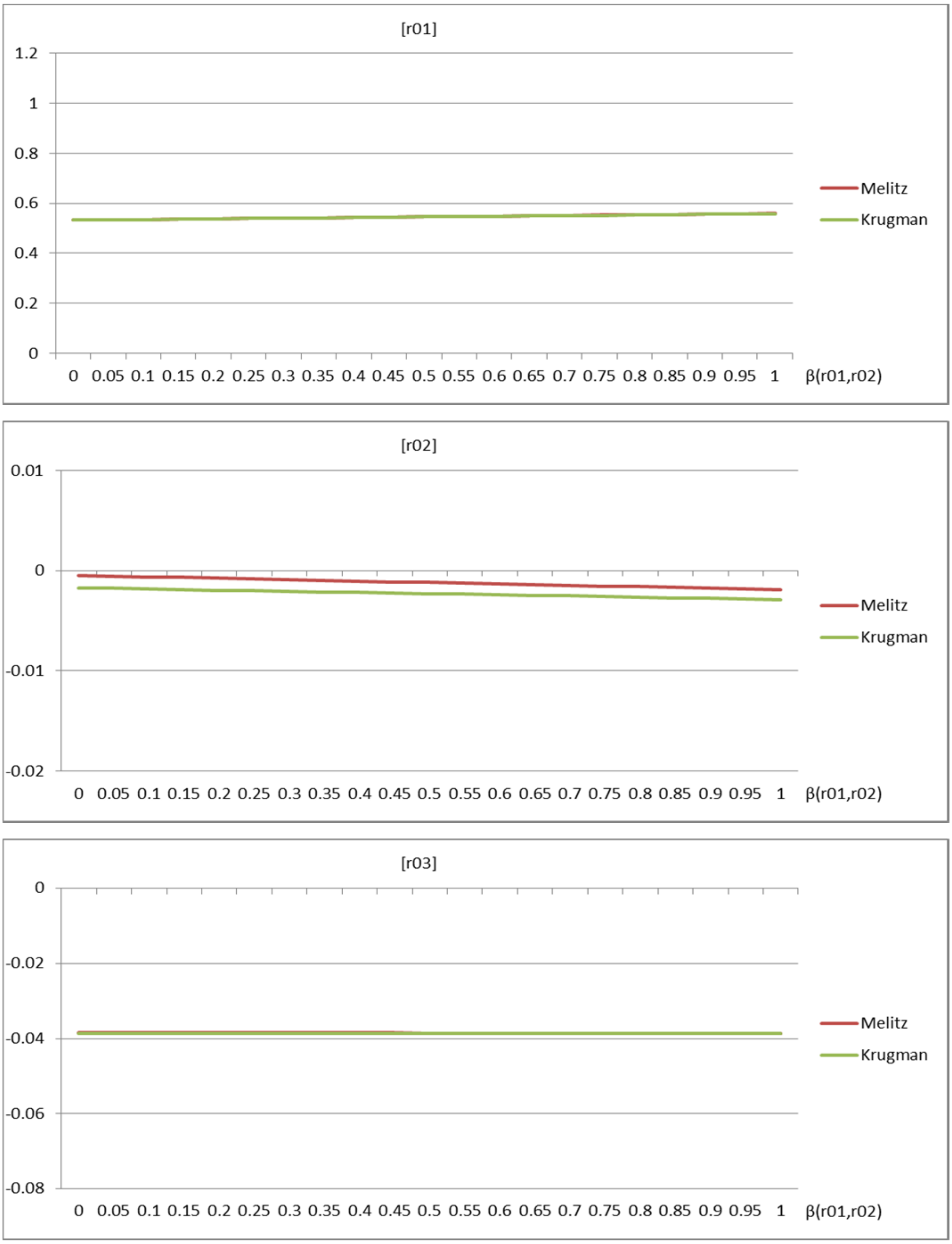


Figure 11. Change in Welfare (%) - Intra-regional FTA in r02 (Intermediate i01)

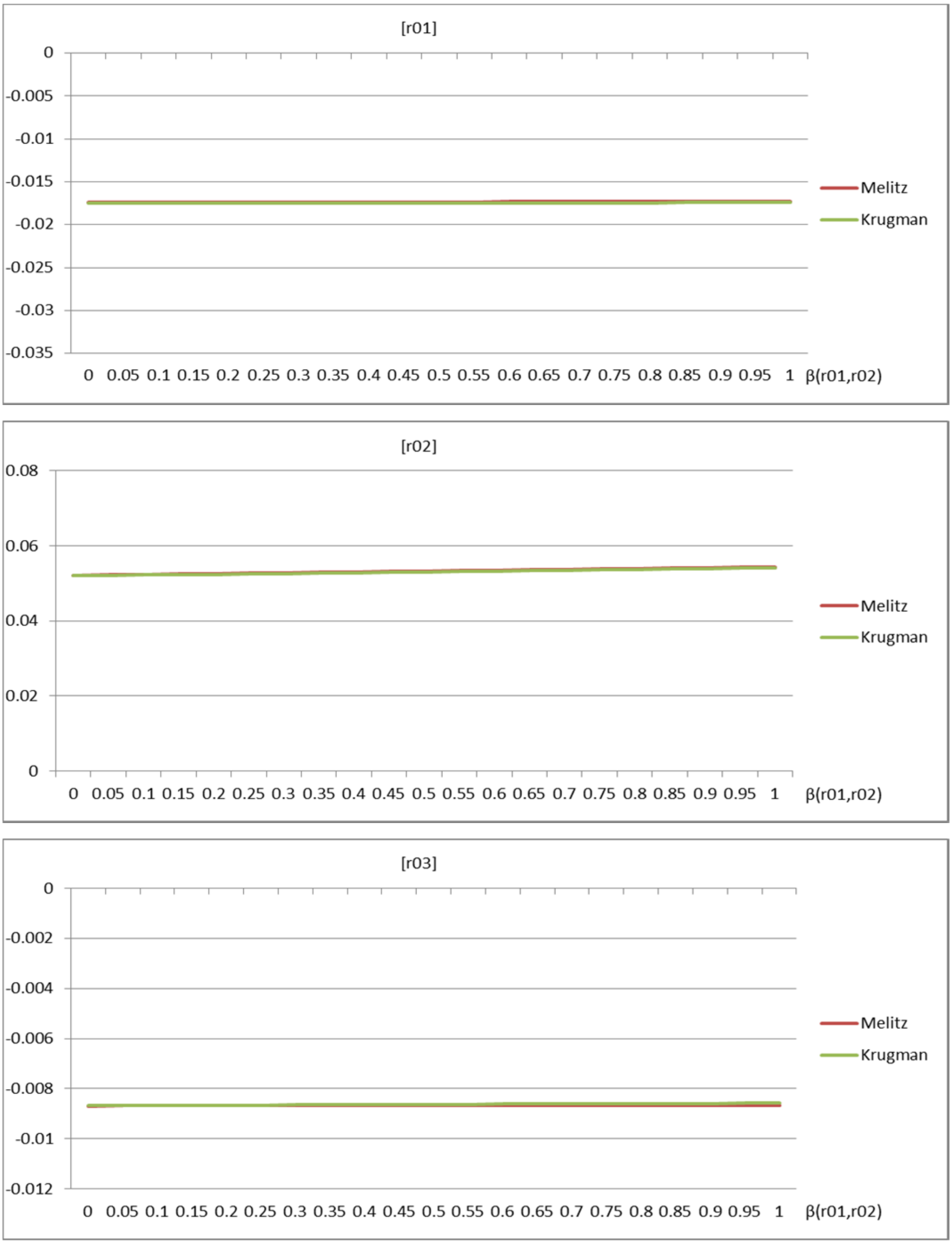


Figure 12. Change in Welfare (%) - Intra- and Inter-regional FTA among r01 and r02 (Intermediate i01)

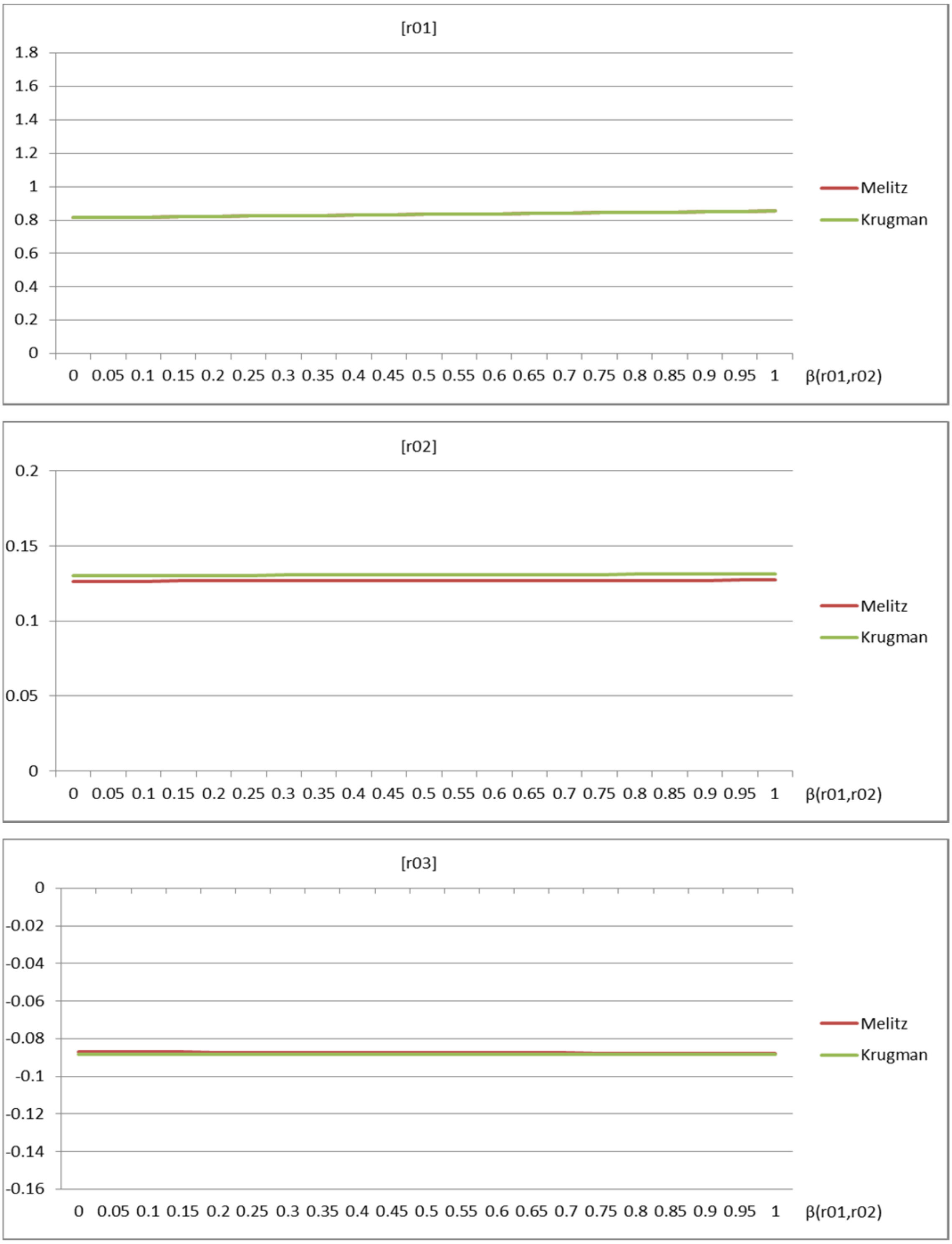


Figure 13. Change in Welfare (%) - Intra-regional FTA in r01 (Intermediate i02)

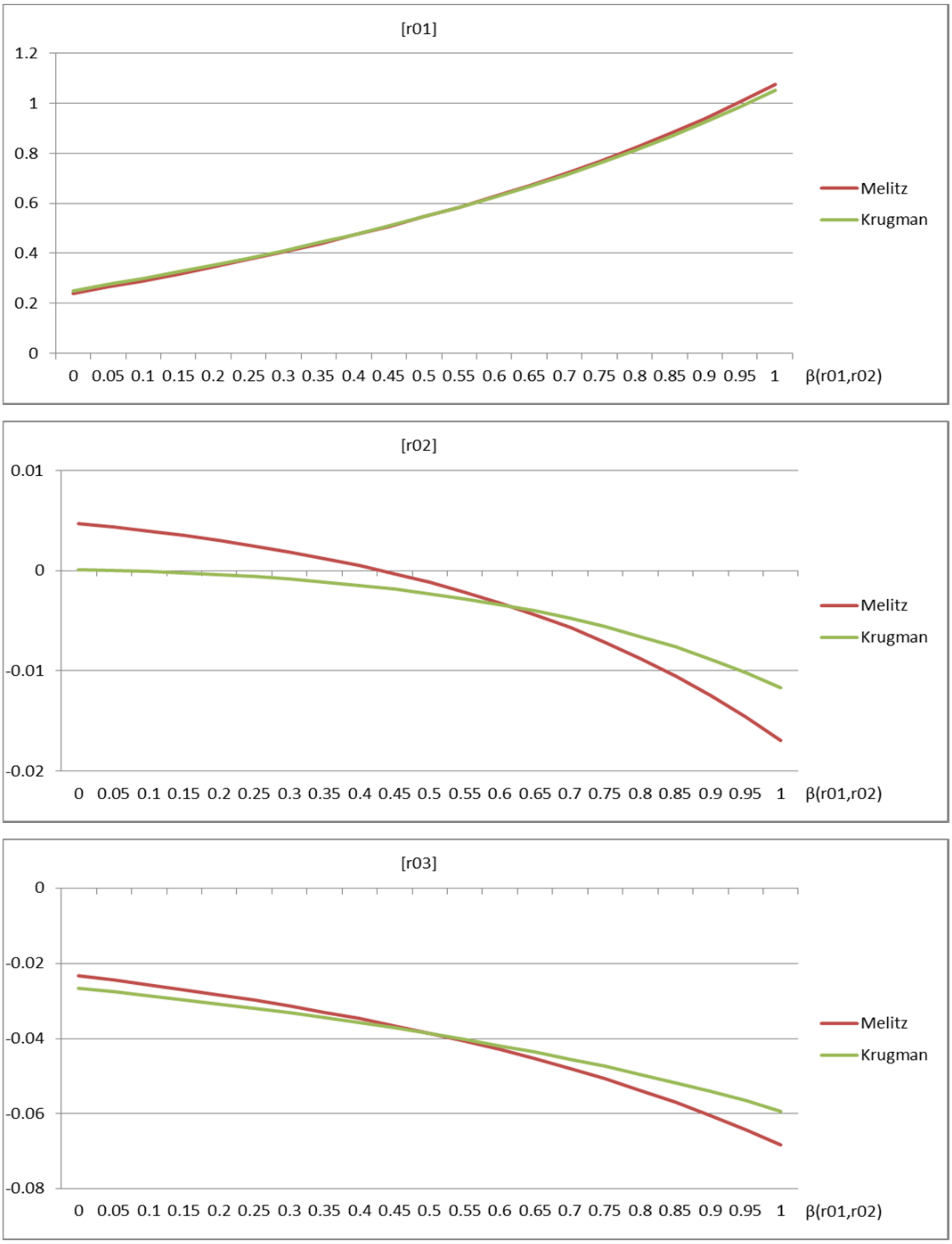


Figure 14. Change in Welfare (%) - Intra-regional FTA in r02 (Intermediate i02)

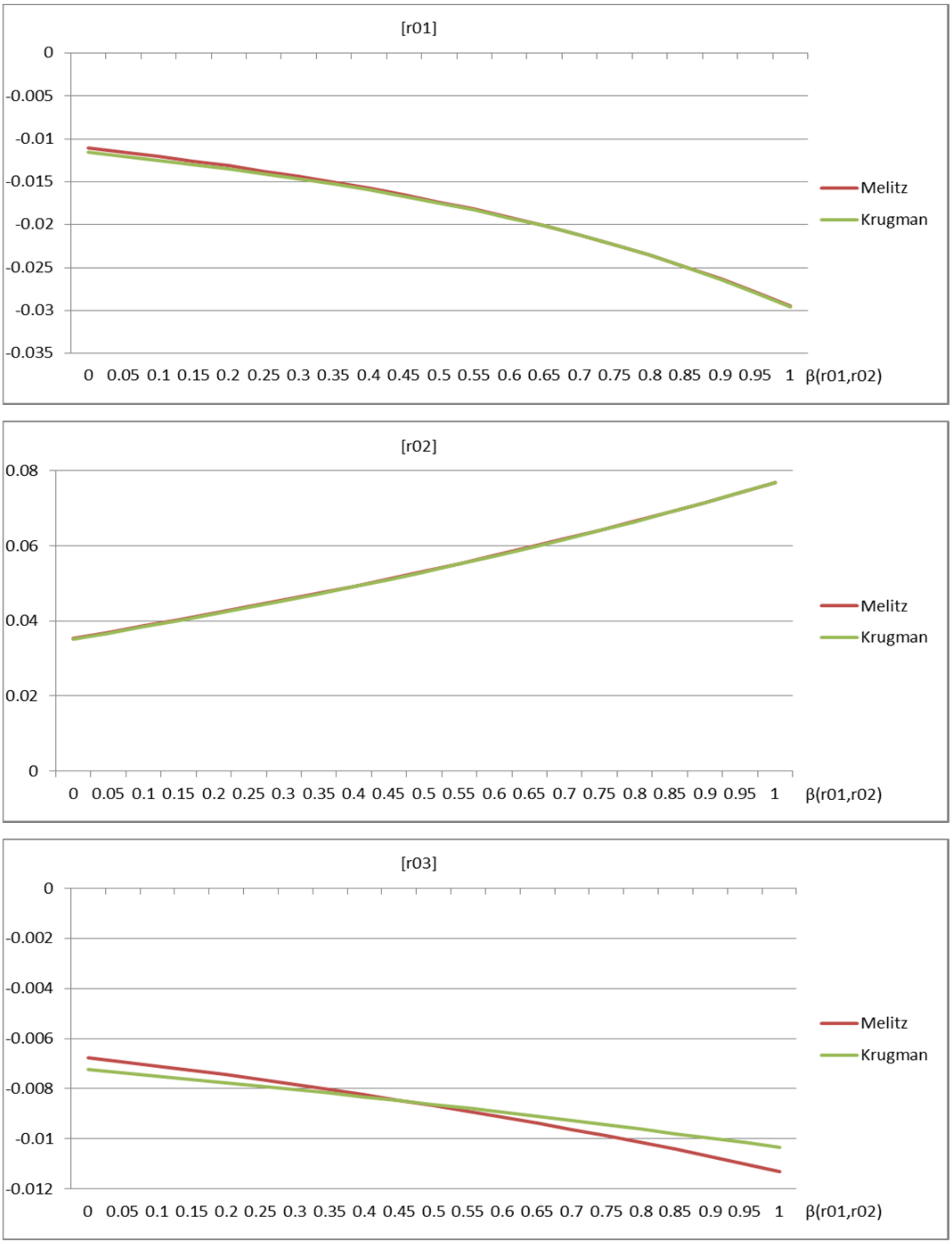


Figure 15. Change in Welfare (%) - Intra- and Inter-regional FTA among r01 and r02 (Intermediate i02)

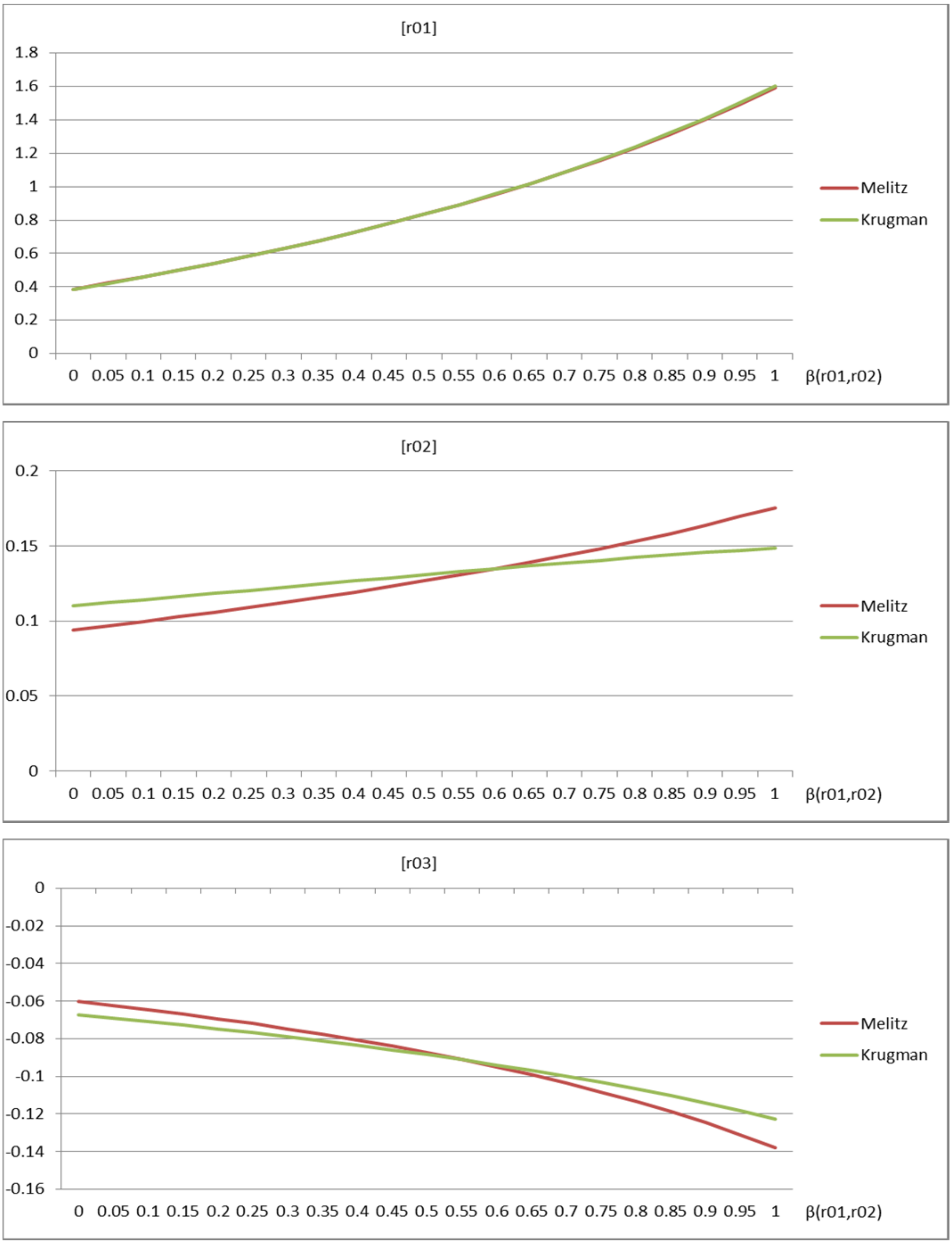


Figure 16. Change in Welfare (%) - Intra-regional FTA in r01 (Intermediate i03)

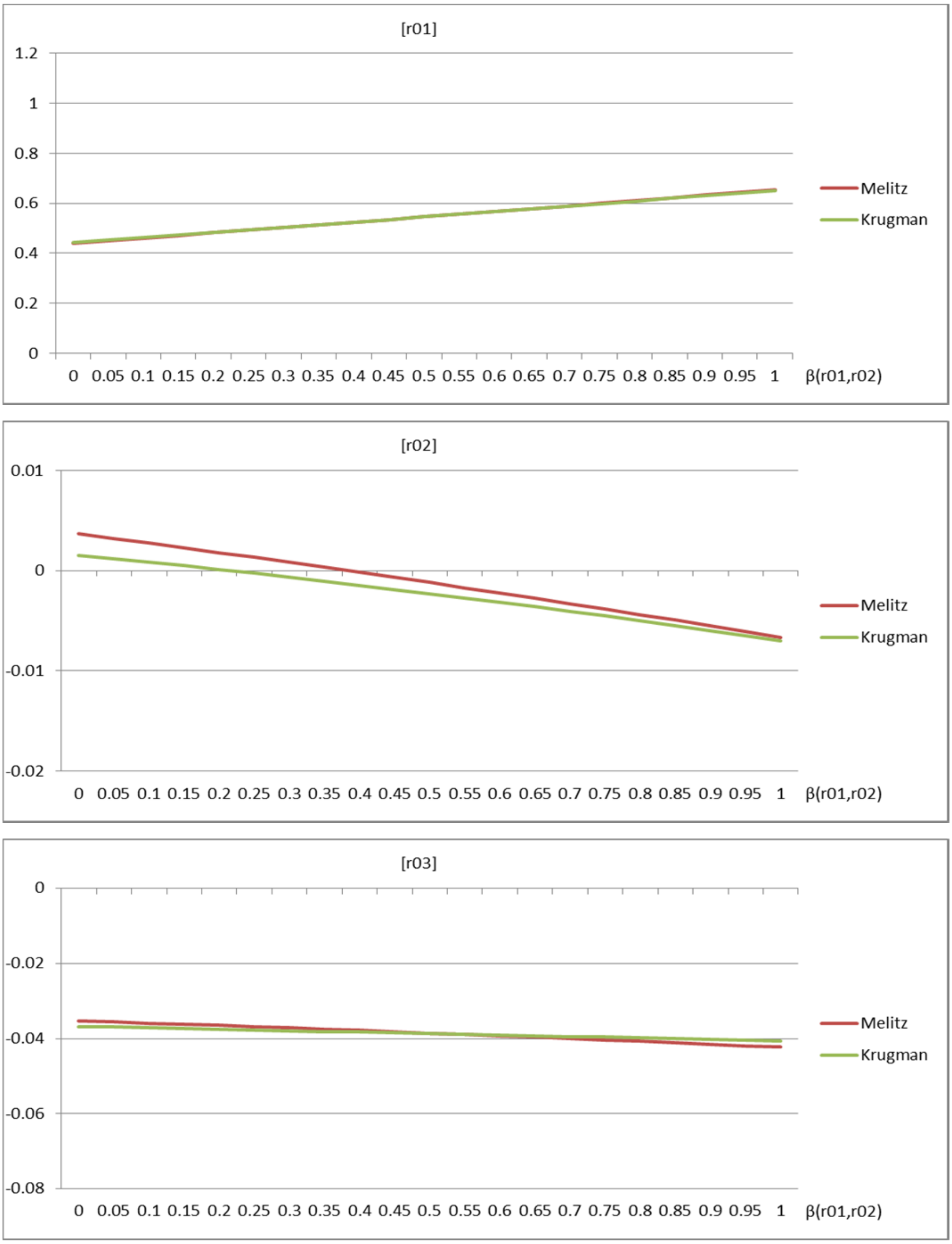


Figure 17. Change in Welfare (%) - Intra-regional FTA in r02 (Intermediate i03)

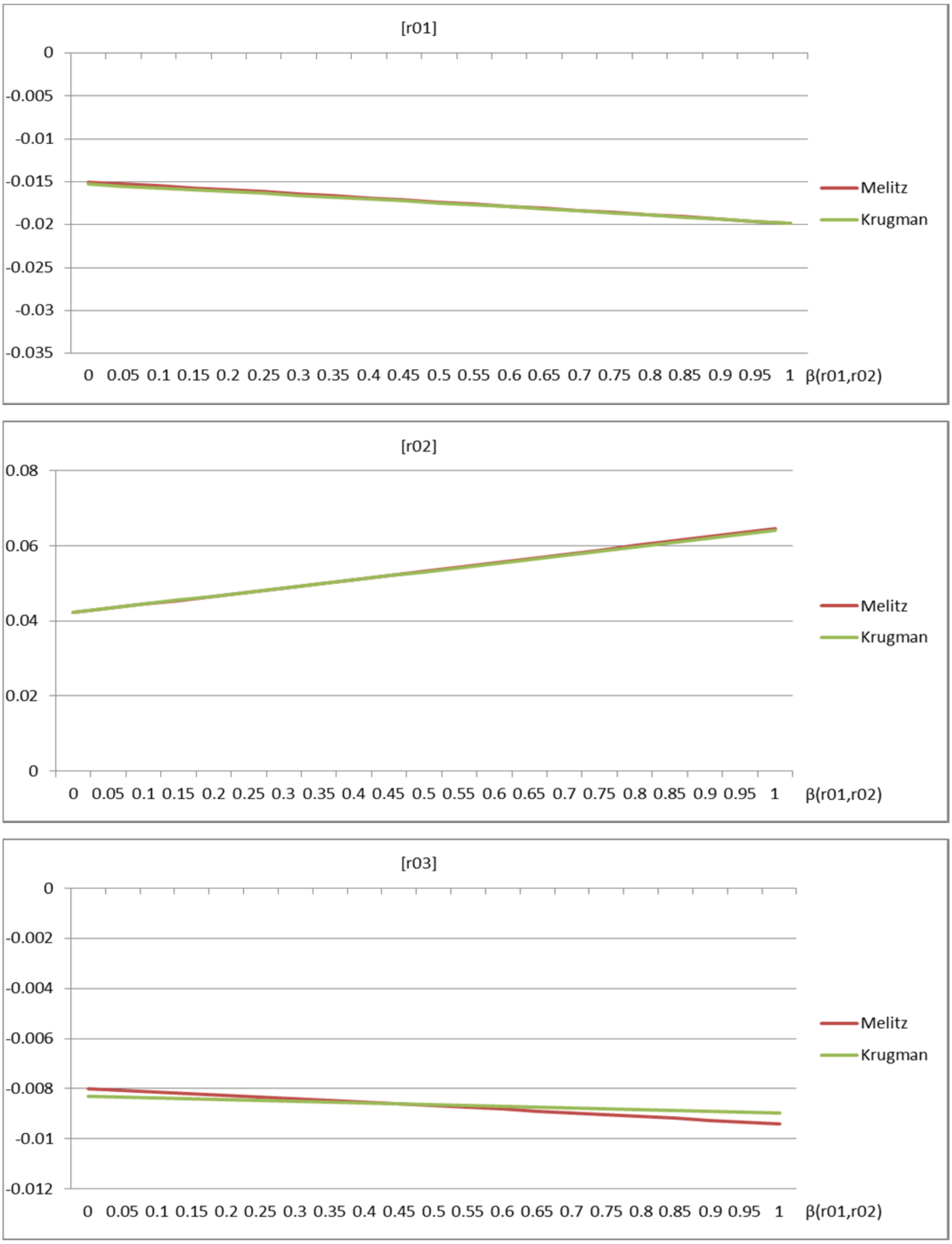
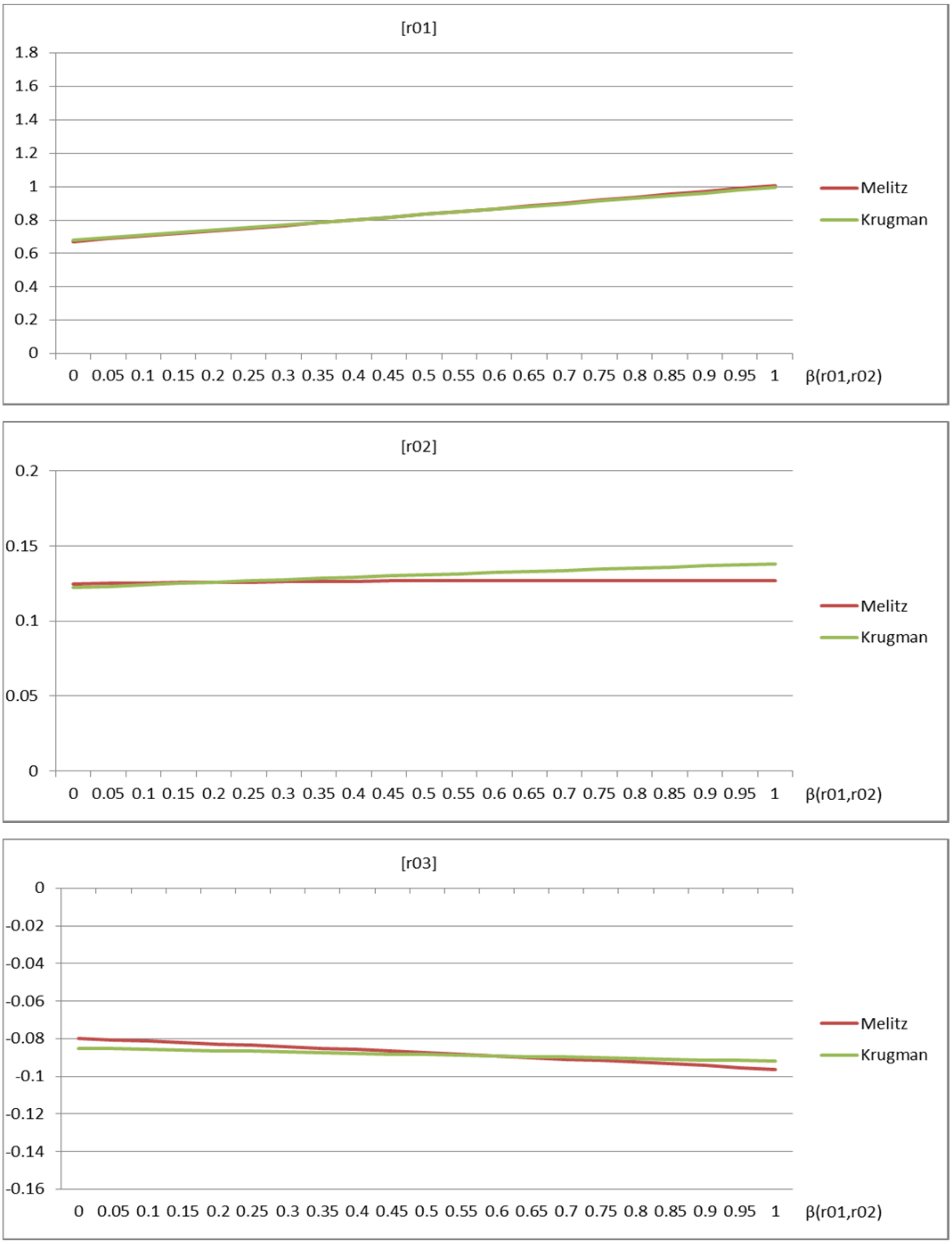


Figure 18. Change in Welfare (%) - Intra- and Inter-regional FTA among r01 and r02 (Intermediate i03)



Appendix. Benchmark Data for the Three-Region Three-Sector Model

The benchmark data set for the three-region, three-sector AGE model that includes the AKME module introduced and used in this study consists of I-O tables for three regions (Table A1), trade flow tables at four different price levels (Tables A2 through A5), which are used to derive τ_{irs}^{M}, τ_{irs}^{T}, and τ_{irs}^{E}, values of inter-regional shipping supply (Table A6), four types of substitution elasticities σ_j^Z, σ_j^Y, σ_j^X, and σ_i^T (Table A7), the proportion of inactive firms on the intra-regional link $G_{rs(r=s)}$ (Table A8), the shape parameter γ and the extensive margin ε (Table A9), and the importer's LoV β_s. Although there is essentially no positive meaning to derive $G_{rs(r\neq s)}$ using values for $G_{rs(r=s)}$ and ε, we demonstrate the practice for example based on the following equation:

$$\left\{\frac{(1+\tau_{rs(r\neq s)})TF_{rs(r\neq s)}}{(1+\tau_{rs(r=s)})TF_{rs(r=s)}}\right\}^{\varepsilon} = \frac{1-G_{rs(r\neq s)}}{1-G_{rs(r=s)}}.$$

The former three are obtained from the GTAP 8.1 database for 2007, and used to construct social accounting matrices (SAMs) for three regions (Table A10). As noted in Section 3, the original 129 countries/regions and 57 commodities/activities are respectively aggregated to three. The regions consist of the Asia-Pacific (r01), the North and South Americas (r02), and the European Union and the Rest of the World (r03), and the three sectors are the primary industries (i01), manufacturing (i02), and services (i03). The primary production factors also are aggregated into three: capital (a01); labor (a02); and land and natural resources (a03). Since the data aggregated by GTAPAgg contains minor rounding errors, which makes I-O tables imbalanced, the discrepancies caused by such errors are all absorbed by the final demand part.

The rest are just assumed by the author. Some of the substitution elasticities are determined based on the information provided by GTAP database. For the proportion of inactive firms on the intra-regional link $G_{rs(r=s)}$ and the extensive margin ε, we chose the same values as Zhai (2008) assumed. The shape parameter γ is determined based on the empirical studies such as done by Balistreli *et al*. (2011). The values of β_s are just selected from zero to unity.

In the tables, AT0x and CT0x also are production sectors. C, E, M, Z, TZ, VA0x, FM, HH, WT, and IS respectively denote final demand, exports, imports, gross output, indirect taxes on production, primary factors, producers, the representative consumer, exports/imports, and inter-regional shipping.

Table A1. Input-Output Tables for Each Region (US$ Billion)

r01	i01	i02	i03	C	E-M	Z
i01	202.512	1525.609	267.368	490.699	-556.963	1929.225
i02	311.001	6363.255	2506.497	3078.391	669.349	12928.492
i03	243.280	2001.736	4237.989	8687.287	204.420	15374.712
a01	344.683	1312.111	3664.479			
a02	562.766	1372.319	4035.730			
a03	450.048					
TZ	-185.066	353.461	662.650			
Z	1929.225	12928.492	15374.712			

r02	i01	i02	i03	C	E-M	Z
i01	103.680	1036.017	135.730	173.991	-66.698	1382.721
i02	212.534	3361.213	2374.859	4152.762	-814.439	9286.929
i03	266.893	1821.135	6353.325	15198.947	62.740	23703.039
a01	331.079	985.196	4337.191			
a02	192.618	1700.987	8423.217			
a03	212.366					
TZ	63.550	382.382	2078.717			
Z	1382.721	9286.929	23703.039			

r03	i01	i02	i03	C	E-M	Z
i01	179.535	1354.596	316.076	525.869	388.729	2764.805
i02	347.772	5399.876	3359.112	5726.046	-654.896	14177.910
i03	403.101	2639.516	8063.168	15277.397	274.797	26657.980
a01	808.035	1611.618	6401.402			
a02	457.152	1811.149	5893.926			
a03	506.249					
TZ	62.961	1361.155	2624.295			
Z	2764.805	14177.910	26657.980			

Table A2. Trade Flows at Producer Prices (US$ Billion)

		r01	r02	r03	E (Exports)
r01	i01	1896.718	9.266	23.241	1929.225
	i02	11155.367	832.722	940.402	12928.492
	i03	14794.680	119.303	265.180	15179.163
r02	i01	84.147	1228.837	69.737	1382.721
	i02	334.180	8509.764	442.986	9286.929
	i03	137.497	23259.293	260.129	23656.919
r03	i01	406.156	179.933	2178.717	2764.805
	i02	521.219	549.062	13107.629	14177.910
	i03	238.113	261.703	25857.829	26357.644
M (Imports)	i01	2387.021	1418.035	2271.694	
	i02	12010.766	9891.548	14491.016	
	i03	15170.290	23640.300	26383.137	

Table A3. Trade Flows at FOB Prices (US$ Billion)

		r01	r02	r03	E (Exports)
r01	i01	1898.548	9.348	23.359	1931.255
	i02	11172.883	858.921	966.300	12998.104
	i03	14794.680	119.303	265.180	15179.163
r02	i01	84.479	1228.897	69.896	1383.272
	i02	335.754	8513.442	445.493	9294.689
	i03	137.497	23259.293	260.129	23656.919
r03	i01	411.791	182.415	2226.328	2820.534
	i02	522.836	551.304	13119.400	14193.539
	i03	238.113	261.703	25857.829	26357.644
M (Imports)	i01	2394.818	1420.660	2319.583	
	i02	12031.473	9923.666	14531.193	
	i03	15170.290	23640.300	26383.137	

Table A4. Trade Flows at CIF Prices (US$ Billion)

		r01	r02	r03	E (Exports)
r01	i01	1922.097	10.254	26.918	1959.268
	i02	11242.964	897.872	1015.088	13155.924
	i03	14794.680	119.303	265.180	15179.163
r02	i01	111.657	1246.610	80.100	1438.367
	i02	348.959	8569.366	457.372	9375.697
	i03	137.497	23259.293	260.129	23656.919
r03	i01	431.406	190.235	2260.533	2882.174
	i02	544.514	572.019	13235.434	14351.967
	i03	238.113	261.703	25857.829	26357.644
M (Imports)	i01	2465.159	1447.099	2367.551	
	i02	12136.437	10039.257	14707.894	
	i03	15170.290	23640.300	26383.137	

Table A5. Trade Flows at Tariff Inclusive Market Prices (US$ Billion)

		r01	r02	r03	E (Exports)
r01	i01	1927.432	10.421	27.801	1965.654
	i02	11319.359	930.651	1070.935	13320.945
	i03	14794.682	119.303	265.180	15179.164
r02	i01	115.804	1248.148	82.329	1446.280
	i02	363.189	8583.972	475.129	9422.291
	i03	137.497	23259.293	260.129	23656.920
r03	i01	442.951	190.850	2265.947	2899.748
	i02	576.595	586.745	13286.741	14450.081
	i03	238.113	261.703	25857.874	26357.690
M (Imports)	i01	2486.188	1449.418	2376.076	
	i02	12259.143	10101.369	14832.805	
	i03	15170.292	23640.300	26383.183	

Table A6. Inter-regional Shipping Supply (US$ Billion)

r01	r02	r03
195.549	46.120	300.335

Table A7. Substitution Elasticities

	σ_j^Z	σ_j^Y	σ_j^X	σ_i^T
i01	0.85	0.70	0.75	5.00
i02	0.90	1.20	0.80	4.00
i03	0.90	1.50	0.80	2.00

Table A8. Proportion of Inactive Firms ($G_{rs(r=s)}$)

r01	r02	r03
0.40	0.40	0.40

Table A9. Other Data

γ	ε
5.00	0.60

Table A10. Social Accounting Matrices for Each Region

r01	Expenditures:	Activities			Commodities			Factors			Institutions		Trade		Total
Receipts:		AT01	AT02	AT03	CT01	CT02	CT03	VA01	VA02	VA03	FM	HH	WT	IS	TT
Activities	AT01				0							-2.031	1931.255		1929.255
	AT02					0						-69.612	12998.104		12928.492
	AT03						0					0	15179.163	195.549	15374.712
Commodities	CT01	202.512	1525.609	267.368								490.699			2486.188
	CT02	311.001	6363.255	2506.497								3078.391			12259.143
	CT03	243.280	2001.736	4237989								8687.287			15170.292
Factors	VA01	344.683	1312.111	3664.479											5321.273
	VA02	562.766	1372.319	4035.730											5970.815
	VA03	450.048													450.048
Institutions	FM							5321.273							5321.273
	HH	-185.066	353.461	662.650	21.028	122.706	0.002		5970.815	450.048	5321.273		-511.941	-20.244	12184.733
Trade	WT				2394.818	12031.473	15170.290								29596.581
	IS				70.341	104.964	0								175.305
Total	TT	1929.225	12928.492	15374.712	2486.188	12259.143	15170.292	5321.273	5970.815	450.048	532.273	12184.733	29596.581	175.305	

r02	Expenditures:	Activities			Commodities			Factors			Institutions		Trade		Total
Receipts:		AT01	AT02	AT03	CT01	CT02	CT03	VA01	VA02	VA03	FM	HH	WT	IS	TT
Activities	AT01				0							-0.551	1383.272		1382.721
	AT02					0						-7.760	9294.689		9286.929
	AT03						0					0	23656.919	46.120	23703.039
Commodities	CT01	103.680	1036.017	135.730								173.991			1449.418
	CT02	212.534	3361.213	2374.859								4152.762			10101.369
	CT03	266.893	1821.135	6353.325								15198.947			23640.300
Factors	VA01	331.079	985.196	4337.191											5653.465
	VA02	192.618	1700.987	8423.217											10316.822
	VA03	212.366													212.366
Institutions	FM							5653.465							5653.465
	HH	63.550	382.382	2078.717	2.319	62.112	0		10316.822	212.366	5653.465		649.746	95.909	19517.389
Trade	WT				1420.660	9923.666	23640.300								34984.626
	IS				26.439	115.590	0								142.029
Total	TT	1382.721	9286.929	23703.039	1449.418	10101.369	23640.300	5653.465	10316.822	212.366	5653.465	19517.389	34984.626	142.029	

r03	Expenditures:	Activities			Commodities			Factors			Institutions		Trade		Total
Receipts:		AT01	AT02	AT03	CT01	CT02	CT03	VA01	VA02	VA03	FM	HH	WT	IS	TT
Activities	AT01				0							-55.729	2820.534		2764.805
	AT02					0						-15.630	14193.539		14177.910
	AT03						0					0	26357.644	300.335	26657.980
Commodities	CT01	179.535	1354.596	316.076								525.869			2376.076
	CT02	347.772	5399.876	3359.112								5726.046			14832.805
	CT03	403.101	2639.516	8063.168								15277.397			26383.183
Factors	VA01	808.035	1611.618	6401.402											8821.055
	VA02	457.152	1811.149	5893.926											8162.227
	VA03	506.249													506.249
Institutions	FM							8821.055							8821.055
	HH	62.961	1361.155	2624.295	8.526	124.911	0.046		8162.227	506.249	8821.055		-137.805	-75.666	21457.954
Trade	WT				2319.583	14531.193	26383.137								43233.913
	IS				47.968	176.702	0								224.670
Total	TT	2764.805	14177.910	36657.980	2376.076	14832.805	26383.183	8821.055	8162.227	506.249	8821.055	21457.954	43233.913	224.670	

Table A11. Global Input-Output Table (US$ Billion)

Commodity	Activity	r01			r02			r03			C			ISS	Trade Cost	Z
		i01	i02	i03	i01	i02	i03	i01	i02	i03	r01	r02	r03		(-)	TT
r01	i01	191.619	1058.130	204.212	0.200	9.107	0.524	1.074	18.855	4.310	473.471	0.589	3.561		-36.429	1929.225
	i02	293.012	5858.648	2351.912	16.589	315.806	168.980	29.615	402.572	217.052	2815.787	429.276	421.696		-392.453	12928.492
	i03	236.890	1948.167	4058.886	2.237	10.465	79.404	6.079	31.340	121.283	8550.739	27.197	106.477	195.549	-0.002	15374.712
r02	i01	2.258	96.886	13.089	99.813	860.126	125.601	3.181	55.838	12.763	3.570	162.608	10.547		-63.560	1382.721
	i02	6.952	195.010	59.741	185.486	2846.301	2099.343	13.139	178.604	96.297	101.486	3452.842	187.089		-135.361	9286.929
	i03	2.339	19.609	65.563	259.748	1787.714	6099.741	5.963	30.743	118.973	49.985	15112.091	104.449	46.120	-0.000	23703.039
r03	i01	8.636	370.593	50.066	3.667	166.785	9.605	175.280	1279.903	299.003	13.657	10.793	511.761		-134.943	2764.805
	i02	11.037	309.596	94.844	10.459	199.105	106.536	305.017	4818.700	3045.763	161.118	270.645	5117.260		-272.172	14177.910
	i03	4.051	33.959	113.540	4.908	22.956	174.180	391.059	2577.432	7822.912	86.563	59.659	15066.471	300.335	-0.046	26657.980
V	a01	344.683	1312.111	3664.479	331.079	985.196	4337.191	808.035	1611.618	6401.402						
	a02	562.766	1372.319	4035.730	192.618	1700.987	8423.217	457.152	1822.149	5893.926						
	a03	450.048			212.366			506.249								
TZ		-185.066	353.461	662.650	63.550	382.382	2078.717	62.961	1361.155	2624.295						
Z		1929.225	12928.492	15374.712	1382.721	9286.929	23703.039	2764.805	14177.910	26657.980						