A CGE analysis of the welfare effects of Trade Liberalization under Different Market Structures

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ABSTRACT

Using a static world computational general equilibrium model with 16 sectors and 14 regions, this paper compares welfare effects of trade liberalization of the perfectly competitive model and eight imperfectly competitive models. Our main findings are as follows. First, the size of the welfare impact systematically depends on the type of model. Second, the welfare impact of the perfectly competitive model is not necessarily smaller than those of imperfectly competitive models. Third, the integrated market model tends to have a larger welfare impact than the segmented market model. Fourth, the model with the fixed number of firms tends to have a small welfare impact. Finally, the variety effect tends to have a stronger influence on the welfare effects of liberalization than do scale and markup effects. Differences in the models can be viewed as differences in the economic structures of the regions being analyzed, and therefore the analysis in this paper makes it possible to derive policy implications with regard to the relationship between economic structure and trade liberalization.

KEY WORDS: Trade liberalization; Imperfectly competitive models; Computable general equilibrium analysis;

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Introduction

Computable general equilibrium (CGE) analysis of trade policy was initially based on perfect competition with constant returns to scale technology (CRTS). However, with the development of the new trade theory, CGE analysis has adopted imperfectly competitive models with increasing returns to scale technology (IRTS).[1] Taking into account the various types of imperfect competition and economies of scale, such studies examine the effects of trade liberalization initiated by GATT/WTO and FTAs, and provide useful information about policy making. However, they have one significant shortcoming: the model choice is rather arbitrary.

When the perfectly competitive model is used for CGE analysis, the structure of the model is fairly standardized. However, if we attempt to incorporate imperfect competition and economies of scale into CGE models, a number of alternative models arise and, as a result, a wide variety of models is used in research. These models differ in aspects such as, for example, the type of economies of scale, form of competition, market structure, and the assumptions on entry and exit. As results of the studies can be altered according to assumptions about the model structure, it is desirable to use the most realistic model. However, there is no consensus on the existence of a realistic model. The second best solution is to show how results are altered according to the model structure. To do this, CGE studies usually incorporate sensitivity analysis of the model structure in order to test the validity of the results. In addition, some survey articles (e.g. Baldwin & Venables 1995, Piermartini & Teh 2005) try to show how results are altered according to the model structure by comparing results from different CGE studies. However, sensitivity analysis can only examine very limited sensitivity and does not compare models used in a comprehensive framework. On the other hand, survey articles compare a wide variety of studies that use different models, but comparison of results from different studies does not mean comparison of different models because different studies use not only different models but also different data and scenarios.

To address this problem, some studies endeavored to use a unified framework to examine how results from trade liberalization are altered by the assumptions about the model structure, in particular, the market structure. For example, Francois & Roland-Holst (1997) (hereafter, F&R) and Willenbockel (2004) are studies along this line. Taking into account the wide variety of models, these studies attempted to demonstrate how the results from the simulations are influenced by model structure and provide useful information for model selection.

However, these studies have various shortcomings in their models, data, and scenarios. First, types of models taken up in F&R are biased: large group monopolistic competition model (LGMC model hereafter) and conjectural variation model. The simulation of F&R also has some shortcomings. First, the authors assume a very small model with only six regions and 12 sectors. The dimension of the model is smaller than that of recent trade CGE analysis, which usually considers more than 10 regions and sectors.[2] Second, they consider only one liberalization scenario. This also inhibits the application of their results to other CGE analysis because their results are likely to depend on the specific scenario.

Willenbockel (2004) is valuable work in that the author analyzes a large variety of imperfectly competitive models. However, the model used in his paper is extremely simplified. Compared to CGE models actually used for trade policy analysis, the structure of his model is very rudimentary. In addition, the data used for his simulation is not only simplified but also imaginary. With respect to scenario, Willenbockel (2004) considers only one scenario, which is that the tariff rate on one good in a region is changed. These features mean that his analysis provides only a numerical example and inhibits the direct application of the results to actual trade liberalization.

To sum up, although the two studies discussed above take into account various models, their analyses are rudimentary in both model and data construction, and they analyze only a single policy scenario. Because of these shortcomings, it is difficult not only to derive general insights from their analyses but also to apply their results to a large scale CGE analysis actually used to evaluate trade policy.

The purpose of this paper is to overcome the shortcomings of the previous studies and to provide a comprehensive comparison of different imperfectly competitive models in a more realistic setting. The characteristics of our analysis are as follows. First, we use a more elaborate model. Our model is a world trade model with 16 sectors and 14 regions and incorporates not only final demand but also intermediate inputs. Second, we consider four scenarios of trade liberalization, that is, world trade liberalization and three FTAs. This enables us to investigate how different scenarios alter the results of trade liberalization. In addition, we consider a wide variety of models. Models examined in this paper are the perfectly competitive model and the following eight imperfectly competitive models: (1) Cournot model, (2) large group monopolistic competition model, (3) Cournot model with homogeneous goods, (4) Cournot model with a fixed number of firms, (5) quantity competition model with non-Cournot conjectural variation, (6) Bertrand model, (7) integrated market Cournot model, and (8) integrated market Bertrand model. Using these models, we can evaluate the implications of different assumptions of strategic variables, entry-exit, market segmentation/integration, conjectural variation, and love of variety. In brief, we compare various types of imperfectly competitive models under various liberalization scenarios, using a more elaborate model and data.

Our main findings are summarized as follows. First, in many liberalization scenarios, the integrated market models and the large group monopolistic competition model (model 6, 7, and 2) tend to produce large welfare gains, while the model with a fixed number of firms, the model with homogeneous goods, and the Cournot model (model 4, 3, 1) tend to produce small welfare gains. It is also shown that this rank order of models by welfare change is not greatly affected by the liberalization scenario although there are a few exceptions. This result indicates that the size of the welfare impact systematically depends on the type of the model used for the simulation. This can be useful information for interpreting results from different imperfectly competitive models. However, our analysis shows at the same time that this tendency is not necessarily relevant to all participants of liberalization. It implies that differences in results by model depend strongly on which region is analyzed.

The second finding is that the welfare impacts of the perfectly competitive model are not necessarily smaller than those of imperfectly competitive models. As imperfectly competitive models include factors that do not exist in the perfectly competitive model, it is often recognized that imperfectly competitive models will generate a larger welfare impact than the perfectly competitive model (for example, see the following survey articles: Baldwin & Venables 1995 and Piermartini & Teh 2005). However, our simulation, which takes into account various imperfectly competitive models, liberalization scenarios, and participating regions in a unified framework, demonstrates that the welfare impact of the perfectly competitive model is not so small. Rather, the perfectly competitive model generates the largest welfare increase in some participants. This result indicates that the common recognition above is not supported. The third finding is that the integrated market model tends to have a larger welfare impact than the segmented market model. Fourth, the model with the fixed number of firms tends to have a small welfare impact. Finally, we found that, in determining welfare effects of liberalization, the variety effect tends to play a dominant role and, conversely, scale and markup effects tend to play a lesser role. This result is also noteworthy because the scale effect is usually recognized as one of the most important factors in imperfectly competitive models.

Finally, we would like to mention the policy implications of our analysis. We showed that differences in the models lead to differences in effects of liberalization. Differences in the models can be viewed as differences in the economic structures of the regions being analyzed, and therefore the analysis in this paper makes it possible to derive policy implications with regard to the relationship between the economic structure and trade liberalization. For example, we showed that the integrated market model tends to have a larger welfare impact than the segmented market model. This indicates that trade liberalization yields only a small welfare impact under the situation where markets in different regions are segmented by physical and institutional barriers. From this, we can derive the policy implication that the effects of liberalization will be magnified by promoting market integration, for example, removing physical and institutional barriers between markets in different regions. Similarly, the result that the model without entry and exit tends to have a small welfare impact indicates that welfare impact of liberalization will be small under the situation where there are strong barriers to entry and exit. This leads to the policy implication that the effects of liberalization will be enlarged by policies for promoting competition, namely, removing barriers to entry and exit. As these arguments show, our analysis suggests what policies the governments should implement to derive the larger gain from trade liberalization.

This paper is organized as follows. In the next section, we present the models used for simulation. Section 3 explains the benchmark data. Section 4 explains the determination of parameters and Section 5 explains the policy scenarios. Section 6 presents the results of the computations. Finally, concluding remarks are provided in Section 7.

Model

In this section, we describe the structure of the model used in the simulations. The model is a multisector multiregion static general equilibrium model. The model includes 16 sectors and 14 regions presented in Table 1.[3] We consider not only a model with CRTS technology and perfect competition (the perfectly competitive model) but also models with IRTS technology and imperfect competition (the imperfectly competitive models). In the following, we first explain the structure of the perfectly competitive model. We only present a brief explanation of the model components. A detailed description of the model is provided in a supplementary paper (Takeda, 2008) available from the author.

<Table 1 here>

Perfectly Competitive Model

As the perfectly competitive model, we use the simplified version of the GTAP standard model (Hertel, 1997).[4] Using intermediate inputs and four primary factors (capital, skilled labor, unskilled labor, and land), firms produce goods under CRTS technology to maximize profits. All markets of goods and factors are assumed to be perfectly competitive and thus all producers are price takers.

The production function is a two-stage CES function. The input structure is as follows. First, primary factors are aggregated into a primary factor composite through a CES function with elasticity of σ^{PF}_i, and then primary factor composite and intermediate inputs are used to produce goods using a Leontief technology.

To represent the demand side, we assume a representative household for each region. As we do not consider government explicitly, final demand is the sum of private demand and government expenditure. Final demand is derived from the optimizing behavior of this representative household. The utility function for the household is a Cobb-Douglas function of consumption goods. The household income consists of factor income and tax revenues. Endowment of primary factors is assumed to be constant.

As with other CGE analysis, we use the Armington assumption to explain cross-hauling in trade (Armington, 1969). The Armington assumption implies that domestically produced goods and imported goods are imperfect substitutes. In addition, we assume that imports from different regions are imperfect substitutes as in the GTAP model. The aggregation of domestic and imported goods and the aggregation of imports from different regions are achieved through the CES functions displayed in Figure 1. σ^A_i in the figure represents the elasticity of substitution between domestic and imported goods (Armington elasticity) for goods i, and σ^M_i is the elasticity of substitution between imports from different regions.

<Figure 1 here>

<Table 2 here>

Imperfectly Competitive Models

Next, we explain the imperfectly competitive models. In imperfectly competitive models, there are economies of scale and thus firms behave as price makers. However, even in the imperfectly competitive models, sectors AFF and MIN are assumed to be perfectly competitive sectors with CRTS technology. The assumption that AFF is a perfectly competitive sector is common in many CGE studies. The assumption that MIN is perfectly competitive is for a computational reason.[5]

Type of Models

Table 2 lists the models examined in the simulation. Model PC is a perfectly competitive model explained in the previous section. Model CD is a benchmark model of all imperfectly competitive models. Alternative imperfectly competitive models are derived from model CD by changing the assumptions. Thus we first explain the structure of model CD. In model CD, we make the following assumptions.

A1: Economies of scale arise from the existence of fixed costs.

A2: Varieties of different firms in a sector are assumed to be differentiated and aggregated using a CES function.

A3: Each firm behaves in a Cournot fashion, that is, each firm determines its output, taking the output of all other firms as fixed.

A4: Markets in different regions are segmented.[6] Thus, firms can independently control output and prices in different regions.

A5: Free entry and exit are possible. This implies that the number of firms is endogenously determined so that the zero profit conditions are satisfied.

A1 is applied to all imperfectly competitive models, while A2-A5 are modified according to the different models. With respect to A2, we add variety aggregation, keeping the Armington assumption (see Figure 1). Although some imperfectly competitive CGE models abandon the Armington aggregation and only consider the variety aggregation[7], we adopt the Armington variety aggregation because the absence of the Armington aggregation can significantly alter the structure of the model and thus makes difficult the comparisons between perfectly competitive and imperfectly competitive models. Since our aim is to compare different assumptions on market structure, we want to keep the same structure in other aspects and thus we decide to keep the Armington aggregation also in imperfectly competitive models.

Model LGMC is the large group monopolistic competition model frequently used in theoretical analysis (e.g. Krugman, 1980). In this model, it is assumed that each firm recognizes the number of firms as sufficiently large. As a result, model LGMC has the following two features: (1) markup rate is kept constant (equal to the inverse of the elasticity of substitution),[8] and (2) scale of each firm (total output of each firm) is kept constant. As these features seem to be somewhat unrealistic, the validity of this model may be questionable. However, this model is frequently used not only in theoretical analysis but also in CGE studies, and thus we decided to consider also this model.[9] Model CH changes the assumption of product variety. It assumes that products of different firms are perfect substitutes (homogeneous goods).[10] By comparing model CH with model CD, we can examine the role of the love of variety. In model CF, the assumption on entry is modified. It assumes that the number of firms is fixed at the benchmark level. This assumption indicates (1) a situation where there are strong entry barriers to markets, or (2) a situation in the short run. The former situation is of importance because entry barriers are often observed in actual economies; the latter situation is also worth analyzing because it often takes some time for economies to adjust to external shocks. In addition, theoretical analysis such as that in Horstmann & Markusen (1986) and Markusen & Venables (1988) shows that the effects of trade policy can vary drastically, depending on whether free entry and exit are possible or not. Thus, we consider the model of a fixed number of firms as well. Note that in our model, each firm produces one variety and thus the assumption of a fixed number of firms implies the fixed number of varieties.

Model QCV changes the assumption on conjectural variation. Model CD assumes Cournot conjecture, that is, each firm determines its output, taking the output of all other firms as fixed. On the other hand, in model QCV, each firm determines its output, taking the output of all other firms as variable. Although this non-Cournot conjecture model may rarely be used in theoretical analysis due to its complexity, it is often used in CGE analysis.[11] The Cournot competition model is the representative model in the imperfect competition models and is used in both theoretical and empirical analysis. However, this does not necessarily guarantee the actual validity of the Cournot competition model. Moreover, Eaton & Grossman (1986) demonstrate that the welfare effects of trade policy can be strongly influenced by the assumptions on conjectural variation. Thus, it is of great importance to show how the assumptions on conjectural variation affect results.

Model BD is a Bertrand competition version of model CD, that is, it assumes that a firm's strategic variable is price and that each firm determines its prices, taking the prices of all other firms as fixed. As with the Cournot model, the Bertrand model is one of the most popular imperfectly competitive models and is used frequently in both theoretical and empirical works. However, because it is difficult to evaluate which model is the more realistic, we decided to consider the Bertrand model as well as the Cournot model.

Although all models listed so far assume segmented markets, there is another frequently used model: the integrated market model. In the integrated market model, where arbitrage trade across different regions is possible, firms cannot independently set output for markets in different regions and only control total output. Moreover, they cannot set different prices for different regions. Studies such as Markusen & Venables (1988) show that the effects on trade policy can vary significantly, depending on whether the market is segmented or integrated. Thus, we attempt to consider integrated market models. Model IC is the integrated market version of model CD and model IB is the integrated market version of model BD.

Characteristics of the Models

In the previous section, we explained how the assumptions change in different models. In this section, we examine how the effects of trade liberalization are influenced by different assumptions. The effects of trade liberalization include efficiency gains, terms of trade effect, and in the case of FTAs, trade creation and diversion effects. However, these effects are present in both the perfectly competitive and the imperfectly competitive models. Because we want to focus on differences among imperfectly competitive models, we consider the effects that are present only in the imperfectly competitive models. These effects include (1) the scale effect, (2) the variety effect, and (3) the markup effect.

The scale effect indicates the effect caused by a change in a firm's output. As there is a fixed cost, an increase in the output of each firm lowers the average cost. Thus, the expansion of the scale of each firm raises welfare. The variety effect is the effect caused by change in the number of product varieties. This effect arises due to the assumption of the love of variety. There are two types of love of variety: (1) love of variety in consumption (Dixit & Stiglitz, 1977), and (2) love of variety in intermediate inputs (Ethier, 1982). As variety in our model is used both for consumption and intermediate inputs, both types of love of variety are present. Due to this love of variety assumption, an increase in product variety raises welfare.

The markup effect is the effect associated with a change in markup rates. Since the markup rate represents rate of deviation between price and marginal cost, the low value of the markup rate is desirable for the world as a whole, realizing a more efficient outcome. However, for individual regions, the low value of the markup rate is not necessarily desirable.[12]

Three effects presented above are incorporated into the models as follows. First, model PC has no effect. Second, models CD, QCV, IC, BD, and IB contain all three effects. In model LGMC, scale and markup effects are not present because the scale and markup rate of each firm are kept constant. Model CH does not contain variety effect because of the assumption of homogeneous goods, as it excludes the love of variety. Model CF does not contain the variety effect because the number of firms is constant and because there is a one-to-one relationship between the number of firms and varieties. These effects are used in interpreting the results of the simulation later.

Benchmark Data

In this section, we describe the benchmark data for the simulation. For details of the data, please see the supplementary paper, Takeda (2008). As the benchmark data, we use GTAP version 6, whose benchmark year is 2001.[13] The original GTAP 6 data contain 87 regions and 57 sectors. We first aggregate the original data into 14 regions and 16 sectors and then convert the data into a format that can be used in GAMS.[14] Francois & Roland-Holst (1997) also use GTAP data. However, regions and sectors in that analysis are more highly aggregated than in the current paper. The data used for simulation in Willenbockel (2004) are fictitious; they do not reflect actual data. Thus, we argue that our analysis is based on a more elaborate and realistic data set than the previous studies.

Although the main content of liberalization is the reduction of barriers to trade for goods, reduction of barriers to services trade has developed into an important issue. However, we cannot analyze the effects of reduction of services barriers using GTAP 6 data because services barriers are not included. Thus, to analyze services barriers, it is necessary to create data for services barriers from other sources. Brown *et al.* (2002) are the study along this line. Their study derives data for services barriers from data on gross margins of multinational firms. In this paper, we use the hypothetical tariff rates on services trade (trade of EGW, TAT, OSP, and OSG) derived in Brown *et al.* (2002). In the simulation conducted later, we consider the reduction of these services tariffs. However, the services tariff data adopted in this paper may not be appropriate. Thus, we also consider the case with no services tariffs in the sensitivity analysis.

Parameters and Calibration

Values of elasticity parameters are determined exogenously. We use GTAP 6 values for elasticity of substitution among primary factors (σ^{PF}_i). As to Armington elasticity (σ^A_i), we basically use GTAP 6 values. However, for the TWA, ELE, and OMF sectors, we use values derived by multiplying the original GTAP values by 0.8 for computational reasons.[15] As to elasticity of substitution among imports from different regions (σ^M_i), we assume $\sigma^M_i = 2 \times \sigma^A_i$, following the GTAP model. In addition to the two elasticities above, imperfectly competitive models include elasticity of substitution of varieties (σ^D_i and σ^F_i). For these two parameters, we assume $\sigma^D_i = \sigma^F_i = 2 \times \sigma^M_i$, following Harrison *et al.* (1996). The values of σ^{PF}_i and σ^A_i are reported in Table 1. With regard to these elasticity parameters, we conduct a sensitivity analysis. Imperfectly competitive models include parameters and variables that do not appear in the perfectly competitive model, such as fixed cost, the number of firms, markup rates, and elasticity of substitution of varieties. In addition to these parameters and variables, model QCV includes conjectural variation parameters. Among these parameters, elasticity parameters are determined exogenously as explained above.[16] To conduct the simulation, it is necessary to determine the values of other parameters and variables. As results of the simulation are likely to be influenced by the approach for determining parameters and variables, it is desirable to choose the proper approach. However, there exists no standard method and different studies use different methods.[17] Here, we choose the approach we think the most appropriate for comparing various imperfectly competitive models in a comprehensive framework. The approach used for model CD is as follows.

1. The fixed cost is calibrated, given exogenous CDR (Cost-Disadvantage Ratio).[18]
2. Markup rates and the number of firms are calibrated so that the zero profit condition is satisfied at the benchmark equilibrium.

As the value of the exogenously given CDR, we assume 0.15 for all regions and sectors. Actually, it is desirable to assume different values for different regions and sectors. However, as we cannot obtain good estimates of CDR for individual sectors, we assume the common value. As to the value of CDR, we conduct a sensitivity analysis. Models CH, CF, BD, IC, and IB adopt the same approach for calibration as model CD. On the other hand, in model LGMC, markup rates become constant and it is not possible to apply the aforementioned approach. Therefore we use the approach where the number of firms is exogenously determined and the fixed cost is calibrated.[19] The model QCV also cannot use the approach of model CD, because it includes conjectural variation parameters. In this case, following the approach of Harrison *et al.* (1996), we calibrate conjectural variation parameters, given the number of firms. As the benchmark number of firms, we assume 50 for all IRTS sectors.

<Table 3 here>

<Table 4 here>

Scenarios of Trade Liberalization

Trade liberalization can take various forms, such as unilateral liberalization, multilateral liberalization, and FTA. In addition, the extent and range of liberalization can often vary widely. If we attempt to examine the effects of a particular liberalization process, it is desirable to take into account, as fully as possible, the details of the liberalization process; such details include, for example, which regions participate and which goods are liberalized and to what extent. However, the main purpose of this paper is not to analyze a particular liberalization process but to compare various imperfectly competitive models in a unified framework. Thus, we only consider the simple liberalization scenarios. The list of liberalization scenarios used in the simulation is shown in Table 3.

Scenario SG is the liberalization of the world as a whole. In this scenario, all regions in the world lower their tariffs. Although world liberalization is not likely to be realized in the near future, it is one of the most important scenarios to be considered because it is likely to provide the upper limit of welfare gains among all liberalization scenarios. Scenarios SF1-SF3 are free trade agreements among specific regions. SF1 represents FTAA (Free Trade Area of the Americas) in which five regions in the American continents participate. SF2 is an FTA between EU and MERCOSUR. SF3 is an FTA of ASEAN+3, which is likely to generate a strong impact in Asia. The participants are the ASEAN 10 regions, China, Korea, and Japan. There are two reasons why these three FTAs are included. First, three FTAs cover the major continents (the American continents, Europe, and Asia), and second, the economic scale of participants is relatively large and thus FTAs in these regions are expected to have a large impact. In the simulation, the existing tariffs and export subsidies in the participating regions are proportionally reduced by 80%.[20]

As explained above, the scenarios taken up in this paper are by no means comprehensive and their contents are highly simplified. However, previous studies such as Francois & Roland-Holst (1997) and Willenbockel (2004) only considered a single scenario. In addition, Francois & Roland-Holst (1997) only considered multilateral liberalization and did not analyze FTAs, and Willenbockel (2004) only considered a policy where a region imposes a tariff on a good. Compared to the previous studies, our analysis covers a wider range of scenarios.

Results of the Simulation

In this section, we present results of the simulation and their interpretation. The simulation uses GAMS.[21] In analyzing trade liberalization, not only the welfare effects but also the effects on various variables are usually examined. In particular, when we attempt to evaluate the effects of a particular liberalization scenario in a particular model, we usually analyze not only the welfare effects themselves but also the factors that affect welfare. However, our main aim is to show how the effects of liberalization can vary, depending on model structure, and not to evaluate a particular liberalization scenario. Thus, we focus on effects on welfare, which is the most interesting variable.[22] All results of the simulation other than welfare effects are available from the author upon request.

Results

Table 4 reports EV (equivalent variation) of participating regions by scenario and model and the rank order of models with respect to EV. The values in the table are shaded according to the size of EV, that is, the darker the area, the larger the value. First, let us examine the case of scenario SG. In scenario SG, the following results are observed from Table 4. Although a few regions experience welfare loss, welfare of many regions increases as a result of global liberalization. This indicates that global liberalization is likely to generate welfare gains for most regions.

Second, as to global welfare, rates of welfare increase are relatively high for models IC, IB, LGMC, and those for models CF, CH, and CD are relatively low. The similar argument can be applied also to individual regions. These results indicate that models IC, IB, and LGMC tend to generate relatively large welfare gains, and models CF, CH, and CD tend to generate relatively small welfare gains although there are a few exceptions. In addition, the table shows that imperfectly competitive models do not necessarily have a larger impact than the perfectly competitive model. The world EV of the perfectly competitive model is fourth largest in nine models. Moreover, in some regions, the perfectly competitive model generates the largest EV of all models. It is often predicted that imperfectly competitive models have a larger impact than the perfectly competitive model because the former include additional effects such as the scale effect. However, our simulation demonstrates that this prediction is not necessarily true.

Next, we examine the results from the three FTA scenarios. Although most participants experience welfare gains also in FTA scenarios, gains are generally smaller than in global liberalization.[23] Moreover, the rank order of models by EV is also altered in some regions. As these results demonstrate, global liberalization and FTAs generate some different effects, but the qualitative results are almost the same in both scenarios. That is, welfare gains in models IC, IB, and LGMC are relatively large and those in models CF, CH, and CD are relatively small. Although we consider only four liberalization scenarios, our results suggest that differences in liberalization scenarios have a small impact on qualitative aspects of welfare effects for participating regions.

Let us summarize the results obtained above. First, it is shown that in many scenarios, models IC, IB, and LGMC generate a large welfare increase and models CF, CH, and CD generate a small welfare increase. This result is noteworthy because it has not been derived in previous studies and provides useful information for interpreting results from different imperfectly competitive models. However, it is also shown that this rank order of models by welfare change does not necessarily hold in all regions and a completely different rank order is applied in different regions. It follows that, although there is a certain tendency in the size of welfare change by model, it depends crucially on which region is the focus of the analysis. In the previous studies, results are derived from the analysis that focuses on a particular region. However, our analysis shows that it is misleading to apply results derived from one region to other regions. Moreover, our analysis demonstrates that the perfectly competitive model does not necessarily generate smaller welfare gains than imperfectly competitive models. This is an interesting result in the sense that it is against the common recognition that welfare gains in imperfectly competitive models will be larger than in the perfectly competitive model.

Interpretation of Results

First, let us consider the implication of the assumption on market segmentation. In the previous section, we derived the result that model IC tends to generate a large welfare increase. In particular, the welfare gains from model IC are largest in many regions. At the same time, Table 4 shows that welfare increase in model CD tends to be small. Since model IC is an integrated market version of model CD, this suggests that the integrated market model tends to have a larger welfare impact than the segmented market model. The same argument is applicable to the Bertrand model, that is, in the Bertrand competition, the integrated market model (model IB) generates a larger welfare impact than the segmented market model (model BD).

Second, let us examine model CF. In model CF, the number of firms (varieties) is fixed and thereby sectoral output is adjusted only by firm scale. This means that model CF has the strong scale effect and no variety effect. It is not theoretically clear how this characteristic affects the consequence of liberalization, but the simulation shows that model CF generates a smallest welfare gain in all models.

Next, let us consider model LGMC. Our result shows that model LGMC tends to generate a large welfare gain. As explained in Section 2.3, model LGMC does not include scale and markup effects. Thus, the large welfare increase in model LGMC suggests that in determining welfare effects of trade liberalization, variety effect is more important than scale and markup effects. This argument is supported also by the above result that model CF generates a small welfare increase because, in contrast to model LGMC, model CF has scale and markup effects but does not include the variety effect. As to imperfectly competitive models, the scale effect tends to attract a lot of attention. However, our simulation shows that the scale effect is not as important as expected.

One reason for this seems to be that the scale effect can work in a negative direction. Usually, the positive aspect of the scale effect that liberalization leads to the expansion of industries and thereby decreases average costs attracts most attention. However, liberalization creates industries that experience decreases in output at the same time. If this negative effect is strong, the net impact of the scale effect becomes small. Although it is not clear whether this is the principal cause, it could at least be one cause for depressing the scale effect. The size of the three effects (scale, markup, and variety effects) cannot be determined theoretically and thus it is not possible to evaluate the importance of each effect a priori. Our analysis provides one answer to this problem, that is, that the variety effect tends to play more important roles than scale and markup effects in determining the welfare effects of trade liberalization.

Next, let us compare model LGMC with model CH. The difference between the two models is that the former incorporates a variety effect but does not have any markup effect while the latter has a markup effect but does not have any variety effect. The welfare effect of model CH is generally much smaller than that of model LGMC. This also reinforces the result that the variety effect tends to play a more important role than the markup effect. By comparing models CD and BD, we subsequently examine the difference between Cournot competition and Bertrand competition. First, while the size of the welfare impact of model CD is similar across regions, that of model BD varies widely across regions. On the other hand, the world welfare change is similar in two models. The same argument is applicable to the integrated market models, that is, model IC and IB. This result indicates that while the assumption of Cournot and Bertrand competition does not make much difference in analyzing the world as a whole, it becomes important in the analysis of a particular region. Finally, let us compare model QCV with model CD. The non-Cournot conjecture model generally generates a larger welfare impact than the Cournot conjecture model in most regions. However, differences in the results between the two models are not very large. It follows that the two different assumptions have a small impact on welfare effects.

So far, we conducted the simulation and derived various results. In implementing the simulation, we have postulated various assumptions. Because some of these assumptions have no sound foundation, we attempted a sensitivity analysis to examine how results change when the assumptions are modified. The assumptions we considered are (1) barriers to services trade, (2) the calibration method, (3) the value of Armington elasticity, and (4) the value of benchmark CDR. Although we do not present the numerical results here in order to save space, the sensitivity analysis shows that quantitative results are significantly changed in some cases, but that qualitative results are not greatly affected in most cases. For the complete results of the sensitivity analysis, see the supplementary paper.

Concluding Remarks

With the development of the new trade theory, the use of imperfectly competitive models has increased within CGE analysis. However, there is no consensus on which imperfectly competitive model is the most realistic. Thus, under the present situation, various imperfectly competitive models are used in different studies. Against this tide, studies such as Francois & Roland-Holst (1997) and Willenbockel (2004) attempted to show how assumptions on model structure influence the effects of trade policy. However, these studies have several flaws in their models, data, and scenarios. In contrast to these studies, we compare various imperfectly competitive models in a unified framework, taking into account the various liberalization scenarios. Using a static world general equilibrium model with 16 sectors and 14 regions, we compare the perfectly competitive model and eight imperfectly competitive models in a unified framework. As the benchmark dataset, we use GTAP version 6 data whose benchmark year is 2001. As liberalization scenarios, we consider global liberalization and three FTAs. Our main findings are summarized as follows.

First, the welfare of most participants is likely to increase as a result of trade liberalization. However, it is also shown that some participants experience welfare loss and not all participants necessarily gain from liberalization. As for the rank order of models by welfare change, it is shown that models IC, IB, and LGMC tend to produce large welfare gains, while models CF, CH, and CD tend to produce small welfare gains. This rank order is not greatly affected by scenarios. Thus, if the first three models are used, effects of liberalization tend to be large, and if the latter three models are used, effects of liberalization tend to be small. Although various models are used in different studies, choice of model is likely to affect results. Our analysis demonstrates which results tend to be derived from each model. This can be useful information for interpreting results from different imperfectly competitive models. However, our analysis shows at the same time that the result is not necessarily applied to all participants and completely different results are derived for some regions. This means that differences in results by model depend strongly on which region is analyzed.

In addition, we obtained the following results. First, the welfare impacts of the perfectly competitive model are not necessarily smaller than those of imperfectly competitive models. Second, the integrated market model tends to have a larger welfare impact than the segmented market model. Third, the model with the fixed number of firms tends to have a small welfare impact. Finally, we found that, in determining welfare effects of liberalization, the variety effect tends to play a dominant role and, conversely, scale and markup effects tend to play a lesser role. To test for the robustness of the results, we conducted several sensitivity tests. By changing the assumptions, quantitative results are modified significantly in some cases. However, it is confirmed that most of qualitative results remain the same. Thus, we can conclude that the above results achieve robustness to some extent.

Recently, CGE analysis incorporating imperfect competition has been widely used for evaluating the effects of actual multilateral liberalization and FTAs. However, under the current situation, different models are used in different studies and a standard model has not yet been established. We argue that our analysis provides useful information for interpreting results from different imperfectly competitive models.

Note

1. For example, imperfectly competitive models are used in the following CGE studies: Harris (1984), Cox & Harris (1985), de Melo & Tarr (1992), Harrison *et al.* (1996), Bchir *et al.* (2002), Brown *et al.* (2002), Brown *et al.* (2006), and Francois *et al.* (2005).
2. The dimensionality does not necessarily affect results. However, the large difference in the dimensionality is likely to lead to different results.
3. Recent CGE analysis often employs a large-scale model with more than 20 sectors and regions. Our model is comparatively small. The reason for using a relatively small model is that some types of imperfectly competitive models include far more variables than the perfectly competitive model and are significantly difficult to compute. To compare as many models as possible in the unified framework, we need to limit the number of sectors and regions.
4. Our model differs from the GTAP model in three main aspects. First, savings and investment are determined endogenously in the GTAP model, while they are exogenously constant at the benchmark level in our model. Second, the regional welfare (utility) in the GTAP model is determined through a Cobb-Douglas function of private demand, government expenditure, and savings, while we aggregate private demand and government expenditure into a single final demand and assume that utility is derived only from this final demand. Third, the GTAP model assumes that the aggregation of domestic and imported goods (Armington aggregation) is conducted separately according to their uses, while our model assumes that Armington aggregation is conducted as a whole irrespective of their uses.
5. When MIN is assumed to be imperfectly competitive, the model becomes significantly unstable and cannot be solved. To make the model stable, MIN is assumed to be perfectly competitive even in the imperfectly competitive model.
6. This is the so-called segmented market assumption. For the details of the segmented market model, see, for example, Brander & Krugman (1983) and Markusen & Venables (1988).
7. For example, the Francois model (Francois *et al.*, 2005) and the Michigan model (Brown *et al.*, 2002, 2006) abandon the Armington assumption and only consider the variety aggregation.
8. Strictly speaking, markup rates that each firm faces slightly change due to the existence of transport cost.
9. For example, the following papers employ model LGMC: Francois & Roland-Holst (1997), Francois (1998), Francois *et al.* (2005).
10. The assumption of homogeneous goods means that σ^D_i and σ^F_i in Figure 1 are infinite.
11. For example, the following studies adopt a non-Cournot conjectural variation models: Burniaux & Waelbroeck (1992), Melo & Tarr (1992, Chap.7), Harrison *et al.* (1996), Francois & Roland-Holst (1997), and Santis (2002).
12. In a model with a fixed number of firms, the rise in markup rates for exports increases profit and thus will improve the welfare of the region. On the other hand, in a model with free entry and exit, profit is appropriated by the new entry. Whether this new entry generates positive effects or not depends on the scale and variety effects.

13. For the details regarding the GTAP data, see the GTAP web site http://www.gtap.agecon.purdue.edu/.
14. For GAMS, see http://www.gams.com/. For data conversion, we use GTAP6inGAMS utility by Rutherford (2006).
15. We use slightly smaller values because when using the original values we encountered computational difficulty in solving the model.
16. Some studies employ the approach where elasticity parameters are calibrated given other parameters and variables (e.g., Smith & Venables 1988). In this approach, elasticity parameters can take quite different values according to the models. This feature is undesirable when we compare different models. Thus, this paper does not employ such an approach.
17. For example, Smith & Venables (1988), Harrison *et al.* (1996), Francois & Roland-Holst (1997), Grether & Müller (2000), Bchir *et al.* (2002), and Santis (2002) adopt different methods for determining parameters and variables.
18. CDR is defined as CDR≡(AC-MC)/AC.
19. The benchmark number of firms in model LGMC does not affect the results of the simulation (rate of change in variables). Thus, the benchmark number of firms is normalized to unity.
20. The reason why we assume 80% reduction in tariff rates in stead of 100% is that when we assume 100% reduction in tariff rates, we often encountered computational difficulty in solving the model. Since we want to compare as many models as possible, we assume modest tariff reduction.
21. All GAMS programs for the simulation are available from the author upon request.
22. Since our model has a highly complicated structure, it is quite difficult to derive clear insights even if we closely examine individual variables. For example, in the imperfectly competitive model, the various effects pointed out in Section 2.3 are present. These effects have different impacts in different regions and sectors, and affect welfare in a complicated fashion. In addition, even if we could derive a clear insight in one scenario and one model, the same insight would not necessarily be applicable to other scenarios and models. Thus, we must provide different interpretations and explanations for each scenario and model. For these reasons, we decide to focus only on the most interesting variable, that is, welfare.
23. Although it is not reported, EV of non-participants turns out to be negative in almost all cases.

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Table 1: Region and sector list.

Region	Description	Sector	Description	σ^{A}_{i}	σ^{PF}_{i}
OCE	Oceania	AFF	Agriculture, forestry and fishery	2.42	0.23
CHN	China + Hong-Kong	MIN	Mining	5.75	0.20
JPN	Japan	FBT	Food, Beverages ando	2.49	1.12
KOR	Korea	TWA	Textiles, Wearing Apparel, an^{d} Leather products	3.78*	1.26
ASE	ASEAN10	WPP	Wood and Paper products	3.10	1.26
XAS	Rest of Asia	CHM	Chemical products	2.92	1.26
CAN	Canada	MET	Metal products	3.56	1.26
USA	United States	MVT	Motor vehicles and transport equipment	3.15	1.26
MEX	Mexico	ELE	El^{e}ctronic equipment	4.40*	1.26
XCS	Rest of Central and Southern America	OME	Machinery and equipment nec	4.05	1.26
MER	MERCOSUR	OM^{F}	Manufactures nec	3.75*	1.26
EUR	European Union (25 countries)	EGW	Electricity, Gas manufacture, and Water	2.80	1.26
XER	Rest of European regions and the former Soviet Union	CNS	Construction	1.90	1.40
ROW	Rest of the world	TAT	Trade and transport	1.90	1.68
		OSP	Other private services	1.90	1.26
		OSG	Government services	1.90	1.26

Values of elasticity of substitution are taken from GTAP data (version 6).
* Values of TWA, ELE, and OMF are derived by multiplying original values by 0.8.

Table 2: Model type.

Model name	Description
PC	Perfectly competitive model.
CD	Cournot model.
LGMC	Large group monopolistic competition model.
CH	Cournot model with homogeneous goods.
CF	Cournot model with fixed number of firms.
QCV	Quantity competition model with non-Cournot conjectural variation.
BD	Bertrand model.
IC	Integrated market Cournot model.
IB	Integrated market Bertrand model.

Table 3: List of liberalization scenarios.

Scenario name	Description	Participants
SG	Global liberalization	All regions
SF1	FTAA	USA, CAN, MEX, MER, XCS
SF2	EU+MERCOSUR	EUR, MER
SF3	ASEAN+3	ASE, JPN, KOR, CHN

Table 4: Welfare effects of trade liberalization (EV, billion US$).

Scenario	Region	PC	CD	LGMC	CH	CF	QCV	BD	IC	IB	AVR (A)	STD (B)	100*B/A
	OCE	3.0	3.4	4.1	2.7	3.3	3.8	3.2	4.1	3.5	3.5	0.5	13.8
	CHN	15.5	14.5	17.4	13.4	13.5	16.3	13.8	19.5	15.6	15.5	2.0	13.0
	JPN	9.8	11.5	11.6	11.0	10.5	11.6	12.9	14.7	14.2	12.0	1.6	13.6
	KOR	12.8	14.0	14.8	13.3	13.9	14.6	12.9	15.4	13.4	13.9	0.9	6.4
	ASE	8.0	8.8	9.8	7.7	8.2	9.0	9.3	11.1	10.8	9.2	1.2	12.9
	XAS	3.2	3.1	4.3	2.4	2.7	3.8	3.8	6.8	5.6	4.0	1.4	35.8
	CAN	1.7	1.1	1.5	0.8	0.6	1.1	1.0	1.6	1.2	1.2	0.4	32.7
SG	USA	13.4	10.6	13.5	9.1	6.7	10.4	11.5	17.3	14.3	11.9	3.1	26.4
	MEX	0.4	0.3	0.1	0.6	-0.2	-0.1	0.7	0.5	0.5	0.3	0.3	106.1
	XCS	1.6	-0.1	0.8	0.1	-0.5	0.3	-0.1	1.6	0.7	0.5	0.8	154.8
	MER	5.2	3.4	4.5	3.8	2.9	4.1	3.3	5.6	4.1	4.1	0.9	21.7
	EUR	35.2	32.5	36.1	29.5	26.7	31.2	33.7	40.7	36.9	33.6	4.2	12.5
	XER	8.4	4.1	6.5	4.1	2.5	5.4	4.2	7.4	5.9	5.4	1.9	34.7
	ROW	2.7	1.2	4.0	-0.1	0.2	2.7	2.0	6.2	5.1	2.7	2.1	79.7
	World	121.0	108.5	129.2	98.5	90.9	114.1	112.2	152.6	131.8	117.6	18.6	15.8
	CAN	1.2	1.0	1.3	0.7	0.9	1.0	0.8	1.2	0.9	1.0	0.2	19.2
	USA	5.6	5.2	5.7	5.1	4.9	5.3	5.1	6.1	5.4	5.4	0.4	6.8
SF1	MEX	0.5	0.7	0.7	0.6	0.6	0.7	0.7	1.0	0.9	0.7	0.2	21.1
	XCS	1.5	1.6	2.1	1.1	1.5	1.8	1.7	2.7	2.2	1.8	0.5	26.6
	World	3.0	2.2	3.3	1.7	1.3	2.4	2.5	5.0	3.8	2.8	1.1	39.8
	MER	1.5	1.3	2.0	0.9	1.2	1.7	1.4	2.6	1.9	1.6	0.5	30.8
SF2	EUR	15.9	13.8	16.1	10.9	12.3	13.1	13.2	15.6	13.9	13.9	1.7	12.6
	World	7.7	6.5	8.3	4.5	5.2	6.1	7.4	9.3	8.7	7.1	1.6	22.9
	CHN	3.0	1.0	2.6	0.9	-0.4	1.8	0.9	3.5	2.2	1.7	1.2	72.5
	JPN	6.6	6.6	7.0	6.7	6.4	6.9	6.9	8.2	7.6	7.0	0.6	8.2
SF3	KOR	7.6	8.5	9.0	8.0	8.5	8.9	7.8	9.4	8.2	8.4	0.6	7.2
	ASE	5.1	5.7	6.1	5.0	5.4	5.8	6.6	6.9	7.4	6.0	0.8	13.7
	World	11.0	10.2	12.2	9.4	8.0	11.0	10.7	14.3	12.8	11.1	1.9	16.9

AVR is the average of EV and STD is the standard deviation of EV.

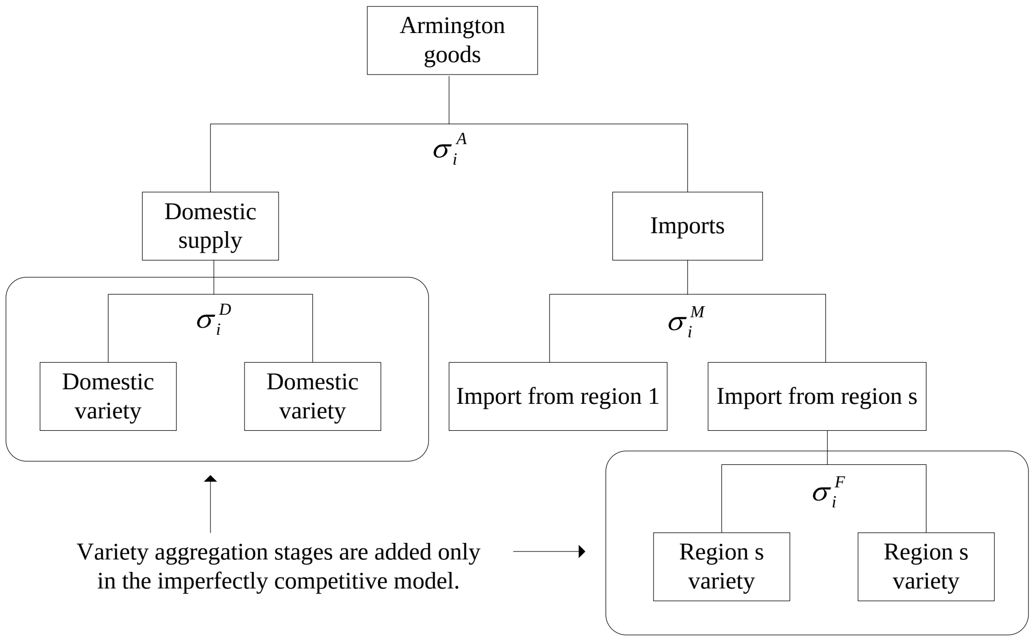

Figure 1: Armington and variety aggregation.