Regional Effects of Trade Liberalization in Japan: A CGE Analysis Based on an Interregional Input-Output Table*

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Abstract

Since the 1990s, computable general equilibrium (CGE) analysis has been widely used as a tool for evaluating the quantitative effects of trade policy, and many CGE studies have concerned trade liberalization in Japan. However, no study has attempted to examine the regional effects of liberalization; that is, how trade liberalization affects individual Japanese regions. Given that trade liberalization is likely to generate dissimilar effects in different regions, and because concern with regional disparities has grown, it is of great importance to analyze the regional effects of trade liberalization. Using a bottom-up regional CGE model, this paper quantitatively evaluates the regional effects of trade liberalization in Japan. We use a static single-country model with 23 sectors and 8 domestic regions and the Interregional Input–Output Table for Japan 2000 as the benchmark data. The main results are as follows. First, trade liberalization increases welfare and GDP in Japan as a whole. This finding is consistent with previous studies in this area. Second, the magnitude of the GDP and welfare effects differs significantly across regions. In particular, high-income regions like Kanto, Chubu and Kinki have large gains while low-income regions like Hokkaido, Tohoku and Kyushu-Okinawa have small (or negative) gains. That is, trade liberalization exacerbates existing regional disparities. These results indicate that if policy makers have an interest in regional disparity, they should implement some form of redistributive policy in conjunction with trade liberalization.

JEL classification: D58, F10, R13

Keywords: Regional computable general equilibrium (CGE) model, Trade liberalization, Interregional input–output table

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1. Introduction

Since the 1990s, computable general equilibrium (CGE) analysis has been widely used as a tool for evaluating the quantitative effects of trade policy. In particular, one of the main concerns of CGE analysis is multilateral liberalization conducted through the World Trade Organization (WTO) and regional liberalization including free trade agreements (FTA). With respect to trade liberalization relating to Japan, many CGE studies have been undertaken; for example, Hertel, Walmsley, and Itakura (2001), Brown, Deardorff and Stern (2003), Kiyota (2006) and Takeda (2007, 2008a). These studies have analyzed the nationwide effects of liberalization on welfare and GDP in Japan. In addition, they have analyzed the effects on individual agents and goods. For example, Takeda (2007) investigated the impacts of trade liberalization on the production of individual sectors and goods, while Hertel et al. (2001) analyzed the effects on the trade flows of individual goods. Brown et al. (2003) analyzed the effects of trade liberalization on employment (factor markets).

As shown, analysis has been made of various aspects of the effects of trade liberalization in Japan. However, as far as the authors are aware, no study has attempted to examine the regional effects of liberalization; that is, how trade liberalization affects individual regions. If all regions in Japan have similar impacts flowing from liberalization, it is of no purpose to analyze regional effects, but the effects of liberalization are likely to vary considerably by region because different regions have diverse patterns of production. When production patterns differ across regions, it is likely that liberalization generates positive impacts on production in some regions and negative impacts in other regions. As a result, the total effects of liberalization are likely to vary across regions.

As geographical conditions strongly affect the production of agricultural products, there is a natural focus on certain regions. In addition, Japan imposes strong trade restrictions on the import of agricultural products and so liberalization tends to strongly impact upon production. Thus, the above argument especially applies to agricultural products, and liberalization is likely to exercise quite different effects in regions with and without substantial agricultural production. Moreover, a similar argument applies to some manufacturing products. For example, most automobile production in Japan is in the Chubu and Kanto regions. As automobiles are one of Japan’s main export goods, it is also likely to be impacted upon by trade liberalization.

As the above argument shows, the regional effects of trade liberalization can differ significantly because of large differences in regional production patterns, but the previous CGE studies on trade liberalization in Japan have given little attention to the regional effects of liberalization. For a better understanding of trade liberalization policy, it is then of great importance to analyze any regional effects. In addition, the expansion of regional disparities in Japan also increases the importance of the analysis of the regional effects of trade liberalization. Regional disparity in this context is the economic disparity between large and local cities caused by the concentration of economic activity in large cities and the outflow of employment from local cities.

Although regional disparities have always existed, it is only recently that they have been the subject of much attention. Indeed, the Japanese government has implemented various policies to alleviate regional disparity. For example, Fukuda Cabinet established the new National Spatial Plan in 2007. One of the objectives of this plan is to correct the regional disparity.[1] Of course, it is not possible to implement regional policy solely with trade policy as a number of factors cause regional disparity. However, if trade liberalization contributes to the widening of regional disparity, and if the correction of disparity is an important policy objective, policy makers may regard liberalization as undesirable. How to balance the interests of Japan as a whole and those of individual regions is not an easy question to answer because it includes value judgments. However, whatever interests the government places greater emphasis on, the analysis of the regional effects of trade liberalization undoubtedly provides useful information for policy making. Consequently, this paper comprises an investigation of the regional effects of trade liberalization in Japan.

Although no known study investigates the regional effects of Japanese trade liberalization, extant CGE studies analyze liberalization in other countries. See, for example, Haddad, Domingues and Perobelli (2002), Domingues and Lemos (2004), and Haddad and Perobelli (2005). All of these

[1] In addition, the Japanese government has established Regional Revitalization Bureau Cabinet Secretariat. For the details, see http://www.kantei.go.jp/jp/singi/tiiki/index.html.

studies analyzed the effects of trade liberalization on individual regions in Brazil; however, Haddad et al. (2002), Domingues and Lemos (2004), and Haddad and Perobelli (2005) employ quite different approaches. Haddad et al. (2002) employs a top-down approach where a nationwide CGE model first derives the effects on the nation as a whole, and then the nationwide effects are broken down to 23 regional effects. Alternatively, Domingues and Lemos (2004) and Haddad and Perobelli (2005) use a bottom-up approach where a region-level CGE model is constructed at the start. There are advantages and disadvantages with both approaches, and it is not easy to determine which approach is better, but, in terms of the structure of the model, the second approach is clearly superior. Thus, we construct the model where individual regions are explicitly incorporated. We base our model mainly on the regional model in Ban (2007). To construct the bottom-up regional CGE model, it is necessary to obtain not only Social Accounting Matrix (SAM) data for individual regions but also interregional trade data. In this sense, the bottom-up approach is very data demanding. For the interregional trade data, this paper uses Interregional Input–Output Data for Japan, 2000 (hereafter, interregional IO data) provided by Arai and Ogata (2006). The original interregional IO data include 52 sector goods and 9 regions, which we aggregate into 23 sector goods and 8 regions.

Given that the purpose of our paper is to analyze the effects of trade liberalization, what is important is how to incorporate international trade. It is actually desirable to take account of foreign countries as the Global Trade Analysis Project (GTAP) model does explicitly, but it is quite difficult to create a model with multiple domestic regions and multiple foreign regions because of data requirements. Thus, this paper assumes a model with exogenous terms of trade. However, unlike a small-country model, we do not assume constant terms of trade and instead take account of changes in the terms of trade. The other parts of the model are similar to a standard trade CGE model. With respect to the benchmark data, we modify tariff data according to the GTAP data because tariff data in the interregional IO data do not reflect nontariff barriers.

Using the model and data described, we simulate the removal of tariffs in Japan and analyze the effects on GDP, welfare and output. The main results are as follows. First, we find that liberalization increases welfare and GDP in Japan as a whole. This is consistent with the results derived from nationwide CGE models. Second, the effect on GDP in individual regions varies significantly across regions. The largest increase in per capita GDP is 23.0 thousand yen in the Chubu region, while the smallest increase is only 12.0 thousand yen in the Kyushu region. The difference in the increase in per capita income across the two regions is almost double. Third, welfare effects display even larger differences across regions. The largest per capita equivalent variation (EV) is 27.5 thousand yen in the Chubu region, while the smallest per capita EV is –0.8 thousand yen in the Hokkaido region. Finally, our analysis shows that high-income regions, such as the Kanto, Chubu, and Kinki regions, have large GDP and welfare effects, while low-income regions, such as Kyushu, Tohoku, Shikoku, and Hokkaido, have small GDP and welfare effects (in some cases, negative). This means that trade liberalization leads to the expansion of regional disparity.

To distinguish the causes of the regional differences in the effects of liberalization, we decompose the effects on GDP and welfare. We derive the following results. First, the regional differences in the effects on GDP arise from large differences in the effects on consumption, exports to foreign countries and domestic regions, and imports from domestic regions. Second, the regional differences in the effects on welfare take place because of large differences in the effects on factor income and central government transfers. In particular, those regions with high welfare increases have large increases in factor income and small decreases in transfer income, while regions with low welfare increases have small increases in factor income and large decreases in transfers.

To examine the robustness of the results, we conduct several sensitivity analyses of the model, data and parameters. Although the absolute size of the effects varies significantly in some cases, the result that trade liberalization leads to large differences in GDP and welfare effects across regions and exacerbates regional disparity remains. As a result, the qualitative results are to some extent robust. However, the sensitivity analysis also shows that the regional welfare effects strongly depend on the assumption of redistribution by way of taxes and transfers.

The argument that trade liberalization, which has a positive effect on the nation as a whole, can generate not only winners but also losers has been pointed out some time ago. However, our analysis is novel in the sense that we confirm winners and losers in terms of regional and quantitative effects. As already discussed, previous CGE studies on trade liberalization in Japan have taken account of the effects on sectors and factors but not regions. In addition, although regional differences in the effects of trade liberalization have received attention, the quantitative effects on individual regions have not been analyzed. Our quantitative analysis shows that trade liberalization in Japan is likely to have significantly different impacts across regions and to exacerbate existing regional disparities.

Furthermore, we will make publicly available the program and data used for our simulation. CGE analysis is often criticized as a black box because most CGE studies do not usually provide details of the model, data, and parameters used in the simulation. To avoid this criticism, we have decided to make all of the simulation program and data used in this paper publicly available. Disclosure of the program and data has the following implications. First, if the program and data are available, it is possible to understand the details of the simulation more accurately. Second, possession of the simulation program and data (along with the software) enables complete replication of the simulation. This enables us to check details of the simulation not reported in the original paper and thus improves understanding of the analysis. In addition, it is also possible to conduct simulations that do not appear in the original paper. For example, one can undertake sensitivity analysis not present in the original paper. The program and data are available from the authors upon request or at the authors' website.

Finally, we summarize the policy implications of our analysis. We have shown that trade liberalization in Japan is likely to worsen regional disparities. This means that if policy makers have a great interest in regional disparity, they should implement some form of redistribution policy alongside trade liberalization. In fact, our analysis shows that income redistribution alleviates the regional disparity arising from the effects of trade liberalization. However, we should at the same time note that redistribution of income only alleviates the disparity in regional welfare effects and cannot alleviate the disparity in the GDP (or production) effects.

2. Model

As discussed earlier, one approach for analyzing the regional effects of trade liberalization is a top-down CGE model such as that used in Haddad et al. (2002), who first derived nationwide effects using the CGE model and then decomposed them into their regional effects. Although this approach has some advantages, there are two important shortcomings. First, the top-down CGE model does not treat individual regions explicitly. Second, the decomposition of the nationwide effects into regional effects tends to be ad hoc. To avoid these shortcomings, and as in Domingues and Lemos (2004) and Haddad and Perobelli (2005), this paper adopts a bottom-up CGE model in which Japan is divided into individual regions. We mainly base our model on Ban (2007). However, we make various modifications because Ban's model is not for the purpose of trade liberalization. For the benchmark data, we use the interregional IO table of Japan provided by Arai and Ogata (2006). Although the original interregional IO table has 52 sectors and goods, we aggregate these into 23 sectors and goods, as shown in Table 1. In addition, we aggregate the Kyushu and Okinawa regions into a single region, Kyushu-Okinawa, and therefore there are eight regions in our model: Hokkaido (HOK), Tohoku (TOH), Kanto (KAN), Chubu (CHB), Kinki (KIN), Chugoku (CHG), Shikoku (SIK), and Kyushu-Okinawa (KYU).[2] In the following, we explain the structure of the model. For the purpose of brevity, we do not provide the full description of the model here. For further details, see the supplement and simulation program available from the authors (Takeda 2008b).

2.1. Production Side

Using intermediate inputs and primary factors, each sector produces a good under constant returns-to-scale technology to maximize profits. All markets are perfectly competitive and all producers act

[2] The "Hokkaido region" includes only Hokkaido; the "Tohoku region" includes Aomori, Iwate, Miyagi, Akita, Yamagata, and Fukushima; the "Kanto region" includes Ibaragi, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Yamanashi, Nagano, and Shizuoka; the "Chubu region" includes Toyama, Ishikawa, Aichi, Gifu, and Mie; the "Kinki region" includes Fukui, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama; the "Chugoku region" includes Tottori, Shimane, Okayama, Hiroshima, and Yamaguchi; the "Shikoku region" includes Tokushima, Kagawa, Ehime, Kochi; and the "Kyushu-Okinawa region" includes Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima and Okinawa. Apart from the aggregation of Okinawa and Kyushu into a single region, this classification is identical to the original interregional IO table.

as price takers. As primary factors, we assume labor, capital, and land: land is a specific factor used only in the agricultural (AGR) sector.

The production function in a region is the nested constant elasticity of substitution (CES) function in Figure 1. The input side of production consists of two stages. First, we aggregate labor and capital (and land in the AGR sector) into a composite primary factor. Next, we aggregate the composite primary factor and other intermediate inputs through a Leontief function. This type of production functions is used in the standard trade CGE models like GTAP. Symbols like E_XX represent the elasticity of substitution between different inputs. With respect to the output side of production, we assume that output is allocated to domestic and export markets through a constant elasticity of transformation (CET) function with elasticity E_T.

To analyze the regional impacts, it is of importance how to model interregional movement of primary factors, in particular, labor. But it is not an easy task to consider interregional factor movement in a realistic manner because it depends on various factors such as wage rate, tax, price level, cost of living and administrative services. Therefore, we assume that primary factors are immobile across regions. In this sense, our model is the short-run model. Primary factors in a region are freely mobile across sectors and the allocation of primary factors across sectors is determined so that factor prices in all sectors are equalized. In the sensitivity analysis, we also analyze the case where primary factors are imperfectly mobile across sectors.

2.2. Demand Side

To represent the demand side, we assume a representative household in each region. The utility of the household is a Cobb–Douglas function of consumption and saving. In addition, consumption is a Cobb–Douglas function of individual consumption goods. Figure 2 represents the utility function. In the simulations conducted later, we calculate the welfare effects of trade liberalization. These welfare effects are the effects on the utility of the representative household.

The representative household supplies primary factors to industry and earns factor income. We assume that the endowment of primary factors is an exogenous constant. In addition to factor income, the representative household obtains transfer income from the central government.

2.3. Trade with Foreign Countries

As our main purpose is to analyze trade liberalization, it is of great importance to know how to incorporate trade with foreign countries. It is desirable to treat foreign regions explicitly, as with many trade CGE models (such as the standard GTAP model). However, it is quite difficult to do this when we decompose domestic regions because it not only requires a great deal of data but also makes the model more complicated. Thus, it is necessary to simplify the structure of trade with foreign regions. For this purpose, we immediately consider the following two approaches:

[A1] to assume a small country, and

[A2] to represent foreign regions with import supply and export demand functions.

In Approach A1, the terms of trade are exogenously constant, as in Ban (2007). This may not be a problem if we analyze domestic policies. However, the assumption of constant terms of trade is undesirable in the analysis of trade policy. Alternatively, A2 enables us to analyze the terms-of-trade effect from trade liberalization because import and export prices change endogenously. However, A2 requires the specification of the import supply and export demand functions, and if specified improperly, the analysis is likely to lead to false results.[3]

This paper adopts a similar approach to A1, but we do not assume constant terms of trade, preferring instead to alter the terms of trade. Because the terms of trade in our model are determined exogenously, we use the following approach to derive change in the terms of trade. First, we conduct a simulation of world trade liberalization using the GTAP model and derive the change in the Japanese terms of trade. Second, after applying the results from the GTAP model to our model, we exogenously change the terms of trade in Japan when we simulate trade liberalization. This approach enables us to consider the terms-of-trade effects associated with trade liberalization in the framework of a simple model with exogenous terms of trade. However, there are many differences between the

[3] Domingues and Lemos (2004) use the A2 approach.

GTAP model and the model herein, and it may not be appropriate to apply the results from the GTAP model to our analysis. Therefore, we analyze the case with constant terms of trade in the sensitivity analysis.

As in other CGE models, we use the Armington assumption for each region. Armington aggregation is through a two-stage CES function in Figure 3. First, domestic goods from eight regions (including the own region) are aggregated into composite domestic goods through a CES function. Second, the import goods and composite domestic goods are aggregated. Note that standard trade CGE models like the GTAP model aggregate imports from different regions because they have imports from multiple regions, while our model aggregates domestic supply from different domestic regions. Aggregated Armington goods are used for the consumption, investment, government expenditure, and intermediate inputs in each region.

2.4. Government

Because we decompose domestic regions, it may be desirable to take account of not only the central government but also local governments. However, it is very difficult to incorporate local governments into our model in a realistic manner, mainly because of data limitations. Accordingly, we assume that there is only the central government and do not consider the local governments explicitly. In addition, we assume that the central government only plays a role in the redistribution of income; that is, the central government collects taxes and redistributes these into regional households. Our model takes account of several taxes, including import tariffs. The central government first collects the revenues from these taxes and then reallocates these to regional households according to some rule. Our model includes regional government expenditure, which is financed by regional income. We assume that regional government expenditure is held constant in real terms.

Given that the income of each region depends on the amount of central government transfers, the effects of liberalization can depend on the rule used for redistribution. There are many possible rules for redistribution of income, but the main focus of this paper is not the local public finance issue but the effect of trade liberalization. Thus, we assume the following simple redistribution rule:

[1] First, we derive the benchmark value of transfers as the difference between regional expenditure and regional factor income.[4]

[2] Second, we assume that the amount of transfers in all regions change proportionally with trade liberalization.

The second assumption means that if, for example, the total amount of transfer to all regions decreases by one percent because of trade liberalization, the amount of transfers to individual regions decreases by one percent.

2.5. Elasticity of substitution

We assume the values in Table 2 for the elasticity of substitution (EOS) in the CES functions. Among these, the EOS between domestic and imported goods (E_DM) and that between domestic goods (E_DD) are likely to have large impacts on the effects of trade liberalization. To see how, we employ different values for these parameters in the sensitivity analysis.

3. Data

For the benchmark data of the simulation, we use the Interregional IO Table for Japan in 2000 by Arai and Ogata (2006).[5] The Ministry of Economy, Trade, and Industry (METI) periodically provides interregional IO tables for Japan but not for 2000. Arai and Ogata make available a good substitute for the METI interregional IO table. Data on production, intermediate inputs, consumption, exports, and imports are from the interregional IO table. In addition, we use the Annual Report on National Income (ARNI) and the GTAP to derive the tax data. In the following section, we explain how we create the data on factor income, taxes, and transfers.

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[4] Transfers from the central government = regional consumption expenditure + regional investment (saving) expenditure + regional government expenditure − regional factor income.

[5] Interregional IO Table for Japan 2000 is available at http://www.meti.go.jp/statistics/tyo/tiikiio/result/result_s1.html.

3.1. Primary factor

The data on primary factors are based on the IO table. Payment to labor in the individual sector is the sum of "consumption expenditure outside households" and "compensation of employees". Similarly, payment to capital is derived by summing "operating surplus" and "depreciation of fixed capital". In addition to labor and capital, our model assumes a factor specific to the agricultural sector; namely, land. Payment to land is derived by separating it from payment to capital in the IO table according to the GTAP 6 data.

3.2. Taxes and Transfers

The model includes five taxes: tariffs, commodity taxes on imports, production taxes, labor income taxes and capital income taxes. Tariff and commodity taxes on imports are taken from the IO table.[6] Production tax indicates indirect taxes in the IO table. In fact, this indirect tax mainly comprises consumption taxes, and thus it may be inappropriate to consider it as tax for production. However, because the purpose of this paper is not to analyze indirect taxes, we use indirect taxes as production taxes for simplicity.

Given that the data on labor and capital income taxes are not included in the IO table, we derive these from the Annual Report on National Income in the following manner.[7] First, according to ARNI, the value of "current taxes on income, wealth etc. for total economy" in 2000 is 44.207 trillion yen. We regard this as the total value of labor and capital income taxes. Second, ARNI reports that the value of "current taxes on income, wealth etc. for households" is 27.609 trillion yen. We regard this as the value of labor income taxes. Finally, the value of capital income tax is derived as the difference between two values (16.598 = 44.207 – 27.609). Note that because the endowment of labor and capital is exogenously fixed, and because the tax rates for all regions are equal, these taxes have no distortionary effects.

Table 3 reports the data on taxes. In addition, Table 3 provides GDP and per capita GDP for the individual regions. The following relation derives the GDP for each region:

$$GDP = C + I + G + X - M + DX - DM$$

where C is consumption, I is investment, G is government expenditure, X is exports to foreign countries (the rest of the world), M is imports from foreign countries, DX is exports to domestic regions and DM is imports from domestic regions. The table shows that the scale of individual regions differs significantly. The population data in Table 3 are for per capita GDP. The population data are from NIPSSR (2005). The rank order of per capita GDP is KAN, CHB, KIN, CHG, HOK, SIK, TOH and KYU. The highest per capita GDP is 4.4 million yen in KAN, and the lowest is 3.2 million yen in KYU. This means that the difference between the two regions is 1.2 million yen. It also shows that the disparity in regional income is sizable.

Finally, we examine the transfer data. The data on transfers use the approach detailed in Section 2.4. Column "Share (%)" reports the share of transfers to each region from total transfers. The table shows that except for KAN, CHB and KIN, the share of transfers is larger than GDP. That is, regions other than KAN, CHB and KIN receive relatively large transfers. In this sense, small regions receive relatively large transfers. T/I (%) indicates the share of transfer income in total income for each region. The value of T/I (%) reaches 25% to 30% in HOK, TOH, SIK and KYU, while it is only 14% in KIN and 9% in KAN and CHB. This shows that small regions tend to depend more heavily on transfers.

3.3. Data for Trade and Production

The effect of trade liberalization depends on trade flows and tariffs in the initial equilibrium. In the following, let us examine the benchmark data for trade flows and tariffs. First, Table 4 reports the value of exports, imports and net exports (= exports minus imports). Goods with positive net exports

[6] "Commodity taxes on imports" include consumption taxes, alcohol taxes, and gasoline and petroleum taxes on imports (see MIC, 2005).

[7] For details, see ESRI (2003).

include, for example, MAC, TMC and TRD. Although imports of MAC are very large, exports are far larger, and therefore net exports are positive. On the other hand, goods with negative net exports include, for example, FUE, FOO, SER, WAP and AGR. It follows that Japan has a comparative disadvantage in FUE, FOO, SER, WAP and AGR.

Column "IO" in the table includes the tariff rates calculated from the tariff revenue in the IO table (strictly speaking, these are average tariff rates because the tariff rate differs across regions). Column "GTAP" contains the tariff rates in the GTAP Ver. 6 data. "Diff" is the difference in the two tariff rates. Generally, the differences in the tariff rates are very small, but with some goods, particularly AGR and FOO, there are large differences. To be precise, the tariff rates for these goods are much higher in the GTAP tariff data than in the IO table data.

There are several reasons for this difference. One reason is the difference in the benchmark year of the datasets (2001 for GTAP and 2000 for the IO table); another is differences in the classification of goods. However, the more fundamental difference is that GTAP data include nontariff barriers while the IO table does not. Because we want to take account of the removal of nontariff barriers, we decided to modify the tariff data in the IO table according to the GTAP tariff data. Thus, the benchmark tariff rates for our model become the rates in column IO′.

Finally, consider the data on sectoral value-added in the individual regions. Table 5 reports the share of sectoral value-added. Using these figures, we can observe the production structure in each region. First, the share of the services sector is generally the same for all regions. Second, in HOK, the share of AGR and FOO is very high, while the share of manufacturing goods is low. Similarly, TOH, SIK and KYU have a high share for the AGR sector. Conversely, KAN, CHB, KIN show a low share of AGR and a high share of manufacturing goods such as MAC, CHM and TMC. These figures suggest that trade liberalization is likely to have large impacts on HOK, TOH, SIK and KYU because these regions have high shares in AGR and FOO with high trade barriers.

4. Simulation

The simulation is executed with the numerical software General Algebraic Modeling System (GAMS).[8] The GAMS program for this simulation is available from the authors. As explained in Section 2.3, when we remove tariffs, we alter the terms of trade. The GTAP model simulation derives this change in the terms of trade in the following manner.

[1] First, we aggregate the sectors in the GTAP 6 data according to the classification of goods in Table 1. Similarly, we aggregate the regions in the GTAP data into two regions: Japan and the rest of the world.

[2] Second, we conduct a simulation for reciprocal trade liberalization between Japan and the rest of the world using the GTAP model.

The above simulation produces the changes in the terms of trade resulting from trade liberalization. Applying this result to our model, we alter the terms of trade when we conduct our own liberalization experiment. The GTAP program for this simulation is also available from the authors upon request. See the program for details.

5. Results of the Simulation

5.1. Nationwide Effects

In this section, we examine the results of the simulation. The first case is "the benchmark case" so as to distinguish it from the other cases in the sensitivity analysis. Table 6 reports the results from the benchmark case.[9] ΔGDP indicates the change in real GDP for each region (in billions of yen). ΔpcGDP is the change in per capita real GDP (in thousands of yen), and GDP (%) is the percentage change in real GDP. EV is the equivalent variation of individual regions (in billions of yen), and

[8] For details, see the GAMS website (http://www.gams.com/).

[9] All simulation results are available from the authors. Because the program and data used for the simulation are also available from the authors, it is possible for any interested person to replicate the entire simulation.

pcEV is per capita EV (in thousands of yen).[10] Welfare (%) is the percentage change in the utility of the regional household.

We first examine the nationwide effects and then move to the regional effects. The nationwide effects comprise nationwide change in GDP and welfare. The table shows that GDP in Japan increases by 2,122 billion yen (0.41% increase), which means that trade liberalization leads to a positive effect on Japanese GDP. Similarly, EV in Japan is 2,121 billion yen, and the rate of increase in welfare is 0.54%; that is, trade liberalization leads to positive welfare effects in Japan as a whole. These results indicate that trade liberalization has positive effects in Japan as a whole, in terms of both GDP and welfare. This is consistent with the findings of other studies that have analyzed trade liberalization in Japan.

5.2. Regional Effects

Next, let us move to our main interest; that is, the regional effects of trade liberalization. First, we examine the GDP effects. As individual regions differ significantly by size, there is not much point in comparing GDP (or ΔGDP) in each of the regions directly. Thus, we compare individual regions by comparing the change in per capita GDP (ΔpcGDP). The table provides the following results. First, the change in per capita GDP is largest in CHB (an increase of 23 thousand yen), while it is lowest in KYU (an increase of 12.0 thousand yen); that is, the size of the change in per capita GDP in CHB is twice as large as in KYU. This indicates that there is a major difference in the GDP effect across regions. Second, we consider the welfare effects using per capita EV (value of pcEV). Per capita EV in all regions (except HOK) is positive, while in HOK it is negative, although its magnitude is small. This means that HOK experiences a welfare loss from trade liberalization. Moreover, the results show that the size of the welfare effects differs significantly across regions. For example, per capita EV in KAN, CHB, and KIN exceeds 20 thousand yen, while that in KYU, SIK and TOH is only 3 to 7 thousand yen. These findings show that regional disparities in the welfare effect are far larger than in the GDP effect.

Let us now examine the GDP and welfare effects for the individual regions in detail. Table 7 reports the rank order of the benchmark per capita GDP, ΔpcGDP and pcEV. The table shows that the rank order of ΔpcGDP and pcEV resembles that of per capita GDP. That is, high-income regions, such as KAN, CHB, and KIN, tend to have large GDP and welfare gains, while low-income regions, such as KYU, TOH, and SIK, tend to have small GDP and welfare gains (or losses for at least some regions). This suggests that trade liberalization is likely to exacerbate the existing regional disparities.

In order to analyze the causes of the change in GDP, we decompose the change in per capita GDP. Given that GDP is defined as GDP = C + I + G + X – M + DX – DM, the change in per capita GDP can be decomposed into changes in these seven factors. Table 8 reports the results. Note that contribution of G is not reported because we assume that G is constant at the benchmark value. Changes in investment (I) differ across the regions, but its absolute values are very small and thus negligible. Because trade liberalization increases imports in all regions, the contribution of imports (M) to changes in per capita GDP is negative for all regions, but its size is similar for all regions.

Trade liberalization increases exports in all regions and thus increases per capita GDP in all regions, but the size of the contribution of exports differs significantly across regions. For example, the contribution of exports in CHB and SIK exceeds 100 thousand yen, while in HOK it is only 8.8 thousand yen. Similarly, there is large difference in the size of the contributions of C, DX, and DM. Additionally, the sign of the contribution of DX and DM reverses in some regions. These results show that the effects of trade liberalization on the components of GDP, particularly C, X, DX, and DM, differ significantly across regions. That is why there is a large difference in the change in per capita GDP.

Similarly, let us now decompose per capita EV. Welfare depends on household expenditure (income), defined as follows[11].

[10] Population is fixed at the benchmark value in all of the simulations.

[11] Let p^U denote the price index of utility (unit expenditure function) and U denote the utility level and M denote the income of the representative household. Then, the following relations holds:

$$p^U U = M$$

Household expenditure = factor incomes + transfers from the central government – regional government expenditure

Thus, per capita EV decomposes into three parts: changes in factor income, changes in transfers, and changes in regional government expenditure. Table 9 reports the results of the decomposition. This shows that the contribution of factor income is positive for all regions. Conversely, the contribution of transfers is negative for all regions. This is because trade liberalization reduces government revenue and therefore decreases transfers. Similarly, the contribution of regional government expenditure is negative for all regions because regional government expenditure increases and therefore the share of expenditure spent on consumption and saving decreases.[12] Together, these three components determine per capita EV.

Examining Table 9 closely, we derive the following insights. First, in high-income regions, such as KAN, CHB, and KIN, the positive contribution of factor incomes is large and the negative contribution of transfers and government expenditure is small. On the other hand, in low-income regions, such as HOK, TOH, and KYU, the positive contribution of factor incomes is small and the negative contribution of transfers and government expenditure is large. The reason why the positive effect of the increase in factor incomes is small in low-income regions is that the production of goods with a comparative disadvantage is relatively concentrated in low-income regions. On the other hand, the reason why the negative effect of a decrease in transfers is large in low-income regions is that they depend heavily on transfers and are strongly affected by a decrease in transfer income. Because of these effects, low-income regions obtain relatively low welfare gains from trade liberalization.

Section 3.3 showed that trade liberalization is likely to affect strongly sectors with relatively high tariffs, like FOO and AGR. Let us examine if this actually happens. Table 10 reports the percentage change in output for all sectors in all regions. The shaded area indicates sectors that experience large changes in output (more than 5% in absolute terms). Although there is a slight difference between regions, outputs in the AGR, FOO, TEX, and WAP sectors tend to decrease, and outputs in the TMC, FEM, MFM, and MAC sectors tend to increase. As expected, the rate of decrease in the output of sectors with high trade barriers is large. This is the main reason why the gains in GDP and welfare in HOK, TOH, SIK, and KYU are small.

5.3. Sensitivity Analysis

In the previous section, we examined the regional effects of trade liberalization. However, since some of the model assumptions, data, and parameters in the benchmark case do not necessarily have sound foundation, we undertake sensitivity analysis to examine how the results may change after modifying the assumptions. We conduct six types of sensitivity experiments.

(A) Income taxes
(B) The rule used for transfers
(C) Primary factor mobility
(D) Elasticity of substitution
(E) Terms of trade
(F) Tariff rates

In addition, since M is the sum of factor income (M^F) and transfers from the central government (M^T) minus regional government expenditure (M^G), we have

$$U = (M^F + M^T - M^G)/p^U$$

Using this relation, we can decompose the change in per capita EV into three parts. M^G is given by $p^G G$ where p^G is the price index of government expenditure and G is the real government expenditure. Note that we assume that the real government expenditure is constant but the government expenditure deflated by the price index of utility (i.e. M^G/p^U) can vary. For the details, see the supplementary paper.

[12] $M^G/p^U = p^G G/p^U$ increases because p^G/p^U (the relative price of government expenditure) increases. The rise in p^G/p^U is due to the fact that government expenditure (G) uses the domestic goods more intensively than the private consumption and investment.

Experiment (A) modifies the way we derive the value of income taxes. In the benchmark case, we derive the value for labor income taxes from "current taxes on income, wealth etc. for households" in ARNI. In Experiment (A), we assume that labor income tax is equal to the sum of "current taxes on income, wealth etc. for households" and "social contributions by employers". The reason why we consider this case is that "social contributions by employers" are the same as labor taxes in the sense that both social contributions and labor taxes are deducted from payments to labor. This change alters the benchmark value of taxes and transfers, and thus can influence the effects of trade liberalization.

Experiment (B) modifies the rule used for central government transfers. The benchmark case assumes that transfers from the central government to regional households change proportionally in all regions. In experiment (B), we assume that transfers are determined such that per capita EV in all regions equalizes; that is, all regions gain equally from trade liberalization. Because the benchmark case shows that Japan as a whole has positive impacts from trade liberalization, it is likely that all regions could receive positive gains by properly redistributing the total gain.

Experiment (C) tests the sensitivity of primary factor mobility across sectors. In the benchmark case, we assume that primary factors in a region are freely mobile across sectors and the factor allocation is determined so that factor prices in all sectors are equalized. In Experiment (C), we assume that primary factors are imperfectly mobile across sectors. More concretely, we assume that primary factors are allocated to sectors through a CET (constant elasticity of transformation) function. This assumption on factor movement is used also in the GTAP model. We consider this case because the allocation of primary factors across sectors is not adjusted so smoothly in a real world, especially in the short run. We assume the value of five for elasticity of transformation.

Experiment (D) tests the sensitivity of the value of two EOS: the EOS between domestic goods (E_DD) and the EOS between domestic and imported goods (E_DM). We consider two cases: (D-1) the values of EOS increase by 50% and (D-2) the values of EOS decrease by 50%. In Experiment (E), we change the assumption concerning the terms of trade. In the benchmark case, we assume that the terms of trade change exogenously according to the GTAP model simulation. As it may not be appropriate to apply the results derived in the GTAP model to our own, we consider the alternative case; that is, the terms of trade, as in a small-country model, are fixed. Finally, Experiment (F) modifies the assumption about tariff rates. In the benchmark case, tariff rates in the IO table adjust according to the tariff rates in the GTAP data. In Experiment (F), there is no adjustment to the tariff data in the IO table.

Table 11 provides the results of the sensitivity experiments. As shown, both the regional and nationwide GDP effects in Experiment (A) are almost the same as the benchmark case. This means that the assumption on income taxes has only a small influence on the GDP effects. Similarly, the nationwide welfare effects are similar to those in the benchmark case. However, a similar argument does not apply to the regional welfare effects; that is, the regional welfare effects are markedly different to the benchmark case. This indicates that regional welfare effects depend strongly on assumptions about taxes.

In Experiment (B), per capita EV across all regions is 16.7 thousand yen. This suggests that if we can properly distribute the gains from trade liberalization, all regions could obtain at least 16.7 thousand yen. Although it may not be possible to redistribute income among regions freely using actual policies, Experiment (B) at least shows that the redistribution of income can narrow any disparity in the welfare effects of trade liberalization. On the other hand, the GDP effects in Experiment (B) are almost the same as the benchmark case. The results in Experiment (A) and (B) show that the assumptions on taxes and transfers have only a small impact on the GDP effects but a large impact on the regional welfare effects. Put another way, the redistribution of income can improve any regional disparity in the welfare effects but cannot improve any regional disparity in the GDP effects.

In Experiment (C), the GDP and nationwide welfare effects are almost the same as the benchmark case, but the disparities in regional welfare effects are slightly expanded. In Experiment (D-1) and (D-2), the absolute value of GDP and welfare effects changes. However, the finding that high-(low-)income regions tend to receive large (small) gains is the same across both experiments. In Experiment (E), the GDP and welfare effects generally become smaller. This is because improvements in the terms of trade, which also exist in the benchmark case, disappear in Experiment

(E).[13] Putting aside that the increase in per capita GDP in HOK becomes the largest across all regions, the remaining qualitative results derived in the benchmark case are unchanged. Finally, in Experiment (F), the magnitudes of the GDP effects fall significantly. Similarly, the sizes of the welfare effects (pcEV) tend to get smaller. Although the sizes of the effects of trade liberalization largely change, large regional disparities remain.

We have conducted six separate sensitivity experiments and examined how the GDP and welfare effects alter. Although the quantitative effects change significantly in some cases, the qualitative result that high-(low-)income regions tend to obtain large (small) gains remains the same. This means that the results derived in the benchmark case are to some extent robust. However, one point to note is that the regional welfare effects depend on the assumptions concerning taxes and transfers.

6. Concluding Remarks

Many CGE studies have investigated the various effects of trade liberalization relating to Japan. However, they have ignored regional effects; that is, how trade liberalization affects individual regions. For a better understanding of trade liberalization policy, it is of great importance to analyze any regional effects disregarded in previous work. In addition, concern has grown alongside the escalation of regional disparities. Accordingly, this paper provides a quantitative investigation of the regional effects of trade liberalization in Japan. We use a bottom-up CGE model for Japan with eight domestic regions. For the benchmark data, we use the Interregional Input–Output Table for Japan 2000 by Arai and Ogata (2006).

The main findings of our analysis are as follows. First, we find that liberalization increases welfare and GDP in Japan as a whole. This is consistent with the results derived from the nationwide CGE models. Second, the effect on GDP and welfare in individual regions varies significantly across regions. As a result, trade liberalization exacerbates existing regional disparities. To observe the causes of the regional difference in the effects of liberalization, we decompose the effects on GDP and welfare. The decomposition obtains the following. First, the regional difference in GDP effects is from large differences in the effects on consumption, exports to foreign countries, exports to domestic regions and imports from domestic regions. Second, the regional differences in welfare effects are mainly from large differences in the effects on factor incomes and central government transfers.

To examine the robustness of the results, we conducted several sensitivity analyses on the model, data and parameters. Although the absolute size of the effects varies significantly in some cases, the result that trade liberalization leads to large differences in GDP and welfare effects across regions and exacerbates existing regional disparities remains. Therefore, the qualitative results are, to some extent, robust.

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Table 1: Classification of sectors and goods.

	Symbol	Description	Sectors in the original IO table (52 sectors)
1	AGR	Agriculture, forestry and fishery	Agriculture + Forestry + Fishery
2	MIN	Mining	Mining
3	FUE	Coal, crude petroleum and natural gas	Coal, crude petroleum and natural gas
4	FOO	Foods, tobacco and beverage	Foods, tobacco and beverage
5	TEX	Textile products	Textile products
6	WAP	Wearing apparel and other textile products	Wearing apparel and other textile products
7	WOO	Timber, wooden products and furniture	Timber, wooden products and furniture
8	PPP	Pulp, paper and publishing	Pulp, paper, paperboard and paper products + Publishing and Printing
9	CHM	Chemical products	Basic chemical products + Synthetic products + Final chemical products + Medicaments + Plastic products
10	P_C	Petroleum and coal products	Petroleum and coal products
11	SCP	Stone and clay products	Stone and clay products
12	FEM	Iron and steel	Iron and steel
13	NFM	Nonferrous metals	Nonferrous metals
14	MET	Metal products	Metal products
15	MAC	Machinery	General machinery + Machinery for office and service industry + Household electronic and electric appliances + Electric computing equipment + Communication equipment + Other electronic and communication equipment + Heavy electrical equipment + Other electrical machinery + Precision instruments
16	TMC	Transportation equipment	Passenger motor cars + Other cars + Other transportation equipment
17	OIP	Miscellaneous manufacturing products	Miscellaneous manufacturing products + Recycles
18	CNS	Construction	Construction and repairs + Public construction + Other constructions
19	EGW	Electricity, gas and water supply	Electricity + Gas and heat supply + Water supply and waste management services
20	TRD	Commerce	Commerce
21	FIN	Financial and insurance services and real estate	Financial and insurance, and real estate + House rent
22	TRN	Transport	Transport
23	SER	Other services	Communication and broadcasting + Public administration + Other public services + Research and information services + Other business services + Personal services + Other services

Table 2: Values of elasticity of substitution.

Symbol	Description	Value
E_T	EOT between domestic and export supply	4
E_VA	EOS between primary factors in production function	1
E_DM	EOS between domestic and import goods (Armington elasticity)	4
E_DD	EOS between domestic goods from different regions	8

†EOT: elasticity of transformation

‡EOS: elasticity of substitution.

Table 3: Benchmark data.

	Tax revenue (billions of yen)					Population (thousands)
	Tariffs	Labor income taxes	Capital income taxes	Other taxes	Sum	
HOK	105	1,052	631	1,355	3,143	5,683
TOH	152	1,732	1,090	2,160	5,134	9,817
KAN	738	12,080	7,396	14,820	35,035	49,780
CHB	208	3,156	1,707	3,926	8,998	13,310
KIN	369	4,718	2,900	6,048	14,035	21,685
CHG	110	1,553	887	2,430	4,980	7,733
SIK	61	765	449	1,029	2,303	4,154
KYU	181	2,553	1,539	3,079	7,351	14,764
Japan	1,924	27,609	16,598	34,848	80,979	126,926

	GDP			Transfers		
	Value (billions of yen)	Share (%)	Per capita GDP (thousands of yen)	Value (billions of yen)	Share (%)	T/I (%)
HOK	19,934	3.9	3,508	7,320	9.7	30.8
TOH	33,512	6.6	3,414	8,938	11.8	24.6
KAN	219,221	43.2	4,404	18,374	24.3	8.9
CHB	56,677	11.2	4,258	4,543	6.0	8.8
KIN	86,612	17.1	3,994	11,959	15.8	14.0
CHG	29,099	5.7	3,763	5,898	7.8	20.0
SIK	14,297	2.8	3,442	3,943	5.2	25.0
KYU	47,917	9.4	3,246	14,755	19.5	27.1
Japan	507,268		3,997	75,729		

Table 4: Benchmark trade and tariff data.

Goods	Trade data (billions of yen)			Tariff rates (%)			
	Exports	Imports	Net exports	IO	GTAP	Diff	IO′
AGR	72	1,646	–1,574	2.2	22.6	–20.4	22.6
MIN	11	886	–875	0.0	0.1	–0.1	0.0
FUE	0	6,812	–6,812	0.7	0.0	0.7	0.7
FOO	190	3,327	–3,137	8.6	31.4	–22.8	31.4
TEX	540	353	188	5.1	7.1	–2.0	7.1
WAP	48	2,339	–2,291	8.7	10.9	–2.2	10.9
WOO	51	1,299	–1,248	1.8	1.4	0.4	1.8
PPP	293	541	–248	0.2	0.3	–0.1	0.2
CHM	4,016	2,895	1,122	1.2	1.0	0.2	1.2
P_C	289	1,731	–1,441	0.6	1.6	–1.0	0.6
SCP	585	376	209	0.6	0.6	0.0	0.6
FEM	1,492	424	1,067	1.3	1.0	0.3	1.3
NFM	914	1,763	–849	0.4	0.4	0.0	0.4
MET	520	345	175	0.7	0.5	0.2	0.7
MAC	24,717	11,235	13,481	0.0	0.0	0.0	0.0
TMC	11,772	1,787	9,985	0.0	0.0	0.0	0.0
OIP	1,159	2,391	–1,232	3.7	1.2	2.5	3.7
CNS	0	0	0	0.0	0.0	0.0	0.0
EGW	31	2	29	0.0	0.0	0.0	0.0
TRD	4,492	677	3,814	0.0	0.0	0.0	0.0
FIN	398	371	27	0.0	0.0	0.0	0.0
TRN	4,261	2,885	1,376	0.0	0.0	0.0	0.0
SER	1,635	5,161	–3,526	0.0	0.0	0.0	0.0
Total	57,487	49,246	8,240				

IO: tariff rates derived from the original IO data.

GTAP: tariff rates in the GTAP Ver. 6 data.

Diff: the difference between the tariff rates in the IO and GTAP data.

IO′: benchmark tariff rates in our simulation.

Table 5: Benchmark share of value-added (%)

	HOK	TOH	KAN	CHB	KIN	CHG	SIK	KYU
AGR	5.5	3.7	0.9	1.1	0.6	1.7	3.4	3.2
MIN	0.3	0.2	0.1	0.1	0.1	0.2	0.3	0.2
FUE	0.1	0.0	0.0	0.0		0.0		0.0
FOO	4.1	4.3	2.7	2.8	2.9	3.1	4.1	3.8
TEX	0.0	0.1	0.1	0.6	0.4	0.2	0.2	0.1
WAP	0.1	0.7	0.2	0.3	0.4	0.6	0.7	0.3
WOO	0.5	0.6	0.3	0.7	0.4	0.7	0.9	0.5
PPP	1.7	1.4	2.1	1.5	1.8	1.3	3.0	1.1
CHM	0.4	1.3	2.3	3.1	2.7	3.3	2.6	1.1
P_C	1.5	0.4	0.9	1.3	0.9	3.0	1.6	0.5
SCP	0.6	0.9	0.5	1.4	0.7	0.9	0.8	1.0
FEM	0.4	0.4	0.6	1.4	1.2	2.9	0.3	0.9
NFM	0.0	0.4	0.4	0.7	0.4	0.4	0.5	0.2
MET	0.6	1.0	1.1	1.9	1.7	1.1	1.0	0.8
MAC	0.9	6.8	6.2	7.5	6.5	5.1	3.9	4.3
TMC	0.5	0.6	1.7	6.7	1.0	2.5	0.8	1.2
OIP	0.2	0.5	0.7	1.1	0.8	0.7	0.4	0.5
CNS	9.5	8.9	6.5	7.0	7.0	7.5	7.7	8.1
EGW	2.5	5.5	2.4	2.7	3.5	3.1	3.2	3.1
TRD	13.3	11.9	14.2	13.9	13.8	11.6	11.5	12.5
FIN	16.1	15.3	17.6	11.7	17.5	13.9	15.7	16.1
TRN	6.0	4.6	4.1	4.4	4.4	5.9	5.3	5.2
SER	35.4	30.4	34.4	28.0	31.5	30.3	32.0	35.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6: GDP and welfare effects (the benchmark case)

	ΔGDP	ΔpcGDP	GDP (%)	EV	pcEV	Welfare (%)
HOK	77.7	13.7	0.39	-4.3	-0.8	-0.03
TOH	121.7	12.4	0.36	61.2	6.2	0.23
KAN	837.8	16.8	0.38	1,065.4	21.4	0.63
CHB	305.9	23.0	0.53	366.0	27.5	0.89
KIN	396.9	18.3	0.45	456.3	21.0	0.66
CHG	142.6	18.4	0.48	96.1	12.4	0.45
SIK	62.3	15.0	0.43	28.8	6.9	0.25
KYU	176.7	12.0	0.37	51.2	3.5	0.13
Japan	2,121.6	16.7	0.41	2,120.8	16.7	0.54

ΔGDP: the change in regional GDP (billions of yen).

ΔpcGDP: the change in per capita regional GDP (thousands of yen).

GDP (%): the percentage change in regional GDP.

EV: equivalent variation (billions of yen).

pcEV: per capita equivalent variation (thousands of yen).

Table 7: Rank of GDP and welfare effects (the benchmark case)

	Rank
Per capita GDP	KAN > CHB > KIN > CHG > HOK > SIK > TOH > KYU
ΔpcGDP	CHB > CHG > KIN > KAN > SIK > HOK > TOH > KYU
pcEV	CHB > KAN > KIN > CHG > SIK > TOH > KYU > HOK

Table 8: Decomposition of change in per capita GDP (thousands of yen)

Region	C	I	X	M	DX	DM	Sum
HOK	1.1	-1.9	8.8	-58.7	9.8	54.6	13.7
TOH	8.1	-1.8	33.0	-51.8	-3.8	28.7	12.4
KAN	18.9	2.5	48.5	-54.3	-4.4	5.6	16.8
CHB	22.9	4.6	100.2	-56.0	-28.9	-19.8	23.0
KIN	19.5	1.6	43.6	-61.4	-6.2	21.2	18.3
CHG	11.4	1.0	57.9	-49.8	-8.2	6.1	18.4
SIK	7.5	-0.5	107.0	-51.9	-33.9	-13.1	15.0
KYU	4.3	-0.8	61.7	-44.0	-8.9	-0.2	12.0
Japan	15.3	1.4	54.1	-54.1	-8.3	8.3	16.7

C: contribution of consumption.

I: contribution of investment.

X: contribution of exports to foreign countries.

M: contribution of imports from foreign countries.

DX: contribution of exports to other domestic regions.

IM: contribution of imports from other domestic regions.

Table 9: Decomposition of per capita EV (thousands of yen)

Region	FI	TR	GE	Sum
HOK	18.5	-8.8	-10.4	-0.8
TOH	22.1	-8.4	-7.5	6.2
KAN	31.4	-5.8	-4.2	21.4
CHB	36.6	-4.0	-5.1	27.5
KIN	33.3	-7.2	-5.1	21.0
CHG	28.4	-9.2	-6.8	12.4
SIK	26.5	-11.4	-8.1	6.9
KYU	22.3	-12.0	-6.9	3.5
Japan	29.6	-7.3	-5.6	16.7

FI: contribution of factor income.

TR: contribution of transfer income.

GE: contribution of government expenditures.

Table 10: Percentage change in output (%, benchmark case)

	HOK	TOH	KAN	CHB	KIN	CHG	SIK	KYU
AGR	-11.9	-13.5	-15.2	-15.8	-15.0	-13.8	-14.6	-13.7
MIN	2.8	2.1	0.1	-0.7	0.4	1.3	0.9	2.5
FUE	-1.4	-2.3	-4.7	-8.3		-6.4		-4.5
FOO	-4.9	-8.4	-11.5	-12.0	-12.4	-11.4	-12.3	-10.6
TEX	-5.9	-7.0	-9.8	-9.8	-10.0	-8.9	-11.3	3.5
WAP	-13.6	-10.6	-12.7	-12.7	-12.4	-12.5	-12.8	-12.5
WOO	5.6	2.4	-2.6	-3.1	-2.4	0.3	0.6	-0.2
PPP	3.5	1.0	-1.1	-1.8	-1.2	-0.4	0.4	-1.0
CHM	0.6	1.5	0.1	-1.1	-0.5	3.4	1.9	1.7
P_C	1.7	-1.7	0.1	-0.4	0.1	0.9	-0.2	0.9
SCP	1.4	1.8	0.4	0.3	1.6	0.6	0.6	1.4
FEM	5.9	4.9	3.8	3.0	4.7	5.9	13.5	9.8
NFM	3.9	5.5	4.0	2.4	4.0	4.8	3.4	5.7
MET	1.5	2.0	0.4	-0.6	0.6	0.3	1.3	1.0
MAC	0.7	6.2	4.1	2.4	4.5	3.0	10.1	9.2
TMC	15.4	2.1	7.3	9.9	9.8	9.0	92.1	27.8
OIP	-1.2	0.8	-2.0	-2.3	-0.4	-0.6	-2.6	0.3
CNS	-0.1	-0.2	0.1	0.2	0.1	0.1	-0.1	-0.1
EGW	0.7	1.4	-0.1	0.2	0.1	1.0	0.7	0.5
TRD	1.8	0.9	-0.1	-1.5	-0.2	-0.6	-1.2	-0.5
FIN	0.4	0.0	0.0	-0.2	-0.1	-0.2	0.0	-0.2
TRN	1.4	-0.2	0.6	-0.9	0.2	-0.2	-1.4	-0.4
SER	0.7	0.4	0.1	0.0	0.2	0.0	-0.1	0.1

Table 11: Sensitivity analysis

Scenarios	Regions	ΔGDP	ΔpcGDP	GDP (%)	EV	pcEV	Welfare (%)
BM	HOK	77.7	13.7	0.39	-4.3	-0.8	-0.03
	TOH	121.7	12.4	0.36	61.2	6.2	0.23
	KAN	837.8	16.8	0.38	1,065.4	21.4	0.63
	CHB	305.9	23.0	0.53	366.0	27.5	0.89
	KIN	396.9	18.3	0.45	456.3	21.0	0.66
	CHG	142.6	18.4	0.48	96.1	12.4	0.45
	SIK	62.3	15.0	0.43	28.8	6.9	0.25
	KYU	176.7	12.0	0.37	51.2	3.5	0.13
	Japan	2,121.6	16.7	0.41	2,120.8	16.7	0.54
A	HOK	75.3	13.3	0.37	50.3	8.8	0.31
	TOH	118.7	12.1	0.35	99.3	10.1	0.37
	KAN	821.4	16.5	0.37	923.8	18.6	0.54
	CHB	301.9	22.7	0.53	283.1	21.3	0.69
	KIN	389.1	17.9	0.44	453.1	20.9	0.66
	CHG	140.1	18.1	0.48	106.8	13.8	0.50
	SIK	61.0	14.7	0.42	40.1	9.6	0.35
	KYU	173.2	11.7	0.36	123.7	8.4	0.32
	Japan	2,080.8	16.4	0.41	2,080.1	16.4	0.53
B	HOK	78.1	13.7	0.39	95.0	16.7	0.58
	TOH	122.0	12.4	0.36	164.2	16.7	0.62
	KAN	838.3	16.8	0.38	832.4	16.7	0.49
	CHB	305.6	23.0	0.53	222.6	16.7	0.54
	KIN	397.1	18.3	0.45	362.6	16.7	0.53
	CHG	142.6	18.4	0.48	129.3	16.7	0.60
	SIK	62.4	15.0	0.43	69.5	16.7	0.61
	KYU	177.1	12.0	0.37	246.9	16.7	0.63
	Japan	2,123.2	16.7	0.41	2,122.4	16.7	0.54
C	HOK	71.6	12.6	0.35	-28.7	-5.1	-0.17
	TOH	119.3	12.2	0.35	39.7	4.0	0.15
	KAN	820.7	16.5	0.37	1,067.1	21.4	0.63
	CHB	300.1	22.5	0.52	389.4	29.3	0.95
	KIN	389.2	17.9	0.44	461.3	21.3	0.67
	CHG	137.0	17.7	0.47	99.0	12.8	0.46
	SIK	56.7	13.6	0.39	12.7	3.1	0.11
	KYU	169.9	11.5	0.35	22.4	1.5	0.06
	Japan	2,064.6	16.3	0.40	2,062.8	16.3	0.52

(continued)

Scenarios	Regions	ΔGDP	ΔpcGDP	GDP (%)	EV	pcEV	Welfare (%)
D-1	HOK	112.5	19.8	0.56	13.1	2.3	0.08
	TOH	156.0	15.9	0.46	92.1	9.4	0.35
	KAN	1,030.5	20.7	0.47	1,259.0	25.3	0.74
	CHB	353.0	26.5	0.62	417.8	31.4	1.02
	KIN	511.4	23.6	0.58	569.5	26.3	0.83
	CHG	176.8	22.9	0.60	127.1	16.4	0.59
	SIK	80.6	19.4	0.56	48.5	11.7	0.43
	KYU	217.5	14.7	0.45	110.1	7.5	0.28
	Japan	2,638.3	20.8	0.52	2,637.1	20.8	0.67
D-2	HOK	43.4	7.6	0.22	-20.6	-3.6	-0.13
	TOH	88.3	9.0	0.26	32.7	3.3	0.12
	KAN	645.4	13.0	0.29	876.7	17.6	0.52
	CHB	257.5	19.3	0.45	313.8	23.6	0.77
	KIN	288.5	13.3	0.33	344.3	15.9	0.50
	CHG	110.6	14.3	0.38	66.1	8.5	0.31
	SIK	46.8	11.3	0.32	11.3	2.7	0.10
	KYU	136.6	9.3	0.28	-7.7	-0.5	-0.02
	Japan	1,617.1	12.7	0.32	1,616.6	12.7	0.41
E	HOK	65.9	11.6	0.33	-59.6	-10.5	-0.36
	TOH	68.6	7.0	0.20	-18.5	-1.9	-0.07
	KAN	370.4	7.4	0.17	595.9	12.0	0.35
	CHB	89.1	6.7	0.16	240.8	18.1	0.59
	KIN	208.3	9.6	0.24	265.8	12.3	0.39
	CHG	59.8	7.7	0.20	26.3	3.4	0.12
	SIK	25.8	6.2	0.18	-12.7	-3.0	-0.11
	KYU	74.6	5.1	0.15	-76.8	-5.2	-0.20
	Japan	962.6	7.6	0.19	961.4	7.6	0.24
F	HOK	22.2	3.9	0.11	15.5	2.7	0.09
	TOH	55.8	5.7	0.17	50.4	5.1	0.19
	KAN	500.7	10.1	0.23	599.1	12.0	0.35
	CHB	218.6	16.4	0.38	194.1	14.6	0.47
	KIN	208.9	9.6	0.24	225.4	10.4	0.33
	CHG	91.4	11.8	0.31	62.8	8.1	0.29
	SIK	37.0	8.9	0.26	27.5	6.6	0.24
	KYU	103.5	7.0	0.21	63.1	4.3	0.16
	Japan	1,238.0	9.8	0.24	1,238.0	9.8	0.31

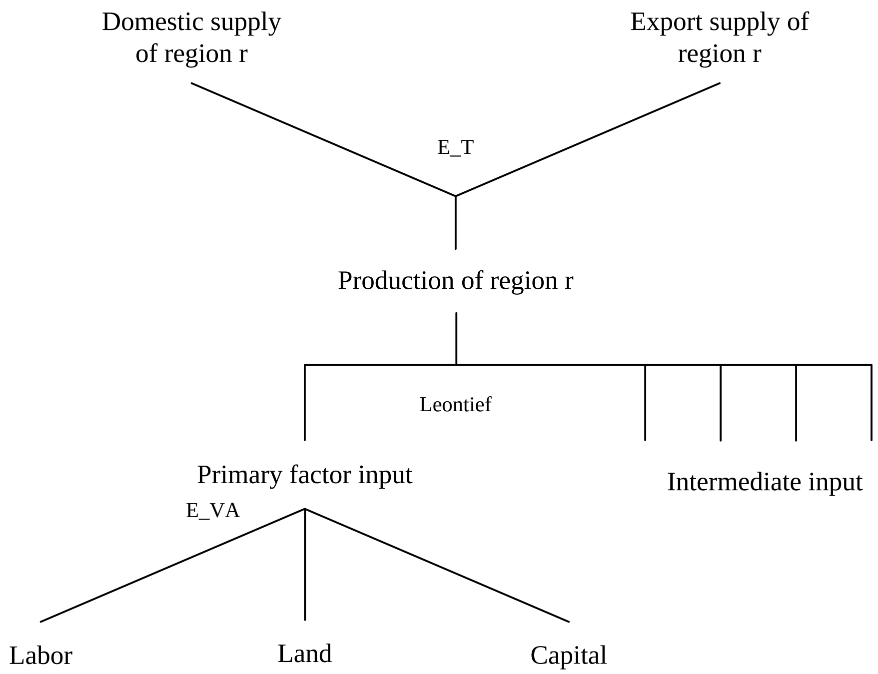

Figure 1: Production function.

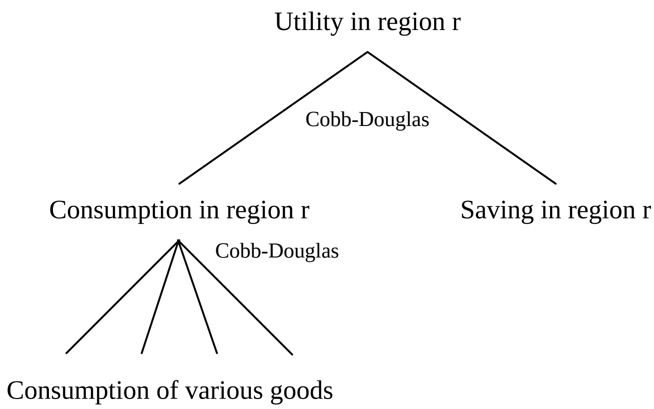

Figure 2: Utility function.

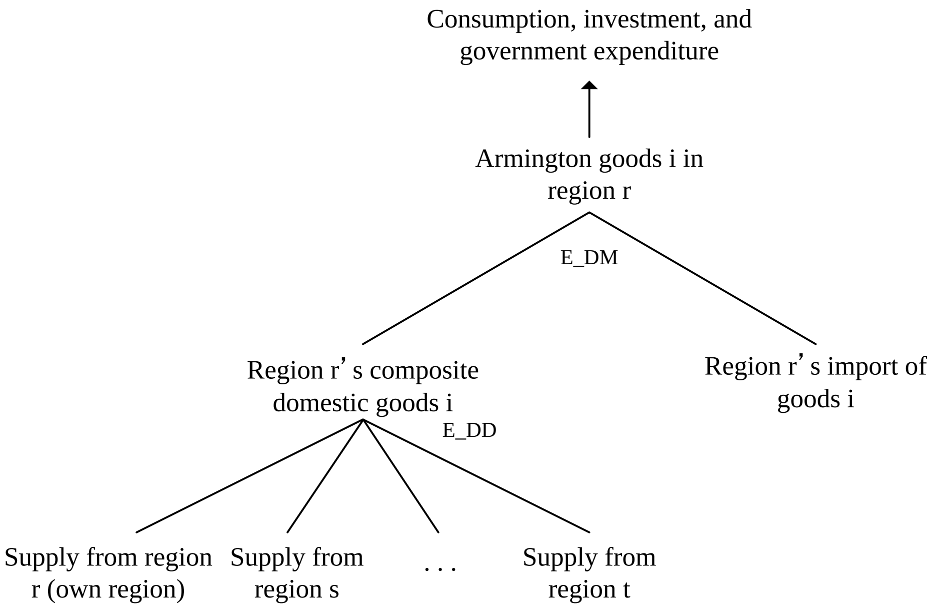

Figure 3: Armington aggregation structure.