# Productivity Shock and National Food Security for Japan

Tetsuji Tanaka[a*] and Nobuhiro Hosoe[b†]

[a]Graduate School of Arts and Sciences, University of Tokyo

[b]National Graduate Institute for Policy Studies

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# 1 Introduction

## 1.1 National Food Security and Japan's Agricultural Policy

Self-sufficiency rate of food has been regarded as a key indicator for Japanese agricultural policy. Japan's self-sufficiency rate is only 40% on a calorie basis, which

*3-8-1 Komaba, Meguro, Tokyo 153-8902, Japan E-mail address: cc57606@mail.ecc.u-tokyo.ac.jp

†7-22-1 Roppongi, Minato, Tokyo 106-8677, Japan Tel: +81-3-6439-6129; Fax: +81-3-6439-6010

E-mail address: nhosoe@grips.ac.jp

is clearly lower than that in other major developed countries. While this low food self-sufficiency is a result of outstanding comparative advantage of Japan's industrial sectors, it brings us a concern of food shortage caused by unexpected events, such as crop failure by bad weather, war, and embargo. Actually, bad weather reduced rice harvest by one-quarter compared with average yield in 1993. There were a soybean embargo due to serious crop failure in the US in 1973 and a grain embargo in response to the USSR's invasion in Afghanistan in 1980. These unexpected events brought concerns about excessive dependency of food supply on imports to Japanese people. They are regarded as important risk factors when Japanese government considers "national food security". The central idea of national food security is how to secure food consumption under such uncertainty of food production and supply in Japan[1].

Among various foods, rice is the most important commodity for Japan. Rice composes 28% of total calorie intake, followed by wheat, which contributes to 13% of total calorie intake in 2001. In expenditure, rice has a share of 29% in total food consumption[2]. Paddy rice sector is the Japan's largest agricultural sector and composes 28% of agricultural value added. The rice sector is, thus, the core sector which is supporsed to be strictly protected from foreign suppliers with an eventual import ban for the sake of

[1]This concept of "national food security" is a unique concept compared with the concept of "food security", which is often discussed in the context of development under increasing population and continuing poverty. Hayami(1997)[10] clarifies their difference.

[2]Source: FAOSTAT

national food security. This high trade barrier is now one of major targets of increasing pressures toward free trade.

Overall impacts of agricultural trade liberalization consist of (1) deterministic efficiency improvements by removal of trade barriers and (2) probabilistic gains and losses from productivity shocks, whose magnitude can be exacerbated or mitigated in accordance with trade openness. We have often analyzed the first aspect of trade liberalization but have rarely done the second. This lack of analysis sometimes drives people to be against trade liberalization without assessing the overall impacts of these two aspects. Only when we take both of them into account at once, we can evaluate whether trade liberalization is really beneficial for national welfare and whether it is a risk factor for national food security.

To answer to the question mentioned above, we develop a stochastic computable general equilibrium (CGE) model focusing on rice sectors in Japan and her rice trade partners. We simulate abolition of import tariffs of paddy rice and/or productivity shocks at a paddy rice sector in Japan and other countries with a Monte Carlo method. In addition, we evaluate effectiveness of buffer stocks, which Japanese government prepared for bad crops and other emergency situations in food supply.

## 1.2 Rice Trade and its Barrier

Japan has strictly prohibited imports of paddy rice but recently permited minimum access imports of rice as a part of the Uruguay Round agreements. Its amount is, however, only 879 thousand tonnes, which is equivalent to 9.3 % of domestic production. Effective trade barrier is estimated higher than 800% (Table 2). While such import penetration is increasing year-by-year, domestic production and consumption of rice is gradually declining as Engel's law predicts (Fig. 2). Because imports of agricultural goods other than rice are extensively carried out, self-sufficiency rate of food are generally very low. Japanese rice farmers and Ministry of Agriculture, Forestry, and Fishery (MAFF) concern that trade liberalization will be also applied to the rice sector in future negotiations for bilateral and multilateral trade liberalization. Thus, their political activities increasingly become strong to protect their domestic market.

Japanese rice consumption is concentrated upon mid- or short-grain rice (a so-called Japonica rice), rather than long-grain rice. The former type of rice is strongly preferred by East Asian countries; the latter type is very popularly produced and consumed in Asian countries. Trade patterns of rice by Japan reflect this tendency (Table 2). There are three major partners for Japan: China, the US, and Australia, which produce Japonica rice[3].

[3]The original data in the GTAP database reports some amount of paddy rice exports by Japan to the rest of Asia (ROA), partly because this is for the purpose of development assistance for near-by

As most of rice is domestically produced and domestically consumed, rice trade is found thin. This means that only a small fraction of domestic production is exported and imported internationally. This characteristic shows clear contrast to other merchandise agricultural commodities, like wheat. Top ten countries produce almost 90% of world total production (Table 4). They are mainly Asian countries, where a climate of high temperature and high humidity is dominating. Their production fluctuates mainly by weather condition. Droughts and cool summer days reduce rice production significantly. While productivity (measured by yields per hectare) seems to have an upward-sloping trend, it sometimes shows sudden drops (Fig. 1). Japan actually experienced a 25% drop of rice yield in 1993.

Once we liberalize the rice market of Japan, shocks in domestic and foreign market directly affect such a thin international markets. Furthermore, taking account of the strong preference toward Japonica rice in Japan, the international market seems much less reliable as an alternative supply source for Japan.

## 1.3 Literature Review

The majority of analysis about rice import barriers by Japan has employed with partial equilibrium framework. For example, Wailes (2005)[9] developed a spatial par-

developing economies, and partly because this is to reduce supply of imported minimum access rice to the domestic market.

tial equilibrium model for the world rice markets to analyze rice trade liberalization. With the same framework, Cramer *et al.* (1993)[1] analyzed impacts of rice tariffication by Japan.

As those analyses employed partial equilibrium models, welfare impacts are evaluated in terms of producer surplus and consumer surplus only for the rice sector. However, substitutability is expected between commodities in household consumption; intersectoral linkages are often assumed in production process. In addition, if impacts of productivity shock are expected to be significant enough to affect a macro economy, there arise not only substitution effects by changes of relative prices but also significant income effects. We need to assess macroeconomic impacts of barriers on rice imports with a general equilibrium framework.

In contrast to partial equilibrium analysis, general equilibrium assessments of Japan's rice sector are scant. For example, Nakajima (2005)[7] employed GTAP-based CGE model to analyze impacts of formation of East Asian Free Trade Area in combination with policy measures to protect Japan's rice sector. Hosoe (2004)[3] developed a CGE model and evaluated how significantly the domestic rice price regulation exacerbated the adverse impacts of the actual productivity shock in Japan in 1993 and how much windfall benefits Japan's emergency rice imports brought about to the rice-exporters to Japan. Hosoe (2004)[3] found substitution between commodities in household consumption would play a significant role in evaluation of welfare impacts of shocks to the rice sector. However, the productivity shock was assumed to experience a deterministic shock, whose magnitude was calibrated to reproduce the historical event of bad crop in 1993.

In assessment of the national food security, we have to consider not only the actual magnitude of the productivity shock but also have to expect smaller and larger magnitude. As for the location of shocks, we can expect productivity shocks in all the countries, other than Japan, too. Our stochastic world trade CGE model in combination with a Monte Carlo method provides a comprehensive framework to analyze international rice markets under uncertainty. This technique has been employed by Harris and Robinson (2001)[5] for analysis about impacts of weather fluctuations induced by El Niño to agricultural sectors with a world trade stochastic CGE model. In their model, productivity of value added was randomized to represent general agricultural productivity shocks and the El Niño-induced ones.

In sum, while there have been quite a lot of debate over national food security in Japan, few have ever considered fluctuation or contingent supply shocks in agricultural sector to evaluate real benefit or possible losses caused by trade liberalization. Though conventional CGE analysis provide a baseline for analysis of agricultural trade liberalization, we need to take account of stochastic property of agricultural productivity in our CGE analysis. We develop a world trade stochastic CGE model in the next section.

# 2 Model and Scenarios

## 2.1 Basic Structure of World Trade Stochastic CGE model

While employing the basic model structure developed by Devarajan *et al.* (1990)[6], we extend the model to analyze the rice sector with uncertainty of productivity. Reflecting the fact that rice trade partners for Japan are limited to Asia-Pacific countries (Table 2), and we distinguish 12 countries using GTAP database version 6 (Table 1). Each country has eight sectors, particularly focusing on rice and other food sectors. Each sector is represented by a profit-maximizing firm with Leontief type production function for gross output and with Cobb-Douglas (CD) type production function for value-added (Fig. 3). Among value added components, capital is assumed to be immobile between sectors, but labor is mobile between sectors. International factor mobility is not assumed. These factors are assumed to be fully employed with flexible factor price adjustment.

Sectoral outputs are split into domestic sales and composite exports using a constant elasticity of transformation (CET) function. The domestic sales and composite imports are aggregated into composite goods with a constant elasticity of substitution (CES) function following Armington (1969)[4]. The composite imports consist of imports (or transportation) from various countries; the composite exports are decomposed into exports to various countries. We use elasticity of substitution suggested in GTAP database for these CES/CET functions. Current account surplus/deficit is set constant in US dollar terms for each country. Exchanges rates are flexibly adjusted so as to achieve the current account balance for each country[4].

## 2.2 Simulation Scenarios

### 2.2.1 Scenario Design

To evaluate overall impacts of trade liberalization of rice market in Japan we consider two scenario factors (1) abolition of trade barriers by Japan and (2) uncertainty of productivity in the paddy rice sector. We assume that productivity shocks can randomly happen in the process of gross output production in all the rice-producing countries. When adverse productivity shocks are anticipated, we can take a counter-measure like (3) buffer stocks to mitigate supply shortages of rice. Considering all these three scenario factors, we set nine scenarios (Table 5). The first two Scenarios T0 and T1 are employed in conventional trade liberalization analysis as the base run and a counterfactual run only taking account of abolition of trade barriers of rice imports by Japan. The following six Scenarios R0, R1, J0, J1, A0, and A1 are set to investigate impacts of trade liberalization subject to productivity shocks in Japan, the rest of Japan (ROJ),

[4]Other than international trade of conventional commodities and services discussed above, there is another international transaction of "international transportation service." We followed Hertel and Tsigas (1997)[8] regarding treatments for this service.

and in all over the world. The last Scenario S is set to analyze effectiveness of Japan's buffer stocks prepared for adverse productivity shocks in her domestic sector. Details of those scenario factors are explained below.

#### 2.2.2 Abolition of Trade Barriers

We assume unilateral abolition of tariff and non-tariff barriers by Japan, which are reported by GTAP database version 6. Originally, Japan sets quite a high tariff and non-tariff barriers on paddy rice imports from her major rice trade partners. The tariff and non-tariff barriers are higher than 800% in terms of import tariff equivalent rate (Table 2).

#### 2.2.3 Assumptions for Productivity Shocks and Buffer Stocks

We estimate variances of paddy rice productivity of the ten countries/regions distinguished in our CGE model based on time series data for 15 years provided by FAOSTAT while controling only their time trend (Table 3). We assume that paddy rice productivity is iid normal variables with these estimated variances. We carry out 1,000 simulation draws for each scenario with the distribution of productivity.

On one hand, when an adverse productivity shock takes place in Japan–whose output is almost perfectly for her own consumption–, domestic consumption will deteriorate but will be partly compensated with imported rice. Similarly, when an abundant rice crop takes place in Japan, she can have a part of its surplus absorbed abroad. As trade liberalization of paddy rice increases her accessibility to foreign rice markets, fluctuation of her rice supply can be more flexibly smoothed through imports. In view of distribution of domestic welfare, given the same magnitude of productivity shocks, trade liberalization will shifts the mean of welfare distribution upward–as conventional trade analysis tells us–and will decrease variance of welfare distribution (Fig. 5). In this case, whether productivity shock is negative or positive, trade liberalization will always bring about preferable impacts to welfare distribution (the upper panel of Fig. 4).

On the other hand, when an adverse productivity shock takes place in the rest of Japan, particularly in China, the US, and Australia, Japan's imports from these countries will decline. Trade liberalization of paddy rice increases Japan's dependency of rice supply on such foreign markets and thus can exacerbate adverse impacts of their productivity shock to Japan. This is the point that agricultural protectionists take serious. However, if a positive productivity shock (i.e., good crop) takes place in other countries, Japan conversely can gain for the same reason. As long as we expect symmetric distribution of productivity shocks abroad, such productivity shocks *per se* will not seriously deteriorate the mean of welfare distribution in Japan but will just increase its variance while trade liberalization brings her deterministic gains through improvements of resource allocation (the lower panel of Fig. 4). Wrapping up these two impacts to get the overall welfare impacts, we cannot immediately judge whether trade liberalization is always welfare improving or not. The thicker lower tail of the welfare distribution under free rice trade implies that trade liberalization might significantly increase the number of cases where welfare under free rice trade is lower than welfare without rice trade liberalization.

#### 2.2.4 Buffer Stocks

The size of buffer stocks is assumed to be as much as 1.5 million tonnes, which is officially kept by Japanese government and is equivalent to about 15% of Japan's annual production. We assume that this buffer stock is released only when a negative productivity shock takes place in Japan so as to maintain the original amount of her paddy rice supply.

When the lost amount of paddy rice production exceeds the size of buffer stocks prepared in advance, market mechanism starts to work with a flexible adjustment of price. As a result, a part of distribution of rice supply is truncated (Fig. 5). For simplicity, we assume the buffer stocks were prepared before the shocks and that there is no capital gains or losses in connection with the release of buffer stocks. By subtracting the maintenance costs of the buffer stocks from the expected social benefits of the buffer stocks measured by equivalent variations, we can quantify net benefits of the buffer stocks.

# 3 Simulation Results

## 3.1 Deterministic Impacts of Trade Liberalization

When we assume abolition of all the tariff and non-tariff barriers on paddy rice imports Japan (Scenario T1), we obtain straightforward results (Table 6). Imports of paddy rice would surge to reduce domestic production in Japan. As the paddy rice sector is tightly connected with the processed rice sector through input-output structure, its production and thus consumption would be also increased[5]. As a result, overall welfare impacts measured with equivalent variations (EV) would be improved by 2,651 million US dollars, which is 0.066% of Japan's GDP (Table 7). Major rice trade partners of Japan would generally gain more than others would.

This result provides a reference point, which conventional trade liberalization analysis shows. In the following six simulations, we consider fluctuation of paddy rice productivity in Japan, in the rest of Japan (ROJ), and in all over the world. Monte Carlo simulations yield distribution of various economic variables, such as output, consumption, EV, etc.

[5]It is not common to directly consume paddy rice but to consume processed rice, which is made by thrashing paddy rice. Thus, it makes sense for us to refer changes of consumption of processed rice rather than that of paddy rice.

## 3.2 Productivity Shocks in the Rest of Japan

Protectionists are concerning that when we are heavily dependent on foreign supply for rice, food supply could be insecure due to, for example, unseen productivity shocks in the ROJ. When we carry out Monte Carlo simulations with Scenarios R0 and R1 and compare their results with others, we can answer whether their concerns are reasonable or not. The results of Scenario R0 show eventually no change in mean of EV but some variance of EV, while the results of Scenario T0 are all deterministic. (Table 8)[6]. The result of $Pr\{EV < EV_{T1}\}$ in Scenario R0 as well as Scenario J0 and A0 indicates that there would be no statistically significant chance for Japan to attain the deterministic gain achieved in Scenario T1 without liberalizing rice imports.

Abolition of trade barriers on paddy rice imports increases penetration of foreign rice, which is subject to uncertainty of productivity. This situation is described by Scenario R1 in Table 8. Its simulation results show that trade liberalization would increase both mean and variance of EV. As discussed in 3.1, this increase of variance itself is often regarded as a risk factor for Japan. The trade liberalization would increase variance of welfare to some extent but would not be so large that it could provide sta-

[6]Even if we do not assume any trade liberalization of paddy rice, EV is found consistently slightly negative in Scenarios R0, J0, and A0. This is due to concavity of utility function we assume. Though we assume normal distribution for productivity shocks, which is risk neutral from an aggregate viewpoint, the Cobb-Douglas type utility function is a risk-averse utility function. Thus, mean of EV is always less than zero.

tistically significant chance for negative welfare impacts to take place as the collumn of $Pr\{EV < 0\}$ suggests.

## 3.3 Productivity Shocks in Japan

There is no reason why we assume productivity shocks only in the ROJ. Once we assume productivity shocks in Japan, the value of trade liberalization under productivity shocks can be assessed from a different viewpoint. The simulation results of Scenario J0 show that productivity shocks in the domestic sector but without trade liberalization would bring about significant magnitude of variance of EV as the shock is assumed to directly hit the domestic market. In this case, the domestic market is eventually isolated from alternative supply sources in foreign countries due to high trade barriers assumed in Scenario J0 (Table 8).

Given the productivity shocks in Japan, the trade liberalization would bring about a double-dividend for Japan (Scenario J1). That is, while mean of EV would increase, variance of EV would decrease. This implies that higher welfare level is guaranteed more securely by trade liberalization. By integrating the domestic market with foreign ones, we can pool risk of productivity shocks internationally. As the column of $Pr\{EV < 0\}$ in Table 8 shows, no possibility of welfare deterioration would be expected under free trade.

### 3.4 Overall Impacts of Productivity Shocks

Comparing the simulation results of Scenarios R0, R1, J0, and J1 with each other, the impacts of productivity shocks in Japan are found dominating those in ROJ. Thus, when we simulate perfectly random productivity shocks in all over the world with and without trade liberalization, simulation results of Scenarios A0 and A1 are generally similar to those of Scenarios J0 and J1, respectively. These results do not support the idea that trade liberalization in combination with productivity shocks should be a risk factor for Japanese economy.

### 3.5 Effectiveness of Buffer Stocks

Buffer stocks are one of common measures to cope with bad crops. Because of restructuring of Japan's food system lead by government, the rice supply shock in 1993 was exacerbated partly by the small amount of rice stocks (0.23 million tonnes) covering only 8% of the annual production. After the bad crop event in 1993, the government increased buffer stocks up to as much as 1.5 million tonnes. We quantify the effectiveness of such buffer stocks prepared for bad crop periods. By the way, to reflect the current situation with high border barriers on paddy rice imports, we do not consider trade liberalization but productivity shocks in all over the world in this particular Scenario S. By comparing simulation results of Scenario A0 with those of Scenario S, we can find benefits of buffer stocks.

In our Monte Carlo simulations with 1,000 draws, there are 530 cases of negative productivity shocks in Japan. The buffer stocks are found large enough to fully cover the lost rice yield in 95.9% of those negative productivity cases. Buffer stocks would increase mean of EV by 50.5 million US dollars, compared with the result of Scenario A0; variance of EV would be slightly decreased.

The issue is how much effectively the buffer stocks could mitigate welfare deterioration. According to MAFF (2001)[2], total storage costs of the buffer stocks are estimated as much as 150 million US dollars per year. When we regard only the improvements in mean of EV as the social benefit of the buffer stocks– omitting procurement costs of buffer stocks–, the buffer stocks would not seem worthy to maintain. We should reduce the amount of buffer stocks or should keep them somewhere abroad, where cheaper storage costs are offered.

# 4 Concluding Remarks

Major findings of our analysis are as follows. (1) There is no statistically significant chance for Japanese economy to be worse off by trade liberalization of rice even though the trade liberalization would increase fluctuations of her welfare caused by productivity shocks abroad. (2) When productivity shocks are assumed in the domestic rice sector in Japan, trade liberalization of rice would contribute to both increases of expected welfare and decreases of welfare fluctuations. Among these two cases in regard to location of productivity shocks, the latter impacts are found overwhelming. In sum, there would be no reason to support the idea to protect the domestic rice market in Japan in accordance with the national food security.

In addition, (3) the current policy to secure rice supply with buffer stocks would not be effective in the sense that the expected gains achieved by the buffer stocks would be clearly less than their annual maintenance costs. It implies the optimal size of the buffer stock should be much less than the current size.

There are some reservations for our analysis. In our Monte Carlo simulations, we assumed that productivity shocks follow normal distribution. However, nature sometimes brings disastrous crop failures. Households are generally regarded as risk-averse agents, who are very sensitive to a slight shortfalls of essential commodities, particularly food, but do not enjoy good harvest so much once they are satisfied with some amount of food consumption in developed countries. We may need to extend our simulation considering choice of functional forms for the productivity shocks and household utility.

In regard to buffer stocks, there are rice stocks as inventories held by dealers, other than the official buffer stocks. Such private inventories also contribute to mitigating shortfalls of rice supply to some extent. Our simulation results about the effectiveness of the official buffer stocks would be found much smaller when we consider such private stocks, too.

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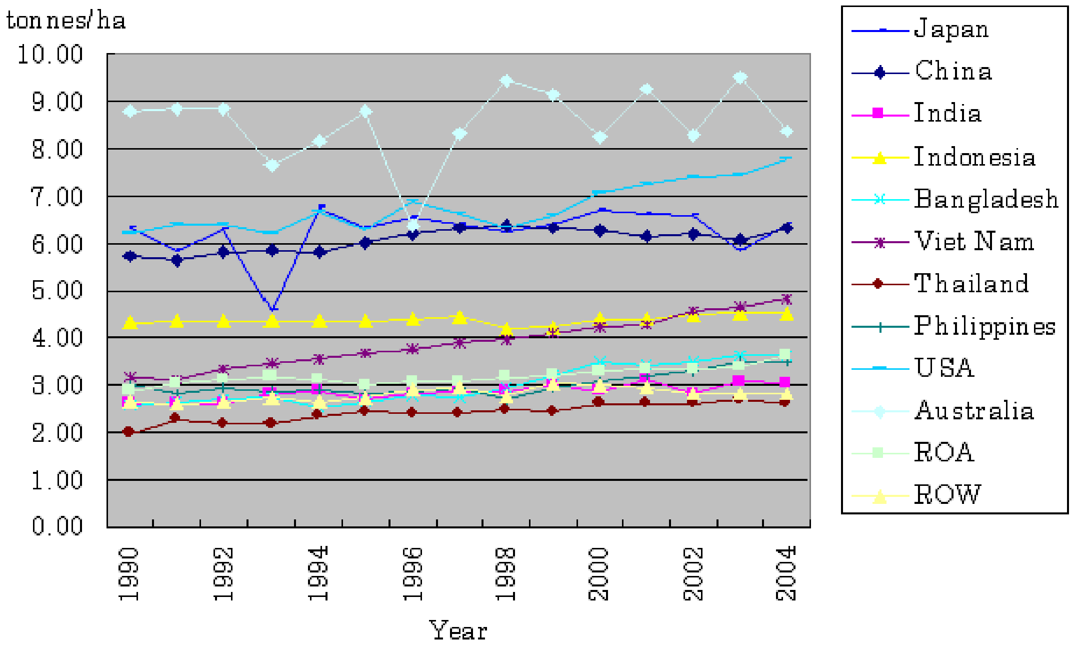


Fig. 1: Paddy Rice Productivity Fluctuation by Country

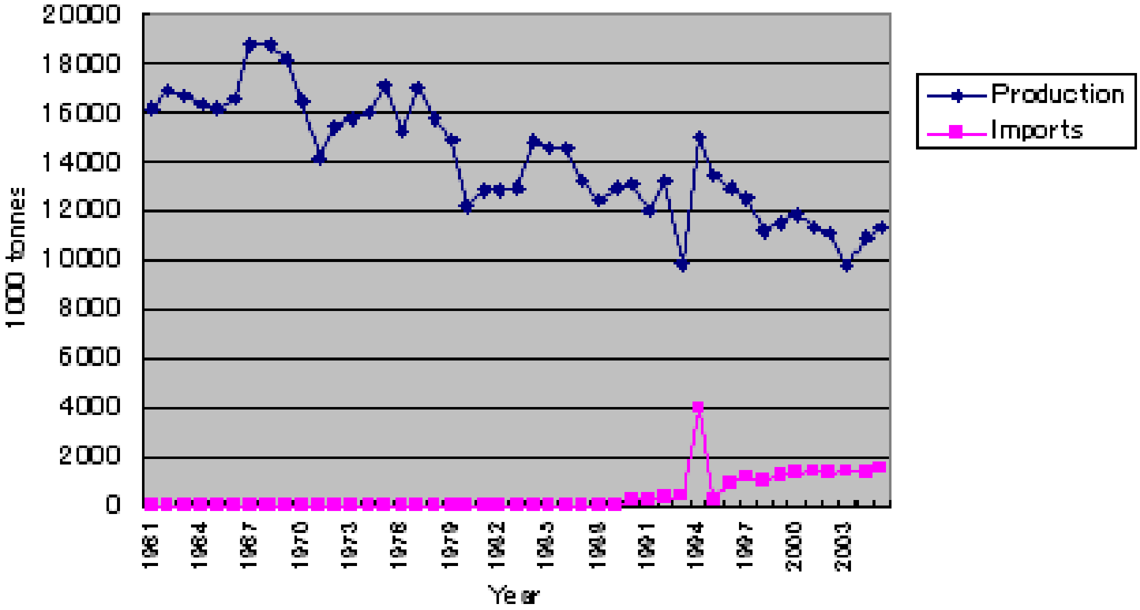


Fig. 2: Rice Production and Imports

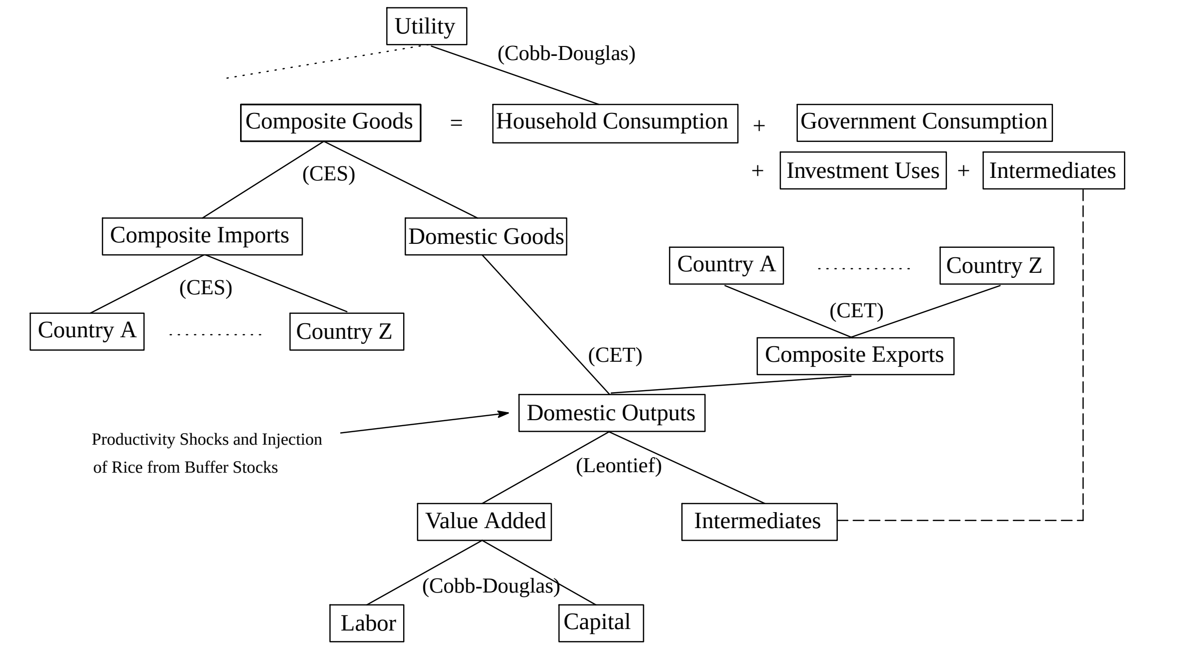


Fig. 3: Model Structure

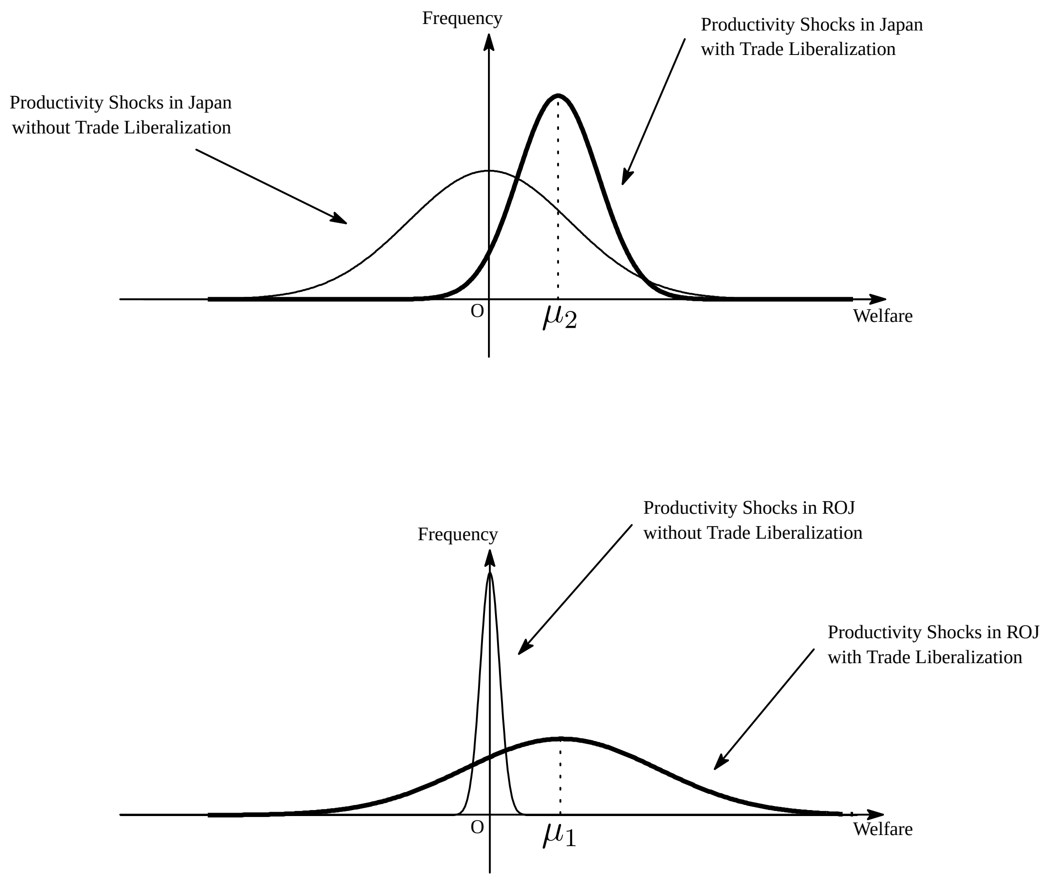


Fig. 4: Impacts of Productivity Shocks and Trade Liberalization on Distribution of Japan's Welfare

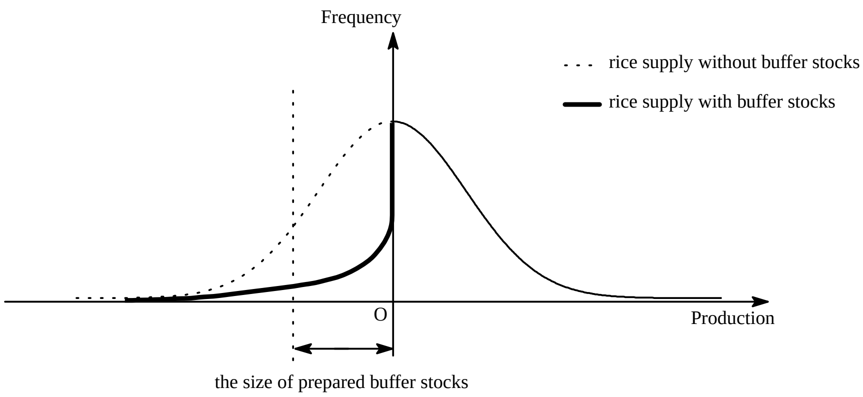


Fig. 5: The Distribution of Rice Supply Considering Buffer Stocks

Table. 1: Country, Regions, and Sectoral Aggregation

| Country/Region | Abbreviation | Sector/Commodity | Abbreviation |
|---|---|---|---|
| Japan | JPN | Paddy Rice | PDR |
| China | CHN | Wheat | WHT |
| India | IND | Other Agriculture | AGR |
| Indonesia | IDN | Processed Rice | PCR |
| Bangladesh | BGD | Other Food | FOD |
| Vietnam | VNM | Manufacturing | MNF |
| Thailand | THA | Services | SRV |
| Philippines | PHL | Transportation | TRS |
| USA | USA | | |
| Australia | AUS | Capital | CAP |
| the rest of Asia | ROA | Labor | LAB |
| the rest of the World | ROW | | |

Table. 2: International Trade of Paddy Rice(mil. USD) and its Tariff Rates (%)

| | | To | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | JPN | CHN | IND | IDN | BGD | VNM | THA | PHL | USA | AUS | ROA | ROW | TOTAL |
| | JPN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 924.4 | 4.1 | 928.5 |
| | | (0) | (0) | (0) | (14.17) | (4.95) | (0) | (0) | (0) | (4.2) | (0) | (0) | (13.59) | |
| | CHN | 1 | 0 | 0 | 0.1 | 0.4 | 12.5 | 0.1 | 0 | 2.4 | 0.2 | 19.1 | 12.3 | 48.2 |
| | | (1000) | (0) | (0) | (13) | (0) | (15) | (0) | (0) | (6) | (0) | (965) | (25) | |
| | IND | 0.4 | 0.1 | 0 | 0.9 | 0.3 | 0 | 0.1 | 0.1 | 14.6 | 0.3 | 5 | 128.7 | 150.5 |
| | | (0) | (0) | (0) | (16) | (5) | (0) | (14) | (25) | (3) | (0) | (18) | (40) | |
| | IDN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.2 | 0.6 |
| | | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (35) | |
| | BGD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (2) | |
| | VNM | 0.2 | 0.1 | 0 | 3.2 | 0.5 | 0 | 0 | 0 | 0.7 | 0 | 0.3 | 5.3 | 10.3 |
| | | (0) | (0) | (0) | (11) | (3) | (0) | (0) | (0) | (0) | (0) | (0) | (11) | |
| From | THA | 0 | 0.1 | 0 | 2.8 | 0 | 0 | 0 | 0 | 0.1 | 0 | 4.7 | 70.9 | 78.6 |
| | | (0) | (1) | (0) | (20) | (0) | (0) | (0) | (0) | (6) | (0) | (803) | (28) | |
| | PHL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.4 |
| | | (0) | (0) | (0) | (12) | (0) | (0) | (0) | (0) | (0) | (0) | (0) | (28) | |
| | USA | 33.2 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 11.9 | 40.3 | 285.6 |
| | | (804) | (1) | (80) | (14) | (0) | (0) | (0) | (50) | (0) | (0) | (364) | (20) | |
| | AUS | 7.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 14.5 | 22 |
| | | (804) | (0) | (0) | (14) | (0) | (0) | (0) | (0) | (4) | (0) | (4) | (47) | |
| | ROA | 1 | 0.4 | 0.1 | 0.2 | 0 | 0.1 | 0.1 | 0 | 8.5 | 0.3 | 1.5 | 54.9 | 167.1 |
| | | (581) | (1) | (0) | (22) | (2) | (0) | (0) | (0) | (4) | (0) | (1) | (13) | |
| | ROW | 2.4 | 0.8 | 0.2 | 0.2 | 0 | 0.1 | 0.2 | 0.1 | 7.3 | 0.5 | 1.8 | 364.9 | 378.7 |
| | | (30) | (0) | (6) | (0) | (0) | (0) | (0) | (3) | (3) | (0) | (0) | (6) | |
| | TOTAL | 45.6 | 1.6 | 0.4 | 7.4 | 1.4 | 12.7 | 0.5 | 0.3 | 33.7 | 1.3 | 969.2 | 996.4 | |

Note: Tariff rates are in brackets.

Source: GTAP database version 6.0

Table. 3: Variance of Paddy Rice Productivity by Country

| Country/Region | Variance |
|---|---|
| China | 0.0007 |
| India | 0.0009 |
| Indonesia | 0.0003 |
| Bangladesh | 0.0026 |
| Viet Nam | 0.0003 |
| Thailand | 0.0010 |
| Philippines | 0.0030 |
| Japan | 0.0067 |
| USA | 0.0014 |
| Australia | 0.0085 |
| ROA | 0.0260 |
| ROW | 0.0374 |

Source: Estimated by the authors

using FAOSTAT considering time trend.

Table. 4: Paddy Rice Production by Country in 2001

| Country | Production (1,000 tonnes) | Share (%) |
|---|---|---|
| China | 179,305 | 30.0 |
| India | 139,900 | 23.4 |
| Indonesia | 50,461 | 8.4 |
| Bangladesh | 36,269 | 6.1 |
| Viet Nam | 32,108 | 5.4 |
| Thailand | 26,523 | 4.4 |
| Myanmar | 21,916 | 3.7 |
| Philippines | 12,955 | 2.2 |
| Japan | 11,320 | 1.9 |
| Brazil | 10,184 | 1.7 |
| Others | 76,716 | 12.8 |
| Total | 597,657 | 100.0 |

Source: FAOSTAT

Table. 5: Scenarios

| Scenario | Trade Liberalization by Japan | Shocks in Japan | Shocks in ROJ | Rice Buffer Stocks |
|---|---|---|---|---|
| T0 | - | - | - | - |
| T1 | x | - | - | - |
| R0 | - | - | x | - |
| R1 | x | - | x | - |
| J0 | - | x | - | - |
| J1 | x | x | - | - |
| A0 | - | x | x | - |
| A1 | x | x | x | - |
| S | - | x | x | x |

ROJ denotes the rest of Japan

Table. 6: Simulation Results of Scenario T1

| | Changes in Quantity (%) | | | | Changes in Price (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Output | Consumption | Imports | Exports | Output | Consumption | Imports | Exports |
| PDR | -41.1 | 64.9 | 3924.2 | 74.5 | -27.2 | -39.4 | -70.2 | -9.7 |
| WHT | 0.5 | -0.3 | 0.1 | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 |
| AGR | -0.3 | 0.3 | -1.2 | 0.7 | -0.3 | -0.2 | 0.1 | 0.2 |
| PCR | 11.6 | 12.0 | -16.2 | 32.3 | -11.3 | -10.7 | -1.0 | -5.3 |
| FOD | 0.2 | 0.2 | -0.7 | 0.9 | -0.2 | -0.1 | 0.2 | 0.1 |
| MNF | 0.3 | -0.1 | -0.4 | 0.6 | 0.1 | 0.1 | 0.3 | 0.2 |
| SRV | 0.1 | 0.0 | -0.3 | 0.4 | 0.0 | 0.0 | 0.2 | 0.2 |
| TRS | 0.1 | 0.0 | -0.3 | 0.4 | 0.1 | 0.1 | 0.2 | 0.2 |

Note: Change from the results of Scenario T0

Table. 7: Japan’s Unilateral Rice Imports of Trade Liberalization (Scenario T1)

| | EV (mil. USD) | EV/GDP (%) |
|---|---|---|
| JPN | 2651 | 0.066 |
| CHN | 54 | 0.005 |
| IND | 4 | 0.001 |
| IDN | -1 | -0.001 |
| BGD | 1 | 0.002 |
| VNM | 2 | 0.006 |
| THA | 8 | 0.007 |
| PHL | 4 | 0.005 |
| USA | 2292 | 0.023 |
| AUS | 146 | 0.043 |
| ROA | 165 | 0.014 |
| ROW | -126 | -0.001 |
| Total | 5198 | |

Table. 8: Simulation Scenarios and Results

| Scenario | Trade Liberalization by Japan | Shocks in Japan | Shocks in ROJ | Rice Buffer Stocks | Distribution of EV Mean (mil. USD) | Distribution of EV Variance | $Pr\{EV < 0\}$ (%) | $Pr\{EV < EV_{T1}\}$ (%) |
|---|---|---|---|---|---|---|---|---|
| T0 | - | - | - | - | 0 | 0 | - | - |
| T1 | x | - | - | - | 2650.8 | 0 | - | - |
| R0 | - | - | x | - | -0.3 | 345 | 49.5 | 100 |
| R1 | x | - | x | - | 2656.2 | 8053 | 0 | 48.0 |
| J0 | - | x | - | - | -150.1 | 1282861 | 53.0 | 99.7 |
| J1 | x | x | - | - | 2599.8 | 295432 | 0 | 53.0 |
| A0 | - | x | x | - | -150.4 | 1281918 | 53.4 | 99.7 |
| A1 | x | x | x | - | 2604.5 | 305415 | 0 | 52.4 |
| S | - | x | x | x | -99.9 | 1131869 | 53.4 | 99.7 |

ROJ denotes the rest of Japan.

$EV_{T1}$ denotes EV in Scenario T1 (i.e. 2,650.8 mil. USD).

The histograms of Japan's EV for each scenario are displayed in Appendix (Fig. 6 and 7).

# Appendix

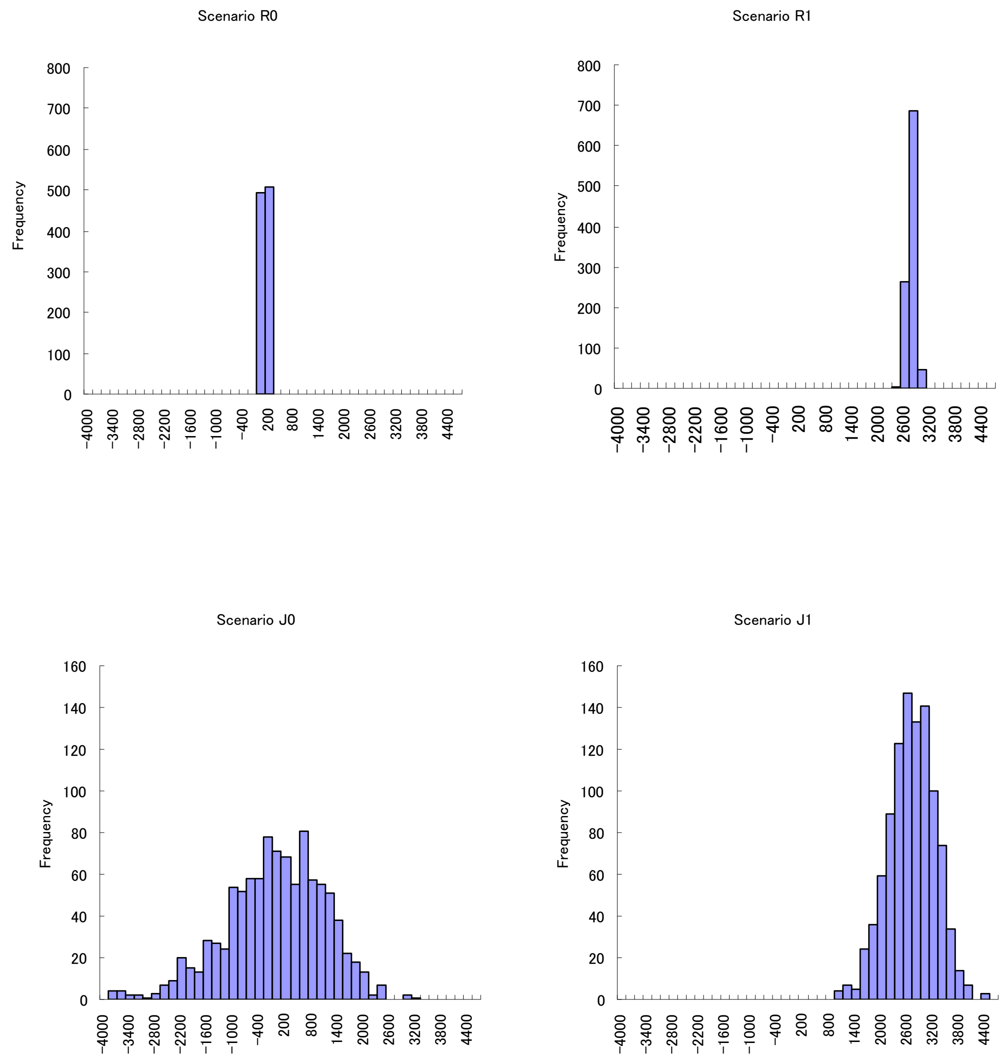


Fig. 6: Histograms of Distribution of Japan's Welfare by Scenario (1)

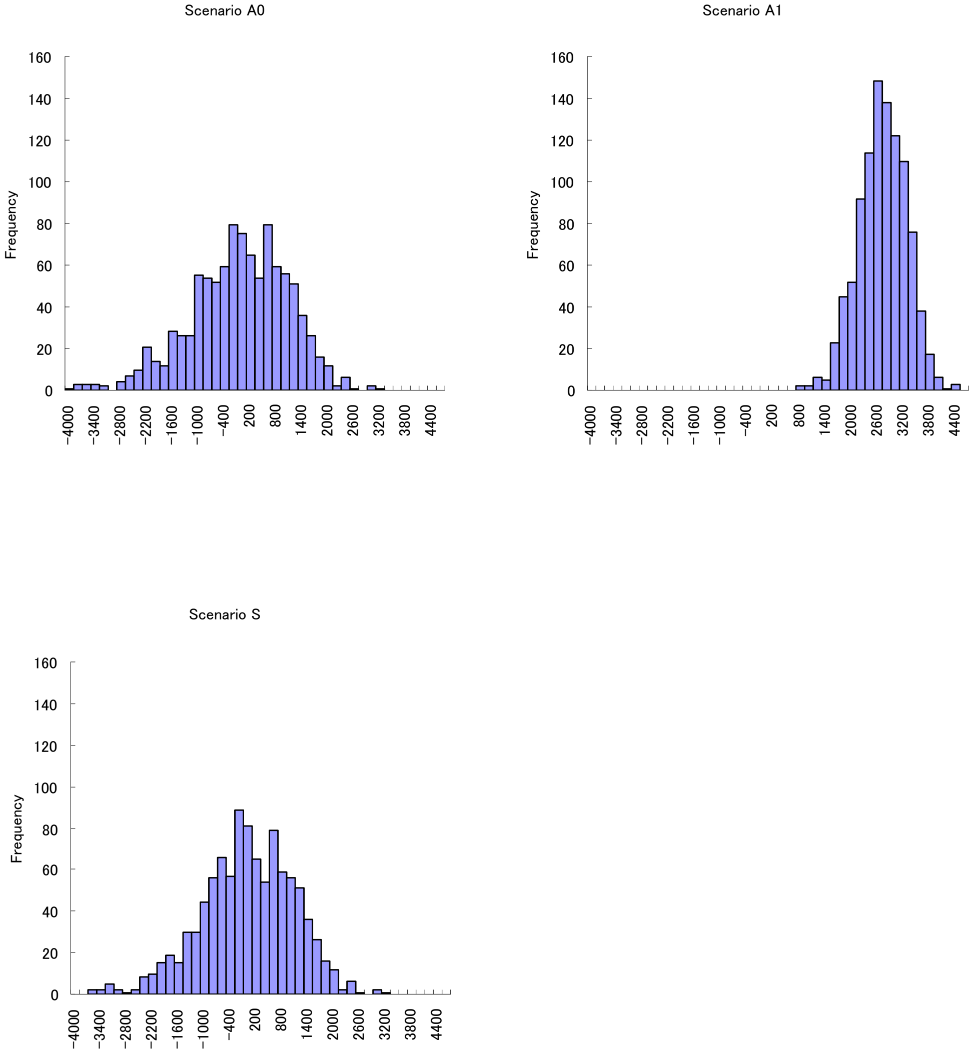


Fig. 7: Histograms of Distribution of Japan’s Welfare by Scenario (2)