Productivity Shock and National Food Security for Japan

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Abstract

Agriculture is a sensitive sector in negotiation of free trade. The Japanese government is against trade liberalization of rice on the ground of "national food security" for securer food consumption under uncertainty of food supply such as crop failure, war, and embargo. Trade liberalization is expected to increase dependency of food supply on imports and thus to make the Japanese economy more susceptible to these risks. We develop a stochastic computable general equilibrium for Monte Carlo simulations considering productivity shocks in various regions and found little chance for trade liberalization to worsen Japan's welfare even with such shocks.

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1. Introduction

1.1 National Food Security and Japan's Agricultural Policy

A 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 is significantly lower than that of other major developed countries. While this low food self-sufficiency is a result of the outstanding comparative advantage of Japan's industrial sectors, it brings us a concern of food shortages caused by unexpected events such as crop failure by bad weather, war, and embargo. Actually, bad weather in 1993 reduced the rice harvest by one-quarter compared with the average yield. There was a soybean embargo due to a 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 made the Japanese government be aware that excessive dependency of food supply on imports is an important risk factor for "national food security." The central idea of the national food security is how to secure food consumption under such uncertainty of food production and supply in Japan[1].

[1] This "national food security" is a unique concept compared with the popular concept of "food security," which is often discussed in the context of economic development under increasing population and continuing poverty. Hayami (2000) clarifies their difference.

Ministry of Agriculture, Forestry, and Fishery (MAFF) (2006) has established a contingency plan to secure domestic food consumption in emergency situations. In this plan, MAFF supposes that the minimum calorie intake is 2,000kcal/person/day, which is about 20% less than usual, and sets two criteria according to seriousness of situations: (a) the emergency case, where supply of all the major grains are not enough to support the minimum calorie intake, and (b) the warning case, where supply of one of the major grains is anticipated to be 20% less than usual. Depending on the emergency levels, various measures are considered such as promoting domestic production, managing emergency stocks, and controlling food markets. Among crops, rice is the most important commodity for Japan. Rice composed 28% of the total calorie intake, followed by wheat, which contributed to 13% of total calorie intake in 2001. In expenditure, rice has a share of 29% in total food consumption[2]. Thus, the government keeps a large amount of emergency stocks of rice---as much as 2.5% of its annual production---as well as other major crops to secure food supply.

Other than these measures, high trade barriers on rice play a particularly important role to achieve almost a perfect self-sufficiency rate of rice to maintain the overall self-sufficiency rate of foods because self-sufficiency rates of the other foods are very low.

[2] Source: FAOSTAT.

Even if gains from trade are expected considerable, proposals for free trade of rice have never been acceptable because free trade lowers the self-sufficiency rate of foods to increase dependency of food supply on imports and make food supply less secure. However, is it really impossible to seek both of the gains from trade and the national food security?

Impacts of agricultural trade liberalization are in two-folds: (1) deterministic efficiency improvements by the removal of trade barriers and (2) stochastic gains and losses from productivity shocks, whose magnitude can be exacerbated or mitigated depending on trade openness. We have often analyzed the first aspect of trade liberalization but have rarely done the second aspect. This lack of analysis about the second sometimes make people be against trade liberalization without assessing the overall impacts of trade liberalization simply because trade liberalization is generally supposed to make the domestic economy susceptible to shocks abroad.

1.2 Rice Trade and its Barrier

Japan has strictly prohibited imports of paddy rice but recently permitted minimum access imports of rice as a part of the Uruguay Round agreements. Its amount is, however, only 646 thousand tons, which is equivalent to 7.1% of domestic production in 2001. The effective trade barrier is estimated to be higher than 800% (Table1). Once abolishing

this trade barrier, imports are expected to have very high share in total rice supply.

Japan's 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 popular in Asian and other countries. Trade patterns of rice by Japan reflect this tendency (Table1). Three major partners for Japan: China, the US, and Australia, which produce japonica rice and are expected to increase their exports to Japan after liberalizing rice trade.

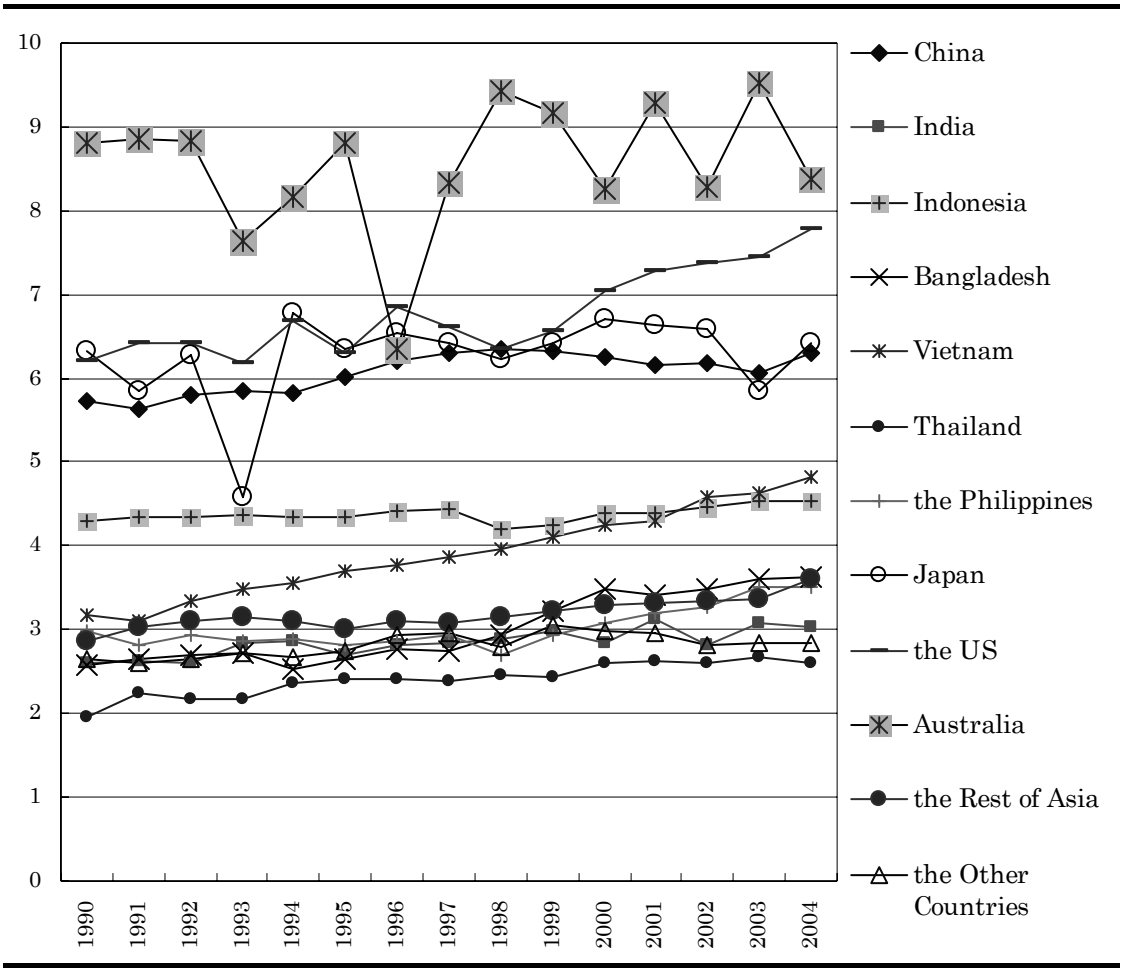
As rice is domestically produced and domestically consumed in most countries, rice trade is found thin. This means that only a small fraction of domestic production is exported and imported internationally. This characteristic shows a clear contrast to other major agricultural commodities, such as wheat. The top ten countries cover almost 90% of the world's total production of rice (Table 1). They are mostly Asian countries, where a climate of high temperature and high humidity is dominating. Their production fluctuates mainly by weather conditions. Droughts and cool summer days reduce rice production significantly. While productivity 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.

Table 1: Paddy Rice Production by Country in 2001

Country	Production [1,000 tons]	Share [%]
China	179,305	30.0
India	139,900	23.4
Indonesia	50,461	8.4
Bangladesh	36,269	6.1
Vietnam	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

Fig. 1: Productivity Fluctuation of Paddy Rice [unit: tons/hectare]



Once we liberalize the rice market of Japan, shocks in domestic and foreign markets will directly affect such a thin international market. Furthermore, taking account of Japan's strong preference toward japonica rice, the international market seems much less reliable as an alternative supply source for Japan. Such facts about international markets of rice seems to support the idea that the national food security has to be achieved only by protecting the domestic rice market for its high self-sufficiency rate, rather than by depending on foreign supply sources.

1.3 Literature Review

The majority of analysis about rice import barriers by Japan has employed partial equilibrium frameworks. For example, Cramer *et al.* (1993) developed a spatial partial equilibrium model for the world rice markets and quantified impacts of rice tariffication by Japan. Wailes (2005) employed the same framework to analyze rice trade liberalization. Hayami and Godo (1995) demonstrated different effects of tariffication and minimum access imports of rice with a single country rice market model for Japan. Cramer *et al.* (1999) carried out similar analysis with a world rice model distinguishing 22 regions. In this analysis, impacts of tariffication on (the national) food security in Japan were mentioned but

were not analyzed explicitly.

As these analyses employed partial equilibrium models, welfare impacts are evaluated in terms of producer surplus and consumer surplus only for the rice sector. However, shocks change rice prices relative to other foods and commodities. Substitution between commodities is expected in household consumption; inter-sectoral linkages are often important in the production process. In addition, if impacts of productivity shocks are expected to be significant enough to affect a macro economy, there arise not only such substitution effects but also income effects. We need to assess macroeconomic impacts of border barriers and productivity shocks on rice imports with a general equilibrium framework particularly when we consider unexpected events which jeopardize the national food security.

In contrast to partial equilibrium analysis, general equilibrium assessments for Japan's rice sector are scant. For example, Nakajima (2006) employed a GTAP-based CGE model to analyze impacts of the formation of the East Asian free trade area in combination with policy measures to protect Japan's rice sector[3]. Hosoe (2004) developed a world trade CGE model to evaluate how significantly the domestic rice price regulation exacerbated

[3] About GTAP, see Hertel (1997).

adverse impacts of the productivity shock in 1993 and how much windfall benefits Japan's emergency rice imports brought about to her rice trade partners. However, the productivity shock was assumed to be just deterministic there in the sense that its magnitude was calibrated to reproduce her historical event of the bad crop in 1993.

In assessing the national food security, we have to consider a wide range of productivity shocks other than the actual ones. As for the location of shocks, we can expect productivity shocks in all the countries, not only in Japan. Our stochastic world trade CGE model in combination with a Monte Carlo method provides a comprehensive framework to analyze international rice markets under uncertainty as Harris and Robinson (2001) analyzed impacts of weather fluctuations induced by El Niño on agricultural sectors with a similar technique. In their model, productivity of value added was randomized to demonstrate agricultural productivity shocks and the El Niño-induced ones.

In sum, while strict protection on rice imports is supposed to contribute to enhancing the national food security under such uncertainty, few have ever considered fluctuation or contingent supply shocks in the agricultural sector to evaluate overall benefits and possible losses from trade liberalization. As conventional CGE analysis infers little about impacts of agricultural trade liberalization under uncertainty, we need to take account of stochastic fluctuation of agricultural productivity in our CGE analysis. We

develop a world trade stochastic CGE model for this purpose in the next section.

In this paper, taking account both of the deterministic gains and the stochastic gains/losses from trade liberalization, we evaluate whether trade liberalization is really beneficial for Japan's national welfare and whether it is a serious risk factor for the national food security with 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 the paddy rice sector with a Monte Carlo method. In addition, we evaluate effectiveness of emergency stocks, which the Japanese government has prepared for bad crops and other emergency situations.

This paper proceeds as follows. Section 2 describes the model structure and simulation scenarios. Section 3 is devoted to discussions about our simulation results. Section 4 concludes our analysis mentioning policy implications.

2. Model and Scenarios

2.1 Basic Structure of World Trade Stochastic CGE model

While modifying the basic model structure of a single-country CGE model developed by Devarajan *et al.* (1990) for multi-country analysis, we extend the model to analyze the rice sector with the uncertainty of its productivity in the world economy.

Reflecting the fact that rice trade partners for Japan are limited to Asia-Pacific countries (Table 2), we distinguish 12 regions using the GTAP database version 6 (Table 3). Each region has eight sectors, particularly focusing on rice and other food sectors. Each sector is represented by a perfectly competitive profit-maximizing firm with a Leontief type production function for gross output and with a Cobb-Douglas type production function for value added (Fig. 2). Among the value added components, labor is assumed to be mobile between sectors to model relatively short-run phenomena under unforeseen shocks, but capital is assumed to be immobile between sectors. International factor mobility is not assumed. These factors are assumed to be fully employed with flexible factor price adjustment.

Table 2: Rice Imports and Its Trade Barriers in Japan

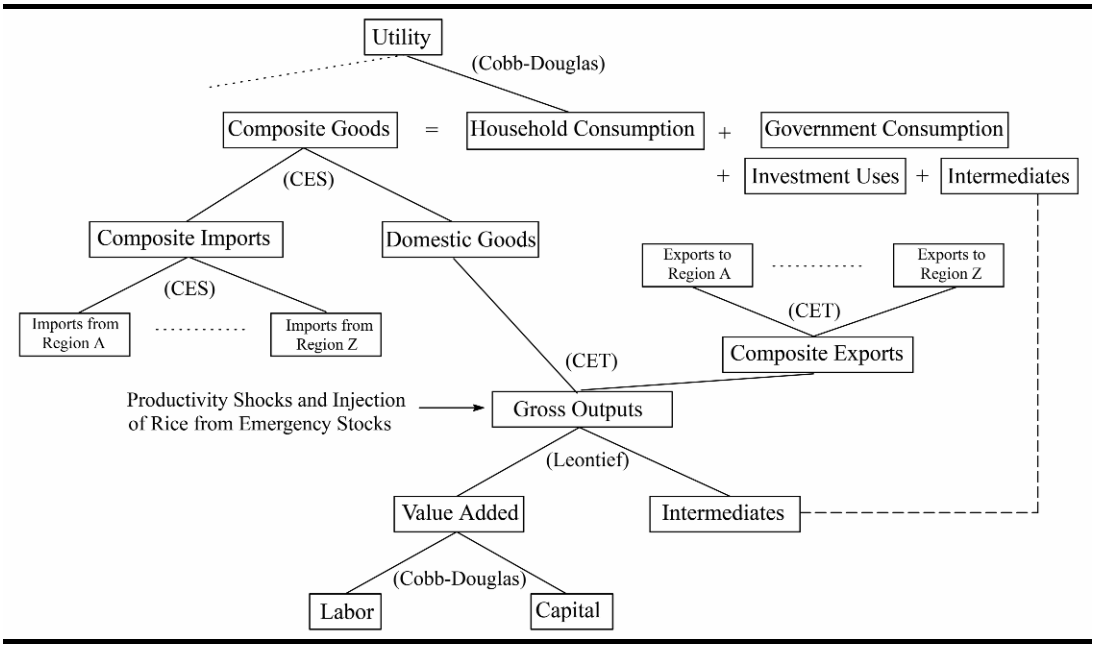
	Imports [mil. USD]	Trade Barriers [%]
China	1.0	1,000
India	0.4	0
Indonesia	0.0	0
Bangladesh	0.0	0
Vietnam	0.2	0
Thailand	0.0	0
the Philippines	0.0	0
the US	33.2	804
Australia	7.4	804
the Rest of Asia	1.0	581
the Other Countries	2.4	30
TOTAL	45.6	

Note: Trade barriers refer to tariff and tariff-equivalent non-tariff barriers.
Source: GTAP database version 6.

Table 3: Regional and Sectoral Aggregation in the Model

Region	Sector
Japan	Paddy Rice
China	Wheat
India	Other Agriculture
Indonesia	Processed Rice
Bangladesh	Other Food
Vietnam	Manufacturing
Thailand	Services
the Philippines	Transportation
the US	
Australia	
the Rest of Asia	
the Other Countries	

Fig. 2: Model Structure



Sectoral gross outputs are split into domestic outputs and composite exports using a constant elasticity of transformation (CET) function. The domestic outputs and composite imports are aggregated into composite goods with a constant elasticity of substitution (CES) function as Armington (1969) assumed. The composite imports consist of imports from

various regions; the composite exports are decomposed into exports to various regions. For these CES/CET functions, we use elasticity of substitution suggested in the GTAP database, which represents similarity of goods differentiated by origin and destination of trade. For example, the elasticity is set 5.05 for paddy rice and 2.60 for processed rice. Current account surplus/deficit is set constant in US dollar terms for each region. Exchange rates are flexibly adjusted so that the current account balance holds in each region.

2.2 Simulation Scenarios

2.2.1 Three Scenario Factors

To quantify overall impacts of the trade liberalization of Japan's rice market on her national food security, we consider the following scenario factors: (1) unilateral abolition of trade barriers on paddy rice imports by Japan and (2) uncertainty of productivity in the paddy rice sector. We assume that productivity shocks randomly happen in the total factor productivity parameter of the gross output production function. When productivity shocks are anticipated, (3) we can manage emergency stocks to mitigate their adverse impacts. We also quantify its effectiveness in the same framework. We set nine scenarios to evaluate how significantly the national food security is jeopardized by these three scenario factors (Table 4). The first two Scenarios T0 and T1 are often employed in conventional trade liberalization

analysis as the base run and a counter-factual run only considering the abolition of rice import barriers by Japan. The following six scenarios of R0, R1, J0, J1, A0, and A1 are set to investigate impacts of trade liberalization subject to productivity shocks in Japan, in the rest of the world (ROW), and all over the world. The last Scenario S is set to analyze the effectiveness of Japan's emergency stocks prepared to mitigate impacts of adverse productivity shocks in her domestic sector. Details of those scenario factors are explained below.

Table 4: Scenario Design

Scenario	Scenario Factors			
	Trade Libera-lization	Shocks in		Emergency Stocks of Rice
		Japan	the ROW	
T0	-	-	-	-
T1	x	-	-	-
R0	-	-	x	-
R1	x	-	x	-
J0	-	x	-	-
J1	x	x	-	-
A0	-	x	x	-
A1	x	x	x	-
S	-	x	x	x

2.2.2 Abolition of Trade Barriers

We assume unilateral abolition of tariff and non-tariff barriers by Japan, which are reported by the GTAP database version 6 (Table 2). The tariff and non-tariff barriers are 800% or higher in terms of an import tariff equivalent rate. Neither boarder barriers in the

other sectors or in the other regions are assumed to change. Abolition of such high trade barriers would increase import penetration to reduce domestic rice production but would bring about gains from trade as conventional trade analysis reports.

2.2.3 Productivity Shocks

We estimate variances of paddy rice productivity of these 12 regions with time series data for 15 years provided by FAOSTAT while controlling only time trend of the productivity (Table 5). We assume that paddy rice productivity follows *i.i.d.* normal distribution $N\left(1,\sigma_r^2\right)$ with these estimated variances. We carry out 1,000 Monte Carlo simulation draws for each scenario.

Table 5: Regression Results of Paddy Rice Productivity
[Dependent Variable: Rice Productivity Index (1990=100)]

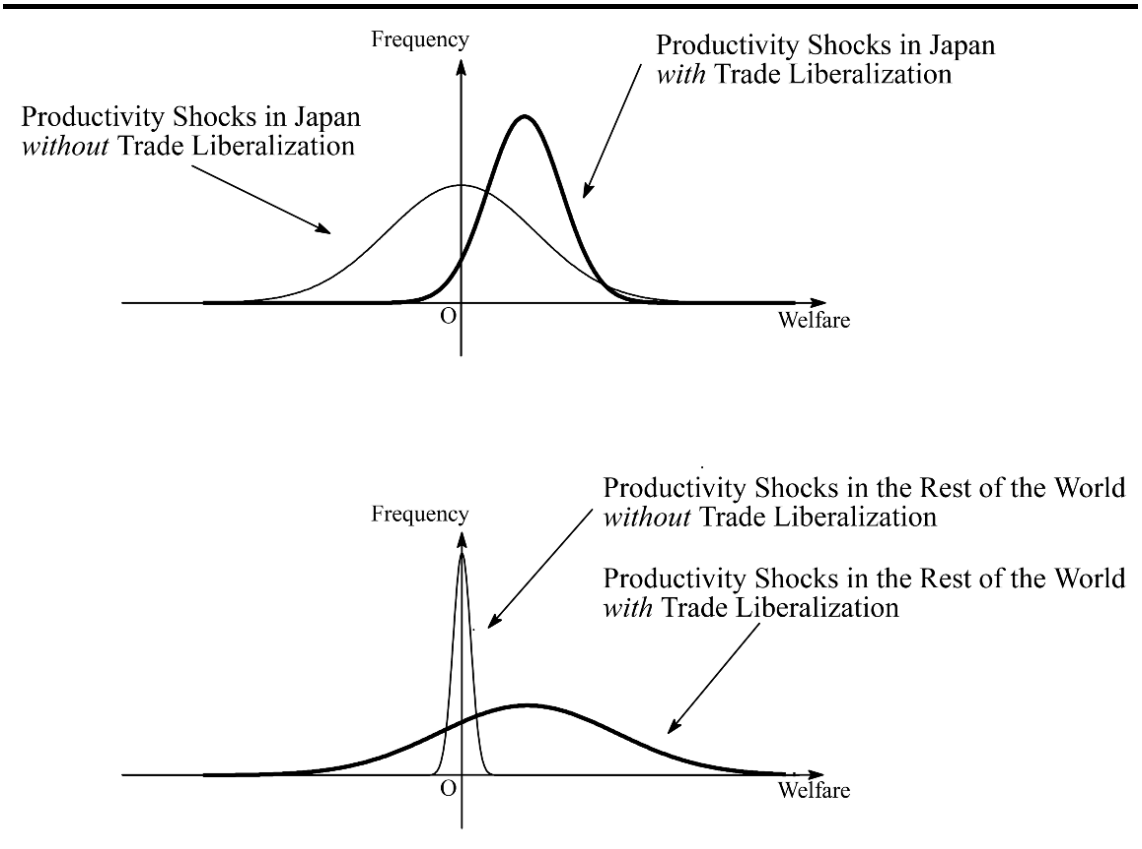
	Intercept	Time Trend	Variance of Residuals	R^2
Japan	-10.3159	0.0057	0.0067	0.088
	(-1.02)	(1.12)		
China	-13.1274	0.0071	0.0007	0.606
	(-4.16)***	(4.47)***		
India	-20.1883	0.0106	0.0009	0.707
	(-5.34)***	(5.60)***		
Indonesia	-4.2385	0.0026	0.0003	0.302
	(-1.92)*	(2.37)**		
Bangladesh	-55.9178	0.0285	0.0026	0.861
	(-8.82)***	(8.98)***		
Vietnam	-59.5086	0.0303	0.0003	0.986
	(-30.31)***	(30.82)***		
Thailand	-33.9142	0.0175	0.0010	0.860
	(-8.70)***	(8.95)***		
the Philippines	-26.0078	0.0135	0.0030	0.550
	(-3.84)***	(3.99)***		
the US	-27.9540	0.0145	0.0014	0.753
	(-6.08)***	(6.30)***		
Australia	-6.5249	0.0038	0.0085	0.032
	(-0.57)	(0.66)		
the Rest of Asia	-21.9361	0.0115	0.0007	0.796
	(-6.82)***	(7.13)***		
the Other Countries	-13.9575	0.0075	0.0013	0.465
	(-3.13)***	(3.36)***		

Note: T-values are in parentheses. *, **, and *** indicate parameters are significant at 10%, 5%, and 1% significance level.

When an adverse productivity shock takes place in Japan–whose domestic output is shipped almost only for her own uses–, her domestic consumption will be reduced but will be partly supported by imported rice. Similarly, when an abundant rice crop takes place in Japan, she can have the surplus absorbed abroad. As trade liberalization of paddy rice increases her accessibility to international rice markets, shocks to her domestic rice production can be more flexibly managed through imports under free rice trade. In view of

statistical distribution of domestic welfare, given the same magnitude of productivity shocks, trade liberalization itself will shift the mean of welfare distribution upward and will decrease the variance of welfare distribution (the upper panel of Fig. 3). In this case, whether a productivity shock is negative or positive, trade liberalization will always bring about preferable impacts to welfare distribution.

Fig. 3: Impacts of Productivity Shocks and Trade Liberalization on Distribution of Japan's Welfare



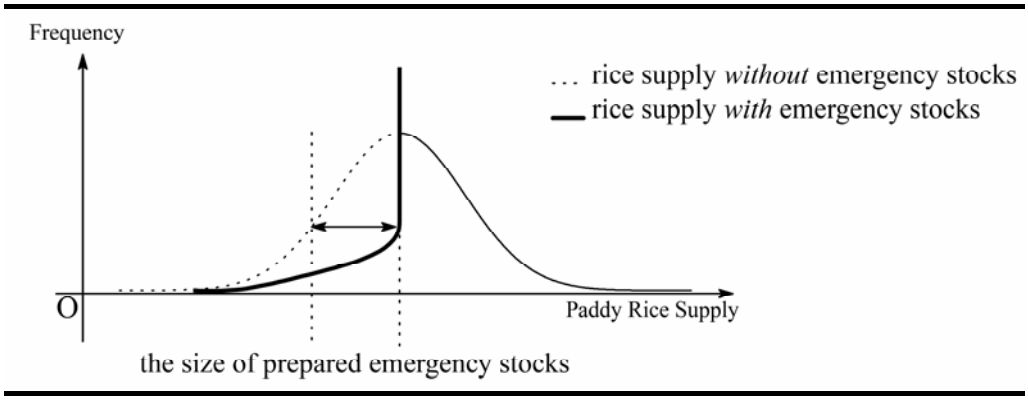
In contrast to the cases with productivity shocks in Japan, when an adverse

productivity shock takes place in the rest of the world, particularly in China, the US, and Australia, Japan's imports from these countries will be jeopardized. 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 shocks to Japan. This is the point that agricultural protectionists strongly stress. However, if a positive productivity shock (i.e., good crop) takes place in those countries, Japan can conversely gain by the same mechanism. 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. 3). In this case, without combining impacts of trade liberalization with those of productivity shocks on the distribution of welfare, 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 shown in Fig. 3 implies that trade liberalization might significantly increase probability that welfare status with rice trade liberalization is worse than that without rice trade liberalization. This could be serious for those who have strongly risk-averse preference.

2.2.4 Emergency Stocks

The size of emergency stocks is assumed to be as much as 1.5 million tons, which is officially kept by the Japanese government and is equivalent to about 17% of Japan's annual production[4]. We assume that this emergency stock is released only when a negative productivity shock takes place in Japan so as to maintain the original amount of her domestic paddy rice supply. When the losses of paddy rice production exceed the size of emergency stocks prepared in advance, market mechanism starts to work with a flexible price adjustment and to increase imports. The emergency stocks truncate a part of the lower shoulder of the distribution of rice supply (Fig. 4).

Fig. 4: Distribution of Rice Supply Considering Emergency stocks



For simplicity of our comparative statics, we assume the emergency stocks were

[4] Recently, the amount of the emergency stocks was reduced to about one million tons.

prepared before the shocks and that the release of emergency stocks does not bring any capital gains or losses to the government. By subtracting the storage costs of the emergency stocks from their expected social benefits measured by a welfare indicator, we can quantify net benefits of the emergency 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 by Japan (Scenario T1), we obtain intuitive results often reported in conventional CGE analyses (Table 6). Imports of paddy rice would surge to reduce domestic production in Japan. This would result in a significant decline of the self-sufficiency rate of rice from 94% to 50%. As the paddy rice sector is closely connected with the processed rice sector through the input-output structure, increases of paddy rice imports and, thus, its supply induced by more imports would increase production and consumption of processed rice[5]. As a result, overall welfare impacts measured with equivalent variations (EV) would be 2,651 million

[5] As it is not common to directly consume paddy rice in final demand but to consume processed rice, we refer changes of consumption of processed rice rather than that of paddy rice here.

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.

Table 6: Simulation Results of Scenario T1 for Japan

	Changes in Quantity [%]			
	Output	Consumption	Imports	Exports
Paddy Rice	-41.1	64.9	3,924.2	74.5
Wheat	0.5	-0.3	0.1	0.5
Other Agriculture	-0.3	0.3	-1.2	0.7
Processed Rice	11.6	12.0	-16.2	32.3
Other Food	0.2	0.2	-0.7	0.9
Manufacturing	0.3	-0.1	-0.4	0.6
Services	0.1	0.0	-0.3	0.4
Transportation	0.1	0.0	-0.3	0.4
	Changes in Price [%]			
	Output	Consumption	Imports	Exports
Paddy Rice	-27.2	-39.4	-70.2	-9.7
Wheat	0.3	0.3	0.3	0.3
Other Agriculture	-0.3	-0.2	0.1	0.2
Processed Rice	-11.3	-10.7	-1.0	-5.3
Other Food	-0.2	-0.1	0.2	0.1
Manufacturing	0.1	0.1	0.3	0.2
Services	0.0	0.0	0.2	0.2
Transportation	0.1	0.1	0.2	0.2

Note: Changes from the Base (Scenario T0).

Table 7: Simulation Results of Scenario T1 for Welfare

	EV [mil. USD]	EV/GDP [%]
Japan	2,651	0.066
China	54	0.005
India	4	0.001
Indonesia	-1	-0.001
Bangladesh	1	0.002
Vietnam	2	0.006
Thailand	8	0.007
the Philippines	4	0.005
the US	2,292	0.023
Australia	146	0.043
the Rest of Asia	165	0.014
Other Countries	-126	-0.001
Total	5,198	

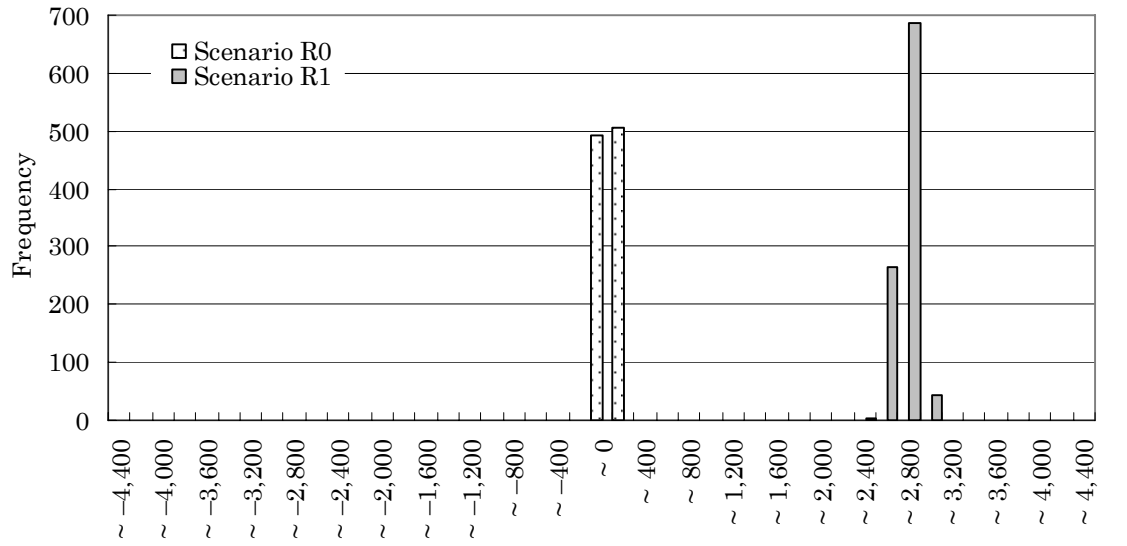
This simulation with Scenario T1 provides a reference result in the sense that conventional trade liberalization analysis shows. In the following six simulations, we introduce fluctuation of paddy rice productivity in Japan, in the rest of the world, and all over the world. Monte Carlo simulations yield distribution of various economic variables, such as output, consumption, imports and exports, their prices, etc. Among them, we focus on distribution of the welfare indicator of EV.

3.2 Productivity Shocks in the Rest of the World

People are often concerned that when we are heavily dependent on foreign supply sources for rice, the food supply could be insecure due to, for example, unforeseen productivity shocks in other countries. 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 the mean of EV but some variance of EV (Table 8), (Fig. 5)[6]. The results of Pr{$EV<EV_{T1}$} in Scenario R0 (and Scenarios J0 and A0 discussed later) indicate that there would be no statistically significant chance for Japan to attain the deterministic gain achieved in Scenario T1 without liberalizing rice imports.

Fig. 5: Impacts of Foreign-made Shocks on Welfare [unit: mil. USD]



[6] Even if we assume only productivity shocks, the EV is found slightly negative in Scenarios R0, J0, and A0. This is due to the concavity of utility function, which implies risk-averseness of preference represented by the Cobb-Douglas utility function.

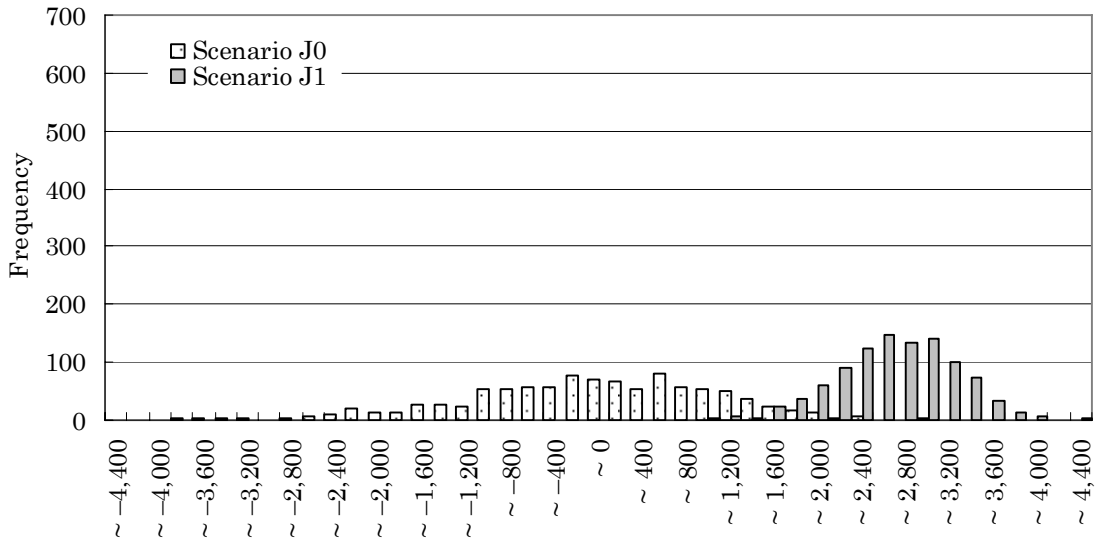
Abolition of trade barriers on paddy rice imports increases penetration of foreign rice, which would make the self-sufficiency rate of paddy rice be almost halved. Imports are subject to uncertainty of productivity abroad. This situation is described by Scenario R1. Its simulation results show that trade liberalization would increase both of the mean and the variance of EV (Table 8), (Fig. 5). Indeed, this increase of the variance itself is often regarded as a risk factor for Japan but would not be so large that it could provide statistically significant chance for Japan to suffer negative welfare impacts as the column of $\Pr\{EV<0\}$ suggests. That is, even if the worst case takes place in terms of welfare, the welfare level achieved under trade liberalization would be strictly better than the welfare without trade liberalization.

3.3 Productivity Shocks in Japan

There is no reason why we assume productivity shocks only outside Japan. When 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 Japan without trade liberalization would make the variance of EV significantly large (Table 8), (Fig. 6). This is because the domestic market is

eventually isolated from alternative supply sources in foreign countries due to high trade barriers.

Fig. 6: Impacts of Domestic-made Shocks on Welfare [unit: mil. USD]

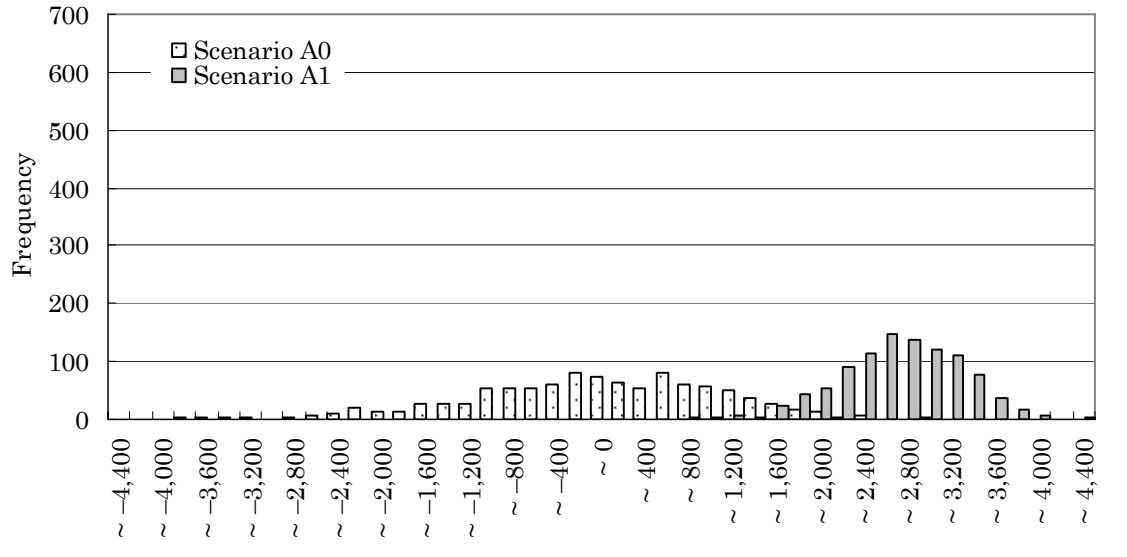


Given the productivity shocks in Japan, the trade liberalization would bring about a double-dividend to her (Scenario J1). That is, while the mean of EV would increase, its variance would decrease. This implies that a higher welfare level is achieved more securely by trade liberalization. By integrating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

3.4 Impacts of Productivity Shocks All Over the World

Comparing the simulation results of Scenarios R0, R1, J0, and J1 with each other, we find that the impacts of productivity shocks in Japan would be the dominant factor for her welfare. Thus, when we simulate perfectly random productivity shocks all over the world with and without trade liberalization, simulation results of Scenarios A0 and A1 would be generally similar to those of Scenarios J0 and J1, respectively (Table 8), (Fig. 7). These results do not support the idea that trade liberalization in combination with productivity shocks should be a serious risk factor for the Japanese economy either.

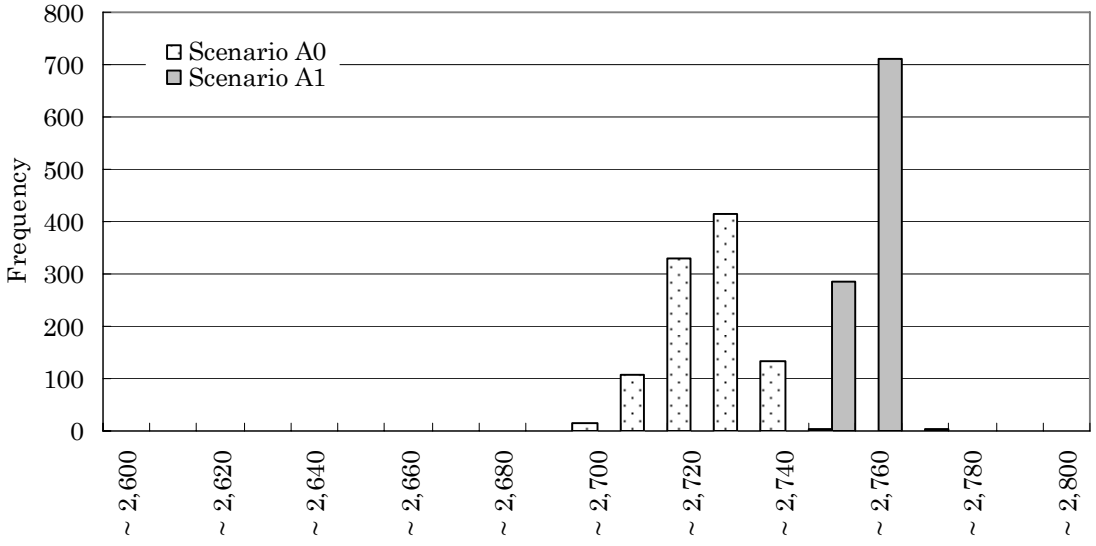
Fig. 7: Overall Impacts of Foreign- and Domestic-made Shocks on Welfare [unit: mil. USD]



While we have described distributions of EV, we can also obtain distributions for

rice consumption and implied calorie intake (Fig. 8). In Scenario A1, the mean of rice consumption would increase by 12%, but its variance would be significantly reduced compared with those in Scenario A0. It suggests that rice trade liberalization would slightly increase the mean of calorie intake but would decrease its variance. Finally, these simulation results never indicate that the warning level, where rice consumption would be reduced by over 20% as discussed in Section 1.1, would take place, or, still less, that the emergency level, where the calorie intake would be lower than 2,000 kcal/day/person, would either.

Fig. 8: Overall Impacts of Foreign- and Domestic-made Shocks on Calorie Intake [unit: kcal/day/person]



3.5 Effectiveness of Emergency Stocks

Emergency stocks are one of popular measures to cope with bad crops. It is reported that impacts of the rice supply shock in 1993 was exacerbated partly by the restructuring of Japan's food system led by the government, which had significantly reduced the government rice stocks to 0.23 million tons—covering 2.5% of the average annual production. After the bad crop event in 1993, the government increased the size of emergency stocks to 1.5 million tons. We quantify the effectiveness of the emergency stocks prepared for bad crop periods. Considering the current situation with high border barriers on paddy rice imports, we do not assume trade liberalization but only productivity shocks all over the world in this particular Scenario S[7]. By comparing simulation results of Scenario A0 with those of Scenario S, we can find benefits of the emergency stocks.

Among 1,000 draws in our Monte Carlo simulation, 530 cases are expected to bring about negative productivity shocks in Japan. The emergency stocks are found large enough to fully cover the lost rice yield in 95.9% of those negative productivity cases. The emergency stocks would increase the mean of EV by 50.5 million US dollars, compared with the result of Scenario A0; the variance of EV would be slightly decreased (Table 8), (Fig. 9).

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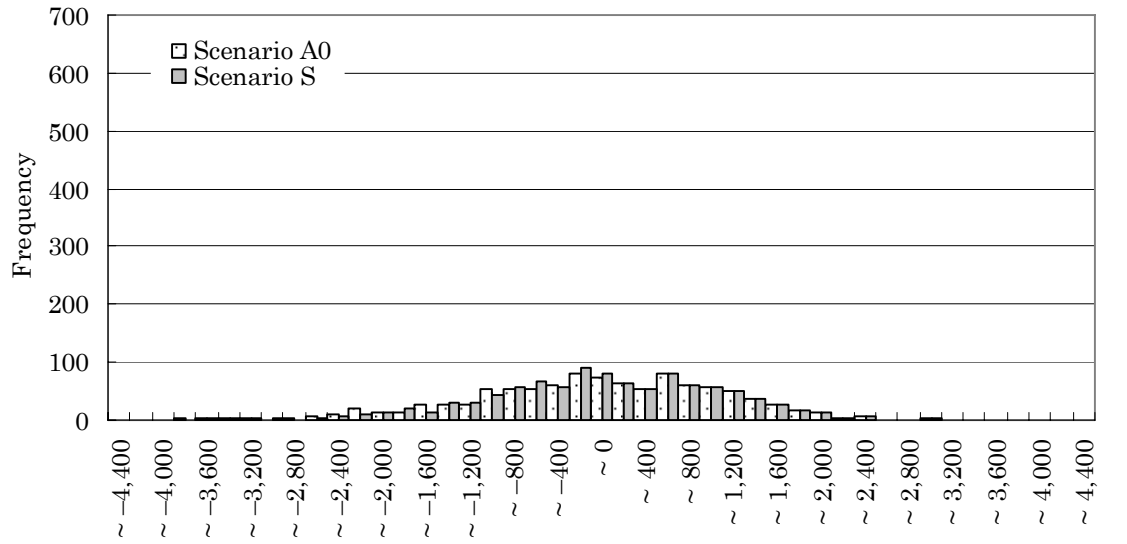
[7] When we assume rice trade liberalization simultaneously, we would achieve better welfare outcome in its mean and its variance as the previous simulation results have proven.

Fig. 9: Effects of Emergency Stocks [unit: mil. USD]



The issue is how effectively the emergency stocks could mitigate welfare deterioration. MAFF (2001) reports that annual storage costs of the emergency stocks in Japan are as much as 150 million US dollars. Even when we regard only the improvements in the mean of EV as the social benefit of the emergency stocks—omitting capital gains and losses from the release of stocks—, the emergency stocks would not seem worthy to maintain in Japan for risk-neutral or moderately risk-averse people. We should reduce the amount of emergency stocks or should keep them somewhere abroad, where cheaper storage costs are offered. For example, annual storage costs are estimated to be 22.5 US dollars per paddy rice ton in Thailand by International Crop Reserve Research Workshop (2001). In this case,

expected benefits of rice stock could be larger than the storage costs.

4. Concluding Remarks

To analyze impacts of factors which can secure or endanger the national food security for Japan, we developed a stochastic world trade CGE model and carried out Monte Carlo simulations. Major findings of our analysis are as follows. (1) When rice productivity shocks are anticipated abroad, there is no statistically significant chance for the Japanese economy to be worse off by rice trade liberalization even though the trade liberalization would increase fluctuations of her welfare caused by the foreign-made productivity shocks. (2) When productivity shocks are anticipated in the domestic rice sector in Japan, rice trade liberalization would increase the mean of welfare and decrease of the variance of welfare. Combining these two findings, we can conclude that there would be no reason to support the idea for protecting the domestic rice market for the national food security in Japan. In addition, (3) the current policy to secure the rice supply with emergency stocks would not be effective in the sense that the expected gains achieved by the emergency stocks would be obviously less than their annual storage costs. It implies that the optimal size of the emergency stock should be much less than the current size and/or that the emergency stock should be kept in some other countries which offer cheaper storage costs.

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

In regard to emergency stocks, there are rice inventories held by private agents like dealers in addition to the official stocks. Such private inventories also contribute to mitigating shortfalls of the rice supply. Our simulation results about the effectiveness of the official emergency stocks would be found much smaller when we consider private stocks.

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Table 8: Simulation Scenarios and Results

Scenario	Scenario Factors				Simulation Results				
	Trade Libera-lization	Shocks in		Emergency Stocks of Rice	Japan's EV		Pr{EV<0}	Pr{$EV<EV_{T1}$}	Self-sufficiency Rate [%]
		Japan	the ROW		Mean [mil. USD]	Variance	[%]	[%]	
T0	-	-	-	-	0	0	-	-	94
T1	x	-	-	-	2,651	0	-	-	50
R0	-	-	x	-	0	345	49.5	100.0	94
R1	x	-	x	-	2,656	8053	0.0	48.0	50
J0	-	x	-	-	-150	1282861	53.0	99.7	94
J1	x	x	-	-	2,600	295432	0.0	53.0	50
A0	-	x	x	-	-150	1281918	53.4	99.7	94
A1	x	x	x	-	2,605	305415	0.0	52.4	50
S	-	x	x	x	-100	1131869	53.4	99.7	91

Note: Distribution of Japan's EV for each scenario is also shown in Fig. 5-7, and 9. Pr{EV<EV_{T1}} denotes EV in Scenario T1 (i.e. 2,651 mil. USD).