JARQ 43 (4), 329–336 (2009) http://www.jircas.affrc.go.jp

The Impact of Renminbi Appreciation on the World Rice Market

Yongfu CHEN[1], Hsiaoping CHIEN[2]*, Jun FURUYA[2] and Osamu KOYAMA[2]

[1] College of Economics and Management, China Agricultural University (Beijing 100094, P. R. China)
[2] Development Research Division, Japan International Research Center for Agricultural Sciences (Tsukuba, Ibaraki 305–8686, Japan)

Abstract

The World Rice Model (WRM) was developed based on a partial equilibrium approach in this paper. The impact of a Renminbi (Chinese Yuan) appreciation scenario on the world rice market was projected to 2020 by WRM. The result indicates that Renminbi appreciation in the short term will lead to a drastic change in the international rice price index. When the Renminbi appreciation rate is greater than 4%, the international rice price index will continue to rise; when it is greater than 8%, China will become the largest rice importer in the world.

Discipline: Agricultural economics
Additional key words: partial equilibrium, Renminbi appreciation, World Rice Model

Introduction

Rice is the staple food for more than half of the world population. With the growth of population and increase in annual rice consumption per capita in countries where rice is not the staple food, world rice consumption is increasing continuously and the world rice trade has expanded greatly. As a result, world rice production (moving average value of three years) increased from 174 million tons in 1965 to 402 million tons in 2005, and the consumption of rice expanded from 172 million tons to 409 million tons with world rice trade expanding from 15 million tons to 540 million tons during the same period.

China, India, Indonesia, and Bangladesh are respectively the world's top-four countries in rice production and consumption. The changes in the Chinese rice market have a profound impact on the world rice market. The Renminbi (Chinese Yuan) had appreciated 8.9% by August 20, 2007, compared with the rate on July 21, 2005. It will cause Chinese rice to lose its competitiveness in price and certainly will make an impact on the Chinese rice market. Furthermore, as the world's top producer and consumer, the changes in the Chinese rice market will also have a great impact on the world rice market.

Literature on the exchange rate and agriculture trade is mainly focused on agriculture response to the exchange rate movement[8], the effect of exchange rate on food supply[5], and the effect of exchange rate on Japanese agricultural income[4]. On the other hand, literature on the world rice model aimed at policy simulation[10] is ample, such as the Global Trade Analysis Project, the International Model for Policy Analysis of Agricultural Commodities and Trade, the World Food Model (WFM) of FAO[2], and the AGLINK model of the Organization for Economic Cooperation and Development. Most of these models employ parameters that are estimated by using data up to the 1990's. Because of the rapid change in the world rice market, these parameters should be estimated by the latest data for modeling the world rice market. In addition, literature on the impact of Renminbi appreciation on the economy of different countries or regions is mainly used in a computational general equilibrium (CGE) model[4,12] or pooled import demand equation[11]. It still has not been found to be used as a new partial equilibrium model to simulate the impact of Renminbi appreciation on the world rice market. As a result, the world rice demand and supply elasticity is estimated in this paper, and a new partial equilibrium model of the world rice market is built up for the impact projection of Renminbi appreciation.

This paper is organized as follows. In the next section, the scope and structure of the World Rice Model (WRM) are presented, the parameters of WRM are

*Corresponding author: e-mail chienp@affrc.go.jp
Received 12 September 2007; accepted 2 February 2009.

estimated and the scenarios of Renminbi appreciation are assumed. The third section provides an analysis on how the world rice market will change in the impact projection by WRM with three assumed scenarios of Renminbi appreciation. The final section discusses what the world rice market will look like in 2020.

World Rice Model

1. The Scope of the World Rice Model

The scope of the World Rice Model (WRM) is Australia, Bangladesh, China (mainland's 33 provinces), India, Indonesia, Japan, Korea, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan of China, Thailand, USA, Vietnam, and the rest of the World (ROW) regions. The output and the consumption of rice in the top 15 countries and regions account for 87% and 86% of the whole world, respectively. In addition, it's worth noting that this paper regards japonica rice and indica rice as the same commodity.

2. The Structure of WRM

The partial-equilibrium dynamic model for multi-countries with a single product is used in WRM, which is built according to WFM. WRM is composed of six aspects: production, import, beginning stocks, consumption, export, and ending stocks. Its structural diagram is shown in Fig. 1, and the basic principle of modeling is explained below.

Firstly, both the import volume (IMQ) and the export volume (EXQ) of rice of all countries and regions are assumed to be a function of the international rice price (WP: the price of Thailand's rice, which is one of the largest rice exporting countries in the world).

$$IMQ = f_1(WP); \quad EXQ = f_2(WP)$$

Secondly, the international rice price is obtained from solving the following market clearing equation for gross rice export and gross rice import in the world by inserting exogenous variables, and the remaining endogenous variables can be obtained simultaneously.

$$F(WP) = \sum f_1(WP) - \sum f_2(WP) = 0$$

WRM is composed of 228 function equations. Among them, 164 equations are related with endogenous variables and the other 64 equations are related with exogenous variables. The main functions given below are used in the modeling of WRM, and the variables in the functions are defined in Table 1.

Function of the harvest area:

$$\log AH_{it} = a_{i0}^{AH} + a_{i1}^{AH} \log AH_{it-1} + b_{i1}^{AH} \log(RP_{it-1}) + b_{i2}^{AH} \log(WHP_{it-1}) + c_{i1}^{AH} \log(Z_{it}) + d_{i1}^{AH} DM0_{it}$$

Function of the yield per unit:

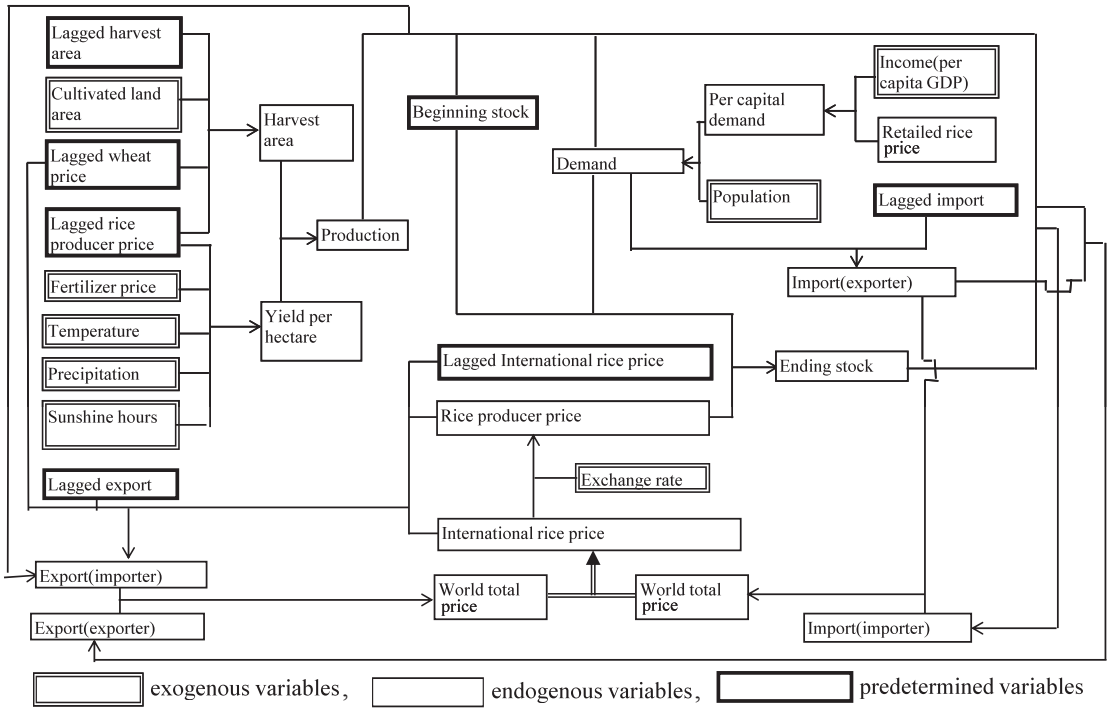

Fig. 1. Structure of WRM

Table 1. Variables used in the WRM and varible definitions

Variable	Definition
AH	the harvest area of paddy rice
RP	the producer price of paddy rice
WHP	the wheat producer price
MZP	the corn producer price
WWHP	the international wheat price (US Gulf Pts)
WMZP	the international corn price (US Gulf Pts)
EXR	the foregin exchange rate
YY	the yield of paddy rice per unit
TP	annual average temperature
PT	annual average precipitation
ST	annual average sunshine hours
FLP	the price of fertilizer
PD	the production of rice
DD	the rice demand per capita
PGDP	the GDP per capita
RTP	the rice retail price
STK	the ending stock of rice
Z	the exogenous variable (the cultivated land area of Japan) in the function of harvest paddy rice area
DM0	a dummy variable in the function of harvest paddy rice area
DM1	a dummy variable in the function of the rice demand per capita (China, India, Indonesia, Malaysia, Thailand is 1 and otherwise is 0)
i	one of 16 countries and regions
t	the year
a, b, c , d	the parameters to be estimated

$$(a)\log YY_{it} = a_{i0}^{YY} + a_{i0}^{YY}\log YY_{it-1} + b_{i1}^{YY}\log(RP_{it-1})$$
$$+b_{i2}^{YY}\log(FLP_{it}/FLP_{it-1}) + b_{i3}^{YY}\log(TP_{it}/TP_{it-1})$$
$$+b_{i4}^{YY}\log(PT_{it}/PT_{it-1}) + b_{i4}^{YY}\log(ST_{it}/ST_{i-1})$$
$$(b)\log YY_{it} = a_{i0}^{YY}\log YY_{it-1} + b_{i1}^{YY}\log(RP_{it-1})$$
$$+b_{i2}^{YY}\log(FLP_{it}) + b_{i3}^{YY}\log(TP_{it}) + b_{i4}^{YY}\log(PT_{it})$$
$$+b_{i4}^{YY}\log(ST_{it})$$

Function of per capita rice demand:

$$\log DD_{it} = a_{i0}^{DD} + b_{i1}^{DD}DM1_i\log(1/PGDP_{it})$$
$$+b_{i2}^{DD}\log(PGDP_{it}) + b_{i3}^{DD}\log(RTP_{it})$$

Definition of import equation for the net rice export countries and regions:

$$\frac{IMQ_{it}}{IMQ_{it-1}} = (\frac{DD_{it}}{DD_{it-1}})^{c_i}$$

Definition of export equation for the net rice export countries and regions:

$$EXQ_{it} = (PD_{it} + STK_{it-1} + IMQ_{it}) - (DD_{it} + STK_{it})$$

Definition of export equation for the net rice import countries and regions:

$$\frac{EXQ_{it}}{EXQ_{it-1}} = (\frac{WP_{it}/WP_{it-1}}{RP_{it}/RP_{it-1}})^{c_i}$$

Definition of import equation for the net rice import countries and regions:

$$IMQ_{it} = (DD_{it} + STK_{it} + EXQ_{it}) - (PD_{it} + STK_{it-1})$$

Ending stock function of the net rice export countries and regions:

$$\log STK_{it} = a_{i0}^{SK} + b_{i1}^{SK}\log(STK_{it-1}/PD_{it-1})$$
$$+b_{i2}^{SK}\log(RP_{it}) + b_{i3}^{SK}PD_{it}$$

Ending stock function of the net rice import countries and regions:

$$\log STK_{it} = a_{i0}^{SK} + b_{i1}^{SK}\log(STK_{it-1}/DD_{it-1})$$
$$+b_{i2}^{SK}\log(RP_{it}) + b_{i3}^{SK}DD_{it}$$

Related function of the domestic producer price of paddy rice with the international rice price:

$$RP_{it} * EXR_{it} = c_{i1} + (1 + c_{i2})WP_t$$

Related function of the retail rice price with the producer price of paddy rice:

$$\log RTP_{it} = a_{i0}^{PL} + b_{i1}^{PL}\log RTP_{it-1} + b_{i2}^{PL}RP_{it}$$

Related function of the international wheat price with the international rice price:

$$\log WWHP_t = c_1^{WHP} + c_2^{WHP}\log WP_t$$

Related function of the domestic wheat price with the international wheat price:

$$\log(WHP_{it} * EXR_{it}) = c_{i1}^{WHP} + c_{i2}^{WHP}\log WWHP_t$$

Related function of the international corn price with the international rice price:

$$\log WMZP_t = c_1^{MZP} + c_2^{MZP}\log WP_t$$

Related function of the domestic corn price with the international corn price:

$$\log MZP_{it} * EXR_{it} = c_{i1}^{MZP} + c_{i2}^{MZP}\log WMZP_t$$

Identity of world rice market equilibrium:

$$\sum_{i=1}^{16} IMQ_{it} = \sum_{i=1}^{16} EXQ_{it}$$

3. Database

The sources of demand, supply and trade of rice are mainly from PS&D of United States Department of Agriculture. The macro economy data is from international financial statistics (IFS) of IMF and National Accounts Main Aggregates Database of United Nation Statistic Division. The sources of prices for rice, wheat, corn, and fertilizer are from IRRI, JIRCAS STAT Ver.3.1 and FAO STAT of Food and Agricultural Organization of UN. The rice data for China is from China Statistics Yearbook and Agriculture Product Cost and Revenue Data edited by National Development and Reform Commission of China. The sources of climate data mainly come from World Climate Data and Monitoring Programme (http://www.wmo.ch/pages/prog/wcp/wcdmp/monthly.html). Because it is monthly climate data for approximately 2,000 surface data collection stations worldwide, it is processed to the monthly data of various countries and regions by Katsuo Okamoto of the National Institute for Agro-Environmental Sciences. The actual data used in modeling is the average monthly data during the paddy growth period, based on the results of the partition of main-crop planting seasons in the various countries and regions prepared by the USDA in 1994. Furthermore, it needs to be noted that weather data of China is the monthly data from its sixteen paddy-rice-growing provinces[1].

4. Parameters estimation and modeling

OLS is the method mostly used for the parameter estimation in WRM, and for some time series data such as changing price, some parameters are estimated using ML-ARCH (Maximum Likelihood- Autoregressive Conditional Heteroskedasticity). Except for the function of yield per unit using samples from 1970 to 2000, the samples for the estimation of other parameters are from 1960 to 2004. The estimation results are shown in Tables 2 and 3. As seen in these results, most of the parameters are significant.

After the parameter estimation, based on the above structural diagram the WRM is developed by using Visual Basic of MS-EXCEL. The Newton method is used in solving the nonlinear system of the above market clearing equation for gross rice export and gross rice import in the world.

5. Assumption of WRM Scenarios

In the baseline scenario, it is assumed that the annual growth rate of world GDP per capita is 3%, which is the average during the period of 1971–2004, the annual

Table 2. Elasticity of paddy production and estimated results

Country/region	Price elasticities of paddy harvest area		Elasticities of per unit area yield			
	Paddy rice price	Wheat price	Paddy rice price	Fertilizer price	Temperature	Precipitation
Australia	0.152*		0.252***	–0.142*	–0.985***	
Bangladesh	0.015*		0.011*	–0.076	–1.012**	0.098*
China	0.041*		0.025***		–0.252***	0.139***
India	0.046***		0.241***	–0.038***	–0.764***	0.261***
Indonesia	0.021**		0.018**	–0.037**	–1.350***	0.190**
Japan	0.326***		0.114***	–0.248**	1.184***	–0.178***
Korea	0.121**	–0.207***	0.046***		–0.147***	0.064***
Malaysia	0.078*		0.120***		–0.037**	
Pakistan	0.145***	–0.061	0.060***	–0.167***	–0.047***	
Philippines	0.013*		0.040***	–0.017***	–0.469***	0.077***
Sri Lanka	0.088**		0.070***	–0.108***	1.988***	0.017*
Taiwan, China	0.041*		0.041***		0.219***	
Thailand	0.088**		0.251***	–0.065***	–0.423***	
USA	0.330***		0.018*	–0.054***	0.323***	–0.321***
Vietnam	0.025		0.051**		–0.941**	
Other countries	0.039**		0.020***	–0.058***	–0.215***	0.123***

*: Significant at the 0.1 probability level. **: Significant at the 0.05 probability level. ***: Significant at the 0.01 probability level.

Table 3. Rice demand elasticity and estimated results

Country/region	Demand elasticity			Parameters of income in demand function	
	Income	Rice price	Wheat price	Reciprocal of per capita GDP	Logarithm of per capita GDP
Australia	0.762	–0.1**			0.762***
Bangladesh	0.154	–0.026 ***			0.154**
China	–0.097 [a]	–0.003***	0.004***	–65.00***	–0.159***
India	0.120 [a]	–0.087***		–231.81***	–0.242***
Indonesia	0.129 [a]	–0.015***		–230.06***	–0.121***
Japan	–0.363	–0.153**			–0.363***
South Korea	–0.177	–0.135**			–0.177**
Malaysia	–0.245 [a]	–0.087***		285.38***	–0.174***
Pakistan	0.298	–0.106***			0.298***
Philippines	0.344	–0.024***			0.344***
Sri Lanka	0.343	–0.087**			0.209**
Taiwan, China	–0.283	–0.378***			–0.283***
Thailand	–0.066 [a]	–0.021***		119.59***	–0.019***
USA	0.208	–0.072***			0.208***
Vietnam	0.196	–0.097***			0.196***
Other countries	1.005	–0.048**			1.005***

a: Represents the income elasticity calculated using the parameter of reciprocal of per capita GDP, logarithm of per capita GDP and per capita GDP in 2004. *: Significant at the 0.1 probability level. **: Significant at the 0.05 probability level. ***: Significant at the 0.01 probability level.

growth rate of China's GDP per capita is 7.5%[3], and the annual Renminbi appreciation rate is 0%, while for other countries and regions the exchange rate for their currency against the US dollar is the average during the period of 1971–2004 (this scenario is also named as the 0% scenario). It is assumed that the weather condition of all countries and regions is invariable and the population size is the forecast results of UN. The cultivated land area of Japan is assumed to decline by –1.3% per annum based on the trend of the past 17 years since Japan's agriculture is downsizing. Furthermore, the prices of fertilizer in various countries and regions are assumed to be the same as past trends since WRM is developed based on the historical data. The base period is set as the year of 2004 and the simulation period is from 2005 to 2020. Two other scenarios of Renminbi appreciation are also assumed: a 4% scenario and 8% scenario, as shown in Fig. 2.

Results

Based on the above three scenarios, the simulations on Renminbi appreciation are projected by WRM. The simulation results are discussed from three aspects: world rice price index, rice trade volume of China and rice trade volume fluctuation of the other 15 countries and regions in the world.

1. World rice price index

Figure 3 shows the simulated results based on different Renminbi appreciation scenarios. The results show that the international rice price index will increase sharply in the short term. However, for the different appreciation rates of Renminbi, the projected results are very different in the long term. The international rice price index for the 0% scenario will decrease in the long term, but for the 4% or 8% scenario it will increase in the future, and especially for the 8% scenario the increase will be linear. Compared with the 0% scenario, the international price index for the 4% and 8% scenarios will be higher than 16% and 32% on average, respectively. Therefore, a Renminbi appreciation will result in a great change in the international rice market in the long term, and it may also cause turbulence in the international rice market in the short term. If the annual Renminbi appreciation rate is more than 8%, the

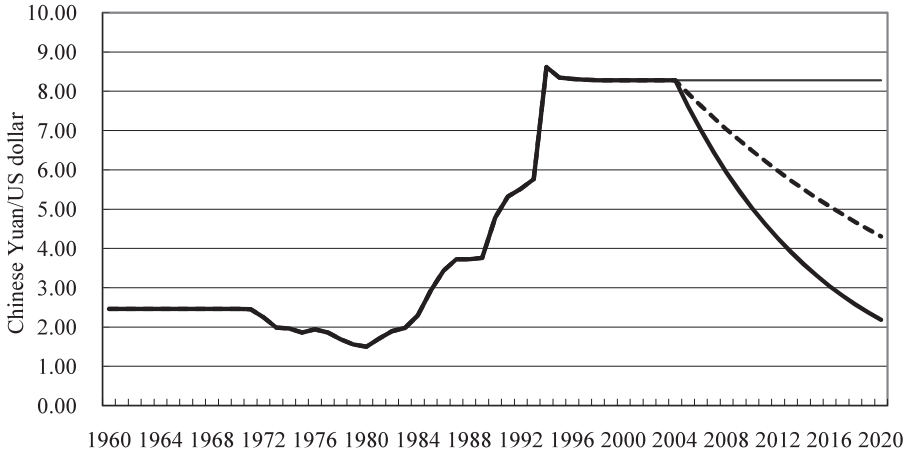

Fig. 2. Assumption of Renminbi exchange rate change and appreciation rate
Source of raw data: Exchange rate data (1960–2004) is from IMF website. Exchange rate data after 2005 is calculated by author based on assumption of RMB appreciation rate.

RMB appreciation rate(0%), RMB appreciation rate(4%), RMB appreciation rate(8%)

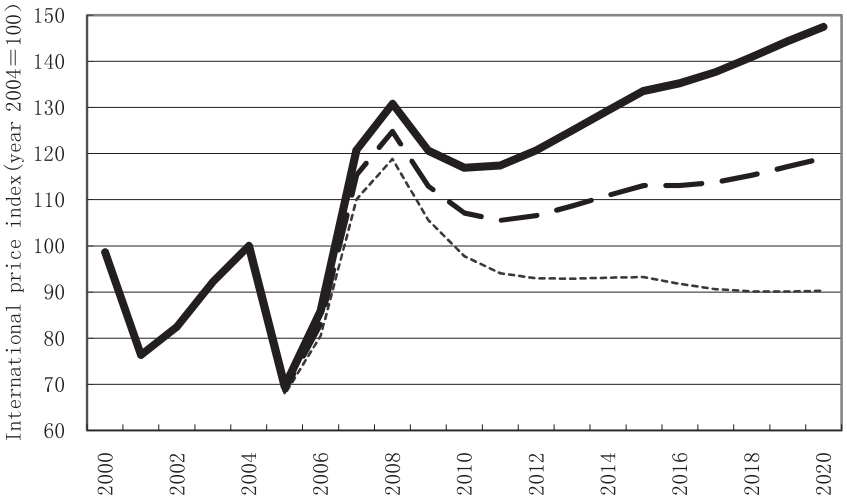

Fig. 3. Simulated results of international price index based on Renminbi (RMB) appreciation scenarios (year 2004 = 100)
Source of data: Simulated results by author.
Simulated data is from the year of 2005.

RMB appreciation rate(0%), RMB appreciation rate(4%), RMB appreciation rate(8%)

international rice price will increase continuously in the long term.

2. Net exports of the main rice exporting countries in the world

Table 4 shows the simulated results of different Renminbi appreciation scenarios. By 2010, the world rice trade situation will mostly be the same as that of 2000. However, the rice exports from Thailand and Vietnam will increase to a great extent, and the rice imports of net rice importers, such as Bangladesh, Indonesia, Philippines, Malaysia, Japan, and the ROW regions will increase gradually. While by 2020, compared with 2000, the world rice trade situation will change greatly. It is projected that India will be the biggest rice net exporting country and Vietnam probably will be the second biggest rice net exporting country in the world. However, for the ROW regions, Bangladesh and Philippines, the net rice imports

Table 4. Simulated results of net exports of every country based on different Renminbi appreciation scenarios

Year	2000	2010			2015			2020		
Appreciation rate of Renminbi	–	0%	4%	8%	0%	4%	8%	0%	4%	8%
				1,000 tons						
India	1685	6784	7085	7391	12496	13261	14039	21325	22584	23821
Vietnam	3488	6084	6863	7536	8109	10504	12713	9381	14902	20123
Thailand	7521	13592	14129	14663	13113	14610	16074	13260	15736	18059
Pakistan	2429	2184	2347	2505	1655	2139	2588	1333	2187	2932
USA	2245	2958	3067	3177	2393	2668	2944	2010	2443	2866
Australia	549	237	272	306	118	219	309	–5	162	262
South Korea	–95	1984	1908	1834	988	786	605	785	462	196
Sri Lanka	–18	–229	–182	–137	–230	–116	–15	–178	1	146
Japan	–198	–269	–237	–205	–317	–249	–180	–253	–161	–70
Malaysia	–596	–692	–646	–602	–780	–655	–539	–810	–611	–438
Taiwan, China	117	–423	–408	–392	–524	–490	–457	–581	–529	–480
Indonesia	–1500	–4945	–4755	–4569	–4959	–4394	–3867	–3632	–2654	–1796
Philippines	–1410	–3632	–3546	–3464	–5136	–4896	–4681	–6531	–6131	–5801
Bangladesh	–672	–5167	–4996	–4833	–8258	–7761	–7317	–11069	–10189	–9459
China	1577	3914	468	–2807	12053	1926	–7525	16268	–2942	–20284
Other countries	–12894	–22380	–21368	–20403	–30720	–27553	–24690	–41303	–35262	–30076

Source of data: Simulated results by author.

will obviously increase.

3. Net rice exports of China

The simulated results of China's net rice exports are illustrated in Fig. 4. It shows that if Renminbi has no appreciation (the 0% scenario), net rice exports of China will increase continuously. By 2010, it will be 3.914 million tons and by 2020, it will be 16.268 million tons. If the annual Renminbi appreciation rate is assumed to be 4%, China's net rice exports will decline after it increases to 2.656 million tons in 2013. By 2018, China will become a net importing country and by 2020, China's net rice imports will reach 2.942 million tons. In the 8% scenario, by 2010, China will become a net importing country and its net rice imports will be 2.807 million tons and by 2020, it will increase to 20.284 million tons. The above results show that, if the Renminbi appreciation is kept at zero, China's rice market will be in excess in the long term. If the annual Renminbi appreciation rate is 4%, it will affect China's net rice exports greatly, and if it is 8%, China will have a gap for rice supply in the short term and in the long run, this gap will become bigger and bigger. By 2020, China will be the largest net rice importer, accounting for 1/3 of the world's rice imports.

Discussion

This paper analyzes the impact of Renminbi appreciation on the world rice market through the policy simulations for three different scenarios of Renminbi appreciation. According to the simulated results above, two conclusions can be drawn. Firstly, the Renminbi appreciation will result in a very large fluctuation in the international rice price index in the short term and even cause turbulence in the international rice market. Specifically, if the annual Renminbi appreciation rate is 8%, it will cause the international rice price index to go up continuously in the long term, and China will become a large net rice importing country in the world. Secondly, compared with other countries and regions, Renminbi appreciation will affect China's rice market more severely and directly. At the same time, it will have an influence on the rice imports of the ROW regions, Bangladesh, Philippines, and so on. These countries and regions may play a key role in causing a global expansion in rice trade. Especially, the net rice exports of India and Vietnam will increase rapidly in the

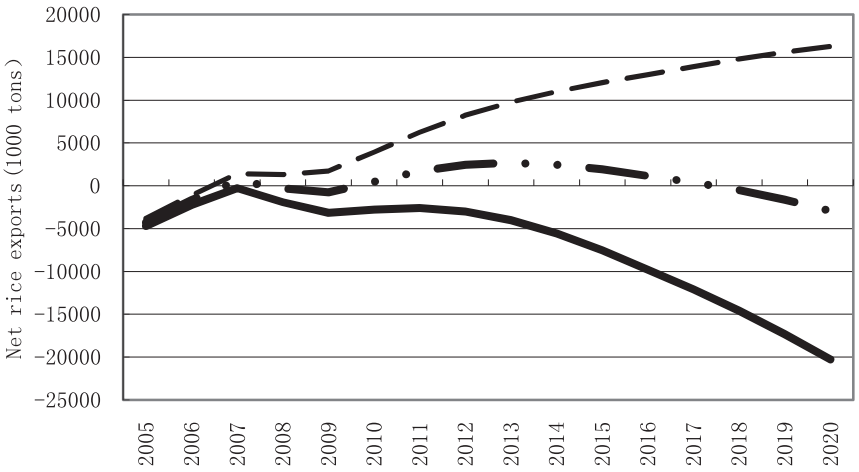

Fig. 4. Simulated results of rice net exports of China based on different Renminbi (RMB) appreciation scenarios

Source of data: Simulated results by author.
Simulated data is from the year of 2005.

long term. Thus if the speed of Renminbi appreciation is very rapid, China will be a net rice importing country, the international rice price index will increase, and it may lead to a shortage of rice and a loss of economic welfare in the other net importing countries and the ROW regions.

Acknowledgments

This research was funded by JIRCAS and was also supported by National Key Technology R&D Program of China (Project No. 2008BADA8B02) and Knowledge Innovation Program of Chinese Academy of Sciences (KSCX-YW-09-01). The authors wish to thank all partners, especially Katsuo Okamoto. The authors are also grateful to the comments from two anonymous referees, the researchers of JIRCAS, Guixia Qian of Inner Mongolia University, Bingjia Shao of Chongqing University, and Xian Xin of China Agricultural University. Lastly, there are many limitations in using WRM as a partial equilibrium simulation model and it may lead to an overestimation in the results because it can not respond to the impact of Renminbi appreciation on the price of fertilizer. More research from now will be required.

References

1. Chien, H., Chen, Y. & Okamoto, K. (2006) Climate influential factors on rice supply and demand trends. *J. Rural Econ*., Special Issue 2006, 151–157.
2. FAO (1993) World food model (WFM), model specification, supplement, FAO agricultural commodity projections to 2000, ESC/M/93/1, Rome.
3. He, J. & Kuijs, L. (2007) Rebalancing China's economy-modeling a policy package. *World Bank China Research Paper No. 7*, September 2007.
4. Kwack, S. Y. et al. (2007) Consistent estimates of world trade elasticities and an application to the effects of Chinese Yuan (RMB) appreciation. *J. Asian Econ.,* **18**, 314–330.
5. Mattos, J. de D. V., Ito, S. & Usami, K. (2003) Macroeconomic policies and the food supply: Exchange rate in a model with non-tradables. *Jpn. J. .Farm Manag.,* **41**(1), 122–125.
6. Oga, K. (1998) Prediction on world food supply and demand of 2020-Development and use of international food policy simulation model. ed. JIRCAS, Rural Culture Association, Tokyo, pp.151 [In Japanese].
7. Orden, D. (2002) Exchange rate effects on agricultural trade. *J. Agric. Appl. Econ*., **34**, 303–312.
8. Schuh, E. G. (1974) The exchange rate and U.S. agriculture. *Am. J. Agric. Econ*., **56**, 1–13.
9. USDA (1996) Major world crop areas and climatic profiles, Agricultural handbook no. 664. World Agricultural Outlook Board, USDA.
10. Wailes, E. J. (2005) Review of existing global rice market models. *In* Rice is life: scientific perspectives for the 21st century, eds. Toriyama, K., Heong, K. L. & Hardy, B., Proceedings of the World Rice Research Conference held in Tokyo and Tsukuba, Japan, 4–7 November 2004, 502–505.
11. Zhang, J. & Fung, H.- G. (2006) Winners and losers: Assessing the impact of Chinese Yuan appreciation. *J. Policy Model.,* **28**, 995–1009.
12. Zhang, J. & Gan, J. (2007) Who will meet China's import demand for forest products? *World Dev.,* **35**, 2150–2160.