Global Warming and its Impact on the Agricultural Sector

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1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) reports global surface temperature change for the end of the 21st century is likely to exceed 2 ℃ for RCP 8.5 and that warming will not be regionally uniform (IPCC, 2013). The impact of the temperature rise exceeding 2 ℃ on the production of the major crops (wheat, rice and maze) in Tropical and Temperate regions is likely to negative. (IPCC, 2014)

There are many previous studies to estimate the impact of temperature on agricultural sectors(Mendelsohn,et. al(1994), Exenberger et al. (2014) etc). However, they did not consider the impact of the temperature rise on the agricultural sector via international trade. The international trade affects the impact on the agricultural sector via change in comparative advantage resulting from the productivity change. There are limited studies to consider how international trade affects the impact of climate change (Reily and Hohmann(1993), Costinot et al (2016)). They mainly identified how the impact of climate change on the agricultural sector affected GDP under consideration of international trade. Costinot et al (2016)) show that international trade reduced substantially the negative impact of climate change on global GDP. It is important to examine the impact of climate change on the agricultural sector at the country level especially for the developing countries since the income in the agricultural sector is lower.

In this study, firstly we explore how temperature affect the land productivity (crop yield) in the agricultural sector by estimating the land productivity function and simulate the impact of temperature rise in 2050 on the productivity using projection by MIROC5, an atmosphere–ocean general circulation model. Secondly, we investigate how change in productivity due to temperature change affects the agricultural sector and GDP of each country/region via change in trade using the GTAP model.

2. Methodology

2.1 Estimation of Land Productivity Model and Impact of the Temperature Rise

In our study, we estimate the agricultural land productivity function using the

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country level panel data expressed as follows.

$$\ln(Land\ Productivity_{it}) = \alpha_1 \ln(Temperature_{it}) + \alpha_2 \ln(Temperature_{it}) * \ln(Income\ per\ capita_{it}) + \alpha_3\{\ln(Temprature_{it})\} * D_{desert_i} + \alpha_4 \ln(Temperature_{it}) * D_{cold\&cool_i} + \alpha_5 \ln(Temperature_{it}) * D_{temperate_i} + \alpha_6\{\ln(Temperature_{it})\}^2 + \alpha_7\{\ln(Temperature_{it})\}^2 * D_{desert_i} + \alpha_8\{\ln(Temperature_{it})\}^2 * D_{cold\&cool_i} + \alpha_9\{\ln Temperature_{it}\}^2 * D_{temperate_i} + \alpha_{10} \ln(Rain_{it}) + \sum \beta_k X_k + \mu_i + \varepsilon_{it}$$

We collected unbalanced panel data with 186 countries/regions for 24 years (1991-2014). We obtained all the agricultural data from the Food and Agricultural Organization's FAOSTAT data base (www.fao.org/faostat/en/#data) and the country level climate data such as temperature and precipitation from Climate Change Knowledge Portal of the Word Bank (http://sdwebx.worldbank.org/climateportal/index.cfm?page=downscaled_data_download&menu=historical). Using these panel data, we estimated the fixed effect model. Then using the significant variables and projection of the temperature by MIROC5 model under RCP85 scenario, we calculated the impact of the temperature rise in 2050 relatively to 2010 on the land productivity.

2.2 Simulation of the Impact of the Productivity Change on the Agricultural Sector

We constructed the computable general equilibrium model (GTAP model) with 12 sectors including agricultural sector and 68 countries/regions. Then we calculated the change in the productivity of each countries/regions affect the agricultural sector and real GDP via international trade due to change in comparative advantage.

3. Main Findings

Our main findings are as follows

(1)The analysis of 2.1 shows that the temperature rise raises productivity in the cool-temperate zone countries (3.2～6.7%) but reduces productivity in temperate zone (－0.1~－3.4%) and in tropical zone (－0.1~－6.8%).

(2)The analysis 2.2 shows that ①the positive impacts of temperature rise on US and Canada after trade adjustment, +4.51% and +6.07% respectively are larger than the positive impacts on the productivity, 6.34% and 13.1 % respectively, ②the negative impact after trade adjustment is smaller than the negative impact on the productivity for many countries, ③the negative impact after trade adjustment is larger than the negative impact on the productivity for some countries such as Japan, Germany, Egypt, Cote d'Ivoir.