A Ricardian analysis of climate change impacts on Japan's agriculture

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1. Introduction

Agriculture is one of the economic activities most vulnerable to climate change, and understanding the impact of climate change on agriculture is critical for establishing a sustainable food supply chain. When evaluating the effects of climate change, it is important to consider the effects of mitigation of climate change effects caused by adaptation measures such as planting temperature-tolerant crops or shifting cropping seasons. However, in general, it is difficult to “explicitly” consider such effects because farmers will conduct a variety of adaptation measures as climate changes.

To incorporate the various adaptation behaviors, it is one of the effective means to employ the model that “implicitly” captures farmers' adaptive actions. The Ricardian model, developed by Mendelsohn et al. (1994), is a commonly used approach for evaluating the impact of climate change on agriculture. Unlike the production function approach, the Ricardian model relies on farmers' profit-maximizing behavior (referred to as full adaptation) under the exogenous conditions they face. This advantage has led to the widespread application of the Ricardian approach across different geographical contexts and scales, despite some criticism.

This study aims to estimate the effects of climate change on Japan's agricultural sector using the Ricardian model. The originality of this study lies in the development of the first Ricardian model that implicitly considers farmers' full adaptation to a changing climate in Japan, thus predicting future agricultural net revenue. Additionally, this study contributes to the existing literature by incorporating solar radiation as a climatic variable in the Ricardian model.

2. Methodology and Data

In Ricardian analysis, farmland value or farmland rent values are frequently used as a proxy for agricultural productivity. However, these values are strictly regulated in Japan. In other words, the variation in farmland rent values is primarily explained by institutional factors rather than climatic or geographical factors. As a result, we used farmers’ net revenue rather than farmland values or farmland rent values for expressing farmers’ productivity in Japan. We assume a

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quadratic relationship between climate and farm productivity. We added exogenous variables in addition to climatic conditions to control observable exogenous factors. The control variables included geographical, soil, market variables, and farmer characteristics.

To determine farmers' net revenue, we used farm-level data from the "Statistical Survey on Farm Management" (SSFM) collected by the Ministry of Agriculture, Forestry, and Fisheries in 2012, 2013, and 2014. When calculating the variables, we used three-year averages. As a result of the data processing, 2,468 farm-level samples are left for econometric analysis. To create climate variables, we used the Agro-Meteorological Grid Square Data (GSD) created by the method of Ohno et al. (2016) and provided by the National Agriculture and Food Research Organization (NARO). It is well known that without considering spatial autocorrelation, OLS estimates are often biased and inconsistent, and/or inefficient. In this study, we estimated a spatial error model (SEM) to deal with the spatial autocorrelation between the error term.

3. Main Results and Conclusion

The main findings of this study are as follows: First, the coefficients of Ricardian regression show that changes in temperature significantly impact farmers' net revenue, even after accounting for the adaptation measures. In contrast, except for spring, the effect of precipitation change on farmers' net revenue was not statistically significant. Although the inclusion of solar radiation can improve the goodness-of-fit of the model in terms of information criteria, solar radiation did not show a statistically significant impact on farmers' net revenue.

As a result of our future predictions based on Ricardian regression, negative effects of climate change are not observed in most regions in Japan, and northern regions are expected to benefit more than the southern regions. This result indicates that it is possible to increase agricultural productivity and mitigate the negative impacts of climate change if farmers adopt full adaptation strategies. However, full adaptation includes adaptation measures with high economic costs, such as the development of agricultural production infrastructure, which are assumed to be implemented voluntarily. Therefore, this result can be interpreted as a more optimistic scenario for climate change impacts on agriculture.

Reference

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