2022 Doctor's Dissertation

STOCHASTIC FRONTIER ANALYSIS OF RICE FARMS IN BANGLADESH

Graduate School of Economics, Nagoya University

Academic Advisor: Professor SONODA Tadashi

Name: SALAM Md Abdus

STOCHASTIC FRONTIER ANALYSIS OF RICE FARMS IN BANGLADESH

by

SALAM Md Abdus

A Dissertation Submitted to in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Economics

Graduate School of Economics

Nagoya University

Dissertation Advisory Committee:

Professor SONODA Tadashi

Professor NEMOTO Jiro

Professor MANGYO Eiji

March, 2023

STOCHASTIC FRONTIER ANALYSIS OF RICE FARMS IN BANGLADESH

SALAM Md Abdus

Student ID: 441801009

Dissertation Advisory Committee

SONODA Tadashi
Professor
Graduate School of Economics,
Nagoya University

NEMOTO Jiro
Professor
Graduate School of Economics,
Nagoya University

MANGYO Eiji
Professor
Graduate School of Economics,
Nagoya University

Acknowledgement

All praises are due to the Almighty Allah who kindly enabled the author for the successful completion of this dissertation for Ph.D. degree in Economics. First and foremost, I would like to express my heartfelt indebtedness, deep sense of gratitude and profound appreciation to my academic supervisor, Professor SONODA Tadashi, Graduate School of Economics, Nagoya University, Japan for his scholastic guidance, constructive criticism, encouragements and valuable suggestions throughout the tenure that tremendously helped me in completing the dissertation. Right from the very beginning, his insightful suggestions, constant encouragement, reviews, and assistance enabled me to complete the thesis. His suggestions regarding selection of the topic, theoretical development, data analysis, and comparison with existing studies undoubtedly improved the quality of the study. I always cherish the comments he made in the seminars about the thesis.

I would like to take the opportunity to express my immense indebtedness, heartiest respect, and sincere appreciation to my academic co-supervisor, Professor NEMOTO Jiro and seminar supervisor, Professor MANGYO Eiji for their sincere interest, continuous inspiration and constructive comments in improving my dissertation during the entire journey.

I am also thankful to the Graduate School of Economics for providing such a wonderful research environment and resources without which preparation of my thesis would be much difficult. I am appreciative to all the faculty members and staff of the School of Economics. Finally, I would like to expresses my boundless and indebtedness gratitude to my family members and well-wishers who always blessed, inspired and sacrificed a lot in the long process of building my academic career which can never be repaid.

March, 2023

SALAM Md Abdus

Student ID: 441801009

Graduate School of Economics, Nagoya University

Table of contents

List of Tables

List of Figures

Title: Stochastic Frontier Analysis of Rice Farms in Bangladesh

Summary of the Dissertation

Bangladesh is one of the densely populated countries in the world where rice is the staple food, and most people are directly or indirectly depend on agriculture, particularly rice production. In recent Bangladesh, increasing demand for rice to meet increasing population has put pressure on farmers and the government to ensure availability of staple food, rice. Rice was grown in 77% of the total cultivated areas in the year 2018-2019 (Bangladesh Bureau of Statistics (BBS)), and more farmers have planted rice in multiple seasons every year to meet such high demand for rice and also to increase their income. Faced with limited availability of farm land (about 0.5ha per household in recent years), raising productivity or technical efficiency in rice production is one of the most important issues for Bangladesh economy. A number of researchers have studied this topic using various data sets, including aggregate and household-level (or plot-level) data. However, they have not yet reached consistent conclusions about some important topics or have never studied them. The following topics can be important but have not been examined. The specific objectives of this study are (1) to examine the effect of participation in wage work and non-farm business on Bangladesh rice farms, (2) to analyze factors to explain the yield difference between aman and boro rice, and (3) to examine regional technical efficiency and technology gap differences of rice farms in Bangladesh.

This dissertation includes five chapters. Chapter 1 explains overview of Bangladesh agriculture, rice production in Bangladesh, performance of the agricultural sector among the South Asian countries, literature review of the related topics, and the objectives of this dissertation. Chapter 2 investigates effects of participation in wage work and non-farm business on productivity and technical efficiency in Bangladesh rice farms. Chapter 3 investigates factors to explain yield difference between aman and boro rice in Bangladesh. Chapter 4 empirically examines whether there exists difference in technical efficiency and technology gaps across the seven climate zones in Bangladesh. Chapter 5 concludes this dissertation.

Specifically, Chapter 2 investigates effects of participation in wage work and non-farm business on productivity and technical efficiency in Bangladesh rice farms. We examine participation in wage work and non-farm business separately because these two off-farm activities can affect farm productivity and efficiency differently due to farm household income, farm characteristics, and farm investment being different. For our empirical analysis, we use data from a recent nationally representative household survey, Bangladesh Integrated Household Survey in 2015 (BIHS2015). Cross-sectional data on 8883 plots of rice farms from BIHS2015 show that the average rice yield of type W households (households with wage workers) is 4482kg and that of type B households (households with non-farm business workers) is 4890kg, indicating 9.1% higher yield for type B households. To examine the yield difference between the two groups, we estimate stochastic production frontiers separately for these groups, assuming heteroskedastic technical inefficiency. This estimation result is used to explain the yield difference between type W and type B households, which shows that the mean difference in deterministic production frontiers (DPFs) explain 5.5% and the difference in mean technical efficiency explain 2.3% of the yield difference. The mean difference in DPFs is then decomposed into the difference in the endowment of inputs and shift factors (4.2%) and the difference in coefficients of DPFs (1.2%). Furthermore, we find for the difference in the endowment of inputs and shift factors that type B households use more hybrid variety to produce 1.3% higher yield, plant more boro rice to produce 0.92% higher yield, have higher share of plots in Rajshahi division to produce 1.4% higher yield, but have more plots to produce 0.84% lower yield.

Chapter 3 investigates factors to explain yield difference between aman and boro rice in Bangladesh using data from BIHS2015. According to information from BBS, a much higher yield has been observed for boro rice than aman rice: in 2015, boro rice had 42% higher yield than aman rice for HYV (high yielding variety) and 14% higher yield for local varieties. While such a significant yield difference between aman and boro rice has been observed in Bangladesh, few studies have evaluated contributing factors causing the difference. To explain this gap, we estimate stochastic production frontiers using balanced panel data on 2450 plots for rainy and dry seasons to control for plot heterogeneity in SPF estimation. For the 2450 plots, the yield of boro rice was found to be 57% higher than that of aman rice. After estimating an SPF assuming a true random effects model, we decompose the ratio of mean yields of aman and boro rice into the ratio of mean DPFs representing different use of inputs, water sources, or rice varieties. The ratio of mean DPF for boro rice to mean DPF for aman rice was estimated at 1.51, indicating that mean DPF is 51% higher for boro rice. The indexes of input use, water source, and rice variety were evaluated at 1.09, 0.99, and 1.04, respectively, implying that input use was more important than water source or rice variety in explaining the DPF difference.

Chapter 4 empirically examines whether there exists difference in technical efficiency and technology gaps across the seven climate zones in Bangladesh. Rice production in Bangladesh can show such regional difference because of difference in environmental situations, soil quality, farmer practices and techniques, irrigation, farmers' economic conditions, etc. Under this situation, it is natural to assume separate production frontiers for different climate zones and also to evaluate technical efficiency of farmers in these zones by assuming a meta-production frontier which envelopes all the production frontiers for these zones. Cross-sectional data on 13113 plots of rice farm households from BIHS2015 reveals two distinct regional types based on output elasticities. Type A zones (south-eastern and north-eastern zones) have relatively low output elasticity of land (about 0.60) and relatively high output elasticities of labor (about 0.15) and other costs (over 0.10). On the other hand, type B zones (north-western, western, south-western, and south-central zones) have high output elasticity of land (about 0.90) and low output elasticities of labor (about 0.03) and other cost (about 0.04). Compared with type B zones, type A zones produce lower rice yields using larger land but lower levels of other inputs per hectare. Furthermore, production frontiers of type A zones have lower output elasticity of land and higher output elasticities of labor and other costs, and their TE (technical efficiency) and TGR (technology gap ratio) are slightly lower, and hence their MTE is lower. These characteristics show that for farmers in type A zones to increase rice output (or rice yield), an effective way is to increase labor and other costs (e.g., pesticide, rental tools, machinery, seeds). Also, TE and MTE must be improved by encouraging farmers in type A zones to possess their own land and/or to work on their own farm more than work off their farms. Furthermore, to improve TGR in type A zones, the government should encourage technology development, such as introducing salinity, cold, and drought-tolerant rice varieties.

Through the analyses done in these chapters, we found some implications for rice farming households in Bangladesh. In recent developing countries, farmers' participation in non-farm work (including wage work and non-farm business) has helped increase their household income. Following other developing countries, the government of Bangladesh may try to improve their income by creating more opportunities for wage work (e.g., constructing manufacturing plants or building infrastructures). In this case, our result from Chapter 2 suggests rice yield (and hence the total amount of rice produced) will be reduced by wage work participation of households with non-farm business workers or households without nonfarm workers. To avoid reducing rice yield, the government can help households with wage workers adopt more hybrid varieties, plant boro rice, or further reduce the number of plots operated by them. The government can also help them raise their technical efficiency by increasing their farm size. Considering the rapid population increase and limited farmland availability in recent years, the government should consider adopting such policies if it really cares about food security of staple food (rice) as well as the income of farm households (or the entire economy).

Another implication of the analysis is how to reduce the yield gap between aman and boro rice. Our result in Chapter 3 showed a higher contribution of input use (particularly fertilizer and other costs) in explaining the yield difference between aman and boro rice, rather than contributions of water sources and rice varieties, despite these factors were believed to explain the relevant portion of the yield difference. In other words, changing water sources or rice varieties for producing aman rice do not reduce the yield difference between aman rice and boro rice so much, whereas increasing fertilizer or other variable inputs can reduce more of this difference. This might suggest that farmers cannot increase their inputs in aman season due to, for example, credit constraints even if they know how to reduce the difference.

Yet another implication of the analysis is how to deal with different rice yield or output in the two distinct climate zones. For this purpose, our discussion in Chapter 4 suggests that the government of Bangladesh should emphasize more investment in research to develop advanced climate zone-specific technology and should provide input subsidies that have been found to increase rice productivity. Additionally, increasing rice productivity in Bangladesh requires policies that improve farmers' access to extension services to encourage the adoption of climate zone-specific technologies and appropriate crop management practices. Subsequently, public and private organizations should come forward to make investments in agricultural technology acquisition and promote technological innovation by supporting research and development efforts to reduce technological gaps. More specifically, type A zones need to install advanced production technologies to catch up to type B zones.