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Technical efficiency of rice production in the delta of the Vu Gia Thu Bon river basin, Central Vietnam

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ABSTRACT

In recent decades, Vietnam has experienced an incredible increase of total factor productivity (TFP) in rice production. This has allowed the country to rise to become one of the largest rice producers worldwide. Nevertheless, despite these achievements, there are strong signs of a TFP slowdown in Vietnam in recent years, raising concerns about the future development of rice production and appropriate policy measures. We have analyzed the technical efficiency of rice production in the delta of the Vu Gia Thu Bon river basin in Central Vietnam, considering the different rice seasons and the spatial distribution of efficiency scores. We applied stochastic frontier analyses with a simultaneous (one-step) estimation of the parameters of exogenous effects on technical efficiency (TE). We have shown that TE in this region is basically impacted by the scale of production, by fragmentation of the farm and also by the exposition to salinity intrusion risks. The latter factor has never been explicitly included in former technical efficiency studies of rice production in Vietnam. There is a pertinent need for policies targeting farm fragmentation and enlargement of the scale of rice production. The spatial distribution of TE shows that salinity intrusion and the inherent irrigation management problems caused to farmers is a serious negative impacting factor. Adaptation measures on water management in the basin, as well as related to the introduction of salinity resistant rice varieties should be addressed urgently in the region to increase efficiency in rice production.

1. Introduction

Vietnam is the one of the largest rice exporters worldwide, a success due to extensive land and market reforms and introduction of new technologies over the last 30 years. Rice production was decentralized and markets liberalized inducing higher rice prices. Farm profits are now retained by farmers giving people the incentives to invest in the farm. These changes have induced an enormous increase in total factor productivity (TFP) and Vietnam has been able to strongly reduce rural poverty during this period (Hansen & Thang, 2007; Kompas, Che, Nguyen, & Nguyen, 2012). Despite these achievements, there are strong signs of a TFP slowdown in Vietnam since 2002. This can be witnessed in all rice producing regions except for the Mekong River Delta (Kompas et al., 2012). In this context, the latter authors refer to restrictions on land use and market regulations that still call for further reforms. Vietnam has implemented important land reforms that have induced a remarkable improvement in production incentives for farmers on the one hand, but on the other hand may have decisively contributed to a fragmentation of the country's agricultural land. The land allocation process during the reform years in the course of the Doi Moi policy was responsible for this fragmentation process (GSO, 2010; Van Hung, Macaulay, & Marsh, 2007; World Bank, 2003). This process was based on the application of strong equity principles on land/soil quality allocation between households, which led to the distribution of rather small land plots to households with different locations within communes (Ravallion & Martin Van De Walle, 2001; Van Hung et al., 2007).

Another important point regarding productivity is the change in rice landscapes due to strong industrial and urban developments. It is estimated that between 2001 and 2010 ca. 1 million hectares of farm land have been converted to industrial and urban use in Vietnam (Vo et al., 2011). The building of settlements and roads often disrupt the functioning of ancient irrigation systems, isolating farmers from reliable water supply sources (Quang Nam Irrigation Management Company, IMC, personal communication). Environmental effects such as climate change, sea level rise and salinity intrusion are other concerns for rice production in Vietnam, as one of the most affected countries in the world (Chen, McCarl, & Chang, 2012; Dasgupta, Laplante, Meisner,

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Wheeler, & Yan, 2009).

There are few studies regarding technical efficiency (TE) of rice production in Vietnam. The following studies estimated TE levels in rice production in Vietnam, basically using Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis (DEA). These studies related TE to exogenous determinants such as production scales, land fragmentation, education, experience of the household head, ethnicity, type of soils, or the condition of the irrigation system. Kompas et al. (2012) used SFA methods with a Cobb-Douglas (CD) production function specification. The authors used two different data sets, an own farm survey from 2004 for the Mekong River Delta (MRD) and Red River Delta (RRD), and the Vietnamese Household Living Standards Survey (VHLSS) 2004 for the whole country. Van Hung et al. (2007) analyzed efficiency in North Vietnam, using a translog specification of the CD production function to a sample of ca. 200 households in the provinces of Ha Tay and Yen Bai.

Khai and Yabe (2011) concentrated on the effects of policy measures on TE in rice production in the whole of Vietnam. The authors again used a CD stochastic frontier model for measuring TE using the VHLSS 2006 data set. The authors applied a two-step analysis procedure. In the first step, the efficiency scores were estimated, expressing an average production TE. In the second-step, the efficiency scores were regressed on variables believed to impact on technical efficiency (a Tobit regression model was used). Linh (2012) examined technical efficiency in Vietnam comparing SFA results (with a CD specification), with TE estimations from DEA complemented with a bootstrapping procedure for bias correction. The author used the VHLSS 2004 data set for the whole of Vietnam. Tung (2013) also used a two-step bootstrap bias-corrected DEA procedure to analyze the technical and scale efficiency of Vietnam's Mekong Delta rice producers. The author delivered a time trend perspective on efficiency, using data from the Vietnam Living Standard Survey (VLSS) 1998, and the VHLSS for 2002, 2004, 2006, 2008 and 2010. In the first step, the bias-corrected DEA scores were computed, and in the second step, the impacts of independent variables were analyzed through truncated regression procedures. Trong & Napasintuwong's, 2015 study was the only study found to address Central Vietnam explicitly. The authors measured profit efficiency in Central Vietnam among hybrid rice farmers by using SFA. The authors used their own data gathered through a 2012/2013 survey covering information for the Winter-Spring season only. Furthermore, a stochastic translog normalized functional specification of the profit function was applied. The variables judged as impacting on profit efficiency were estimated simultaneously in a single-step procedure.

The research reviewed on rice production efficiency in Vietnam documents strong empirical evidence that current production scales and farm land fragmentation have negative impacts on technical efficiency. The studies also show that larger and less fragmented farms are more efficient. Surprisingly, none of these studies analyzed the potential impacts on production of prevalent environmental conditions, apart from the use of perceived soil fertility indexes. In the Vietnamese deltas, in particular, it is well-known that sea level rise and salinity intrusion represent a huge problem (if not the major problem) in rice production, which is intimately related to the management of the irrigation system. The exclusion of environmental variables that condition production can generally lead to 'omission variable bias' and also to downward bias in estimated TE (Sherlund, Barrett, & Adesina, 2002). Moreover, there are no studies on technical efficiency for Vietnam that explicitly consider the different rice production seasons and respective different environmental conditions.

With regard to the SFA methodology, the majority of the studies reviewed used a two-step procedure to investigate the relationship of inefficiency with a vector of exogenous variables, i.e. the observation-specific inefficiency was measured in the first step with a stochastic production frontier model, followed by regression of the inefficiency scores on the vector of the exogenous variables (a truncated or Tobit regression methodology). The two-step procedure has long been considered as biased because of the misspecification of the model in the first step. The preferred approach should be the simultaneous estimation of the production frontier model and the relationship of efficiency and exogenous variables (Battese & Coelli, 1995; Wang & Schmidt, 2002). Most of the production TE studies undertaken so far for Vietnam concentrate predominantly on the Red River Delta (RRD) and the Vietnamese Mekong River Delta (MRD) or the whole country. Central Vietnam is, so far, almost overlooked in research.

The present study analyzed TE in rice production in the delta of the Vu Gia Thu Bon river basin in Central Vietnam, and hereby considered the temporal and spatial scales often neglected in former studies. We explicitly analyzed TE separately for the two prevalent rice seasons in the region, the Winter-Spring (WSp) and the Summer-Autumn (SA) season, the latter season being the most affected one by salinity intrusion. The spatial representation of TE scores enabled a better understanding of the TE differentials across the different irrigation zones, in relation to salinity intrusion risks and also to the spatial incidence of massive land conversions that have occurred in the last 15 years in the VGTB delta region.

We applied SFA with a simultaneous estimation of the production frontier model and the relationship of inefficiency with a set of exogenous variables related to the scale of production, land fragmentation, as well as education, experience of household head, etc. We have also included environmental variables like the perceived soil fertility and a salinity intrusion risk index across the irrigation zones to capture spatial heterogeneity in environmental conditions that may potentially impact on efficiency.

2. Materials and methods

2.1. The research area

The present study focused on the delta of the Vu Gia Thu Bon river basin (VGTB) in the Quang Nam province in Central Vietnam. The basin is located in the South Central Vietnam climate zone between 107°15′108.20′E and 14°55′16.04 N, with a total area of 10,350 km^2. It includes the entire Quang Nam province, Da Nang city and a considerable part of the Kon Tum province. The elevation of the VGTB ranges from sea level to 2598 m. It is characterized by relatively warm winters, dry summers and a strong monsoon rainy season with typhoons lasting from September to December. The basin is composed of the Vu Gia and Thu Bon rivers, with a delta region, which has 13 rice irrigation zones delineated according to their hydraulic connectivity, as in Fig. 1 (Viet, 2014). The delta of the VGTB river basin is where the most fertile soils for rice production are found and where most rice production takes place. Rice production is by far the most important activity and is mainly found on the alluvial plains of the delta (Pedroso et al., 2017).

2.2. Statistical model

We have applied stochastic production frontier analysis with a Cobb-Douglas specification for estimating technical efficiency, i.e. estimating the ability of the farm to reach the maximum output for a given set of inputs. The econometric model includes two random error terms, a symmetrical noise effect, and a non-negative inefficiency effect. The latter allows us to estimate the technical efficiency of each farm. For more details see the Technical Appendix A and Battese and Coelli (1995) and Kumbhakar and Lovell (2003).

We have constructed two different models per season, with and without environmental variables, a total of four models. The inclusion of the environmental variables (index of perceived soil fertility and the salinity intrusion risk-index) was intended to control for the effects these factors can have when estimating technical efficiency (Sherlund et al., 2002).

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