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Rice Productivity and Technical Efficiency: A Meta-Frontier Analysis of Rice Farms in Northern Ghana

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Introduction

Cereals form the bulk of the food staple in Ghana and the main cereals produced are maize, rice, millet and sorghum. Among these cereals, rice offers the best opportunity to rapidly increase food production, because current yields are far below potential due to low productivity on most rice farms. The quest to attain self-sufficiency in rice production in Ghana has led to the introduction of copious policy interventions by successive governments of Ghana. These have however not yielded the desired results and currently, rice productivity and self-sufficiency are still low. Besides being an important food staple in Ghana, rice is also an important cash crop in areas where it is produced (Asuming-Brempong and Osei-Asare, 2007) and it has also been identified as a strategic food security crop in Ghana. According to MoFA (2009), urbanisation, population growth and changes in consumer habits account for the persistent increase in rice consumption in Ghana over the years. Domestic production however has been inadequate, creating supply deficits which are only met through imports. In 2013, Ghana imported 644,334 Mt of rice valued at $392.30 million (MoFA, 2014). Such overreliance on rice imports has grave implications for Ghana's quest to attain food security, increased income and reduced poverty. It also puts pressure on Ghana's foreign reserves and inhibits investment in other sectors of the economy. According to Asuming-Brempong (1998), Ghana has the right agronomic conditions required for all-year-round production of rice. Nonetheless, these have not been fully exploited owing to some technical and structural limitations such as inadequate mechanization, low usage of agrochemicals, lack of seeds of improved varieties and bad agronomic practices inter alia which have resulted in inefficiencies that repress the development of the local rice industry. Presently, the average yield of rice in Ghana, 2.6 Mt/ha, is far below the achievable yield of 4.0-8.0 Mt/ha (MoFA, 2014). This indicates that on average, rice farms in Ghana are operating far below their potential. Meanwhile with the current level of resource endowment and technology, potentials still exist for these rice farmers to close the existing yield gaps and improve land productivity. This can be done through improvements in the efficiency with which productive resources are used. Northern Ghana produces the bulk of Ghana's rice: Northern (37%) and Upper East (27%) regions (Ragasa et al., 2013). However, rice is cultivated under diverse agro-ecological or climatic conditions in northern Ghana which significantly influence the productivity level of most rice farms. This compels the farmers to use different production technologies leading to output variations among the rice farmers. There is therefore the need to examine and compare the productivity and efficiency levels of rice farms operating under the different agro-ecological conditions for the purpose of formulating location-specific policies for productivity and efficiency gains in both agro-ecologies. Additionally, Langyintuo and Dogbe (2005), found farm families in Ghana, particularly those in northern Ghana to be operating with low levels of productivity, hence the need for this study to ascertain the productivity and efficiency levels and the quantum of gains that can be achieved without using additional inputs.

Material and Methods

Using a farm-level data collected from 788 rice producing households in northern Ghana, this study adopts the stochastic frontier approach to assess the productivity of inputs used, technical efficiency (TE), and the determinants of technical inefficiency. This approach is adopted because it allows the composed error term to be decomposed into the inefficiency effects and the random noise effects. Since agricultural production systems, particularly in the developing world are largely characterised by unforeseen or stochastic circumstances, it is germane to identify the level of deviation from the maximum attainable output that is attributable to conditions under the control of the farmer (inefficiency effects) and conditions beyond the control of the farmer (random noise effects). The use of the stochastic frontier technique is underpinned by the assumption that a homogeneous production technology characterises the sampled farms (Battese et al., 2004). However, farms located under different agro-ecological conditions (environments) do not always have access to a homogenous production technology. Hence, assuming equal technology when indeed they differ may result in attributing unobserved differences in production technology to technical inefficiency (Villano et al., 2010). Therefore, this study further adopts the stochastic meta-frontier approach to measure the differences in production technology relative to the meta-technology after testing for the null hypothesis that a similar production technology is used by rice farmers in both agro-ecological zones. This allows a comparison of the efficiency scores of the different farms relative to the meta-frontier (Battese et al., 2004).

Results and Discussion

The null hypothesis that a similar production technology characterizes rice cultivation across the two zones was rejected. This forms the basis for using the stochastic meta-frontier approach. The estimated coefficients for all the explanatory variables except for quantity of rice seed used are positive, indicating that a percentage increase in labour, farm size, fertilizer and herbicide will increase rice output by 0.14%, 0.58%, 0.23% and 0.11%, respectively. However, by increasing the quantity of seed used by 1%, rice output will decline by 0.08%. This may be ascribed to the excessive recycling of rice seeds for planting by the farmers. The estimated elasticities of labour, farm size and fertilizer are statistically significant at 1%, whilst that of herbicide is at 10%. This shows the relative importance of these inputs in determining the output level of rice in the study area. The estimated returns to scale are 0.80 and 0.82 for farms located in the forest-savannah transition and savannah zones, respectively. This implies that a proportionate increase in all inputs will result in a less than proportionate increase in rice output across both zones. The estimated gamma values for farms located in the savannah and forest-savannah transition zones are 25% and 85%, respectively. This suggests that for rice farms located in the savannah zone, about 25% of the total deviations from the potential frontier output may be attributed to conditions under the control of the rice farmers and about 75% of these deviations may be due to conditions beyond the control of the farmers. This further implies that conditions such as drought, flooding, poor road networks, attack of pests and diseases and measurement errors among others dominate the inefficiency effect in explaining the total variation in rice output. For farms in the forest savannah-transition zone, about 85% of the total deviations from the frontier output is due to technical inefficiency and the random noise constitute about 15% of these deviations.

The mean TE relative to the individual zonal frontiers are 0.61 and 0.88 for farms in the forest-savannah transition and savannah zones, respectively. This implies that on average, rice farms in the forest-savannah transition and savannah zones are producing 61% and 88%, respectively of their individual zonal frontier output. This further shows that with their current levels of resource use and technology, rice farmers in the forest-savannah transition and savannah zones can increase rice output by 29% and 12%, respectively without necessarily employing additional inputs. The mean TE relative to the pooled zonal frontier is 0.69, implying that rice farms are producing about 69% of their pooled zonal frontier output.

The technology gap ratio (TGR) estimates reveal that rice farmers in the forest-savannah transition and savannah zones on average, produce 96% and 51%, respectively of the local rice industry's possible output relative to the accessible technology of the entire rice industry. This implies that rice farmers in the forest-savannah transition zone may be better equipped with modern available technologies suitable to their agro-ecology compared to their counterparts in the savannah zone. This further implies that despite the fact that rice farmers in the savannah zone are producing 88% of their zonal frontier output, their

performance at the local rice industry's level is relatively low (51%) compared to those in the forest-savannah transition zone. The study also reveals that the mean TE relative to the meta-frontier are 0.58 and 0.52, respectively for farms in the forest-savannah transition and savannah zones. This implies that rice farms located in the forest-savannah transition zone are technically more efficient relative to their counterparts in the savannah zone.

According to Onumah et al. (2013), estimates of the level of technical efficiency of a given production unit are necessary but not sufficient to merit policy interventions. There is the need to identify the causes of the variations in the technical efficiency estimates so as to formulate the right policies for the attainment of the full frontier output and this is done by specifying an inefficiency model. The technical inefficiency estimates reveal that farmers in the forest-savannah transition zone with access to training in rice production are technically more efficient relative to their counterparts who lack access to such trainings. This is because such trainings help to boost the technical knowledge of the farmers by introducing them to modern production techniques. An akin finding was reported by Mariano et al. (2010) in their study of rice farms in Philippines. Contrary to expectation, farmers located across the two zones with bunds around their farms are found to be technically less efficient than their counterparts without bunds. This may be due to the excess labour requirements for farms with bunds. For every operation on the farm, additional labour is needed for farms with bunds compared to those without bunds and the inability of the farmers to meet these extra labour needs may translate into inefficiency. This finding contradicts those of Becker and Johnson (2001), who posited that bund construction has the potential to significantly increase rice production in West Africa. Selling at the farm gate, which is a proxy for access to market, increases efficiency across both zones. This is because, a reliable access to produce market will motivate the farmers to put in their best so as to earn more income, leading to increased efficiency of the farmers. Across the two zones, farmers who practice rice monoculture are found to be technically more efficient than their counterparts who engage in intercropping. This may be due to the fact that monoculture helps to reduce excessive competition among the crops for essential soil nutrients and sunlight and this translates into higher yields. Tenure securities also help to improve the efficiency with which rice farmers in the forest-savannah transition zone cultivate. This is because secured land arrangements facilitate investment in productivity enhancing inputs, which translate into higher output for the farmers. This finding is consistent with Donkor and Owusu (2014), who also argued that secured land owners may be motivated to invest in short- and long-term productivity enhancing measures for long term benefits. The distance between the farm and farmer's homestead also affect the efficiency with which the farm owner operates. This is because, farmers who are domiciled farther away from their farms are found to be more inefficient relative to those who live closer to their farms. Farmers who live farther away from their farms are less likely to visit their farms regularly and therefore are less likely to properly cater for the crops. The distance may serve as a disincentive for them to regularly visit the farm and this makes it difficult for the farmers to notice and meet the needs of the crops. This finding concurs with Tan et al. (2010), who argued that significant gains in TE is possible if the travel time to spatially dispersed farm plots are reduced. Across both zones, farmers who engage in other forms of income generating activities are found to be technically less efficient. This is because such engagements are likely to take the farmer's attention away from the crops on the field. It affects the amount of time devoted to essential farm operations which boost crop yield. It may also affect the level of supervision of farm labour operating on the field and these affect crop yield. A similar finding was reported by Mariano et al. (2010).

Conclusions and Outlook

This study adopts the stochastic meta-frontier approach to determine and compare the level of TE of rice farms in two different agro-ecological zones of northern Ghana using a cross-sectional data from 788 farmers. The findings show that all the input variables contribute positively to rice output except the quantity of rice seed which reduces output. The study also shows that rice farms in both zones are characterized by decreasing returns to scale, implying that by doubling all inputs, rice output less than double across both zones. Rice farms located in the forest-savannah transition and savannah zones are found to be 61% and 88% technically efficient, respectively. The empirical findings further show average technology gaps of 96% and 59% for farms located in the forest-savannah transition and savannah zones, respectively. This indicates that farms located in the forest-savannah transition zone are operating closer to the domestic rice industry's frontier relative to their counterparts. With the mean TE relative to the meta-

frontier of 0.58 and 0.52 for farms in the forest-savannah transition and the savannah zones, respectively, the study concludes that rice farms in the forest-savannah transition zone are technically more efficient relative to their counterparts in the savannah zone. Factors such as farm ownership, participation in rice training programs, rice monoculture and selling rice at the farm gate reduce technical inefficiency. Technical inefficiency is however increased by engaging in off farm activities, construction of bunds around the farm and the distance of the farm from homestead. The study recommends the use of proper land tenure arrangements aimed at ensuring easy access of farmers to land for rice cultivation. Policy makers should also focus on policies that will enhance rice farmers' access to markets to sell their produce. Frequent and effective training programs geared towards enhancing farmer's technical knowledge and farm management skills should be provided. Households engaged in off-farm income generating activities are also encouraged to invest their resources, time and cash, in farm operations as a way of contributing to the efficiency of agricultural production systems. Enhancing farmer's access to seeds of improved rice varieties which are adaptable to their agro-ecologies will also help improve rice productivity in Northern Ghana. These are issues that future policies and programs may have to consider in the quest to improve farm-level performance.

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