EFFICIENCY MEASUREMENT AND EFFICIENCY STUDIES: A REVIEW

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ABSTRACT
The paper reviewed the efficiency measurement and efficiency studies in Nigeria. The review of the efficiency studies at National and International level shows that researchers who have applied the Data Envelopment Analysis (DEA) did not apply the Double Bootstrapping procedure. Most of the researchers continue to use the Tobit or OLS in the two-stage DEA, which gives unreliable estimates of the determinants of efficiency. There is thus a need for researchers to apply the Double Bootstrapping DEA procedure in order to obtain more valid information on the determinants of efficiency.

INTRODUCTION

Definition and types of efficiency

Fried, Lovel and Schmidt (2008) have defined efficiency as a comparison between observed and optimal value of output and input. Efficiency is improved if more outputs are generated without changing inputs, or if the same outputs are generated with fewer inputs. According to Bravo-Ureta and Rieger (1991), substantial resources can be saved through efficiency measurement.

Allocative efficiency in input selection involves selecting that mix of inputs (such as land, labour and capital) which produce a given quantity of output at minimum cost (given the input prices which prevail) (Coelli, Prasada Roa, O'Donnell & Battese, 2005). Technical efficiency is defined as the ability of a firm to obtain maximum output from a given set of inputs (Farrell, 1957). Economic efficiency or total efficiency is the product of technical and allocative efficiencies (Coelli *et al.*, 2005; Coelli, 1996). Economic efficiency can also be defined as the ability of a farm to achieve the highest possible profit, given the prices and levels of output prices of that farm (Bagi, 1982).

Measuring farm efficiency

As an introduction, some items in the literature on approaches to measuring farm efficiency are briefly presented here. Farm efficiency can be measured using Data Envelopment Analyses (DEA) or Stochastic Frontier (SF) methods, which involve mathematical programming and econometric methods respectively (Coelli, Prasada Roa, O'Donnell and Battese, 2005). These techniques are broadly categorized into two approaches: parametric and non-parametric. The parametric SF approach and the non-parametric DEA approach (Sarafidis, 2002) are the most popular techniques used in efficiency analysis. Alene, Manyongand Gockowski, (2006) stated that additional alternatives, such as Parametric Distance Functions (PDF), have also been available since their development by Shephard (1953, 1970), although they are not as popular as the former methods.

The three methods have their advantages and disadvantages see Jirgi 2013.

Assumptions regarding the functional form of the production function or distribution of error term are not needed in DEA (Cooper, Seiford & Tone, 2007). Thus, the question of mis-specifying the frontier does not arise, which is one of the advantages of DEA when compared to SFA. DEA can be applied for multi-output and multi-input data. Another advantage of DEA is that it works well with small samples (Pasiouras, Sifodaskalakis & Zopounidis, 2011). A disadvantage of the DEA approach is that it does not take into account the possible influence of measurement errors and other noise upon the frontier; all deviations from the frontier are assumed to be the result of technical inefficiency (Sarafidis, 2002). This limitation can be overcome by applying the bootstrap procedure to correct the bias in DEA estimators of technical efficiency and establish their confidence interval (Simar and Wilson, 1998, 2000). DEA is also sensitive to outliers. Outliers can cause problems in both DEA and SFA, but for different reasons: while with DEA it is probable to find too much inefficiency in the sample, SFA can fail to discover any inefficiency at all. The solution to this limitation in both approaches is to remove the outliers from the analysis and proceed without them. In this study, DEA will be used in order to obtain more reliable estimates of the efficiency levels of the farmers. DEA will also be used because of its applicability in multi-output and multi-input data as it relates to the monocropping and intercropping systems of this study.

Coelli *et al.* (2005) explained two types of orientation measures: input-orientated measures and output-orientated measures. The input-orientated technical efficiency measures indicate the amount by which input quantities can be proportionally reduced without changing the output quantities produced. The output-orientated measure answers

the question of the amount of output quantities to be proportionally expanded, using the same quantities of input. The absence of an error or stochastic disturbance term in DEA means that standard errors (and therefore, confidence intervals) cannot be estimated, which is a serious econometric problem. Advances in DEA literature include using bootstrap to establish the confidence interval of technical efficiency (Simar& Wilson, 2000). Bootstrap will be used to construct confidence intervals for this study. Unlike the stochastic frontier model, DEA does not give an estimate of a farmer's specific variables that affect efficiency. This, however, can be estimated using the Tobit model or ordinary least square regression (Ajibefun, 2008; Gul, Koc, Dagistan, Akpinar & Parlakay, 2009).

International studies on efficiency measurement approaches and efficiency levels

Koc, Gul, and Parlakay (2011) analysed the technical efficiency of second crop maize growing farms in the East Mediterranean region of Turkey using Data Envelopment Analysis (DEA). It was found that maize growers had mean TEs of 0.72 and 0.88 under the assumption of CRS and VRS assumptions, respectively. The mean scale efficiency was 0.81, implying that there were some opportunities for improving resource-use efficiency.

Van der Merwe (2012) used a DEA approach to examine the cost efficiency of raisin producers in Eksteenskuil, South Africa. The result showed that the mean cost efficiency of raisin producers was 0.35. Jordaan (2012) also investigated the technical and cost efficiency of raisin producers in Eksteenskuil, South Africa. The researcher applied DEA using the Double Bootstrapping approach to examine the TE of the farmers. The result showed that the bias-corrected technical efficiency scores of the raisin farmers ranged from 0.21 to 1. The average bias-corrected technical efficiency score was 0.78.

Obare, Nyagaka, Nguyo and Mwakubo(2010) studied the allocative efficiency of Irish potato producers in Nyandarua north district, Kenya, using SFA. The researcher found a mean allocative efficiency of 0.57 among the farmers, and that the potato production in the study area was characterised by decreasing returns to scale.

Khan and Saeed (2011) measured the technical, allocative and economic efficiency of tomato farms in northern Pakistan. The study revealed technical and allocative efficiency indices of 65 and 56% respectively. The mean economic efficiency was 35%.

Khai and Yabe (2011) investigated the technical efficiency of rice production in Vietnam using SFA. The results showed that farmers were relatively efficient, which was depicted by a technical efficiency score of 82%.

Nyagaka, Obare, Omiti and Wilson, N (2010) studied the technical efficiency in resource use of smallholder Irish potato farmers in Nyandarua north, Kenya. The researchers applied a dual Stochastic Parametric Decomposition Technique to derive the technical efficiency indices, and a two-limit Tobit model to examine the influence of socio-economic characteristics and institutional factors on the technical indices. The researchers found that the average technical efficiency was 67%.

From the literature review, it should be noted that various approaches have been applied to estimate efficiencies and their determinants in different countries. The two major approaches used are SFA and DEA. Although DEA has limitations when applied on its own, namely giving biased and inconsistent efficiency estimates, researchers have continued to apply the approach. These shortcomings of DEA, however, can be overcome when applied in conjunction with Double Bootstrapping. When applied together with Double Bootstrapping in the first stage, it gives unbiased and consistent estimates, and in the second stage DEA, the limitations of using Tobit to explore the determinants of efficiency are overcome. From the literature reviewed, only Jordaan (2012) applied DEA using the Double Bootstrapping approach to obtain reliable estimates of efficiency levels of the farmers they studied. Accordingly, the application of the DEA Double Bootstrapping approach in this study will fill in the existing knowledge gap in the subject matter.

Nigerian studies on efficiency measurement approaches and efficiency levels

Ogisi, Chukwuji, Christopher and Daniel (2012) studied the efficiency of resource use by rice farmers in Ebonyi State, south east Nigeria using the DEA approach. The results revealed that about 6% of the farmers attained technical efficiency of 100%. The technical efficiency ranged from 20% to 100%.

Otitoju and Arene (2010) studied the constraints and determinants of technical efficiency in medium-scale soybean production in Benue State, Nigeria, using the Stochastic Frontier approach. The findings showed that the average technical efficiency was about 73%.

Akinbode, Dipeolu,andAyinde (2011) applied the SFA to examine the technical, allocative and economic efficiencies of *ofada*rice farming in Ogun State, Nigeria. The results revealed mean technical, allocative and economic efficiencies of 0.73, 0.93 and 0.67, respectively. Ogunniyi and Ojedokun (2012) investigated the production risk and economic efficiency of rice farmers in Kwara State, Nigeria, using an SFA approach. The average technical efficiency score was 0.87, the mean allocative and economic efficiencies were 0.42 and 0.37,

respectively. The results showed that there were significant allocative and economic inefficiencies among rice farmers in Kwara State.

the Double Bootstrapping procedure. Most of the researchers continue to use the Tobit or OLS in the two The review of the efficiency studies in Nigeria also shows that researchers who have applied the DEA did not apply - stage DEA, which gives unreliable estimates of the determinants of efficiency (Simar& Wilson, 2007).

There is thus a need for researchers to apply the Double Bootstrapping DEA procedure in order to obtain more valid information on the determinants of efficiency. It is also clear from the literature review that information on the inclusion of risk aversion as a determinant of efficiency is scanty. Such information is important in order to generate reliable knowledge on the influence of risk attitudes on the decision-making behaviour of farmers and on the determinants of efficiency. In the current study, the Double Bootstrap DEA approach will be used to determine the explanatory variables that influence the technical efficiency of the farmers. The influence of risk attitude on the efficiency of farmers will also be explored.

CONCLUSION

The review of the efficiency studies in Nigeria also shows that researchers who have applied the DEA did not apply the Double Bootstrapping procedure. Most of the researchers continue to use the Tobit or OLS in the two-stage DEA, which gives unreliable estimates of the determinants of efficiency. There is thus a need for researchers to apply the Double Bootstrapping DEA procedure in order to obtain more valid information on the determinants of efficiency.

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