A META-ANALYSIS OF TECHNICAL EFFICIENCY IN NIGERIAN AGRICULTURE

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Abstract

This study sheds light on how study specific-characteristics impact mean technical efficiency (MTE) in Nigerian agriculture. Also the paper extracts consensus message about MTE and its drivers in Nigerian agriculture based on studies covering the period 1999-2008. A meta-analysis using truncated regression was employed on a total of sixty four studies which yield eighty six observations for the econometric analysis. The regression results show that MTE in Nigerian agriculture increased significantly over the years. Study specific-characteristics such as sample size, number of inputs used as well as studies with focus on crop and livestock production were found to significantly impact MTE. Further analyses show that studies in the Northcentral, Southwest, and Southsouth regions of the country produced higher MTE. Within the sample, seventy one observations contain quantitative results on sources of technical efficiency differences usually incorporating socio-economic variables. Based on this, fifty three percent identified educations as a significant determinant of technical efficiency while thirty eight percent showed that experience is important. Extension is shown to be an important determinant by twenty three percent of the observations while nineteen percent identified age as significant determinant of technical efficiency in Nigerian agriculture over the years.

Keywords: Meta-regression, Technical Efficiency, Truncated Regression, Agriculture, Nigeria

JEL Classifications: D24, Q12

Introduction

The agricultural sector in Nigeria plays an important role for the overall economy through its significant contributions to rural employment, food security, non-oil foreign exchange earnings, and provision of industrial raw materials for other sectors in the country. In terms of growth, the sector has achieved significant success in recent times as it attained the 7% growth target in the National Economic Empowerment and Development Strategy (NEEDS) - a macro-economic policy framework currently implemented in the country.

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike. Thiam *et al.* (2001) highlighted the importance of efficiency as a means of fostering production which has led to proliferation of studies in agriculture on technical efficiency around the globe. Analysis of technical efficiency in agriculture has received particular attention in developing countries because of the importance of productivity growth in agriculture for overall economic development. Improvements in technical efficiency constitute a major component of total factor productivity growth, and are identified in the literature as particular important in developing countries (Brümmer *et al.* 2006). E.g., in Nigeria considerable effort has been devoted to analysis of farm level efficiency by both academician and policy analysts in the country for more than a decade.

The present study is designed to provide the basis for understanding the distribution of mean technical efficiency and its drivers in Nigerian agriculture. A meta-dataset generated from the existing literature on technical efficiency in Nigerian agriculture covering the period 1999-2008 is used for the empirical analysis.
Summarizing these studies in a quantitative way can help to develop a clear picture of the distribution of technical efficiency in Nigerian agriculture by answering the following questions based on the studies covering the period under investigation:

i. How did the average technical efficiency of Nigerian agriculture develop?
ii. What is the impact of study specific characteristics such as choice of functional form, number of observations, size of inputs used, and the degree of aggregation of output variable on mean technical efficiency?
iii. Do differences with respect to technical efficiency exist between crop, cash and livestock productions?
iv. Do differences persist between the geopolitical zones of the country?
v. Which farmers´socio-economic variables influence their mean technical efficiency most?

The present study builds on earlier studies by Thiam *et al.* (2001) and Bravo-Ureta *et al.* (2007). While Thiam *et al.* (2001) synthesized studies in developing countries, Bravo-Ureta *et al.* (2007) covered studies in both developed and developing countries. Both studies share a weakness as each cited study is treated as an experiment based on a sample from a single population by implicitly assume a common benchmark for the comparison: i.e., the existence of a population MTE is implicit in these studies. We correct this weakness by directing our attention to a single country which in this case is Nigerian agriculture. This advantage is in our view more than outweighed by the easier interpretation of MTE.

II. A review of stochastic frontier methodology and meta-analysis

The concept of production efficiency as proposed by Farrell (1957) describes a measure of overall efficiency of a firm (later in literature renamed economic efficiency (EE)) as the product of technical efficiency (TE) and allocative efficiency (AE). While Farrell defined technical efficiency (TE) as the firm's ability to produce maximum output given a set of inputs and technology, he conceptualized allocative efficiency (AE) as the measures of the firm's success in choosing the optimal input proportions.

Broadly, two quantitative approaches are developed for measurement of production efficiency; parametric (deterministic and stochastic frontier models) and non-parametric (Data Envelopment Analysis (DEA)) approaches. The advantages and limitations including model specification issues regarding these approaches are extensively discussed in Kumbhakar and Lovell (2000) and Coelli *et al.* (2005).

Meta-analysis has become the standard method of searching for general patterns in a body of existing specific research result. Policy analysts often use meta-analysis to generalize findings from substantial body of existing literature especially when there is a large literature reporting such valuation worldwide (Hedges and Olkin 1985). Hess and Von Cramon-Taubadel (2008) identified three major ways through which meta-analysis can be put into use which includes; *combining evidence, separating wheat from shaft, and evaluating methods*.

A general method for carrying out meta-analyses is the use of regression techniques among others. Meta-regression is defined as a quantitative method used to evaluate the effect of methodological and other study-specific characteristics on published empirical estimates of some indicators (Alston *et al.* 2000).

III. Methodology

Data source and description

We used a variety of sources to compile the list of papers cited in this study[1]. Our initial search yields a total of 87 studies covering 1999-2008. Because studies based on dual representations of the technology frontier as well as non-parametric (e.g., DEA) models in Nigerian agriculture obtained were insignificant in number, we direct our energy on studies with the application of primal- stochastic frontier production model in this study. Therefore by considering the three methodological threats in meta-analysis (*comparing apples and oranges*, *publication bias*, and *junk in junk out*) highlighted by Hess and Von Cramon-Taubadel (2008), 64 studies were considered for the analysis out of the initial search of 87 studies. None of the studies employed panel data.

In a meta-analysis, each study constitutes a single observation with sufficiently large number of independent observations. However, because some of the studies reported more than one MTE, a total of 86 observations were eventually used for the meta-analysis.

The study specific variables hypothesized to explain MTE are identified based on the theoretical framework and the earlier cited studies by Thiam *et al.* (2001) and Bravo-Ureta *et al.* (2007). Table 1 contains the summary statistics of variables used for the meta-regression analysis. MTE, DATAYEAR, NO.OBSER, NO.INPUT, and RANGE represented the mean technical efficiency estimate from each study, year of the survey, number of observations, number of inputs used, and the range of the estimated mean technical efficiency, respectively. D_{Output} is a dummy variable which is equal to one if the output of the study is not aggregated (i.e., a single output) and zero if aggregated. D_{Cobb} is equal to one if the functional form is Cobb-Douglas. Further binary variables were defined for studies focusing on food crops (D_{Food}), cash crop (D_{Cash}), and livestock ($D_{non\text{-}crop}$) productions. The list of binary control variables is completed by five regional

[1] The principal ones were: Google Scholar, ISI Web of Science, ASC index, previous bibliography, ajol.info, personal request from the authors and other online database. Some of the data bases include: American-Eurasian J. Agric. & Environ. Sci.; J. of Agri. & Soc. Sci; Research J. of Agric. Biol. Sci.; Agrekon; J. of Central Eur. Agric; Agric. Journal; : J. of Food, Agric. & Env.; Int. J. of Poultry Sci.; Int. J. Agric. Rural. Dev.; Int. J. of Science. Sci; Quarterly J. of Int. Agric.; J. of Agric.& Soc. Sci.; J. of Soc. Science; Research. J. of Applied Sci.; World J. of Agric. Sci.; J. of Animal and Vert. Adv; African Development Review; J. of Agric. & Rural Devt. in the Tropics and Subtropics; . App. Econ. Letter; J. Hum. Ecol. and Eur. J. of Soc. Sci. among others.

indicators (Northcentral, Northeast, Southwest, Southeast, and Southsouth, respectively -see figure 2)[2].

Table 1: Summary statistics of variables used in the meta-regression

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
MTE	86	0.7377	0.1447	0.22	0.99
DATAYEAR	86	2005.023	2.6103	1995	2007
NO.OBSER	86	126.977	124.96	30	1086
NO.INPUT	86	4.8851	1.0278	3	5
D_{Food}	86	0.5930	0.4699	0	1
D_{Cash}	86	0.1279	0.3586	0	1
$D_{non\text{-}crop}$	86	0.2791	0.3799	0	1
D_{Output}	86	0.7209	0.4591	0	1
D_{Cobb}	86	0.8140	0.4074	0	1
RANGE	86	0.6341	0.2174	0.03	0.96
$D_{Northcentral}$	86	0.1163	0.2549	0	1
$D_{NorthEast}$	86	0.0581	0.2341	0	1
$D_{SouthWest}$	86	0.5233	0.4653	0	1
$D_{SouthEast}$	86	0.0814	0.2106	0	1
$D_{SouthSouth}$	86	0.2209	0.3586	0	1

Empirical Model

Previous meta-regression for technical efficiency (Thiam *et al.* 2001 and Bravo-Ureta *et al.* 2007) employed a *two-limit* Tobit i.e., the two studies employed censored regression approach on MTE. McDonald (2008) argued that efficiency scores such as MTE are not generated by a censoring process but are fractional data by construction. According to the author, Tobit estimation in this situation is an inappropriate and therefore in consistent estimator.

Further, McDonald (2008) advocates the use of OLS for fractional data as against Tobit regression. In view on this, we propose a truncated regression as against Tobit as well as OLS, because MTE is by definition constrained between zero and one so that the probability mass outside the unit interval is zero. That is $E\left(MTE_i / X_i\right)$ when OLS is used rarely provides the best description of the coefficients as truncated regression by construction takes the limits of MTE into account unlike OLS while Tobit due to its data generating process (DGP) is out of contention (*for detail argument against Tobit see McDonald(2008)*).

[2] Nigeria is divided into 6 geopolitical zones (regions) which also reflect the agro-ecological zones in the country. Unfortunately, throughout our literature search, we are unable to locate a single study from the Northwest zones of the country.

To provide answer to the research questions raised in the section 1 of this paper, we examine the impact of the identified study-specific characteristics on their MTE using the linear regression model below:

$$MTE_{it} = \psi_0 + \sum_{k=1}^{4} \alpha_k X_{kt} + \sum_{j=1}^{10} \beta_j D_{jt} + \varepsilon_{it} \quad \text{t= 1995, ….. 2007} \qquad 1$$

where: MTE is as earlier define. X_k represented the continuous variables which includes; DATAYEAR, NO.OBSER, NO.INPUT and RANGE. D_j represented the dichotomous dummy variables such as; D_{Food}, D_{Cash}, $D_{non\text{-}crop}$, D_{Output}, D_{Cobb}, $D_{Northcentral}$, $D_{NorthEast}$, $D_{Southwest}$, $D_{Southeast}$, and $D_{Southsouth}$. α_k and β_j are parameters to be estimated while ε_{it} represented the error term.

We estimate parameters of equation 1 by both OLS as well as truncated regression as basis of providing comparisons. Both results are presented in the Appendix (Table B). We found that the estimated parameters of the truncated regression in present study is robust compared to the OLS as shown in the Appendix. This can be attributed again to the fact that coefficients of OLS cannot be guaranteed to lie in the unit interval because dependent variable MTE is bounded between 0 and 1by DGP.

Guided by the work of McDonald (2008) that $E\left(\varepsilon / X_{it}\right)$ in equation 1 is rarely normal because of the DGP of MTE, we test the residuals of the truncated regression for normality as suggested by the author. The result, however, shows that normality assumption is rejected at p-value 0.0006.

If non-normality is detected, McDonald (2008) suggested a number of ways to solve this problem. This includes taking the logarithm of the MTE and relates it either to the explanatory variable or the logarithm of the observations or by simply transform the MTE by a Box-Cox transformation (Box-Cox, 1964). We opted for the Box-Cox transformation because of its widely used in empirical analysis (see Poirier 1978) and more important that most of the explanatory variables are dummy variables. Hence, Box-Cox regression is employed thereafter to make the residuals normal (see last column of Appendix A). From the Box –Cox, we obtain an estimated θ of 2.473 p-value less than 0.001 against the null of θ equal to one.

The transformed MTE equals:

$$\left(transMTE_{it} = \frac{MTE^{2.473} - 1}{2.473} \right) \qquad 2$$

Table 3 shows the result of the re-estimated equation 1 using equation 2 as the new dependent variable. These results are found to be robust against various possible violations of the model assumptions: Neither normality, homoscedadasticity, or lack of functional misspecification is rejected.

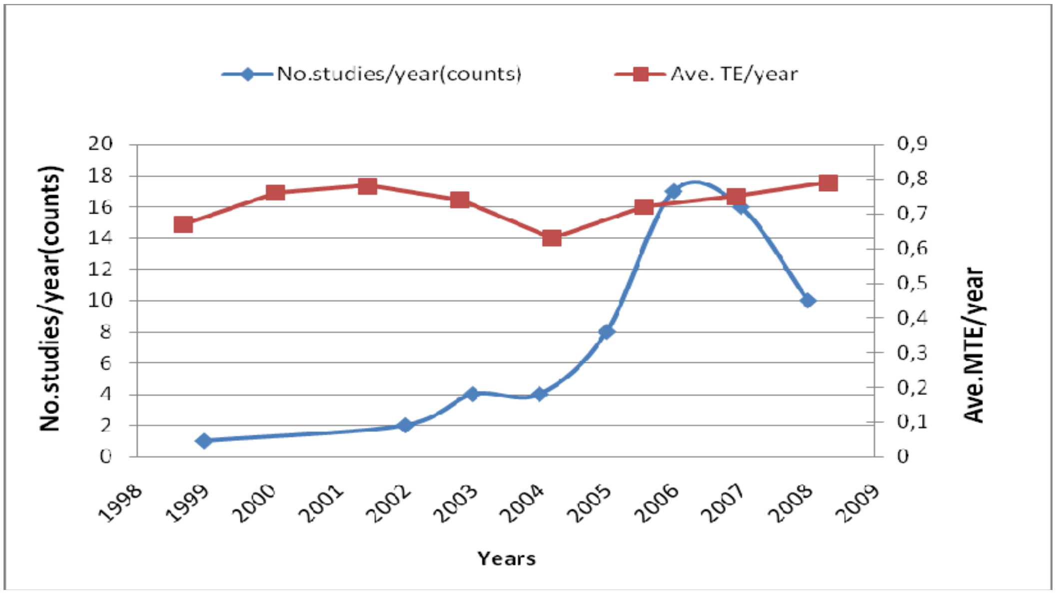
One of the specific problems of meta-analysis is lack of independence across observations (Espey *et al*. 1997) which is often responsible for biased standard errors. In the present study, this problem is unlikely to be particularly severe. None of the studies used for the construction of the meta-dataset contributed more than the five data points which is the recommended limit by Espey *et al*. in order to avoid this problem. Likewise, none of the study uses the same dataset as all study relied on primary dataset while standard dataset on Nigerian farms are hard to found.

IV. Results and Discussion

Figure 1 shows the distribution of the number of studies and the average MTE per year obtained from the pooled dataset[3]. The number of published studies reaches a peak 2006, and has only slightly fallen since then. The observed rising and falling trend in the distribution of MTE suggests that most of the published studies have a comparable time lag between year of sampling and year of publication. Further details (e.g., regarding authors, year of publication, the region where these studies were carried out, type of product, number of observations, etc., from each study is presented in Table A of the Appendix.

[3] We found that the studies cut across various sub-sector of Nigerian agricultural production systems. This include: food crops, cash crops (such as ; cocoa, oil palm, rubber latex), and non-crops (such as ; poultry, bee-keeping, and fish, rabbit, pig and crustacean)

Figure 1: The distribution of the number of studies and average MTE per year (1999-2008)



Summary statistics of average MTE by the variables used in the meta-regression analysis are presented in Table 2. Studies on cash crop have the highest MTE with 0.81 followed by non-crops (0.75) and food crops (0.66) in that order. The average MTE for studies with single output - dependent variable is 0.82 compared to 0.66 for studies with aggregated output variable. This result is not surprising because in the process of aggregating, much information is lost which might have improved the predicted efficiency of the farms under investigation.

Regarding the unconditional effect of the choice of functional form, we observed an average MTE of 0.79 for studies with Cobb-Douglas, and 0.69 for translog. In contrary, Thiam *et al.* (2001) and Bravo-Ureta *et al.* (2007) reported higher average MTE for studies with translog compared to Cobb-Douglas. We find that there is no statistical difference between the MTE of Cobb-Douglas and translog in this study.

Table 2 shows the summary statistics of the average MTE according to the regions where the studies were carried out in Nigeria. The unconditional MTE for studies in the Southwest region was at MTE of 0.842 representing (52%) of the observations, followed by the Northeast 0.779 (6%), Southsouth 0.723 (22%), Northcentral 0.720 (12%), and Southeast 0.631 (8%). However, these results should be interpreted with caution because of few observations recorded in some of the regions.

Finally, the overall average MTE computed from all the studies is 0.739. This result is significantly not different from 0.737 obtained by Bravo-Ureta *et al.* (2007) for Africa countries and 0.68 obtained by Thiam *et al.* (2001) for developing countries. This finding, however, suggests that, there is a large potential for improvement in Nigerian agricultural production systems, as about 26% of the agricultural output in the country could be expanded without any additional use of inputs in comparison to what could be achieved under full technical efficiency.

Table 2: Distribution of average mean technical efficiency by the variables

Variables	**No. of Obser.**	**No. of Studies**	**Mean technical efficiency (MTE)**		
			Average	**Maximum**	**Minimum**
Food crops	51(59%)	40(63%)	0.656	0.93	0.41
Cash crops	11(13%)	9(14%)	0.806	0.97	0.69
livestock	24(28%)	15(23%)	0.754	0.99	0.22
Single output	62 (72%)	44 (69%)	0.823	0.99	0.22
Aggregated output	24 (28%)	20(31%)	0.656	0.93	0.53
Cobb-Douglas	70 (81%)	56(88%)	0.791	0.99	0.22
Translog	16 (19%)	8(12%)	0.688	0.82	0.53
Northcentral	10 (12%)	7(11%)	0.720	0.81	0.62
Northeast	5 (6%)	4(6%)	0.779	0.97	0.69
Southwest	45(52%)	31(49%)	0.842	0.99	0.53
Southeast	7(8%)	7(11%)	0.631	0.78	0.41
Southsouth	19(22%)	15 (23%)	0.723	0.91	0.22
Overall Study	**86**	**64**	**0.738**	**0.99**	**0.22**

Table 3 gives the results of the truncated regression after the transformation of MTE[4]. Comparing estimates in Table 3 to results of the untransformed MTE presented in the third column of Table B in the Appendix, we found that estimates in Table 3 are for the most part significant and have plausible signs as they are robust to changes in the specification of the meta-regression. Hence, the estimates show that over time, a higher and significant MTE estimates is obtained with year of dataset (DATAYEAR), sampling size (NO.OBSER) and number of inputs used (NO.INPUT). The observed improvement in MTE over time can be attributed to a number of factors key of which include associated effects of extension-education on agricultural productivity in the country (a confirmation of this assertion will be discuss later in the paper). Likewise, the observed positive and significant impact of the sample size seems to suggest that

[4] All estimates were obtained from STATA, version X.

studies with large sample size tend to record higher MTE-signifying robustness in the estimated MTE with large sample size. Of course this is consistent with law of large sample (asymptotic efficiency).

The results on whether there exist any differences with respect to technical efficiency among food crops, cash crop and livestock productions in Nigeria, shows that studies on food crops (D_{Food}) and livestock ($D_{non\text{-}crop}$) produce higher MTE estimates while cash crops produce lower MTE estimates. This finding is corroborated by the annual statistical report released by the Central Bank of Nigeria, which shows a significant drop in the national production of key cash crops in the country (CBN 2006) including cocoa and oil palm.

The results of the impact of the choice of functional form and the degree of aggregation of the output variable on the MTE show that the estimate of the dummy for Cobb-Douglas functional form exhibits a positive but insignificant sign while studies with non-aggregated output (i.e., single product) produce significant higher MTE estimates. The negative and significant coefficient of RANGE implies higher range of technical efficiency produces lower MTE in Nigerian agriculture. This observation is in contrary to the findings of Thiam *et al.* (2001).

The joint hypothesis of excluding the regional dummies is rejected. Hence, the positive and significant coefficients of the binary control variables; $D_{Northcentral}$,$D_{SouthWest}$ and $D_{SouthSouth}$ indicate that studies in the Northcentral, Southwest and Southsouth regions of the country produce higher MTE in comparison to the reference regions. In contrast, studies from the Northeastern ($D_{NorthEast}$) and the Southeastern ($D_{SouthEast}$) part of the country have a lower MTE.

The last column of Table 3 presents the result of a unit change in the study-specific variables to percentage change in MTE. We found that MTE increased by approximately 4, 1, and 3 percentage points, respectively, if year of the dataset, sampling size, number of inputs used increased by one unit. In contrast, MTE decreases by 0.7 percentage points if the range of technical efficiency estimates increased by 1%.

Table 3: Meta-regression of the transformed mean technical efficiency

Variables	**parameters**	**Truncated Regression**	**(dMTE/dx)[a]**
DATAYEAR (X_1)	α_1	2.177*** (0.712)	0.0356** (0.017)
NO.OBSER (X_2)	α_2	0.420*** (0.124)	0.0112*** (0.004)
NO.INPUT (X_3)	α_3	2.516* (1.489)	0.0309* (0.018)
$^{+}D_{Food}$ (D_1)	β_1	0.649** (0.328)	0.0169** (0.008)
$^{+}D_{Cash}$ (D_2)	β_2	-0.534*** (0.188)	-0.0061*** (0.002)
$^{+}D_{non\text{-}crop}$ (D_3)	β_3	1.894* (1.036)	0.0261* (0.014)
$^{+}D_{Output}$ (D_4)	β_4	0.249** (0.115)	0.0103** (0.005)
$^{+}D_{Cobb}$ (D_5)	β_5	3.694 (2.399)	0.0381 (0.024)
RANGE (X_4)	α_4	-1.713*** (0.355)	-0.0071*** (0.002)
$^{+}D_{Northcentral}$ (D_6)	β_6	1.064** (0.549)	0.0842*** (0.031)
$^{+}D_{NorthEast}$ (D_7)	β_7	-2.178* (1.224)	-0.0148* (0.008)
$^{+}D_{SouthWest}$ (D_8)	β_8	1.429*** (0.395)	0.0651*** (0.019)
$^{+}D_{SouthEast}$ (D_9)	β_9	-1.115* (0.667)	-0.0136* (0.007)
$^{+}D_{SouthSouth}$ (D_{10})	β_{10}	3.210*** (0.634)	0.0321*** (0.011)
CONSTANT	ψ_0	1.469** (0.690)	- -
Log likelihood	LL	119.108	-
Chi-square value	χ^2	49.14***	-

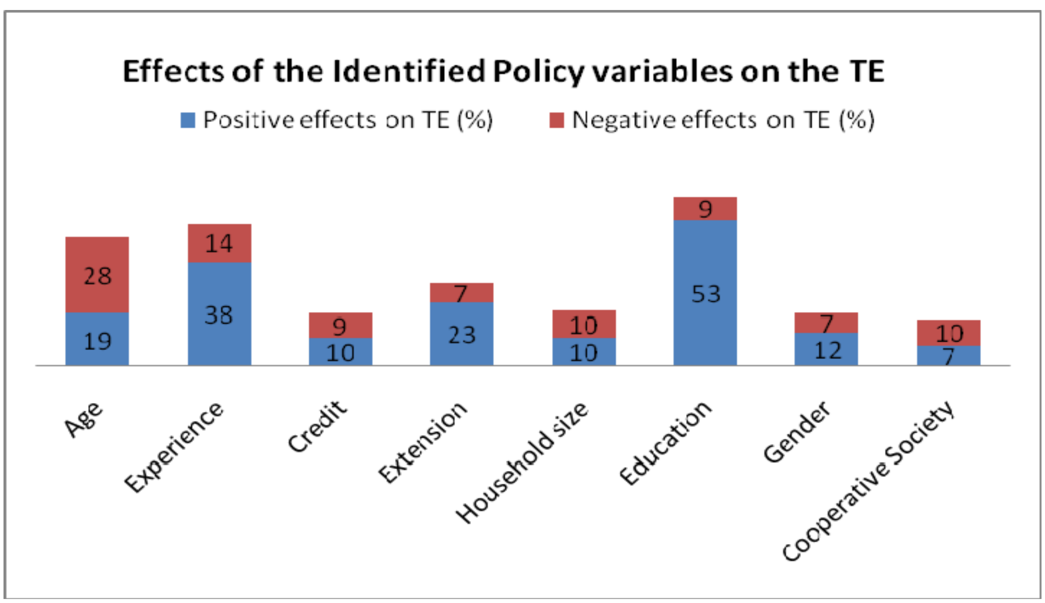
*For all implies: *** significant at the 1%; ** significant at 5%; * significant at 10%. Figure in parentheses represented the standard error; [a]marginal effects are calculated assuming a discrete change from 0 to 1⁺.*

Bravo-Ureta *et al.* (2007) highlighted the importance of technical efficiency as a relative measure of managerial ability for a given technology. Improvement in technical efficiency can be viewed as improvements in decisions-making which, in turn, are related to variables such as knowledge, experience, and education, among others. This suggests why many studies often contain quantitative results on sources of technical efficiency differences in addition to the estimated technical efficiency either in a single step or two steps method.

Therefore, to shed light on the common influence of such variables on the MTE in Nigerian agriculture, we take a closer look at those studies that estimated sources of efficiency differential in addition to the estimated technical efficiency for further analysis in order to identify which farmers' socio-economic variables influence the MTE in Nigerian agriculture most over the years. Seventy one of the observations (83%) contain quantitative results on the sources of efficiency differential, usually incorporating socio-economic variables such as age, experience, credit, extension, household size, education, gender and membership in cooperative societies. Figure 3 revealed that education ranked highest with significant impact on the MTE as extracted from the studies. This is followed in this order by years of experience, extension-education, age, gender, credit, household size, and membership in cooperative as shown in the figure.

Based on this, our findings suggests that education, years of experience, and extension contacts among others provide a measure of managerial ability through which Nigerian agricultural productivity could experience a push into new direction of growth and development. Of course such repositioning depends on the right policy measures that will address human capital (such as education) and institutional framework (such as efficient extension delivery system) developments in the country over time.

Figure 3: Identified policy variables and percentage of occurrence



V. Summary and conclusions

This study seeking to infer relevant policy conclusions from the existing studies on the technical efficiency in Nigerian agriculture employed a meta-analysis on a total of 64 studies which yield 86 observations. Specifically, the study provides an overview of technical efficiency in Nigerian agriculture while explaining the variation in the mean technical efficiency (MTE) as reported by various studies conditioned on the study specific characteristics. That is, we regressed the MTE on the study specific characteristics which includes frontier methodology, sample size and number of input used among others. By examining studies across the country, the study highlighted regional differentials in TE estimates. Finally, using descriptive statistics, we identify the key drivers of technical efficiency in Nigerians agriculture of the years.

Empirical findings show that MTE in Nigerian agriculture increased significantly over the years. Sample size, number of inputs used and aggregated output variable (i.e., single output variable) as well as focus of the study on crop and livestock production was also found to be significant. The study reveals that cash crops tend to have lower MTE. Studies with lower ranges of TE also tend to have higher MTE estimates. The results of the regional effects on the MTE estimates using regional dummies indicate a mixed pattern. Studies in the northcentral, southwest, and southsouth regions of the country produce significantly higher MTE estimates while studies in the northeast and southeast regions have a lower MTE. The implication of this heterogeneity across regions might imply that improving efficiency and productivity in Nigerian agriculture requires regional specific- policy responses.

A further finding of the study which has implications for policies to improve productivity in Nigerian agriculture is the evidence that over the years, education, experience, extension and credit significantly influence MTE of Nigerian agriculture. This observation confirms what has been found in many studies relating to developing agriculture (Philip 1994; Weir 1999 and 2000; Asadullah 2005).

Finally we acknowledge that the selection of variables for the meta-analysis was constrained by lack of published information on the study- specific characteristics used as explanatory variables in the regression. Nevertheless, the future challenge is to be able to increase the data points and the depth of information on each farm so that more data-demanding approaches (both parametric and non-parametric techniques) could be applied in order to gain further insights on the overall impact of certain variables on efficiency differentials in Nigerian agriculture.

References

Aburime, I. L. O.A. Omotosho and H. Ibrahim (2006): An Analysis of Technical Efficiency of Beekeeping Farms in Oyo state, Nigeria. *Eur. J. of Soc. Sci.* 1. Pp, 1-8.

Adeoti, A. I (2006): Farmers' Efficiency under Irrigated and Rainfed Production Systems in the derived savannah Zone of Nigeria. *J. of Food Agric. & Env.* .4 (3&4): 90-94.

Adeoti, A. I and J.O. Adeoti (2008). HIV/ AIDS and Farmer's Production Efficiency in Benue State Nigeria. *African Journal of Biomedical Research,* Vol.11: 145-153.

Adepoju,A. A. (2008). Technical Efficiency of Egg Production in Osun State. *International Journal of Agricultural Economics and Rural Development* 1(1): 7-14.

Agbabiaje, J. O. (2003). Technical indices of Performance in Poultry Production by Size in Ogun state Nigeria. *African Journal of Livestock Extension*. Vol. 2: 24-29.

Ajani,O.I.Y and P.C. Ugwu (2008). Impact of adverse Health on Agricultural Productivity of Farmers in Kainji Basin North-Central Nigeria using a stochastic production frontier approach. *Trends in Agricultural Economics* 1(1): 1-7.

Ajao, A.O, J.O. Amao and S.B. Williams (2005). Determinants of Technical Inefficiency of Fish Farms in Oyo State Nigeria, *Journal of Sustainable Development,* Vol.2 (2) 33-39.

Ajibefun, I.A and O.A. Abduikadri (1999). An Investigation of Technical Inefficiency of Production of Farmers under the National Directorate of Employment in Ondo State, Nigeria. Rout ledge, land. *App. Econ. Letter* 6:111-114.

Ajibefun, I.A; G.E. Battese, and A.G. Daramola (2002). Determinants of Technical Efficiency in Small holder Food crops farming: Application of Stochastic frontier production function. *Quarterly J. of Int. Agric.,* 41(No.3): 225-240.

Ajibefun, I.A. (2006). Cropping System, Technical Efficiency and Policy options: A Stochastic Frontier Analysis of Nigerian Small-Scale Farmers, *Quarterly J. of Int. Agric* .45, No. 2: 145-169.

Ajibefun, I.A (2003). Determinants of Technical Efficiency in Traditional Agricultural Production: Application of Stochastic Frontier Modeling of Food Crop Farmers in South-western Nigeria. *African Journal of Economic Polic*y.Vol.10.No.2: 31-56.

Ajibefun, J.A., A.G. Daramola and A.O. Falusi (2006). Technical Efficiency of Small-Scale Farmers: An Application of the Stochastic Frontier Production Functions to Rural and Urban Farmers in Ondo state, Nigeria. *International Economic Journal*. Vol. 20.No.1: 87-107.

Akanni, K.A (2008). Catch Levels and Capital Investment of Artisinal Fishermen in Lagos State Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences* 8: 361-368.

Alabi, R. A. and M. B. Aruna (2005). Technical Efficiency of Family Poultry Production in Niger-Delta, Nigeria. *Central European Journal of Agriculture*. Vol. 8. No. 4: 531-538.

Alston, J.M., M. C. Marra, P.G. Pardey and T.J.Wyatt (2000). Research Returns Redux: A Meta-Analysis of the Returns to Agricultural R & D. *The Australian Journal of Agricultural and Resource Economics*. 44 (2): 185-215.

Amaza, P. S. and K. Ogundari (2008). An Investigation of Factors that Influence the Technical Efficiency of Soybean Production in the Guinea Savannas of Nigeria. *J. Food, Agric. & Env.*6 (1): 92-96.

Amaza, P.S., Y. Bila and A. C. Iheanacho (2006). Identification of Factors that Influence Technical Efficiency of Food Crop Production in West Africa: Empirical Evidence from Borno State, Nigeria. *J. of Agric. & Rural Devt. in the Tropics and Subtropics*.Vol.107, No. 2, pp 137–145.

Amaza, P. S. and J. K. Olayemi (2002). Analysis of Technical Efficiency in Food Crop Production in Gombe State, Nigeria *App. Econ. Letter* 9:51-54.

Amos, T. T. D. O. Chikwendu and J. N. Nmadu (2004). Productivity, Technical Efficiency and Cropping patterns in the Savanna zone of Nigeria. *J. Food, Agric. & Env.* Vol.2 (2): 173-176.

Amos, T.T. (2007a). An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Nigeria. *J. Soc. Sci.*, 15(2): 127-133.

Amos, T. T. (2007b): Production and Productivity of Crustacean in Nigeria. *J. Soc. Sci.,* 15(3): 229-233.

Asadullah M. N and S. Rahman (2005). Farm Productivity and Efficiency in Rural Bangladesh: The role of Education Revisited. *Working Paper CSAE WPS/2005-10, Centre for the Study of African Economies*, University of Oxford.

Awoniyi, O. A. and B. T. Omonona (2006). Production Efficiency in Yam Based Enterprises in Ekiti State Nigeria. *Central European Agriculture,* Vol. 7 No.4: 627-636.

Awoyemi, T. T. and A. I. Adeoti (2006). Gender Inequalities and Economic Efficiency: New Evidence from Cassava-based Farm Holdings in Rural South-western Nigeria *African Development Review* .pp.428-443.

Bamiro, O. O (2008). Technical Efficiency in Pig Production in Ogun State Nigeria. *Research Journal of Animal Sciences* 2 (3): 78-82.

Bamiro, M. O., D.O.A. Phillip and S. Momoh (2006). Vertical Integration and Technical Efficiency in Poultry (Egg) Industry in Ogun and Oyo States, Nigeria. *Int. J. of Poultry Science* 5 (12): 1164-1171.

Binuomote, S.O, J. O. Ajetomobi and A. O. Ajao (2008). Technical efficiency of Poultry Egg Producers in Oyo State Nigeria. *International Journal of Poultry Science* 7(12):1227-1231.

Bravo-Ureta, B.E., D. Solis, V.H. Moreira Lopez, J.F.Maripani, A. Thiam and T. Rivas (2007). Technical Efficiency in Farming: A Meta-Regression analysis. *Journal of Productivity Analysis*. 27: 57-72.

Box, G .E. P and D. R. Cox (1964). An Analysis of Transformations. *Journal of the Royal Statistical Society, Series* B.26, 211-252.

Brümmer, B., T. H. Glauben and W. Lu (2006).Policy reform and productivity change in Chinese agriculture: A distance function approach. *Journal of Development Economics*, 81: 61-79.

CBN (2006). Central Bank of Nigeria Annual Report and Statement of Account Publication for the year ending 2005. Abuja Nigeria.

Coelli, T.J., D. S. P. Rao, C.J. O'Donnell and G. E. Battese (2005). *An Introduction to efficiency and Productivity Analysis*. 2nd Edition. New York. Springer.

Effiong, E.O and G.C. Onuekwusi (2007). Maximum Likelihood Estimation Techniques of Rabbit Production in Akwa Ibom State Nigeria. *Research Journal of Applied Sciences* .2 (2): 165-169.

Ekunwe, P. A. and S. I. Orewa (2007). Technical Efficiency and Productivity of Yam in Kogi State Nigeria. *Journal of Applied Sciences* 7(13):1818-1820.

Erhabor, P.O. and C. O. Emokaro (2007). Relative Technical Efficiency of Cassava farmers in Three Agro-ecological Zones of Edo state, Nigeria. *Journal of Applied Sciences* 7(13):2818-2823.

Espey, E., J. Espey and W. D Shaw (1997). Price Elasticity of Residential Demand for Water: A Meta-Analysis. *Water Resources Research* Vol.33.No.6: 1369-1374.

Fapohunda, O.O., S.O. Ojo and A.M. Balogun (2005). Analysis of Productivity of Bio-technical Factors and Technical Efficiency of Aquaculture Production in Ondo State, Nigeria. *J. of Animal and Vert. Adv.* 4 (5): 535-539.

Farrell, J. M. (1957). The Measurement of Productive Efficiency. *J. Royal stat*. 120, Part III pp 253—290.

Giroh, D.Y., E.F. Adebayo and M. Joyce (2008). Analysis of the Technical Efficiency of Rubber latex exploitation in Edo state, Nigeria. *Research Journal of Applied Sciences*. 3(2): 128-132.

Giroh, D. Y and E.F. Adebayo (2007). Comparative Productivity Analysis of Permanent and Non-permanent Rubber Tappers in State Rubber Farms of Nigeria. *Journal of Agriculture & Social Sciences*, Vol.3.No.4:107-111.

Hedges, L. V. and I. Olkin (1985). *Statistical Methods for Meta-Analysis*. Academic Press Inc., New York.

Hess. S. and S. von Cramon-Taubadel (2008). A Metal-Analysis of General and Partial Equilibrium Simulations of Trade Liberalization under the Doha Development Agenda. *The world Economy* Vol.31: 804-840.

Idiong, I. C. (2007): Estimation of Farm Level Technical Efficiency in Small Scale Swamp Rice Production in Cross River State of Nigeria: A Stochastic Frontier Approach. *World J. of Agric. Scic.* 3 (5): 653-658.

Idiong, I. E. C. Onyenweaku, B. S. Ohen and I. D. Agom (2007). A stochastic Frontier Analysis of Technical Efficiency in Swamp and Upland Rice Production Systems in Cross-River State, Nigeria. *Agricultural Journal* 2(2):299-305.

Iheke, O.R. (2008). Technical Efficiency of Cassava Farmers in Southeastern Nigeria: Stochastic frontier approach. *Agricultural Journal*. 3(2): 152-156.

Ike, P. C., and Odjuvwuederhie. E. I (2006). Determinants of Yam Production and Economic Efficiency among Small-Holder Farmers in Southeastern Nigeria. *J. of Central Eur. Agric.* Vol. 7. No. 2 (337-342).

Iwala, O.S. J.O. Okunlola and P. B. Imoudu (2006). Productivity and Technical Efficiency of Oil Palm Production in Nigeria: *J. of Food, Agric. & Env*.4 (3&4): 1 8 1 - 1 8 5.

Kareem, R.O., A.O. Dipeolu, A.B. Aromolaran and S.B. William (2008). Economic Efficiency in Fish Farming: hope for Agro-Allied Industries in Nigeria. *Chinese Journal of Oceanology and limnology*. Vol. 26.No.1: 104-115.

Kumbhakar, S.C. and C.A.K. Lovell (2000). *Stochastic frontier Analysis*. Cambridge University Press, Cambridge.

McDonald, J (2008). Using Least Squares and Tobit in Second Stage DEA Efficiency Analyses. *Flinders Business School Research Paper Series 2008-3 ISSN 1441-3906*, Flinders University Adelaide USA.

Nwaru, J. C, C. E. Onyenweaku and A. C. Nwosu (2006). Relative Technical Efficiency of Credit and Non-Credit User Crop Farmers. *African Crop Science Journal*, Vol. 14. No. 3: 241-251.

Ogundari, K. and S. O. Ojo (2005). Determinants of Technical Efficiency in Mixed Crop Food Production in Nigeria: A Stochastic Parametric Approach. *East Africa Journal of Rural Development*, Vol. 21, No. 1. pp. 15-22.

Ogundari, K., and O.A. Aladejimokun (2006). Resource-use and Technical Efficiency of Small-Holder Cocoa Producers in Ondo State: A Stochastic Frontier Analysis. *Applied Tropical Agriculture*, Vol.11 (1) 26 - 31.

Ogundari, K., and O. Odefadedun (2007). Comparative Analysis of Resource-Productivity and Technical Efficiency of Cocoa Producers: A Study of Farmers under Training & Visit and Farmers Field School Extension System in Nigeria. *Quarterly J. of Int. Agric*. Vol.46.No.3: 205-219.

Ogundari, K. (2008). Resource-Productivity, Allocative Efficiency and Determinants of Technical Efficiency of Rain-fed Rice Farmers: A Guide for Food Security Policy in Nigeria. *Agric.-Economic.* Czech, 54 (5): 224-233.

Ohajianja, D. O. (2005a): Economic Efficiency among Small Scale Poultry Farmers in Imo State, Nigeria: A Stochastic Frontier Production Model Approach. *Int. J. Agric. Rural. Dev*. 6: pp19-25.

Ohajianya, D.O. (2005b): Technical Efficiency among Small holder Cassava Farmers in Imo State. *Int. J. of Soci. Science* .Vol.4:106-115.

Ojo, S. O. (2003): Productivity and Technical Efficiency of Poultry Egg Production in Nigeria. *Int. J. of Poultry Sci*. 2 (6): 459 - 464

Ojo, S.O. (2005): Food and Health Productivity and Technical Efficiency of Palm Oil extraction Mills in Nigeria: *J. of Food, Agric. & Env.* Vol.3 (1): 2 1 - 2 4.

Ojo, S.O., J.A. Afolabi and O.A. Fagbenro (2006). Profitability and Technical efficiency of Artisanal Fisheries Production in Nigeria. *Journal of Sustainable tropical Agricultural Research.* Vol. 19: 23-30.

Okike, I., M. A. Jabbar, V.M. Manyong, J.W. Smith and S.K. Ehui (2004). Factors affecting Farm-Specific Production Efficiency in the Savanna Zones of West Africa. *Journal of African Economies*, Vol. 13. No.1: 134-165.

Okezie, C. A and B.C. Okoye (2006): Determinants of Technical Efficiency among Egg Plant (*Solanum sp*) Farmers using the Stochastic Frontier Model in Isialangwa Are of Abia State. *Agric. Journal* .1 (3): 119-122.

Okoruwa, V. O and B. Bashaasha (2006). Technical Efficiency of Upland and Lowland Rice Production Systems in Niger state Nigeria. *Moor Journal of agricultural Research*. Vol.7: No.2: 93-99.

Okoruwa, V.O, O. Ogundele and B. Oyewusi (2007). Production Efficiency of Nigeria Farmers: A Case study of Northcentral NNigeria. *China Agricultural Economics*. Vol. 5 No.4: 498-511.

Olarinde, L.O., A.O. Ajao and S.O. Okunola (2008). Determinants of Technical Efficiency in Bee-keeping farms in Oyo state, Nigeria: A Stochastic Production Frontier Approach. *Research Journal of agriculture and Biological sciences*. 4 (1): 65-69.

Onyenweaku, C. E and C. O. Effiog (2005). Technical Efficiency in Pig Production in Akwa Ibom State, Nigeria. *Int. J. Agric. Rural. Dev*. 6:pp51-57.

Onyenweaku, C . E and A. C. Nwosu (2005). Application of Stochastic Frontier Production function to the Measurement of Technical Efficiency in Food Crop Production in Imo State Nigeria. *Niger Agric. Journal* 36: 1-12.

Philips, J.M., (1994). Farmer Education and Farm Efficiency: A Meta-Analysis. *Economic Development and Cultural Change*, 43, 149-165.

Poirier, D. A (1978). The use of the Box-Cox transformation in limited dependent variable Models. *Journal of the American Statistical Association*, 73. 284-287.

Shehu, J. T and S. I. Mshelia (2007). Productivity and Technical Efficiency of Small-scale Rice Farmers in Adamawa State Nigeria. *Journal of Agriculture & Social Sciences,* Vol.3.No.4:117-120.

Thiam, A., B. E. Bravo-Ureta and T. Rivas (2001). Technical Efficiency in Developing Country Agriculture: a meta-analysis. *Agricultural Economics*. 25: 235-243.

Tijani, A.A. (2006). Analysis of the Technical Efficiency of Rice Farms in Ijesha Land of Osun State Nigeria. *Agrekon, Vol. 45, No 2*.

Tijani, A. A and O. I. Baruwa (2008). Technical Efficiency of Cacao Farms in Osun State Nigeria, *African Journal of Contemporary Issues*. Vol. 6, No. 4: 14-23.

Udoh, E.J. (2005). Technical Inefficiency in Vegetable Farms of Humid Region: An Analysis of Dry Season Farming by Urban Women in South-South Zone, Nigeria. *J. Agri. & Soc. Sci.* 01–2–80–85.

Udoh, E.J and N.A. Etim (2008). Measurement of Farm-level Efficiency of Water-leaf (*Talinum triangulare*) Production among City Farmers in Akwa Ibom State, Nigeria. *J. Sustainable. Dev. Agri. and Env.,* Vol. 3: 47-54.

Udoh, E. J and A. E. Nsikak (2007). Cocoyam farms in Akwa-Ibom state, Nigeria. A stochastic production frontier Approach. *Journal of sustainable Development in Agriculture and Environment* Vol. 2. No.1: 1-8.

Udoh.E. J and O. Falake (2006). Resource-Use Efficiency and Productivity among Farmers in Nigeria. *Journal of Agriculture & Social Sciences*, Vol.2.No.4:264-268.

Udoh,E. J(2006). Modelling Indices of Efficiency and Sustainable Land-Use and Management among Migrant Farmers in a Farm settlement of Cross-River State Nigeria, *Journal of Agriculture & Social Sciences,* Vol.2.No.2:67-71.

Ukoha, O.O and A.A. Chuckwuma (2007). Technical Efficiency of Small Scale Poutltry-Egg Production in Nigeria: Empirical Study of Poultry farmers in Imo State Nigeria: *Research Journal of Poultry Sciences* 1 (3-4): 16-21.

Umoh, G. (2006). Resources-use Efficiency in Urban Farming: An application of Stochastic Frontier Production Function. *International Journal of Agriculture and Biology*, Vol. 8. No.1: 38-44.

Weir, S. (1999) .The Effects of Education on Farmer Productivity in Rural Ethiopia. *Working Paper CSAE WPS99-7, Centre for the Study of African Economies*, University of Oxford.

Weir, S. and Knight, J. (2000). Education Externalities in Rural Ethiopia: Evidence from Average and Stochastic Frontier Production Functions. *Working Paper CSAE WPS/2000.4, Centre for the Study of African Economies*, University of Oxford.

Appendix:

Table A: Survey of empirical application of SFM in Nigerian agriculture

Authors	Year	Region	Product	Sample size	Mean TE
Amaza & Olayemi	2002	Northeast	Food crops	123	0.69
Amos *et al.*	2004	Northcentral	Food crops	72	0.62
Adeoti and Adeoti	2008	Northcentral	Food crops (With HIV)	55	0.52
Adeoti and Adeoti.	2008	Northcentral	Food crops (Non-HIV)	100	0.70
Ukoha and Chukwuma	2007	Northeast	Egg Production	60	0.58
Ajibefun	2006	Southwest	Cassava	50	0.76
Ajibefun	2006	Southwest	Maize	50	0.70
Ajibefun	2006	Southwest	Rice	50	0.72
Agbabiaje	2003	Southwest	Poultry (small scale)	56	0.99
Agbabiaje	2003	Southwest	Poultry (medium scale)	40	0.99
Agbabiaje	2003	Southwest	poultry (large scale)	44	0.97
Okoruwa *et al.*	2007	Northcentral	Rice	240	0.83
Ajani and Ugwu	2008	Northcentral	Food crops	120	0.85
Bamiro	2008	Southwest	Pig Production	100	0.43
Nwaru *et al.*	2006	Southeast	Food crops (loan-benef.)	57	0.50
Nwaru *et al.*	2006	Southeast	Food crops (non-benef.)	75	0.44
Olarinde *et al.*	2008	Southwest	Bee-keeping	60	0.85
Ike & Odjuvwuederhie	2006	Southeast	Yam	120	0.41
Kareem *et al.*	2008	Southwest	Fish (concrete pond)	34	0.88
Kareem *et al.*	2008	Southwest	Fish (earth pond)	51	0.89
Okike *et al.*	2004	Northeast	Food crops	314	0.68
Okike *et al.*	2004	Northeast	Food crops	246	0.86
Onyenweaku & Effiong	2005	Southsouth	Pig	60	0.84
Ohajianya	2005a	Southeast	Poultry	180	0.43
Ojo *et al.*	2006	Southwest	Fish	200	0.68
Umoh	2006	Southsouth	Food crops	90	0.72
Amaza *et al.*	2006	Northeast	Food crops	1086	0.68
Ajibefun & Abdulkadri	1999	Southwest	Food crops	98	0.67
Amos	2007a	Southwest	Cocoa	250	0.72
Udoh & Nsikat	2007	Southeast	Cocoyam	90	0.85
Onyenweaku & Nwaru	2005	Southeast	Food crops	187	0.57
Amaza & Ogundari	2008	Northeast	Soybean	182	0.79
Udoh & Falake	2006	Southsouth	Food crops	120	0.73
Udoh	2006	Southsouth	Food crops	180	0.77
Ekunwe & Orewa	2007	Northcentral	Yam	200	0.62
Tijani	2006	Southwest	Rice	45	0.87
Amos	2007b	Southwest	Crustacean	200	0.70
Awoniyi & Omonona	2006	Southwest	Yam (wetland farmers)	30	0.80
Awoniyi & Omonona	2006	Southwest	Yam(upland farmers)	75	0.79
Shehu & Mshelia	2007	Northeast	Rice	180	0.96
Iwala *et al.*	2006	Southsouth	Oil palm	241	0.78
Ojo	2005	Southwest	Oil palm	100	0.75
Ogundari & Ojo	2005	Southwest	Food crops	240	0.87

Table A (Continued)

Authors	Year	Region	Product	Sample size	Mean TE
Okezie & Okoye	2006	Southeast	Eggplant	120	0.78
Idiong	2007	Southsouth	Rice	112	0.77
Ajibefun *et al.*	2002	Southwest	Food crops	67	0.82
Ogundari & Aladejimokun	2006	Southwest	Cocoa	240	0.73
Erhabor & Emokaro	2007	Southsouth	Cassava (Edo south)	63	0.72
Erhabor & Emokaro	2007	Southsouth	Cassava (Edo central)	40	0.91
Erhabor & Emokaro	2007	Southsouth	Cassava (Edo north)	53	0.83
Iheke	2008	Southeast	Cassava	160	0.77
Ojo	2003	Southwest	Poultry	200	0.76
Idiong *et al.*	2007	Southsouth	Rice (swamp)	56	0.77
Idiong *et al.*	2007	Southsouth	Rice (upland)	40	0.87
Bamiro *et al*	2006	Southwest	Poultry	114	0.88
Ajibefun *et al.*	2006	Southwest	Food crops (rural)	100	0.66
Ajibefun *et al.*	2006	Southwest	Food crops (urban)	100	0.57
Awoyemi & Adeoti	2006	Southwest	Cassava (male)	183	0.88
Awoyemi & Adeoti	2006	Southwest	Cassava (female)	104	0.95
Tijani & Baruwa	2008	Southwest	Cacao	126	0.52
Ogundari	2008	Southwest	Rice	96	0.75
Alabi & Aruna	2005	Southsouth	Poultry	116	0.22
Giroh *et al.*	2008	Southsouth	Rubber latex	100	0.80
Aburime *et al.*	2006	Southwest	Bee-keeping	33	0.55
Adepoju	2008	Southwest	Egg Production	86	0.76
Adeoti	2006	Northcentral	Rice (irrigated)	130	0.84
Adeoti	2006	Northcentral	Rice (rain-fed)	104	0.67
Ohajianya	2005b	Southeast	Cassava	180	0.56
Ajao *et al.*	2005	Southwest	Fish	100	0.72
Udoh	2005	Southsouth	Vegetable	320	0.66
Binuomote *et al.*	2008	Southwest	Egg Production	51	0.82
Akanni	2008	Southwest	Fish (MPF)	120	0.65
Akanni	2008	Southwest	Fish (MF)	102	0.80
Ogundari & Odefadehan	2007	Southwest	Cocoa (T & V)	80	0.69
Ogundari & Odefadehan	2007	Southwest	Cocoa (FFS)	80	0.77
Ajibefun	2003	Southwest	Food crops (Ekiti state)	100	0.65
Ajibefun	2003	Southwest	Food crops (Ogun state)	82	0.56
Ajibefun	2003	Southwest	Food crops (Ondo state)	100	0.66
Ajibefun	2003	Southwest	Food crops (Osun state)	93	0.71
Ajibefun	2003	Southwest	Food crops (Oyo state)	86	0.62
Okoruwa & Bashasha	2006	Northcentral	Rice (upland)	120	0.81
Okoruwa & Bashasha	2006	Northcentral	Rice (lowland)	120	0.76
Giroh & Adebayo	2007	Southsouth	Rubber latex	129	0.50
Fapohunda *et al.*	2005	Southwest	Fish	120	0.83
Udoh & Etim	2008	Southsouth	Waterleaf	70	0.82
Effiong & Onuekwusi	2007	Southsouth	Rabbit	60	0.62
Overall average					**0.738**

§All studies cited here employed parametric frontier.

Table B: Meta-regression of un-transformed mean technical efficiency

Variables	OLS[a] Regression	Truncated[a] Regression	Box Cox[b] Regression
DATAYEAR	2.517	3.020*	1.142**
	(2.955)	(1.086)	(0.050)
NO.OBSER	0.030	0.650**	0.673**
	(0.612)	(0.243)	(0.042)
NO.INPUT	2.015	2.017	1.213
	(1.737)	(1.614)	(0.250)
D_{Food}	0.063	0.278	0.216
	(0.199)	(0.485)	(0.301)
D_{Cash}	-0.175*	-0.095*	-0.024*
	(0.104)	(0.039)	(0.066)
$D_{Livestock}$	1.027	1.058	1.082
	(0.766)	(1.017)	(0.00)
D_{Output}	0.026*	0.031*	0.011**
	(0.016)	(0.017)	(0.042)
D_{Cobb}	3.206	3.624	3.009
	(3.162)	(1.566)	(0.283)
RANGE	-1.418***	-1.325***	-2.208***
	(0.323)	(0.350)	(0.000)
$D_{Northcentral}$	0.721*	0.977*	1.021**
	(0.414)	(0.511)	(0.031)
$D_{NorthEast}$	-1.272	-1.823*	-2.010*
	(0.971)	(1.085)	(0.097)
$D_{SouthWest}$	0.930**	1.113***	1.157***
	(0.330)	(0.429)	(0.000)
$D_{SouthEast}$	-1.006	-1.054*	-1.340
	(0.875)	(0.599)	(0.084)
$D_{SouthSouth}$	1.085**	2.003**	2.749***
	(0.378)	(0.485)	(0.000)
CONSTANT	2.319	1.689*	1.599
	(1.363)	(0.879)	
Log likelihood	-	70.564	87.736
F	7.10***	-	-
χ^2	-	26.79***	47.79***

*For all implies: *** significant at the 1%; ** significant at 5%;*
** significant at 10%. [a]Figure in parentheses represented the standard error*
[b]Figure in parentheses represented the p-value