RETHINKING THE TECHNICAL EFFICIENCY OF SMALL SCALE YAM FARMERS IN NIGERIA USING CONVENTIONAL AND NON-CONVENTIONAL INEFFICIENCY PARAMETERS

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ABSTRACT
The study investigated whether socio-cultural factors accentuate technical efficiency of yam farmers in Kogi State, Nigeria in addition to the socio-economic normally postulated. Primary data collected from 180 yam farmers randomly selected from three local government areas, one from each of the socio-cultural group of the State was used. Results indicated that there is more number of socio-cultural factors that determine the level of technical efficiency of yam farmers than the socio-economic. The results further show that male farmers are more affected by socio-cultural factors than female. In addition, the Okuns seems to be more affected while the Igalas were least affected. However, some of the socio-cultural practices are shrouded in some form of secrecy and research effort should be geared towards empirical understanding of their operation. Yam farmers should be provided with more comprehensive and adequate extension support to manage their farms in line with modern and improved production technologies, rather than basing their production decisions on factors alien to modern agricultural production.

KEYWORDS
Yam farmers, socio-economic, socio-cultural, technical efficiency, modern agricultural production

Introduction
Since the stochastic frontier production function procedure was devised (Farrel, 1957, Aigner et. al., 1997, Battese and Coelli, 1988 and Kumbhakar et. al., 1989), quite a number of studies to estimate farm level technical efficiency (TE) using it have been conducted, although all the studies estimated the TE using the socio-economic parameters of the farmers (Rahman, 2013, Ogunyinka and Ajibefun 2003, Rahman, 2003, Ojo *et. al*., 2009, Oluwatusin, 2011, Nmadu et. al, 2012). The socio-economic factors in the above studies include age of the farmer, gender, level of education, marital status and or number of wives, number of children and or size of family, numbers of years in farming, membership of farmers association, cooperatives of unions, number of extension contacts, distance to farm or markets or financial institutions. These factors are believed to influence the way farmers manage their farms and thus determine the level of technical and or allocative efficiencies. No major attempt has been made to determine the effects of socio-cultural parameters and other intrinsic farm practices on the level of TE. Efficiency and or productivity of farm production are a success measuring scale in agriculture and it is central to poverty reduction in rural areas. An increase in the efficiency of production leads to improvement in the welfare of the farmers and enhance food security (Rahman, 2013, Kumshakar and Lovell, 2000). A technically efficient farm operates on the production frontier while a technically inefficient farm operates away from the frontier but could be made efficient by increasing its output with the same input level or using fewer input to produce the same level of output (Rahman, 2013, Ogunyinka and Ajibefun 2003, Olayide and Heady, 1982, Yotopoulos *et al.*, 1970, Ali and Flinn, 1989, Rahman, 2003, Ojo

et. al., 2009 and Oluwatusin, 2011). Increases in agricultural production in Nigeria are almost entirely dependent on farm size expansion while increases due to increased productivity and or TE are negligible. In this regard, the only remedy to increasing farm output may be to improve technology and enhance TE of farm production (Simpa, 2011, Olayide, 1980).

Yam production is carried out by small scale farmers with the use of rudimentary production technology. For example, yams are planted in mounds about 1m high and 1m apart (Anonymous, 2013a, Mignouna *et al*., 2009, Oguntade *et al*., 2010, Wikipedia, 2013). The mounds are made manually. To harvest, the mounds are broken using local hoes and the tuber is removed. Land clearing and weeding are done using herbicides and manual means. All these operations are carried out manually, making yam production labour intensive. As a result of these factors, the study of technical efficiencies of yam farmers is important because agriculture in Nigeria is dominated by small-scale farmers who engage in the production of bulk of food requirements of the country (Asogwa *et al.*, 2006, Ajibefun, 2002, Ajibefun and Daramola, 2003). However, studies on TE of yams farmers have been carried based on only socio-economic characteristics in the past and no attention was made in quantifying the possible effects of certain socio-cultural practices associate with its production. No other crop is highly celebrated like yam; in yam producing areas (Babalaye, 2003, Justin, 2010, Chukwu and Ikwelle, 2000, Aidoo, 2009, Salami, 2011 and Adeniyi, 2012). Considerable amount of rituals have developed around its production and utilization. Important cultural values are attached to yams especially during festivities, marriage and other social ceremonies among others in many farming communities in Nigeria and other West Africa countries where the size of yam enterprise is a strong determinant of social status. For example, prospective groom's wealth is measured by the number of big yams he could produce and a groom presents a minimum of 200 tubers of yam to the in-law as a proof that he can take care of their daughter in addition to other religious and sociocultural taboos especially among the Igbos (Urachukwu, 2007).

The link between sociocultural practices and economic behaviour and outcomes has received little attention in empirical studies. Only recently have economists started looking at explanations and effects of specific customs, taboos and superstitions on agriculture (Stifel *et al*., 2009). In Nigeria, traditional ceremonies still accompany yam production and consumption and belief in certain sociocultural practices (Olayide, 1980, Orkwor *et al.* 1998, Diop, 1998, Stifel *et al*., 2009). On the relationship between taboos and agriculture and household consumption, Benabou and Triole (2007) and Fudenberg and Livine (2006) developed theoretical model to explain the persistence of superstitions and taboos involved in yam production. In addition, Anyanwu *et al*. (2003) and Simpa (2011) confirmed that some of the socio-cultural practices includes designating some lands as evil hence not cultivated; designating some work taboo days in which crops are not planted and animals are not grazed; and prohibition of female gender from some farm operations or from production of certain crops; and that this situation is affected by farmers' level of education. For example, yam is considered the king of crops and should be produced by men only among the Igbos in south-eastern Nigeria (Ahamefule, 2013, Anonymous, 2013). Ruud (1960) and Stifel *et al*. (2009) worked on customs and taboos in Madagascar and its effects on agriculture and observed that farmers are prohibited from working farms for four days of the week and this may influence agricultural productivity and TE. On the contrary, Masalu *et al.* (2010) and Colding and Carl (2010) looked at how cultural beliefs help in improving agriculture and pointed out that some of these practices may help to reduce pressure on fishing activities and habitats. Oyeleke (2010) also admitted that culture and religious practices have influence on utilization of agricultural resources but religion may help to correct some taboos which are against the

economies of agricultural resources. From the above studies and findings, socio-cultural practices have a lot of implications on agricultural productivity and well-being of the farmers and as a result they may be important factors in the determination of technical inefficiencies of farmers particularly yam farmers as yam production is surrounded with observance of diverse socio-cultural practices. In view with the foregoing, the main goal of this study is to determine the TE of yam farmers under different management paradigms and specifically to estimate the TE of the respondents and determine whether TE is accentuated when differing economic and cultural practices are used by the farmers. The specific objectives are to describe the demographic characteristics of the yam farmers in the study area, estimate the frontier production functions of the farmers, estimate the technical efficiencies of the farmers under socio-economic and socio-cultural practices and compare the technical efficiencies of the farmers under different scenarios. The assumption is that no effect exists in TE of the respondents in spite of the diverse cultural practices involved in yam production in the study area.

Methods

This study was carried out in Kogi state of Nigeria. It is located between latitude 6°30′N and 8°30'N and longitude 5°51′E and 8°00'E in the Guinea forest-savanna ecological zone of Nigeria. There are three major tribes in the state; namely Okun, Ebira and Igala; and other minority tribes like Nupe, Bassa, Oworo, Ogori/Mangogo and Eggan (Kogi Agricultural Investment Plan, 2012). The population of the state is 3,314,043 (NPC, 2006) and has a tropical climate which is essentially characterized by two main seasons, the rainy from March to October and dry from November and February. The annual rainfall is between 1016 and 1524 mm. Agricultural activities spread through the two seasons, with high intensity during rainy season. The state has maximum and minimum temperatures of 33.2°C and 22.8°C; and relative humidity is 68–70% (KO–SEEDS, 2004). The state usually experience dry and cold weather due to harmattan in the month of December and January. Kogi State has the confluence of Rivers Niger and Benue at Lokoja (Wikipedia, 2012) and has a total land area of about 30,354.74 km^2 (KO-SEEDS, 2004) with extensive plains, alluvial and swampy features and these occur in areas along the rivers Niger and Benue valleys (Kogi ADP, 1995). Majority of the population (about 90%) resides in rural areas and are engaged in agricultural production (yam, cocoyam, cassava, maize, soybean, melon, sorghum, rice, cowpea, groundnut, and benne seed), trade and commerce in agriculture, fishing, food processing, handcraft as well as in small and medium scale enterprises (Kogi ADP, 1995, KO–SEEDS, 2004).

For sampling frame and data collection, the state was divided into three blocks based on their cultural affiliations: West made up of Okuuns, Central made up of Ebiras and East made up of Igalas. Multi-stage random sampling technique was used to select the sample for the study. First, one Local Government Area each was randomly selected from each block from where two villages involved in yam production were randomly selected. Then 10% of yam farmers were sampled from the selected villages and were interviewed to elicit the data, given a sample size of 180 yam farmers was used for the study. The blocks and other details of sampling are presented on Table 1. The field survey was commenced in November 2012 and concluded in March 2013

Structured questionnaire supplemented with oral interviews was used to collect the data from the respondents. The questionnaire was administered by trained enumerators after intensive training and pre-testing the instrument on another set of respondents different from the selected respondents. The data collected included socio-economic characteristics of the

respondents (conventional inefficiency determinants), socio-cultural practices of yam farmers (non-conventional inefficiency determinants) as well as input-output data on yam production. The full description of the socio-economic and socio-cultural factors in this study is presented on Table 2. The data was collected between October 2012 and March 2013 immediately following the onset of yam harvests of the 2012/2013 farming season.

The data was analysed using descriptive statistics and Stochastic Frontier Production Function (SFPF). In line with Aigner *et al.* (1977), Coelli (1994), Ojo (2007) and Ekunwe (2008), the Cobb-Douglas functional form of SFPF was used as specified equation (1).

$InY = In\ \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + \beta_6 InX_6 + \beta_7 InX_7 + V_i - U_i$ ---- (1)

[1]Where Y = Quantity of yam output (Kg/ha)

X_1 = farm size (ha)[a]

X_2 = planting materials (Kg/ha)[c]

X_3 = hired labour (man-days/ha)[c]

X_4 = staking materials (No/ha)[a]

X_5 = herbicides (litre/ha)[a]

X_6 = fertilizer (Kg/ha)

X_7 = capital input (N)[b]

V_i = Normal random errors assumed to be independent of U_i and normally distributed with zero mean and constant variance $/(0,\delta v^2)/$

U_i = Non-negative random variables which are assumed to account for technical inefficiency in production.

β_0, β_1- β_8 = vectors of technology parameters to be estimated

Where; U_i (inefficiency model) is specified in equation (2).

$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + \delta_{11} Z_{11} + \delta_{12} Z_{12} + \delta_{13} Z_{13} + \delta_{14} Z_{14} + \delta_{15} Z_{15} + \delta_{16} Z_{16} + \delta_{17} Z_{17} + \delta_{18} Z_{18} + \delta_{19} Z_{19} + \delta_{20} Z_{20} + \delta_{21} Z_{21} + \delta_{22} Z_{22} + \delta_{23} Z_{23} + \delta_{24} Z_{24} + \delta_{25} Z_{25} + \delta_{26} Z_{26} + \delta_{27} Z_{27} + \delta_{28} Z_{28} + \delta_{29} Z_{29}$----------(2)

Where Z_1 = Sex (dummy: male =1, 0 female)[a]

Z_2 = Age (years)[b]

Z_3 = marital status (dummy: married = 1, 0 otherwise)[b]

Z_4 = educational level (No. of years spent in school)[a]

Z_5 = family size (No. of people in a farm household)[a]

Z_6 = farming experience (years)[a]

Z_7 = main source of labour (dummy: hired = 1, 0 otherwise)[b]

Z_8 = membership of an organization (dummy: Yes = 1, 0 No)

Z_9 = extension contact (no of contacts in a year)[a]

Z_{10} = distance of farm from settlement (Km)

Z_{11} = quantity of yam as marriage rite (Kg)[a]

Z_{12} = land size evil (ha)[a]

Z_{13} = work tabooed days (No of days)

Z_{14} = quantity of yam for rent on land (Kg)[c]

Z_{15} = land tenure (hired =1, 0 otherwise)[a]

Z_{16} = on-farm storage structures availability (yes =1, 0 otherwise)[c]

Z_{17} = nature of access road to the farm (motor able = 1, 0 otherwise)[c]

Z_{18} = married female children in household (numbers)[a]

Z_{19} = aspiration to be master of yam producers (yes =1, 0 otherwise)[c]

Z_{20} = religion (traditionalist =1, 0 otherwise)[a]

[1] a=variables that had appropriate signs only, b=variables that had contrary signs only, c=variables that exhibited both.

Z_{21} = belief in credit for yam production (yes = 1, 0 No)[a]
Z_{22} =belief in purchase of seed yam production (yes =1, 0 otherwise)[b]
Z_{23} = belief in oracle consultation before planting begins (yes =1, 0 No)[b]
Z_{24} = belief in yam festival celebration before harvest commences (yes=1, 0 No)[c]
Z_{25} = magical transfer of yam productivity either from or by neighbour (yes=1,0 No)[a]
Z_{26} = acceptance of in-law to work on yam plot as marriage rite (yes=1, 0 (No)
Z_{27} = belief in prohibition of women on monthly period (yes=1, 0 No)[a]
Z_{28} = belief in production of bigger yam for marriage rite (yes =1, 0 No)[b]
Z_{29} = belief in sprinkling of domestic waste water (yes =1, 0 No)[c]
$\delta_1 - \delta_{29}$ are scalar parameters that were estimated.

Three estimations were carried on the above model. The first is the full model with both the conventional (socio-economic) and non-conventional (socio-cultural factors) factors. The second is with the conventional factors (Restricted model I) and the third with the socio-cultural factors (Restricted model II) respectively. In addition, the model was segregated into gender (male, female) and socio-cultural groups (Okun, Ebira, Igala). The estimates of all the parameters of the stochastic frontier function and that of the inefficiency model were simultaneously obtained using the Frontier Version 4.1c (Coelli, 1996). After the estimation, the models were tested (generalized likelihood ratio statistic) for significance as shown in equation (3) (Kyi T. and M. von Oppen, 1999, Kimsey, 2009, Rosko and Mutter, 2008).

$$\lambda = -2\log[(L(H_o))-(L(H_a))] \qquad (3)$$

Where $L(H_o)$ and $L(H_a)$ are the values of the likelihood function under restricted and full versions of the model and is distributed approximately as a chi-square with degrees of freedom equal to the difference in the number of parameters in the null and alternative hypotheses. In addition, the significance of the efficiency scores was tested using student t as shown in equation (4).

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \qquad (4)$$

Where $\bar{X}_1$ is the mean TE of yam farmers under full model and $\bar{X}_2$ is the mean TE of yam farmers under various restrictions. S_1^2 and S_2^2; n_1 and n_2 are the variances and sample sizes respectively.

Results

The Socio-economic and other demographic description of the respondents are shown on Table 3 while Table 4 presented a detailed summary of the quantitative variables in the regression models. The results show that the respondents are mostly married (71%) males (83%) in their active years (49 years) who have had up to secondary education (41%) although it appears that most of the women (90%) are widows and half of the respondents (48%) did not acquire any formal education. The respondents practice three main religions i.e. African (44%), Christianity (28%) and Islam (22%) with a family size of eight. In addition, the respondents are small scale farmers (0.78ha) who have acquired 29 years of farming experience and earned a gross margin of NGN466,127.54 (USD2,913.30). The farming enterprise is family based as indicated by the sources of labour supply (62%) and farm finance (65%). However, most of the respondents (80%) are not members of any farming association and have not been adequately serviced by extension agents (92%) as they have received only two visits during the 2012/2013 farming season. These results are very consistent with earlier findings in Nigeria (Adebayo, 2006, Nmadu and Ibiejemite, 2007, Nmadu et. al, 2012, Nmadu et. al, 2013).

Table 5 is a presentation of the diagnostic properties of the estimated parameters[2] and Fig. 1 shows the number of significant parameters from the estimated models. The results on Table 5 shows that all the models estimated are significant in explaining the output and inefficiency of the farmers except Ebira (I). In addition, comparisons of the models show that none of them show any significant difference among themselves, even the Ebira. Furthermore, the results show that all, male, Ebira models as well as Igala (I, II) are in harmony with respect to positive production parameters although Igala (F) seems to be the best. Of the ten conventional and nineteen non-conventional variables only two did not significantly affect the level of TE respectively. In addition, eight, three and six non-conventional and five, three and zero conventional variables exhibited expected, contrary and both signs respectively. Furthermore, the data on Fig. 1 indicated that although there is clear evidence of the over-bearing influence of the socio-cultural factors on TE of the full models, the scenario is quite interesting among the groups. On the basis of gender, it was observed that only the TE of the male farmers were either positively or negatively affected by the socio-cultural practices in spite of the fact the female had the highest TE. This is actually in conformity with most of the cultural practices in which the female are either banned from attending or are the exclusive preserve of men. For example, preparation of corpses for burial is carried out by men only, the waste water from which process is used to prepare yams for planting in some communities. On the basis of the socio-cultural groups, the Ebira group had the highest number of negative socio-cultural factors affecting TE while the Okun group had the highest number of positive factors with equal number of negative factors also. In all, there is no unanimity among the models but there is an indication that non-conventional parameters seem to have greater influences on the policy variables in the determination of TE of yam farmers in Kogi State, Nigeria but not necessarily to improve it as is demonstrated by the female farmers.

The distribution of TE scores of the yam farmers under the different models is presented in Fig. 2 while Table 6 presents the associated properties. The results indicated that Ebira (F, I), Igala (I. II) and Okun (I, II) are significantly different from all (F) while within, Ebira (II) was significantly different from Ebira (F) and Okun (I) was significantly different Okun (F). The pair test of the models show that only Ebira (F) is significantly different from all (F) while for (I), all the cultural affiliations are significantly different and female (II), Igala (II) and Okun (II) are significantly different from all (II). The display of the technical efficiencies on Fig. 2 shows that all the models had a fairly normal distribution but the non-conventional models had a higher efficiency scores {e.g. Igala (II) and Female (II)}.

Discussion

The socio-cultural factors that suppress TE i.e. belief in oracle consultation before planting begins, belief in production of bigger yam for marriage rite and belief in purchase of seed yam production and those that either suppress or accentuate it i.e. belief in yam festival celebration before harvest commences, quantity of yam for rent on land, on-farm storage structures availability, nature of access road to the farm, aspiration to be master of yam producers, and belief in sprinkling of domestic waste water have shown that socio-economic factors alone are not the determinants. Looking closely at the factors suppressing efficiency, first, it must be recognised that they work very strongly with the psychology of the farmer. The farmer is told of the dire consequences that will ensure if he ever tries to go against what the oracle has said. The oracle or the deity does not work with weather but with fulfilment of

[2] The estimates for the various models can be requested from the Authors

certain sacrificial rites. So the farmer is incapacitated in commencing his yam farm operations until the oracle has nodded. In this case, the farmer misses the opportunity to plant when rain establishes and may actually be persuaded to plant even in the worst-weather scenario. This definitely will suppress his TE. The farmer is driven with passion to succeed based on community standards in terms of size of yams produced and whether he should purchase seed yams or not. Supposing the community is against purchase of seed yams and his own seeds are infested with diseases or he does not have enough quantity to plant from previous harvest, then his TE must go down! In the same vein, the farmers' yams will rot in the farm if harvest is due yet the community is not done with the sacrifices or consultation of oracles or deity that will give the go ahead for harvest to commence. The working of these factors are shrouded in some form of secrecy but very pungent in guiding the psychology of the farmers and has the potential to distort observance of timely farm operations thus affecting productivity and hence income. Also, the parameters are not tangible and difficult to manipulate to increase yam production. In addition, female respondents had the highest TE but most of them were widows who face greater production constraints than men especially with regards to property and land rights.

These results have shown that more number of socio-cultural factors determined the level of TE of yam farmers than the socio-economic parameters but their influence did not necessarily raise the level, as shown in the case of the female farmers. However, research effort should be geared towards empirical understanding of their operation. Yam farmers should be provided with more comprehensive and adequate extension support to manage their farms in line with modern and improved production technologies, rather than basing their production decisions on factors alien to modern agricultural production. A special consideration should be given to women farmers and in particular, inheritance rights for widows must be strengthened. Production inputs should be provided through a special wallet to enhance their income and welfare. To ensure that the Nigerian agricultural transformation agenda is effective, policies and programmes should be farmer specific and based on empirical findings.

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Table 1: Socio-cultural blocks with selected villages and number of respondents

Socio-cultural group and thier LGAs	Sampled LGA	Sampled Village	Sampling frame	Sample size
Okun: Ijumu, Kabba/Bunu, Mopa-Moro, Yagba East.Yagba West and Kogi	Ijumu	Aiyetoro-gbede	310	31
		Iyah-gbede	300	32
Ebira: Adavi, Ajaokuta, Ogori/magogo, Okehi, Okene and Konton-Karfe	Okene	Ogunda	320	32
		Achoze	360	36
Igala: Ankpa, Bassa, Dekina, Ibaji, Idah, Igalamela-Odulu, Omala, Ofu and Olamaboro	Dekina	Anyigba	270	27
		Egume	260	22
TOTAL			1800	180

Table 2 Description of the various socio-economic and socio-cultural factors under investigation in this study

Variable	Description	Sign
	SOCIO-ECONOMIC FACTORS	
Z_1	Gender of the yam farmer	appropriate
Z_2	Age of the yam farmer in years	contrary
Z_3	Marital status of the yam farmer	contrary
Z_4	Number of years spent in formal educational system representing educational level/attainment	appropriate
Z_5	Total number of persons in yam farmer's family	appropriate
Z_6	Number of years as a yam farming representing farming experience	appropriate
Z_7	Main source of labour for yam production	contrary
Z_8	Membership status of yam farmers' association/union	NS
Z_9	Number of visits by extension agents in the preceding year	appropriate
Z_{10}	Distance of yam farm from village settlement	NS
	SOCIO-CULTURAL FACTORS	
Z_{11}	Quantity of yam demanded for marriage rite from prospective in-law in the community. The quantity may be beyond the capacity of the farmer leading him to observe some other intrinsic practices to meet up	appropriate
Z_{12}	Size of land in hectares designated as evil and hence is not used to cultivate yams in spite of the fertility	appropriate
Z_{13}	Number of days in a year declared as work taboo in which yam production operations are not allowed in the community	NS
Z_{14}	Quantity of yam used to pay rent on farmland used for yam production which may drive the farmer to want to make up whatever shortfall expected under normal agronomic operations	both
Z_{15}	Type of land tenure used to secure the farmland for yam production in the community which may be guided by other socio-cultural practices	appropriate
Z_{16}	Construction of on-farm yam storage structures in order to enhance the observance of the various cultural practices	both
Z_{17}	Nature of access road to the yam farm, some farmers may prefer their farmland to be in more remote locations to enable them observe some of the cultural practices	both
Z_{18}	Retaining married female children in household as part of yam production practices	appropriate
Z_{19}	Aspiration of the farmer to become a master of yam producers which confers certain community privileges on him including acceptance of marriage proposals by families	appropriate
Z_{20}	The religious persuasion of the yam farmer	appropriate
Z_{21}	Belief that credit can be procured for yam production	appropriate
Z_{22}	Belief in purchase of seed for yam production	contrary
Z_{23}	Belief in consulting oracles before yam planting begins irrespective of the weather forecast	contrary
Z_{24}	Belief in the observance of yam festivals/celebration before yam harvest commences	both
Z_{25}	Magical transfer of yam productivity either from or by neighbours	appropriate
Z_{26}	Acceptance of in-law to work on yam plot as marriage rite	NS
Z_{27}	Prohibition of women on monthly period to carry out any yam production practices	appropriate
Z_{28}	Production of bigger sized yams for observance of marriage rite	contrary
Z_{29}	Sprinkling of domestic waste water, like water used to prepare corpse for burial, on the yam seeds before they are planted	both

Table 3 Socio-economic characteristics of the respondents

Variable	Freq.	%
Age		
21 – 30	21	11.6
31 – 40	20	11.1
41 – 50	56	31.1
51 – 60	54	30.1
Above 60	29	16.1
Total	180	100
Gender		
Male	150	83.3
Female	30	16.7
Total	180	100
Marital Status		
Single	20	11.1
Married	127	70.6
Widow	27	15.0
Divorced	5	2.8
Separated	1	0.5
Total	180	100
Household size		
1 – 5	32	17.8
6 – 10	110	61.1
11 – 15	33	18.3
16 – 20	5	2.8
Total	180	100
Educational Level		
No formal education	86	47.8
Primary	40	22.2
Secondary	34	18.9
Tertiary	6	3.3
Others	14	7.8
Total	180	100
Years of Farming Experience		
1 – 10	19	10.6
11 – 20	36	20
21 – 30	58	32.2
31 – 40	39	21.7
41 – 50	21	11.7
Above 50	7	3.9
Total	180	100
Religion		
African tradition	80	44.4
Christianity	50	27.7
Islam	40	22.2
Others	10	5.7
Total	100	100
Main Source of Labour		
Family	112	62.2
Hired	55	30.5
Communal	13	7.3
Total	180	100
Membership of Farmers Association		
Yes	36	20
No	144	80
Total	180	100
Extension Contacts		
0 – 1	165	91.7
2 – 3	10	5.5
3 – 4	4	2.2
4 – 5	1	0.6
Total	180	100
Main Source of Farm Finance		
Personal savings	117	65.0
Relatives	18	10.1
Friends	13	7.3
Cooperative	22	12.2
Commercial banks	10	5.6
Total	180	100
Farm Size (hectares)		
0.1 – 0.5	79	43.9
0.6 – 1.0	56	31.1
1.1 – 1.5	22	12.2
1.6 – 2.0	16	8.9
2.1 – 2.5	4	2.2
2.6 – 3.0	2	1.1
3.1 – 3.5	1	0.6
Total	180	100
Output (kg)		
717-3,586	36	20.00
3,587-6,456	44	24.44
6,457-9,327	42	23.33
9,328-12,197	25	13.89
12,198-15,067	13	7.22
15,068-17,937	11	6.11
17,938-20,807	6	3.33
20,808-23,678	1	0.56
23,679-26,548	0	0.00
26,549-29,418	2	1.11
Total	180	100
Gross income (NGN)[a]		
16,224-87,556	38	21.11
87,557-158,888	50	27.78
158,889-230,221	42	23.33
230,222-301,553	20	11.11
301,554-372,886	9	5.00
372,887-444,219	12	6.67
444,220-515,551	6	3.33
515,552-586,884	2	1.11
586,885-658,216	0	0.00
658,217-729,549	1	0.56
Total	180	100

a USD =NGN160

Table 4 Descriptive Statistics of the Variables in the Estimated Production Function[3]

Variables	Mean	Standard deviation	Minimum	Maximum
Output (kg)	8022.24	5153.56	717	29,409.00
Farm size (ha)	0.78	0.55	0.10	3.20
Planting materials (kg)	387.97	753.08	25	3,950.00
Labour (man-days)	62.97	196.57	14	2,661.00
Staking materials (Nos)	3,012.00	2,352.72	250	15,000.00
Herbicides (litres)	1.20	0.47	0.50	3.00
Fertilizer (kg)	42.16	18.82	21.00	102.00
Capital input	1,463.56	315.31	740.00	2,308.00
Age (years)	49.41	12.32	21.00	75.00
Years of farming experience	28.57	12.50	5	60
Educational level (years)	9.69	5.10	0	19.00
Household size (Nos)	8.20	3.40	1.00	18.00
Extension contacts (Nos)	2.27	1.86	0	7.00
Distance of farm to settlement (km)	5.70	4.76	1.00	56.00
Quantity of marriage rite yams (kg)	44.26	32.35	0.00	100.00
Evil land (ha)	0.28	0.29	0	1.00
Quantity of yam for rent (kg)	5.77	10.66	0	43.00
Gross margin (GM)	466,127.54	349,750.39	-1,072.50	2,416,180.00
Labour cost	3,622.74	9,928.07	600.00	133,050.00
Seed cost	58,017.88	85,952.93	3,750.00	592,500.00
Herbicide cost	742.97	389.24	0	2,400.00
Fertilizer cost	3,412.86	1,597.39	1,540.00	10,200.00
Staking material cost	4,601.61	3,933.04	400.00	24,000.00

Table 5 Diagnostic properties of the estimated parameters

		σ^2	γ	LR function	LR test	λ^2 all	λ^2 within	λ^2 between		
								F	I	II
All	F	0.716** (0.0304)	0.897*** (0.0501)	124.28	61**					
	I	0.5723*** (0.2356)	0.9573*** (0.0607)	107.7	28**	-5.62	-5.62			
	II	0.5468*** (0.0158)	0.8292*** (0.0551)	118.16	49**	-3.62	-3.62			
Male	F	0.4729*** (0.01)	0.8032*** (0.0761)	102.78	51**	-6.14		-6.14		
	I	0.4199*** (0.5666)	0.9833*** (0.0247)	87.18	20**	-7.23	-5.49		-6.04	
	II	0.374*** (0.0086)	0.6875*** (0.089)	96.84	39**	-6.62	-3.56			-6.12
Female	F	0.8347* (0.4223)	0.9998*** (0.1488)	33.24	25**	-9.02		-9.02		
	I	0.4318*** (0.1146)	1*** (0.1997)	28.97	16**	-9.11	-2.90		-8.73	
	II	0.2713*** (0.0617)	1*** (0.006)	31.12	21**	-9.07	-1.50			-8.93
Ebira	F	0.2294*** (0.0086)	0.909*** (0.1715)	51.96	38**	-8.56		-8.56		
	I	0.5027** (0.0328)	0.9176*** (0.0794)	37.86	10	-8.92	-5.29		-8.49	
	II	0.2819*** (0.0074)	0.6487*** (0.1255)	48.44	31**	-8.66	-2.52			-8.49
Igala	F	0.4817*** (0.0015)	0.847*** (0.0421)	93.81	82**	-6.83	-6.83	-6.83		
	I	0.191*** (0.0048)	0.9213*** (0.0419)	67.95	31**	-8.06	-6.51		-7.37	
	II	0.7229*** (0.0089)	0.786*** (0.1004)	72.79	40**	-7.88	-6.09			-7.63
Okun	F	0.8479*** (0.0032)	0.8478*** (0.0717)	94.2	55**	-6.81		-6.81		
	I	0.1606** (0.0067)	0.8297*** (0.0849)	81.64	29**	-7.51	-5.06		-6.52	
	II	0.9506*** (0.0029)	0.832*** (0.0718)	92.13	50**	-6.94	-1.46			-6.52

[3] On all the Tables, values in parenthesis are standard errors; F=Full model, I=Restricted model I, II=Restricted model II; ***P<0.01, **P<0.05, *P<0.10. Source of all estimates and analysis is FRONTIER 4.1 and source of all data is 2012 field survey

Table 6 Properties of the efficiency scores of yam farmers in Kogi State, Nigeria

		Mean	Min	Max	SD	t-ratio all	t-ratio within	t-ratio between		
								F	I	II
All	F	0.9070	0.4863	0.9842	0.0889					
	I	0.8948	0.6056	0.9802	0.0818	0.96	0.96			
	II	0.9125	0.6038	0.9849	0.0775	-0.45	-0.45			
Male	F	0.9141	0.5821	0.9863	0.0801	-0.54		-0.54		
	I	0.8939	0.5541	0.9792	0.0865	0.96	1.48		0.07	
	II	0.9231	0.6028	0.9848	0.0720	-1.29	-0.73			-0.91
Female	F	0.8781	0.6181	0.9962	0.1055	1.12		1.12		
	I	0.8689	0.6231	0.9991	0.1017	1.51	0.24		1.05	
	II	0.8677	0.6144	0.9997	0.1004	1.57	0.28			1.86*
Ebira	F	0.8269	0.5185	0.9838	0.1127	3.95***		3.95***		
	I	0.8454	0.6019	0.9787	0.0998	3.29***	-0.72		2.71***	
	II	0.9144	0.6215	0.9851	0.0857	-0.43	-3.64***			-0.11
Igala	F	0.9355	0.5885	0.9943	0.0884	-1.48		-1.48		
	I	0.9432	0.6329	0.9896	0.0710	-2.16**	-0.34		-2.98***	
	II	0.9580	0.6245	0.9923	0.0676	-3.14***	-1.01			-2.95***
Okun	F	0.9278	0.6128	0.9907	0.0643	-1.41		-1.41		
	I	0.9546	0.6493	0.9891	0.0497	-3.70***	-1.87*		-4.84***	
	II	0.9390	0.6321	0.9914	0.0618	-2.22**	-0.71			-1.95*

Statistic	Value	Group
Min of mean	0.8269	Ebira combined
Max of mean	0.9580	Igala non-conventional
Min of min	0.4863	All combined
Max of min	0.6493	Okun conventional
Min of max	0.9787	Ebira conventional
Max of max	0.9997	Female non-conventional

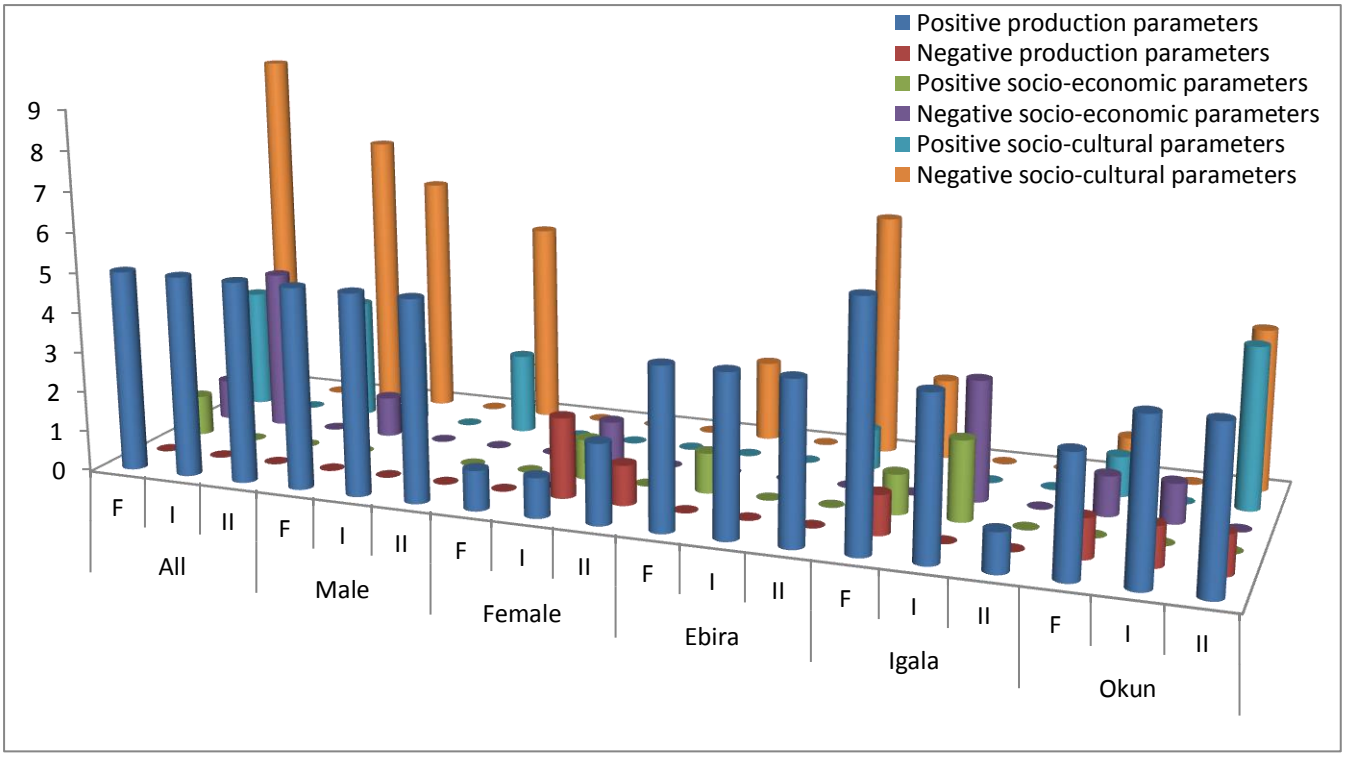

Fig. 1 Number of significant parameters in the various models

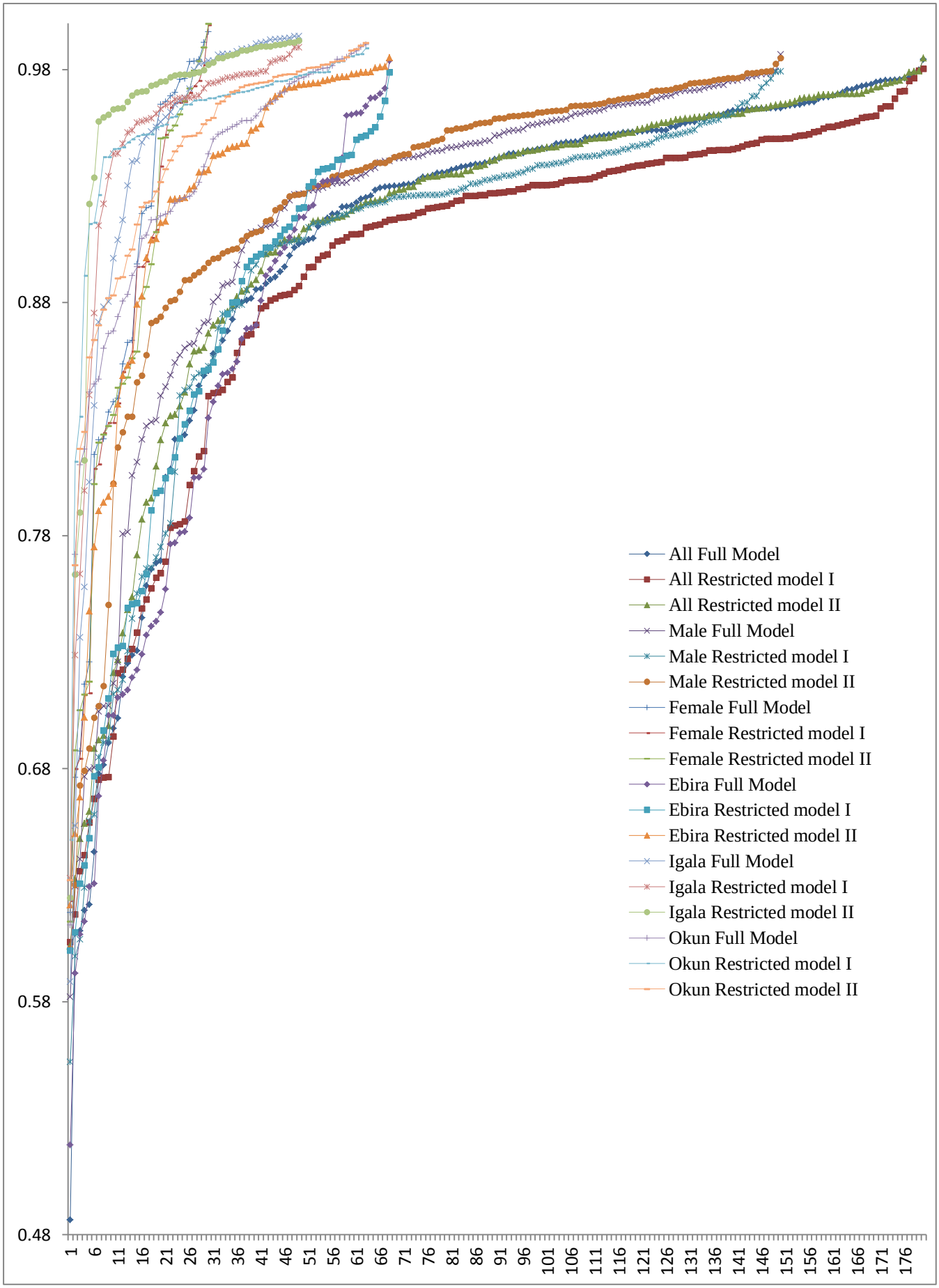

Fig. 2 Efficiency scores of the farmers under the various models