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Households' Dietary Diversity, Farm Income and Technical Efficiency Correlates: Empirical Evidence from Small-scale Farming Households in Nigeria

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Abstract

This study examined the relationship among farming households' technical efficiency, dietary diversity and farm income in Kwara state, Nigeria. Respondents were randomly sampled from among the National Special Programe for food security (NSPFS) beneficiaries and non benficiaies across the 3 geo-political zones in the study area. Stochastic frontier model was used to estimate the respondents' technical efficiency while the dietary diversity score and farm income were analyzed with descriptive and inferential statistics. The Pearson Product Moment Correlation (PPMC) was used to assess the level of relationship among the indicators. The study revealed a significant linear relationship among households' dietary diversity, farm income and technical efficiency. While technical efficiency was inversely related to farm income (r = -0.278, p = 0.01) and dietary diversity (r = -0.206, p = 0.05) on one hand, dietary diversity was positively related to farm income (r = 0.307, p = 0.05). The study has two important implications; first, increasing farm income may be of relevance if the goal of enhancing food security is pursued and benefits of technical efficiency growth may not necessarily translate into enhanced farm income and dietary diversity. This study therefore suggests the provision of infrastructures that would enable the farmers to access the benefits of improved technical efficiency.

Key words

Correlation, technical efficiency, farm income, dietary diversity, Nigeria.

Introduction

Household food security is a necessary condition for nutrition security. To improve households' and community's food security situation, the efficiency of existing utilisation of resources may need to be improved through conserving and, where possible, enhancing the productive capacity of resources (Bokeloh, 2009). In addition, efficient use of agricultural resources can help in achieving certain desirable welfare indicators which are related ultimately with the goal of food security (Alene et al., 2006). Empirical evidences suggest that there are multiple pathways through which increases in agricultural productivity can reduce poverty, including real income changes, employment generation, rural non-farm multiplier effects, and food prices effects (Thirtle et al., 2003; Hazell and Haddad, 2001), and better nutrition (Irz et al., 2001; Timmer, 1995).

However such generalization may not necessarily hold true. The pathways through which efficiency gain can lead to sustainable development is complex and interrelated (Schneider and Gugerty, 2011) and growth may not necessarily lead to the desired outcome of food and nutrition security. This may be particularly relevant at the household level if there is a dearth of infrasuctural facilities and apparatus that could translate such growth into real and sustainable development. While technical efficiency growth may lead to increased output, it may not necessarily translate into enhanced farm income and dietary diversity. This is more if the additional income realized from such growth was spent on other consumer goods and not necessarily on staple food. In view of the various complicated pathways through which technical efficiency growth can result into, this study provides empirical evidence of the association among households' technical efficiencies, dietary diversity and farm income among small-scale farming households in Nigeria.

Specifically, this study tested the following hypotheses:

- There is no significant relationship between farmers' technical efficiency and household dietary diversity score
- There is no significant relationship between farmers technical efficiency and farm income
- There is no significant relationship between farm income and dietary diversity score

Materials and methods

The study was carried out in Kwara State, Nigeria. Specifically, the study was carried out in the three project sites of the National Special Program for Food Security (NSPFS), a World Bank supported agricultural intervention programme that aims at improving farmers' food security and technical efficiency. The programme is located in a site in each of the senatorial zones in Kwara state.

The senatorial zones are: Alapa site in Kwara central located along Ilorin Igbeti in Oyo state. Maize is usually intercropped with sorghum, cassava and groundnut in this zone. Small scale livestock rearing also takes place and there are many cattle Fulani settlers in the area (KWADP, 2006).

Lade is the site in Kwara north. It is located along the road from Ilorin to Patigi. The common crops grown here are millet intercropped with melon, sorghum intercropped with cassava or maize. Crops like rice and groundnut are usually planted solely. Osi site is in Kwara South. The farming systems practiced by the farmers include mix cropping of crops like maize/cassava, maize/yam, sorghum/ yam, melon/maize; cashew cultivation is also popular. There are many Fulani cattle farmers in the village.

The respondents for this study comprised of both crop farmers who are beneficiaries and non-beneficiaries of the NSPFS intervention program in Kwara State. A two-stage sampling procedure was employed in this study.

The first stage involved random selection of 30 NSPFS beneficiary respondents in each of the three programme sites using the NSPFS beneficiaries listing provided by the NSPFS project heads in each of the project site. The second stage involved the random selection of 35 non-NSPFS beneficiary respondents in each of the project sites using the household listing provided by the community head in each village were the programme site is situated. This study eventually used data obtained from75 NSPFS beneficiary respondents and 75 non-NSPFS beneficiary respondents in the three project sites. Primary data were used for this study. The data were collected through the use of structured questionnaire. Secondary data used for the study were sourced from journal publications and from the internet. To test for the variation in our sample data we carried out t-test on our two group of respondents.

1.1. Analytical techniques

Analytical tools employed include descriptive statistics, stochastic frontier model, Household Dietary Diversity Score (HDDS) and Pearson Product Moment Correlation (PMCC).

1.2. Technical efficiency estimation

The Battese and Coelli (1995) formulation of the stochastic production frontier was employed. This encompasses the estimation of technical efficiency and allows the inclusion of explanatory variables within a one-stage estimation procedure.

$$\text{In}Q_i = \text{In}Q_i\,(X_i, \beta) + V_i - U_i \quad (1)$$

The stochastic frontier approach has found wide acceptance within the agricultural economics literature (Battese and Coelli, 1992; Coelli and Battese, 1995), because of its consistency with theory, versatility and relative ease of estimation. To derive the frontier, a production function can be estimated using a set of observations adopting a particular functional form for the production function (in the case of technical efficiency), such as the Cobb-Douglas or Translog Function. The model to be estimated in this study is shown in equation (2), where *i* denotes respondent households:

$$Q_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + V_i - U_i \quad (2)$$

Where

Q_i represents the outputs (maize grain food energy equivalent of the total outputs in kg/kcal), and, (x = 1, 2...., 9) of the i-th beneficiary and non-beneficiary farming households;

X_1 = size of farm land cultivated (ha);

X_2 = hired labour (man days);

X_3 = family labour (man days);

X_4 = quantity of planting materials expressed in maize grain energy equivalent (kg);

X_5 = quantity of Fertilizer (kg);

X_6 = quantity of herbicide (liters);

β_0 = constant terms; β = parameter of production function model to be estimated

The statistical error is represented by V_i, which is assumed to be independent and identically distributed with mean zero and variance σ_v^2. The inefficiency term Ui is positive and assumed to be half normal distributed with variance σ_u^2 (Coelli et al., 2005). The estimation of equation (2) was carried out by the maximum likelihood method. This requires an assumption for the distribution of the inefficiency term, which was assumed to be half normal. Therefore, the entire error term is the sum of two random variables: a half normal (inefficiency part) plus a normal (noise part). As shown in Coelli and Rao (2005), the technical efficiency indicator for farm iis given by the ratio of the actual output to the output at the frontier such as in

$$TEi = \frac{Qi}{\exp\left[Q(Xi,\beta)+Vi\right]} = \exp(-Ui) \quad (3)$$

We estimated the technical efficiencies for the two groups of respondents before pooling the estimates together.

1.3. Households' Dietary Diversity Score (HDDS)

To estimate dietary diversity, a measurement is usually done that include the summing of the number of foods or food groups consumed over a reference period (Krebs-smith et al., 1987). The reference period, in some instances, ranges from 1 to 3 but 7 is also often used (Drewnowski et al., 1997). According to Ruel (2003), measurement of dietary diversity measures consist of a simple count of foods or food groups, some scales developed in developed countries take into consideration the number of servings of different food groups in conformity with dietary guidelines. In developing countries, single food or food group counts have been the most popular measurement approaches for dietary diversity, probably because of their simplicity (Ruel, 2003) and the number of servings based on specific dietary guidelines were not considered (Taren and Chen, 1993; Arimond and Ruel, 2002; Tarini et al., 1999; Onyangoet al., 1998; Ferguson et al., 1993; Hatløy et al., 1998). Indeed the studies of Hatløy et al., 1998 used both single food counts score (FVS) and a dietary diversity score (DDS).

Households' dietary diversity score used in this study was measured by summing the number of foods or food groups prepared and consumed by the household over a reference period of 24 hours separately for the two groups of respondents. Following Swindale and Bilinsky, (2006), the set of 12 food groups which captures all possible food groups household consumed was developed using the FAO food composition table for Africa. (Swindale and Bilinsky, 2006). The following set of 12 food groups was used to calculate the HDDS; Cereals, Fish and seafood, Root and tubers, Pulses/legumes/nuts, Vegetables, Milk and milk products, Fruits J., Oil/fats and oil palm, Meat and poultry offal, Sugar/honey, Eggs, Miscellaneous.

1.4. The Pearson Product Moment correlation (PPMC)

Correlation refers to a quantitative relationship between two variables that can be measured either on ordinal or continuous scales. The variables in this study were measured on a continous scale. The PPMC was therefore used to measure the correlation. The PPMC (denoted as *r*) as used in this study is multivariate and it quantified the relationship between household technical efficiency and farm income and the sum of the household dietary diversity on one hand, and the association between farm income and household dietary diversity score on the other hand. The PPMC can take any value between -1 and +1. A positive correlation implies co-movement in the same direction. A negative correlation implies co- movement in opposite direction. Zero correlation implies a complete absence of joint linear movement. Following (Weisstein, 1999),

$$rxy = \frac{n\,\Sigma xy - \Sigma x\,\Sigma y}{\sqrt{[\sum x2-(\sum x)2][n\sum y2-(\sum y)2]}} \quad (4)$$

Where;

rxy = correlation between technical efficiency and farm income; technical efficiency and household dietary diversity score and farm income and dieatary diversity

N = number of sampled respondents (150)

xy are the variables of interest and they are technical efficiency, farm income and household dietary diversity score

Results and Discussion

1. Socio-economic distribution of respondents

The result of the distribution of respondents according to farm size in hectares of farmland cultivated, experience in years, and household size is presented in Table 1.

The study reveals that the respondents' average farming experience is 24 years (Table 1). Experience has been identified as an important determinant of efficiency. With a relatively higher farming experience, there is an accumulation of knowledge which could be put into practise to reduce cost, enhance efficiency and ultimately income which is positively related to dietary diversity. The t-test further reveal that there is no statistical difference between the average farming experience of the NSPFS beneficiary and non beenficiaries ($p < 0.8$).

As revealed in Table 1, respondents' average farm size is 9.18 ha. from the Table, it is revealed that beneficiary farmers have larger farm sizes than non-beneficiaries ($p = 0.01$). Theoretically, farm size affects technical efficiency, technology adoption costs, risk perceptions, human capital, credit constraints, labor requirements, tenure arrangements and more. With small farms, it has been argued that large fixed costs become a constraint to technology adoption (Abara and

Socio-economic indicators	NSPFS Beneficiary households		NSPFS Non-beneficiary households		All households	
	Freq.	%	Freq.	%	Freq.	%
Farming experience						
<15	12	15.9	16	21.3	28	18.7
16-30	44	58.7	42	56	86	57.3
31-45	16	21.1	13	17.3	29	19.6
46>					7	4.8
Average farming experience (24 years)						
Std deviation 11.18						
T-test = 0.189; p = 0.85						
Farm size (ha)						
1.99-5.0	7	8	21	27.9	27	18.1
5.1-9.0	30	39.9	32	42.6	62	41.3
9.1-12.0	25	33.3	13	17.3	38	25.3
12.1-15.0	6	8	4	5.3	10	6.7
>15.0	8	10.6	5	6.7	13	8.7
Average farm size 9.18 ha						
Standard error 0.422						
(t = 2.4780, p = 0.0143)						
Household size						
5.III	16	21.3	27	36.1	43	28.6
8.VI	29	41.6	34	45.3	63	42
11.IX	12	16	13	17.3	25	16.6
14.XII	13	17.3	1	1.3	14	9.4
16-21	5	6.6	0	0	5	3.4
Minimum household size (3)	1	1.3	2	2.7	3	2
Maximum household size (26)	1	1.3	0	0	1	0.7
(t = 4.2341, p = 0.001)						

Source: Field survey, 2012

Table 1: Distribution of respondents according to experience, farm size and household size.

Singh, 1993) especially if the technology requires a substantial amount of initial set-up cost. With some technologies, the speed of adoption is different for small- and large- scale farmers (Gabre-Madhin and Haggblade, 2001).

According to the study, the average household size for the respondents is 8 members. There is significant difference in the household number of the beneficiary and non-beneficiary household (p=0.01). Household size may have an implication on technical efficiency and food security. More hands may be available for farm labour as a result of higher household size which could be of assistance in farm work. Equally relevant is family size in determining the number of mouths to feed in the household which could affect the quality of food that would be eaten in the households.

2. Distribution of average annual farm income of respondents' households

The result of the distribution of the average annual farming income size is presented in Table 2.

The result of the distribution of the average annual farm income of households as presented in Table 2. As shown in the Table, the mean annual farming income of the household was N264,102, of which only 14.7% of the non-beneficiary household earned above this amount when compared to the 32% of the beneficiary households.

3. Technical efficiencies distribution of beneficiary and non-beneficiary respondents

Table 3 presents the result of the technical efficiencies distribution of the respondents in the study area.

The model parameters for the two respondent categories, the sigma squared and the gamma estimates were equally significant at 1% significant level. The significance of the sigma squared result indicate that the variables included in the estimation of our model fit into the model and correctly specified the distribution of the assumption of the composite error term.The gamma results indicate that the variation in the crop farmers' respondents' outputs were due to differences in their technical efficiencies.

The models estimated included 6 independent variables based on their relevance to NSPFS participation in the study area. For the NSPFS crop farmer participants, fertilizers, herbicides farm size and hired labour were all positive and significant at 0.01 significant level. Household size was also significant and positive at 0.10 significant level. However, for the non – beneficiary crop farmer respondents in the study area, it was only the farm size that was significantly positive at 0.01. These results indicate that the incentives assessed by the NSPFS in the form of fertilizers, herbicide and loan facilities contributed positively and significantly to their technical efficiency. However, for respondents who did not participate

Average annual farm income/household (Naira)	**Beneficiary households**		**Non-beneficiary households**		**All household**	
	Freq.	%	Freq.	%	Freq.	%
45,000-104,999	2	3.9	16	21.4	18	9.4
105,000-164,999	13	15.3	28	37.3	41	27.4
165,000-224,999	23	30.5	18	22.9	41	26.8
225,000-284,999	16	19.9	4	5.4	20	12.7
285,000-349,999	10	13.3	5	6.6	15	10.1
345,000-404,999	6	8	0	0	6	4
405,000-464,999	2	2.6	4	5.3	6	4.1
465,000-524,999	3	3.9	0	0	3	2.1
Mean Annual Farm Income						
(N264,102)						
Standard error (N23,258)						
(t= 4.8965, p=0.01)						

Source: Field survey, 2012

Table 2: Distribution of annual and mean farm income of NSPFS beneficairy and non-beneficiary households.

Variables used in stochastic frontier estimation model	NSPFS Beneficiary households			Non-beneficiary households		
	Coef	**Std error**	**t-ratio**	**Coef**	**Std error**	**t-ratio**
Constant	5.198664	0.9999	5.1987*	5.1563	1.2261	4.6911*
Farm size (ha)	3.2307	0.9857	3.2340*	3.6237	1.4059	3.1536*
Fertilizer	1.5759	0.7379	2.1356*	2.1121	1.4595	1.2439
Herbicides	4.10824	1.1968	3.5497*	2.9534	2.3738	1.255
Family labour	1.44928	0.512723	1.8869***	1.4754	1.2157	1.2204
Hired labour	3.1629	1.70047	2.2325*	1.6343	1.9149	0.6932
Planting materials	0.86235	1.2477	0.6912	-0.49097	0.9229	-0.5319
Sigma (δ^2)	10.1539	1.1	10.1539*	8.4076	1.1	8.407*
Gamma	0.9999	0.15508	6.4476*	0.5366	0.1125	4.7697*

*significant at 10%
**significant at 5%
***significant at 1%
Source: Field survey, 2012

Table 3: Maximum likelihood estimation of respondents' technical efficiencies.

Technical efficiencies distribution (%)	NSPFS Beneficiary households		Non-beneficiary households	
	Frequency	**%**	**Frequency**	**%**
< 20	0	0	15	20
21-30	1	1.3	11	14.6
31-40	3	4	5	6.67
41-50	5	7	7	9.3
51-60	4	5.3	3	4
61-70	7	9.3	2	2.7
71-80	13	17.3	2	2.7
81-90	25	33.3	17	22.7
90>	17	22.7	13	17.3
Average technical efficiency	70.1		60.2	
Overall average technical efficiency	65			

Source: Field survey, 2012

Table 4: Distribution of respondents' technical efficiency estimates.

in NSPFS and any other intervention programs, no inputs other than the farm size were significant. Although they equally had access to fertilizers, herbicides and labour, which contributed positively to their technical efficiency, they however were not significantly related to technical efficiency in the study area. This could imply that agricultural interventions in whatever form might have an added benefits in form of extension services like training on how to apply these inputs which could confer additional unquantifiable benefits for farmers.

As shown in the Table, the average technical efficiency for all respondents was 65% the average technical efficiency of Beneficiary households was 70% while for the non-beneficiary household was 60% (Table 4).

4. Household Dietary Diversity Distribution

The result of the distribution of food diversity scores for the respondents is presented in Table 5.

According to the Table 5, the lowest food diversity score reported for the respondents was 2 and the highest was 9. However, the average food diversity score reported by the households was 6.4. The food diversity score for this study represents the number of different food types consumed by the households within the last 24 hours of administering the questionnaire and it was

Food diversity count	NSPFS Beneficiary households	Non-beneficiary households	All households
Lowest food score	5	2	2
Highest food score	9	9	9
Mean food score	7.2	5.74	6.4
Standard deviation	1.23	1.74	1.49

Source: Field survey, 2012

Table 5: Distribution of household dietary diversity estimates.

	Farm Income	Dietary Diversity Score	Technical Efficiency
Farm Income (Pearson Correlation) Sig. (2-tailed), (N=150;)	1		
Dietary Diversity Score (Pearson Correlation) Sig. (2-tailed), (N=150;)	0.307**	1	
Technical Efficiency (Pearson Correlation) Sig. (2-tailed), (N=150;)	-0.278*	-0.206**	1

Note: correlation coefficient (r) is significant at 5% level ** and at 1% level *.
Source: Field survey, 2012

Table 6: Correlation Analysis of Household Dietary Diversity Score, Farm Income and Average Technical Efficiency among Small-scale Farming Households in Kwara state.

based on the 12 food groups defined by Swindale and Bilinsky (2006). The number of food groups eaten within households has been theorised to be a function of certain socio-economic variables and food diversity has been identified as a proxy for measuring how well food secured households are.

5. Correlation analysis of household dietary diversity score, farm income and average technical efficiency

The result of the Pearson correlation analysis among household dietary diversity, household farm income and technical efficiency is presented in Table 6.

The result in Table 6 shows that while technical efficiency score is negatively associated with household farm income ($p < 0.05$) and household dietary diversity score ($p < 0.01$); dieatary diversity and farm income are positively associated at $p < 0.01$. These relationships therefore suggest an inverse relationship between technical efficiency and farm income and dietary diversity estimates among the respondents and conversely affirms a positive linear relationship between average farm income and household dietary diversity score (Table 6).

This implies that as technical efficiency estimate increases, farm income and household dietary diversity decrease, on one hand, and on the other, as farm income increases, household dietary diversity increases. It may be that the negative relationship between income and technical efficiency was as by putting in place efficient processing and market facilities for farmers to store and preserve their outputs, they may all take it to the market at the same time. This could lead to reduced price given the inelastic nature of supply (excess supply). Thus the productivity gain has resulted into a reduction in output prices which is brought about by a glut in market due to lack of efficient processing and marketing facilities. This is further corroborated by the findings of Thirtle et al. (2001) which suggests that productivity gains may not result in poverty reduction if the decline in output prices outweighs the gain from increased productivity. Raising farm income has been suggested as an effective tool to increase dietary diversity (Gonder, 2011), which is further emphasized in this study.

Conclusion

The study revealed the existence of a positive and significant linear relationship between farm income and household dietary diversity, however, the linear relationship between technical efficiency and households' farm income and dietary diversity are negative. This negative relationship could have been brought about by lack of efficient processing and market facilities that would enable farmers optimally utilize the benefits of increased output resulting from productivity gains.

In view of this, this study recommends that while several developmental efforts are towards enhancing farmers' productivity and technical efficiencies, developmental efforts should on the other hand assist farmers in value addition and agricultural processing so that they would optimally utilize the gains accrued from such efficiency gains. Also in the same line, efforts at increasing households' food and nutritional securities should indentify efforts at increasing farmers' income as this is shown to have a direct and positive influence on dietary diversity.

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