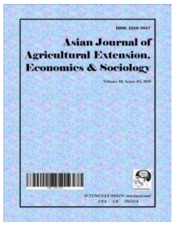

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Production Efficiency of Smallholder Rice Farms under Contract Farming Scheme in Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Author JKB with the support of author SCF designed the study, supervised the data collection, analyzed and wrote the first draft of the manuscript. Author IY contributed to fine tuning the methodology and analyses of the data. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study investigated the production efficiency of smallholder rice farms under Contract Farming and irrigation production in Ghana.
Methodology: Data was collected from 350 rice farmers selected through a stratified sampling technique using structured questionnaires. Descriptive and inferential statistics including stochastic frontier analyses were used to analyse the data.
Results: Contract Farms have higher efficiencies compared to Non-Contract Farms. There are differences in the efficiency distribution of Contract and Non-Contract Farms. The efficiencies of Contract Farms are significantly higher than the efficiencies of Non-Contract Farms under irrigation production and they also have different efficiency distributions. Under the rain fed production

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frontier, efficiencies of Contract Farms are significantly higher than the efficiencies of Non-Contract Farms and their distributions are different. Contract Farms under irrigation production have higher efficiencies than Contract Farms under rain fed production. The efficiencies of irrigation contract farms are significantly higher than the efficiencies of rain fed Contract Farms, however their distributions are similar across rain fed and irrigation production ecologies. Government policies to stimulate contract participation are recommended. We also recommend investment to expand irrigable land area to increase access, as it is one of the reasons why farmers are not practicing irrigation production.

Conclusion: CF has positive influence on farm efficiency hence farmers should be encouraged to produce under CF to increase their current efficiency levels thereby increasing their yields. Aside this, efficiency distribution also shows more CF have higher efficiency scores than their NCF counterparts.

Keywords: Contract farming; irrigation ecology; production efficiency; stochastic frontier and smallholder.

1. INTRODUCTION

There are a number of constraints that limit farm productivity and farm income in sub-Sahara Africa [1]. Cereal crop yields are estimated <1.5 ton/ha while the actual potential is more than 5 tons/ha. The low yields are largely attributable to low use of organic and mineral nutrient resources, which has also resulted in negative nutrient balances [2,3]. The reasons for these poor yields also include; lack of sufficient information about production methods and practices and market opportunities. Poor access of credit and inputs are also important limiting factors. Subsistence smallholder famers are more at risk than larger farmers. Small holder farmers will usually produce for the home first before venturing in to commercial production [1].

Large-scale farming provides solution to some of these production constraints. Large scale farmers have the following advantages; better access to credit, better information about production and marketing opportunities, and greater tolerance of risk. These advantages are often negated by the following constraints, higher production cost and lower motivation of hired labourers compared to family labour. As a result, large-scale agriculture is competitive in many African countries for only a few cash crops, such as sugarcane, banana, plantain, pineapple, rubber tree plantations, cocoa plantations etc [4]. Contract Farming is therefore seen as a way to combine the advantages of large-scale production with the strengths of small-scale production [1].

Besides the positive effects of Contract Farming (CF), several authors have, however, drawn the attention on certain negative aspects of this instrument (biased relationships between contractors and farmers, negative conditions for small-scale farmers, etc.) [5,6]. Other critics also argue Contract Farming is a way for large firms to take advantage of the land and poverty of smallholder farmers. CF is perceived to have a negative impact, leading to higher risk, indebtedness, and income inequality [7,8].

Contract Farming has won so many hearts including agricultural projects, researchers, development organizations and policymakers because of its perceived potential to provide solution/remedies to several of these agricultural constraints simultaneously. Trends in agriculture suggest that the demand for Contract Farming is increasing in developing countries as a result of growth in high value crops and demand for quality product [9].

Technical efficiency measures for Ghana’s agriculture are generally low. [10] Found that average profit efficiency for rice farmers in Northern Ghana is about 63%, with profit efficiency ranging between 16% and 96%. [11] Provided evidence to show that smallholder rice farmers in the Upper East Region of Ghana produce, on average, 34% below maximum output. The estimated technical efficiency for smallholder irrigators and non-irrigators is 53% and 51%, respectively using a simple t-test to compare the significance of their means. [12] in their study of rice farmers under irrigation in Tono also concluded that, the mean technical efficiency estimate for irrigation rice farmers was 0.81 which is an improvement of earlier studies.

This study will enhance or improve knowledge by assessing economic, allocative and technical efficiencies of famers under Contract Farming and also assess the effect of production ecology (irrigation and rainfed) on production efficiency using Stochastic Frontier Analyses (SFA) approach to allow for in-depth analyses of rice production efficiencies. Previous studies have duelled more on single components of rice production efficiencies and did not also disaggregate the production ecologies. The ultimate goal of any rice producer is to attain economic efficiency which is a function of technical and allocative efficiencies. The present study will go beyond the previous studies as indicated to compare efficiencies for irrigated and non-irrigated ecologies and also between contract and non-contract producers to establish how Contract Farming and Irrigation ecology influence production efficiency.

There are two main ways to increase rice production; first of all through increase in area and secondly through increase in productivity. However, land is a major constraint now and hence we need to concentrate on increasing efficiency to increase productivity. The study will conduct a comparative analysis of farm level technical efficiency of households with access to irrigation technology and those without access to irrigation technology. The main objective of the study is to assess the impact of Contract Farming and Irrigation Ecology on farm household technical, allocative and economic efficiencies in Ghana.

There exists a considerable body of literature that analyses the impact of contract farming on the performance of smallholder farms, however very little has been done on efficiency as a performance indicator [13,14]. Out of thirty-three studies reviewed across Asia and Africa only one used efficiency as a performance indicator [15].

2. MATERIALS AND METHODS

2.1 The Study Area

This study covered Northern, Upper East and Volta Regions of Ghana basically because of their rice production potential in the country which is mainly savannah. About 80% of total rice production in Ghana comes from these three regions.

2.2 Data Collection

Stratified sampling technique was used to sample the representative smallholder rice farmers in Northern, Upper East and Volta Regions. At the first stage, three regions were purposively selected based on the level of rice production. The three regions selected, produced about 80% of total rice produced in Ghana. At the second stage of the sampling, each selected region was categorized into two production ecologies (irrigation and rain fed ecologies). At the third stage, of the sampling two management systems (Contract Farming and Non-Contract Farming) was purposively selected from each of the production ecologies. At the fourth and the final stage of the sampling, a total sample of 350 smallholder rice farmers were randomly sampled and interviewed from the population. The study population is about 10000 smallholder rice farmers.

2.3 Data Analysis

The study employed both descriptive and inferential statistical analysis. Descriptive statistics (e.g., mean, minimum, maximums, standard errors of the mean, standard deviation) is used to summarize and describe 350 rice farmers. The stochastic frontier analyses are used to estimate the production efficiencies (technical, allocative and economic).

The parametric stochastic frontier approach is applied to calculate the efficiencies of rice farms under the following frontiers of the observed data. The efficiency analysis is carried out based on four frontiers:

- Pooled data frontier, which analyzed all sample data together (n=350) and represent the general performance of all rice farmers under the two ecologies.
- Irrigation production frontier, which analyzed all irrigated farms data (n=133) and represents the irrigated rice farms performances with respect to CF.
- Rain-fed production frontier, which analyzed rain-fed farms data (n=217) and represents the rain-fed rice farm performances with respect to CF.
- Contract farming frontier, which analyzed CF farms data (n=140) and represents CF performance under different production ecologies.

The results of each frontier efficiency analysis are presented as the mean efficiency levels and the difference in means of Contract and Non-Contract Farmers' efficiency under different production ecologies. These results can be used as a benchmark to improve the efficiency of rice production in Ghana.

3. THEORETICAL AND ANALYTICAL FRAMEWORK

3.1 Measurement of Production Efficiency

Modern efficiency measurements began with the work of [16] that drew upon the works of [17,18] to define a simple measure of firm efficiency. Farrell showed that the measurement of Economic Efficiency (EE) could be broken down into two components (Technical Efficiency (TE) and Allocative (price) Efficiency (AE)). Technical efficiency (TE) is related to technology and refers to the use of minimal possible combination of inputs for producing a certain output (i.e. input orientation) or to obtain maximum possible level of output at the given level of technology (i.e. output orientation). Allocative efficiency (AE) refers to optimal combination of inputs at given input prices. These two efficiency measures are then combined to provide a measure of total economic efficiency.

Relative efficiency indices can be estimated using two methods which include; the Stochastic Frontier Approach (SFA) (Parametric) and the Data Envelopment Analyses (DEA) approach (nonparametric) [19] DEA employs linear programming in its estimation. DEA does not require model specification and assumptions. Under DEA, all deviations from the production frontier are all attributed to inefficiency. Hence it could suffer from statistical noises resulting from data collection mistakes.

The SFA method assumes a relationship between the inputs and outputs and employs statistical techniques to derive the efficiency indices. The error term is decomposed into statistical noise and inefficiency [18] (Coelli, 1995). The stochastic frontier analyses (SFA) also make it easy to test the hypothesis.

The choice of which method to use is unclear [20]. A small number of studies have made side-by-side comparisons of the two methods [21,22,23,24,25] but none of these studies drew any conclusions about which method is superior. These studies typically find quantitative differences in efficiency scores between the two methods, but the ordinal efficiency rankings among DMUs tend to be very similar for both methods. Therefore, the choice of which method to use appears to be arbitrary, as it is pointed out by [26]. We will use both methods to allow us to also compare the results of the two approaches.

3.2 Stochastic Production Frontier Analysis

[27,28] were the pioneers of stochastic frontier analysis which is now widely used by many to measure farm performance [29,30,31,32,33]. The specification allows for the decomposition of the error term into the part associated with the inefficiency u_i and the part that is random and beyond the control of the farmer v_i. u_i error term is either positive or negative and the frontier vary around the deterministic part of the model expressed mathematically as, $exp\ (x_i\beta)$.

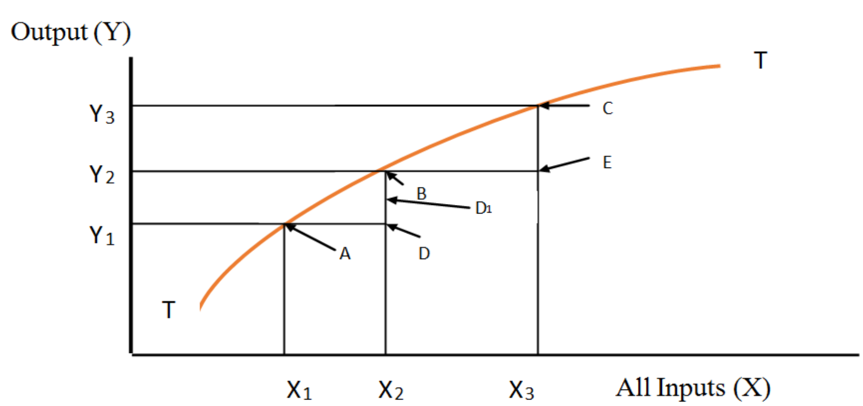

Fig. 1. A production frontier

In Fig. 1, Rice farm D uses X2 inputs to produce Y1 output. If there are no inefficiency effects, the frontier output could be D1. This is the deterministic part of the frontier (point B), therefore the noise and inefficiency effects are negative. The distance between point D and point D1 represents inefficiency, while the distant between D1 and point B represents variation due to random events.

3.3 Model Specifications of SFA for Technical, Economic, and Allocative Efficiency

3.3.1 The production frontier function

$$Y_i = f(X_{\mathrm{i}}, \beta)\, e^{vi - u\, i} \tag{1}$$

Y_i Represents rice output of farmer (i) (paddy), X_{i} represents the inputs used, β represents the parameters to be estimated and *e* the error term representing both the noise *(v_i)* and inefficiency *(u_i)*. The production frontier shows the relationship between farm inputs (labour, fertiliser, seed) and farm outputs (rice output). β represents the propensity of each input to influence the output [31]. For the SFA you need to specify a functional form and the common forms are the Cobb-Douglas and translog production functions.

[32] specified the Cobb-Douglas function as:

$$ln(y_i) = X_i\beta + v_i - u_i \qquad i=1, 2....n \tag{2}$$

Where;

$$TE = \frac{Y_i^*}{Y_i} = exp(-U_i) \tag{3}$$

Where Y_i = the total production frontier, Y_i^*= the stochastic production frontier

3.3.2 The cost frontier function

$$C_i = f(X_{\mathrm{i}}, P_{\mathrm{i}}, \beta)\, e^{vi - u\, i} \tag{4}$$

where *C* denotes the total production cost observed, X_i is the output quantity for household i (rice produced), P_i is the input price vector used, β is the parameters to be estimated and e_i is the composite error term representing both inefficiency, u_i and noise factors, v_i.

$$AE = \frac{C_i^*}{C_i} = \exp(-U_i) \tag{5}$$

Where C_i = the total production cost frontier, C_i^*= the stochastic cost frontier

$$\mathbf{EE} = \mathbf{TE\ x\ AE}$$

EE= economic efficiency

The maximum likelihood estimation technique is used to analyse for the inefficiencies. The determinants of efficiency can also be derived from the maximum likelihood estimation. The endogenous treatment effect model will be used to assess impact of CF on the efficiencies whiles examining the determinants of the inefficiencies and also CF choice.

4. RESULTS AND DISCUSSION

4.1 Effect of Contract Farming on Some Factors of Production of Farm Households

According to Table 1, the mean age difference between Contract Farmers and Non-Contract Farmers is about 3.19 and is significant at 1% significance level. This implies farmer's age has a positive correlation with contract participation. However there is no significant difference between the Contract Farmers farming experienced and that of Non-Contract Farmers experience in rice production. Contract Farmers are richer than Non-Contract Farmers and this is significant at 1%. There is no significant difference in the household size and also the available arable lands of the two groups.

Table 1. Management system effect on means of farm households characteristics

Farm household characteristics	CF (n=140)	NCF (n=210)	Mean difference	t-statistic
	Mean	Mean		
Age of HHH (years)	46.41	43.22	3.19 ***	2.701642
Farmer experience (years)	22.94	24.20	(1.25)	-1.145
Wealth of farm HH GHS	8,256.64	3,214.71	5,041.93 ***	4.643198
Household Size Number	7	7	0.35	1.1456
Total household arable land (Ha)	2.05	2.29	(0.24)	-1.52

**** 1% level of significance; **5% level of significance; *10% level of significance*

According to Table 2, the mean difference of rice farm size of Contract Farmers and Non-Contract Farmers is about 0.24 Ha. The mean difference of fertilizer use, seed use, labour used are 122 kg, 28 kg and 5 persons respectively, which are all significant at 1% level of significance as shown in Table 2. There is no difference in the prices of fertilizer and labour used. Seed price was significant at 1% level of significance with mean difference of -0.12 (GHS), which implies Non-Contract Farmers, bought their fertilizers at relatively cheaper prices than Contract Farmers. Yield is an important variable in assessing farm level performance and it is evidently that Contract Farmers have higher yields than their Non-Contract Farmer colleagues with mean difference of 2725.23 Kg per Ha. Total output of Contract Farmers was far more than the output of Non-Contract Farmers with a mean of about 3,360 Kg of paddy rice. Output price was also significant indicating Contract Farmers earn 0.15 GHS/Kg more than their Non-Contract Farmer counterparts. This implies their farm revenues will also be higher with a significant mean difference of 1,792 GHS. Cost of production of Contract Farmers is far more than that of non-contract producers with mean difference of 170 GHS. Gross margins mean difference is 1,622.00 GHS indicating CF earn more profit than NCF.

4.2 Effect of Agro-ecology on Some Factors of Production of Farm Households

From Table 3, the mean age difference between irrigation farmers and rain fed farmers is about 0.34 and is not significant. There is also no significant difference between the irrigation farmers farming experience and that of rain fed farmers experience in rice production. Irrigation farmers are richer than rain fed farmers and this is significant at 1%. There is no difference in the household size and also the available arable lands of the two groups.

According to Table 4, the mean difference of rice farm size of irrigation farmers and rain fed farmers is about 0.01 Ha and it is not significant. The mean difference of fertilizer use, seed use, labour used are 68.47 kg, 23.13 kg and 3 persons respectively, which are all significant.

Table 2. Production status of contract and non-contract farms

Variables	CF (n=140)	NCF (n=210)	Mean difference	t-statistic
	Mean	Mean		
Rice farm size in Ha	1.33	1.00	0.33***	4.5
Fertilizer used in kg	314.43	192.20	122.23***	5.33
Seed used in kg	90.03	61.61	28.41***	2.82
Labour used	13	8	5.0***	4.9
Fertilizer price in GHS	1.11	1.81	-0.70	-1.57
Seed price in GHS	0.57	0.70	-0.12***	-2.84
Labour price in GHS	36.28	43.07	-6.79	-1.41
Yield per Ha	4357.70	1632.00	2725.23***	10.56
Total output kg	4,880.41	1,520.11	3360.30***	10.75
Output price per kg in GHS	1.46	1.31	0.15***	5.1
Total Revenue GHS	2,642.00	850.08	1791.91***	10.17
Total cost of production GHS	584.98	414.91	170.07***	4.7
Gross margins GHS	2,057.01	435.17	1621.84***	10.32

**** 1% level of significance; **5% level of significance; *10% level of significance*

Table 3. Farm household's characteristics

Variables	Irrigation (n=133)	Rain fed (n=217)	Mean Difference	t-statistic
	Mean	Mean		
Age of HHH	44.71	44.36	0.34	0.28
Farmer experience in years	22.50	24.42	-1.92	-1.73
Wealth of farm HH	8385.63	3298.29	5087.34***	4.5
Household size	7	7	-0.24	-0.7
Total household arable land Ha	2.2	2.19	0.01	0.0447

**** 1% level of significance; **5% level of significance; *10% level of significance*

There is no difference in the prices of fertilizer, seed and labour used. Yield is an important variable in assessing farm level performance and it is evident that irrigation farmers have higher yields than their rain fed farmer colleagues with mean difference of 1703.15 kg per Ha. Total output of irrigation farmers was far more than the output of rain fed farmers with a mean of about 1823.29 kg of paddy rice. Output price is not significant indicating irrigation farmers and their rain fed counterpart receive the same price for their paddy rice. This implies their farm revenues will also be higher with a significant mean difference of 1,101.34GHS. Cost of production of irrigation farmers is far more than that of the rain fed producers with mean difference of 144.34 GHS. Gross margins mean difference is 957.00 GHS indicating irrigation farmers earn more profit than their rain fed counterparts.

4.3 Meta Frontier Analyses of Contract and Non-contract Farms Efficiency

The mean allocative efficiencies for Contract and Non-Contract Farms are 0.83 and 0.53 respectively. However, the mean economic efficiencies of the farms are 0.72 and 0.43 for Contract and Non-Contract Farms respectively. Farmers under Contract Farming are more efficient in their optimal allocation of resources while minimizing waste and inefficiency in their rice production. This implies Contract Farms and Non-Contract Farms can achieve their current production levels with about 28% and 57% reduction in cost of production. Details are shown in Table 5.

There is significant difference in the technical, allocative and economic efficiency means of Contract and Non-Contract Farms. This shows that the contract farms have higher efficiencies than their Non-Contract Farm counterparts hence the null hypothesis is rejected. The efficiencies of contract farms are significantly higher than the efficiencies of Non-Contract Farms see Table 6.

Non-contract farmer's efficiency distribution shows that just about 4 farms are within technical efficiency score of 0-39% and 67 farms are within 90-100% efficiency score followed by 48 of them within 60-69% efficiency score as shown in Fig. 2.

Table 4. Production status of rain fed and irrigation farms

Variables	Irrigation (n=133)	Rain fed (n=217)	Mean Difference	t-statistic
	Mean	Mean		
Rice farm size in Ha	1.17	1.08	0.09	0.91
Fertilizer used in kg	283.54	215.08	68.47***	2.63
Seed used in kg	87.32	64.19	23.13**	2.13
Labour used	12	9	3**	2.29
Fertilizer price in GHS	1.73	1.40	0.32	0.48
Seed price in GHS	0.62	0.66	-0.04	-0.92
Labour price in GHS	38.96	41.21	-2.25	-0.47
Yield per Ha	3778.53	2075.38	1703.15***	5.7
Total output kg	3994.67	2171.38	1823.29***	5.06
Output price per kg in GHS	1.40	1.36	0.04	1.47
Total Revenue GHS	2249.68	1148.34	1101.34***	5.52
Total cost of production GHS	572.43	428.09	144.34***	3.95
Gross margins GHS	1677.25	720.25	957.00***	5.4

**** 1% level of significance; **5% level of significance; *10% level of significance*

Table 5. Summary statistics of efficiency measures of contract and non-contract farms

Meta frontier	CF (n=140)					NCF (n=210)				
	Mean	Min	Max	STD	SEM	Mean	Min	Max	STD	SEM
TE	0.84	0.40	1.00	0.17	0.01	0.77	0.34	1.00	0.18	0.01
AE	0.83	0.16	1.09	0.22	0.02	0.53	0.09	1.00	0.27	0.02
EE	0.72	0.10	1.00	0.28	0.02	0.43	0.07	1.00	0.30	0.02

Table 6. Mean differences of contract and non-contract farms

Meta Frontier	CF (n=140)	NCF (n=210)	Mean Difference	t-statistic
	Mean	Mean		
TE	0.84	0.77	0.07***	3.5
AE	0.83	0.53	0.30***	11.38
EE	0.72	0.43	0.29***	9.23

**** 1% level of significance; **5% level of significance; *10% level of significance*

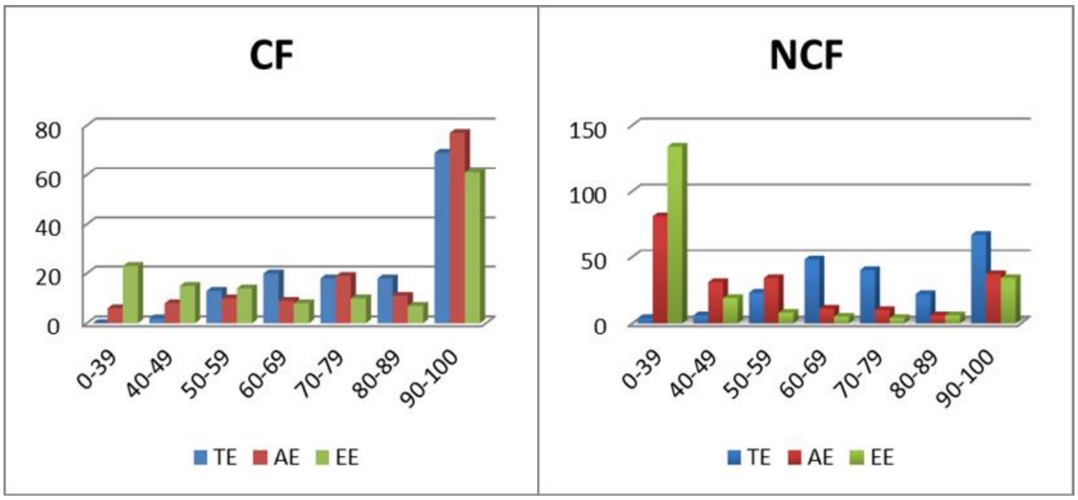

Fig. 2. Efficiency distribution of contract and non-contract farmer's farms

Contract farmer's efficiency distribution shows that there are no farms within technical efficiency score of 0-39%. Majority Contract Farms (69) fall within efficiency score of (90-100%) followed by 20 of them within (60-69%) efficiency score. About 77 and 61 farms fall within allocative and economic efficiency scores of 90-100% respectively. There is clear difference in the distribution among contract farms and non-contract farms as shown in Fig. 2.

4.4 Irrigation Frontier Efficiency of Contract and Non-Contract Farms

There is significant difference in the technical, allocative and economic efficiency means of Contract and Non-Contract Farms under irrigation production. This shows that the Contract Farms have higher efficiencies than their Non-Contract Farm counterparts hence the null hypothesis is rejected. The efficiencies of Contract Farms are significantly higher than the efficiencies of Non-Contract Farms under irrigation rice production see Table 7.

The distribution of the efficiencies across CF and NCF is presented in Fig. 3. Majority of farms under Contract Farming are within 90-100% efficiency. However, majority of farms under NCF are within efficiency score of 0-39%. It is clear that the distributions are different and more farmers under CF recorded higher efficiencies compared to farmers who did not participate in CF.

Table 7. Mean differences of contract and non-contract farms under irrigation

Irrigation frontier	CF	NCF	Mean Difference	t-statistic
	Mean	Mean		
TE	0.867	0.769	0.098	3.44***
AE	0.875	0.542	0.334	8.28***
EE	0.780	0.433	0.347	7.33***

**** 1% level of significance; **5% level of significance; *10% level of significance*

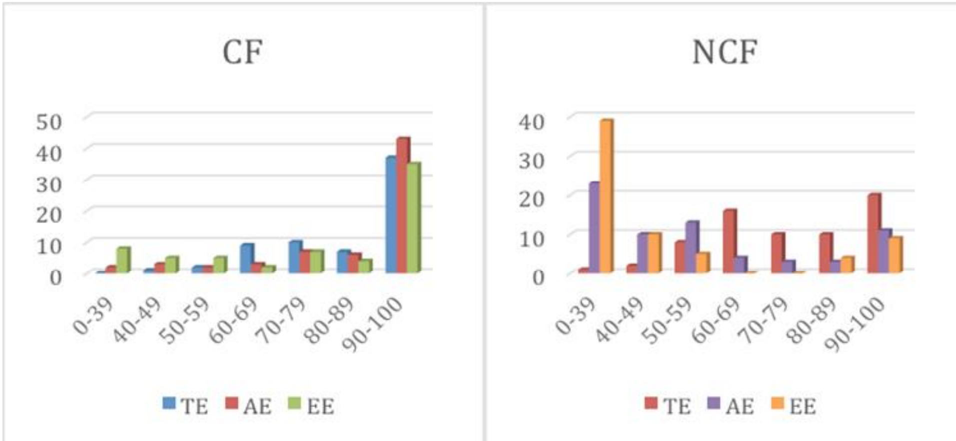

Fig. 3. Efficiency distribution of CF and NCF under irrigation

4.5 Rain Fed Frontier Efficiency of Contract and Non-contract Farms

There is significant difference in the technical, allocative and economic efficiency means of Contract Farms and Non-Contract Farms under rain fed production. This shows that the Contract Farms have higher efficiencies than their Non-Contract Farm counterparts under rain fed production hence the null hypothesis is rejected see Table 8. The efficiencies of Contract Farms are significantly higher than the efficiencies of Non-Contract Farms under rain fed rice production.

The distribution of the efficiencies across CF and NCF under rain fed production is presented in Fig. 4. Majority of farms under contract farming are within 90-100% efficiency. However, majority of farms under NCF are within efficiency score of 0-39%. It is clear that the distributions are different and more farmers under CF recorded higher efficiencies compared to farmers who did not participate in CF.

Table 8. Mean differences of contract and non-contract farms under rain fed production

Rain fed efficiency	CF	NCF	Mean Difference	t-statistic
	Mean	Mean		
TE	0.816	0.775	0.041	1.62**
AE	0.788	0.523	0.265	1.6***
EE	0.669	0.430	0.239	1.6***

**** 1% level of significance; **5% level of significance; *10% level of significance*

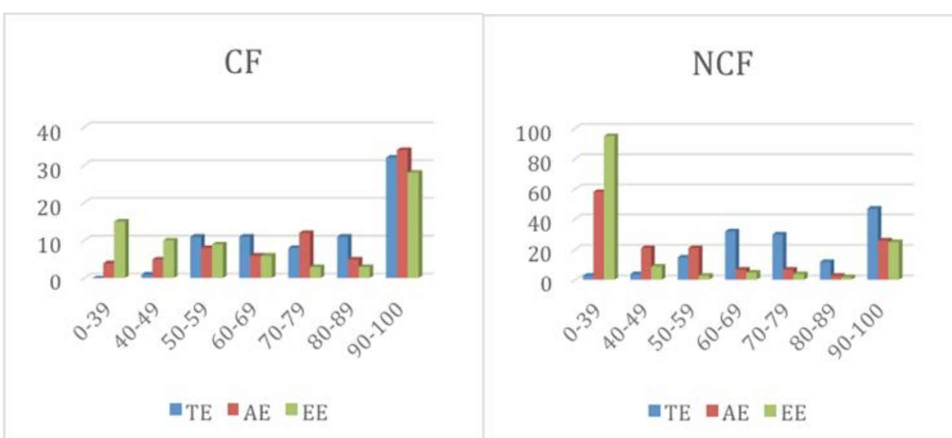

Fig. 4. Efficiency distribution of CF and NCF under rain fed

Table 9. Mean differences of irrigation and rain fed contract farms

CF frontier	IRR-CF	RAIN-CF	Mean difference	t-statistic
	Mean	Mean		
TE	0.867	0.819	0.048	1.7**
AE	0.875	0.789	0.087	2.3***
EE	0.780	0.672	0.108	2.3***

**** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level*

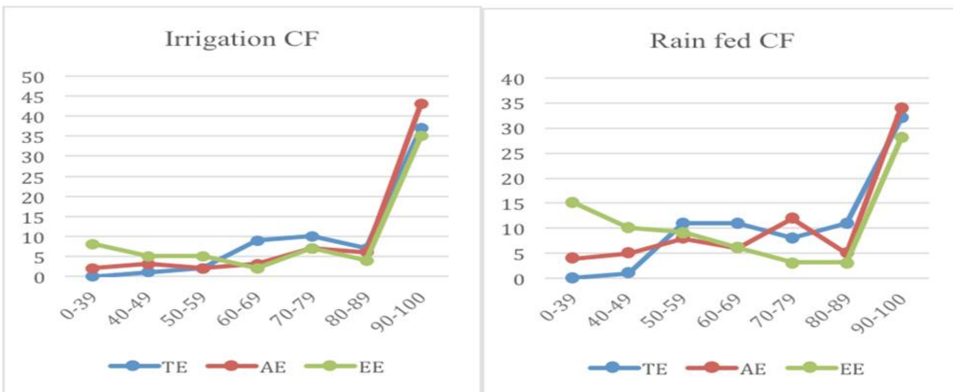

Fig. 5. Efficiency distribution of irrigation and rain fed contract farms

4.6 CF Frontier Efficiency of Irrigation and Rain Fed Farms

There is significant difference in the technical, allocative and economic efficiency means of Contract Farms under irrigation and rain fed production. This shows that Contract Farms under irrigation production have higher efficiencies than their rain fed counterparts hence the null hypothesis is rejected. The efficiencies of irrigation Contract Farms are significantly higher than the efficiencies of rain fed Contract Farms. Hence CF works better under irrigation than under rain fed production See Table 9.

The distribution of the efficiencies of irrigation CF and rain fed CF. Majority of farms under irrigation and rain fed ecologies were within 90-100% efficiency score. It is clear that the distributions are similar across rain fed and irrigation production ecologies see Fig. 5.

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

Contract Farms have higher efficiencies than their non-contract farm hence the null hypothesis is rejected. There is clear similarity in the distribution of Contract and Non-Contract Farms. Under irrigation production, the efficiencies of Contract Farms are significantly higher than the efficiencies of Non-Contract Farms under irrigation rice production and they also have different efficiency distributions. Under the rain fed production frontier, efficiencies of Contract Farms are significantly higher than the efficiencies of non-contract farms and their distributions are also different. Contract Farms under irrigation production have higher efficiencies than Contract Farms under rain fed production hence the null hypothesis is rejected. The efficiencies of irrigation Contract Farms are significantly higher than the efficiencies of rain fed Contract Farms, however their distributions are similar across rain fed and irrigation production ecologies.

The study has clearly established that CF has positive effect on technical, allocative and economic efficiency of rice farms in Ghana. It has also established that there are more farmers with high efficiency scores among CF than NCF. CF is more effective in irrigation ecologies than in rain fed ecologies. We recommend that government and her development partners should continue and intensify the introduction of CF as a management strategy to boost rice production and hence improve livelihood of farmers. Government should put in policies that will stimulate interest of farmers to get involved in

Contract Farming. We also recommend investment to expand irrigable land area to increase accessibility, as it is one of the reasons why farmers are not practicing irrigation production.

Current increases in production volumes are associated more with expansion in area of production with very little from efficiency gain. Considerable increase in yield can be achieved through increase efficiency by getting more farmers involved in CF.

5.2 Recommendations

In order to sustain and improve efficiency of rice production systems in Ghana, we recommend that farmers should be encouraged to participate more in irrigation rice production than the rain fed productions since they are more efficient in their resource allocation. The efficiencies of Contract Farms are higher than the efficiencies of Non-Contract Farms hence we recommend that farmers should be encouraged to get more involved in contract production.

It is clear from the results that contract farming has positive influence on technical, allocative and economic efficiencies of rice producers. Farmers will be more efficient when they produce rice under Contract Farming. Government policy to promote Contract Farming will be in the right direction, as it will help farmers maximize their rice production business.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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