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Contract farming and rice production efficiency in Ghana

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Abstract

Purpose – Even though many studies identify positive effects of contract farming (CF) on the livelihood of farmers, the use of CF as a tool to increase farm performance is unsettled debate. Information on CF is relatively not available in staple food chains. Theoretical considerations have shown that there are challenges in employing CF in staple food chains such as rice. With the increasing trend of rice CF in Ghana, it is very critical to establish its performance in rice production in Ghana. It is therefore imperative to analyse the impact of CF on the performance of smallholder rice farmers.

Design/methodology/approach – A survey was conducted where 350 rice farmers selected through a stratified sampling technique using structured questionnaires were interviewed. Descriptive and inferential statistics including stochastic frontier analyses and endogenous treatment effect regression were used to analyse the data.

Findings – The results from the endogenous treatment effect regression model show that CF improves rice farmers' technical, allocative and economic efficiencies by 21, 23 and 26%, respectively. Farm size and CF were identified as common factors influencing technical, allocative and economic efficiency measures of the farmers positively. It further identified age of farmer, educational level and household labour as factors influencing farmers' participation in CF positively.

Research limitations/implications – It is recommended that CF is a good tool to enhance rice production efficiency, and hence, farmers should be encouraged to participate in CF as strategy to enhance the local rice production in Ghana.

Social implications – The outcome of this study has the potential to influence rice production in the country. The country is a net importer of rice and just about 35% self-sufficient in rice production.

Originality/value – This study is the first to assess performance of CF in rice crop production in Ghana and also one of the few to use efficiency as a performance measure.

Keywords Economic efficiency, Endogenous treatment, Impact, Stochastic frontier

Paper type Research paper

1. Introduction

Small-scale farmers in many developing countries face a number of production constraints, such as limited access to services, including effective extension and rural credit, which are

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crucial pre-conditions for upgrading commodity value chains. Low fertilizer use intensity has been cited as one of the main factors limiting rice productivity growth in Sub-Saharan Africa (SSA) (Koji, 2009; Fuglie *et al.*, 2013). Smallholder rice farmers' poor access to credit is induced by their lack of collateral or by the high interest rates demanded by financial institutions (Deb and Suri 2013; Oya, 2012; Barrett *et al.*, 2012).

There are a number of new technologies available to boost rice production, but just a few farmers are aware of these technologies. This gap is largely due to poor extension farmer ratio, which is estimated to be about 1:1000. There is also poor access to market and lack of economies of scale (Rehber, 2007). The few who have knowledge of the technologies often also lack the capacity to adopt the new and improved technologies due to cost associated with it. Contract farming (CF) is seen as a strategy that can address these deficiencies.

CF has long been prevalent in developed countries and in recent times has spread widely in developing countries (Wong *et al.*, 2014). CF is perceived as a strategy for agricultural transformation in developing countries because of its potential to address agricultural marketing and production challenges mentioned concurrently. Little and Watts (1994); and lack of economies of scale (Rehber, 2007); Christensen *et al.* (1993); Ton *et al.* (2007) and (Mishra *et al.*, 2018a, b and c) have argued that CF can benefit farmers directly through access to credit, inputs, remunerative markets and improved technology, thus increasing their productivity, income and food security. CF also improves access to capital and credit. The engagement of smallholder farmers in CF will result in proper coordination and allocation of resources, goods and services, thereby reducing poverty and improving the livelihoods of farm households (Jari, *et al.*, 2009); hence the need for CF.

Even though many studies identify positive effects of CF on the livelihood of farmers, the use of CF as a tool to increase farm performance is unsettled. Porter and Phillips-Howard (1997); Warning *et al.* (2002); Minten *et al.* (2009); Bolwig *et al.* (2009); Bellemare (2012) and Kumar *et al.* (2018) identified income and productivity gains from CF in Africa. It is also argued that CF can lead to risk-sharing between the producer and the agribusiness firm; hence, it can reduce price and income volatility (Key *et al.*, 1999). Warning *et al.* (2002); Govereh *et al.* (2003); Minten *et al.* (2009); Bellemare (2012) showed that CF reduced market imperfections by providing credit, inputs, technology and information and hence lowered transaction costs (Grosh, 1994; Key and Runsten, 1999; Deininger, 2011). Other studies described CF as a tool for agribusiness firms (contractor) to cheat farmers (Little *et al.*, 1994; Porter *et al.*, 1997; Singh, 2002). Ragasa *et al.* (2017) showed that CF in the Upper West region of Ghana contributed to technology adoption and productivity growth in maize production, but did not result in high profitability because production cost was too high relative to non-contract farmers in their maize CF study. Abdulai *et al.* (2016) also concluded that participation in CF does not necessarily improve smallholder farmers' income despite productivity gains in their soybean CF study in Ghana, similar to the work of Mwambi *et al.* (2016).

Information on CF is relatively not available in staple food chains. Theoretical considerations have shown that there are challenges in employing CF in staple food chains. Some of the challenges includes: contract enforcement would be particularly difficult because the value of the chain is low and the opportunities for quality improvement are limited, and this will impede the use of a price premium as a strategy for contract enforcement; secondly, the presence of a large number of small buyers in the value chain and the fact that the commodities are often bulky and also not highly perishable further increase the risk of opportunistic sales and breach of contract. Hence, it is predicted that CF would not likely work for traditional staple commodities such as rice, soybean, maize and so on because spot markets would be the most efficient system (Berdegué, 2002; Hellin *et al.*, 2009 and World Bank, 2014). With the increasing trend of rice CF in Ghana, it is very critical to establish its performance in rice production in Ghana.

There is considerable literature that analyses the impact of CF on the performance of smallholder farms; however, scarcely is efficiency used as a performance indicator despites its importance for short- and long-term planning (Miyata *et al.*, 2009; Prowse, 2012), hence the motivation for this study.

2. Materials and methods

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. Stratified sampling technique was use to sample representative of smallholder rice farmers in Northern, Upper East and Volta Regions. The three regions were purposively selected based on their rice production potential. Each region was further classified into the two main production ecologies (irrigation and rain-fed ecologies). Each production ecology was further classified into two management systems (contract production and non-contract production). Stratified random sampling is used to guarantee that the sample is representative of the specific sub-groups or strata of this study. The stratified sample formula is specified as:

$$n = \frac{N}{P} Y \tag{1}$$

Where:

n = sample size of the strata

N = size of entire sample

P = population size

Y = layer size

The population of interest for the study included small-scale rice farmers working under irrigation and rain-fed production ecology in Northern, Upper East and Volta Regions of Ghana. The sample by each stratum is shown in Table 1.

3. Analytical framework

The study employed both descriptive and inferential statistical analyses. Descriptive statistics (e.g. mean, minimum, maximums, standard errors of the mean, standard deviation) were used to summarize and describe 350 rice farmers. The stochastic frontier analysis was used to estimate the production efficiencies, which were then used as the dependent variables

Table 1. Farmer sampling

Region	Production ecology	Management system	Est. farmer population	No. of farmers sampled
NR	Irrigation	CF	371	13
		NCF	1086	38
	Rain-fed	CF	914	32
		NCF	1914	67
UER	Irrigation	CF	429	15
		NCF	829	29
	Rain-fed	CF	857	30
		NCF	2,171	76
VR	Irrigation	CF	1086	38
	Rain-fed	CF	343	12
Total sample				350

in the endogenous treatment effect regression model (ETRM) for the outcome model, which is used to estimate the impact of CF on the production efficiencies.

3.1 Measurement of production efficiency

Modern efficiency measurements began with the work of Farrell (1957), who drew upon the works of (Debreu, 1951 and Koopmans, 1951) to define a simple measure of firm efficiency, which could account for multiple inputs. He proposed that the measurement of economic efficiency (EE) can be decomposed into two components; these include technical efficiency (TE) and allocative (price) efficiency (AE). TE is connected to technology and refers to the use of minimal possible combination of inputs for producing a certain output (input orientation) or to obtain maximum possible level of output (i.e. frontier output) at the given level of technology (output orientation), and AE refers to optimal combination of inputs at given input prices. These two measures are then combined to provide a measure of total EE.

Two approaches are used to estimate relative efficiency indices: the parametric or stochastic frontier analyses (SFA) and the non-parametric or data envelopment analyses (DEA) approach (Coelli, 1995). The SFA assumes a functional relationship between outputs and inputs and uses statistical techniques to estimate parameters of the function. It incorporates an term made up of additive components: a symmetric component that accounts for statistical noise associated with data measurement errors and a non-negative component that measures inefficiency in production (Coelli, 1995). The stochastic frontier analyses (SFA) also allows for hypothesis testing. The disadvantage of SFA is that it imposes specific assumptions on both the functional form of the frontier and the distribution of the term. In contrast, DEA uses linear programming methods to construct a piecewise frontier of the data. Because it is non-parametric, DEA does not require any assumptions to be made about functional form or distribution type. It is thus less sensitive to misspecification relative to SFA. However, the deterministic nature of DEA means all deviations from the frontier are attributed to inefficiency. It is therefore subject to statistical noises resulting from data measurement errors (Coelli, 1995). For the sake of this research, the SFA approach was employed to estimate the production efficiencies.

3.2 Specifications of SFA model for production efficiency estimation

The production frontier function. This is specified as

$$Y_i = f(X_i, \beta)\, e^{v_i - u_i} \tag{2}$$

Where Y denotes rice output (paddy), X denotes the factor inputs, the subscript i identifies the rice farm, β represents the parameters to be estimated and e the term representing both inefficiency u_i and noise factors v_i. The rice production frontier shows the relationship between farm inputs (labour, fertilizer, seed, their prices, etc.) and farm outputs (rice yield and farm revenue), and the value of β indicates the relative importance (propensity) of each input to influence the rice production process (Kompas *et al.*, 2006). A parametric production frontier needs to assume a functional form, and two forms that are relatively easy to derive and commonly used in efficiency analysis are the Cobb–Douglas and the translog production functions.

A Cobb–Douglas stochastic frontier, using the terminology of (Coelli *et al.*, 1998), is defined by:

$$\ln(y_i) = X_i\beta + v_i - u_i \quad i = 1, 2 \ldots n \tag{3}$$

where:

$ln(y_i)$ is the logarithm of the rice output of the i-th sample farm (i = 1, 2. . .. 350)

x_i are the logarithms of the input quantities used by the ith farm; these include farm and farm household characteristics, inputs and input prices β is a column vector of unknown parameters to be estimated for each covariate

u_i is the technical inefficiency (TE) of the ith farm, and in this study it is assumed to be an independent and identically distributed (i.i.d.) half normal random variable

v_i is the random error term, assumed to be (i.i.d.) normal random variable with zero mean and constant variance, σv^2, independent of the u_i.

The technical efficiency of the ith rice farm, in time period t, is given by the ratio of observed output to the maximum potential output, as defined by the frontier.

$$TE = \frac{Y_i^*}{Y_i} = exp(-u_i) \tag{4}$$

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

The production cost frontier function. This is specified as

$$C_i = f(X_i, P_i, \beta) \;\; e^{v_i + u_i} \tag{5}$$

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 term representing both inefficiency, u_i, and noise factors, v_i.

$$AE = \frac{C_i^*}{C_i} = \exp(u_i) \tag{6}$$

where C_i = the total production cost frontier, C_i^* = the stochastic cost frontier. This will give us the AE from which EE will be estimated as

$$EE = TE \times AE \tag{7}$$

EE = economic efficiency

The maximum likelihood estimation technique is used to analyse for the inefficiencies. In addition to estimating the levels of TE among farmers, the factors influencing efficiency are also examined under the endogenous treatment effect model.

The endogenous treatment effect model will be used to assess impact of CF on the efficiencies while examining the determinants of the inefficiencies and also CF choice.

3.3 The endogenous treatment effect regression model (ETRM) specification

Estimation of endogenous treatment effect is a common feature in empirical studies in economics. When the treatment can be categorized by a dichotomous indicator function, its effects is typically estimated via instrumental variables or variants of the control function approach motivated by Heckman (1978, 1979).

The endogenous treatment effects model is a linear model that allows for correlation between unobservable factors affecting household choice decisions (contract farming) and those affecting the household efficiency measures (technical, allocative and economic efficiencies). The household technical, allocative and economic efficiencies are a proportion measure with 0 meaning perfect inefficiency and 1 a maximum efficiency. The idea is to model the treatment effect of household CF on the efficiency measures of small-scale rice producers. As in Greene (2002), we use the endogenous treatment regression specification to assess the impact of CF on technical, allocative and economic efficiencies. This model assumes a joint normal distribution between the errors of the selection equation (contract/non-contract and irrigation/rain-fed) and the treatment equation (the measure of technical, allocative and economic efficiencies). We specify the outcome model as follows:

$$Eff_i = X_i'\beta + \delta CF_i + \epsilon_i \tag{8}$$

Where the effect of contract farming (CF_i) on technical, allocative and economic efficiencies (Eff_i) is expressed. The impact of CF on technical, allocative and economic efficiencies is not captured by the δ, because these households were not randomly assigned to participate in the CF or otherwise but were personal choices of the participants to participate in contract farming programme (case of self-selection [1]). Hence, neglecting the potential endogeneity [2] of CF will produce wrong estimates of the treatment model and will overstate the effect of contract participation on farmers' technical, allocative and economic efficiencies. Farmer contract participation decisions and irrigation farming (treatment) are based on the household, individual and farm characteristics G_i and are modeled as:

$$CF_i^* = G_i'\alpha + \mu_i \tag{9}$$

$$CF_i = \begin{cases} 1 & if\ CF_i^* > 0 \\ 0 & \text{Otherwise} \end{cases}$$

Where CF_i^* represents contract farming, X_i and G_i are covariates that are unrelated to the terms. β and α are the parameter estimates. The assumption is that ϵ_i and μ_i are jointly normally distributed with mean vector 0 and variance covariance matrix Σ given as:

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \rho\sigma_1 \\ \rho\sigma_1 & 1 \end{pmatrix} \tag{10}$$

The model can be estimated using the two-step approach or the maximum likelihood approach. This is therefore modelled simultaneously as a CF decision model as in equation (9) and the outcome model as in equation (8). Consistent estimates of household participation in CF decision on their technical, allocative and economic efficiencies are obtained by accounting for the endogenous participation. The determinants of CF decision and that of the efficiencies are jointly determined. The maximum likelihood approach was used to analyse the model.

3.4 Socio-economic characteristics of rice farmers

According to Table 2, the mean age difference between contract farmers and non-contract farmers is about three years 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 experience and non-contract farmers'

Farmer characteristics	CF (n = 140) Mean	NCF (n = 210) Mean	Mean difference	Z-statistic
Age of HHH	46.41	43.22	3.19 ***	2.701642
Farmer experience	22.94	24.20	(1.25)	−1.145
Wealth of farm HH	8,256.64	3,214.71	5,041.93 ***	4.643198
Household size	7	7	0.35	1.1456
Total available arable land	5.07	5.65	(0.58)	−1.52

Note(s): *** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

Table 2.
Farmer characteristics

experience in rice production. Contract farmers are richer than non-contract farmers, and this is significant at 1%. There is no difference in the household size and also available arable land of the two groups.

From Table 3, the mean difference of rice farm size of contract farmers and non-contract farmers is about 0.35 ha and significant at 1% level. The mean difference of fertilizer use, seed use, labour used are 122kg/acre, 28kg/acre and 5 persons/acre, respectively, which are all significant at 1% level. There is no difference in the prices of fertilizer and labour used. Seed price was significant at 1% level with mean difference of −0.12 GHS, which implies non-contract farmers bought their seed at relatively cheaper price than contract farmers. This could be that farmers bought grain and used it as seed because of the relative high cost of certified seed. Yield is an important variable in assessing farm-level performance, and it is evident that contract farmers have higher yields than their non-contract farmer colleagues with difference of 1,090 kg/acre. Total output of contract farmers was far more than the output of non-contract farmers with 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 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 contract farmers earn more profit than their non-contract counterparts.

4. Results and discussion

4.1 Impact of contract farming on technical efficiency and its determinants

Results from ETRM on impact of contract participation on TE and its determinants are presented in Table 4. The Wald test is significant indicating the goodness of fit of the endogenous treatment effect model. The likelihood ratio test of independence of CF participation and TE equations indicate that we can reject the null hypothesis of no correlation between CF and TE. This implies CF is positively correlated with TE. The estimated average treatment effect (ATE) of participating in contract production is 0.21 of the TE. Thus, CF can help farmers increases their TE by 21% which is in line with the findings of Khai *et al.* (2011); Mishra *et al.* (2018a, b and c); Dube and Mugwagwa (2017) and Le Ngoc (2018). The estimated correlation between the treatment assignment errors and the outcome errors is (−0.66) indicating that the unobservables that increased TE also tend to occur with the unobservables that influence CF participation (self-selection occurred in CF participation).

Variables	CF (n = 140) Mean	NCF (n = 210) Mean	Mean difference	t-statistic
Rice farm size (ha)	1.31	1	0.31***	4.5
Fertilizer used (Kg)	314.43	192.20	122.23***	5.33
Seed used (Kg)	90.03	61.61	28.41***	2.82
Labour used	13	8	5.0***	4.9
Fertilizer price (GHS)	1.11	1.81	−0.70	−1.57
Seed price (GHS)	0.57	0.70	−0.12***	−2.84
Labour price (GHS)	36.28	43.07	−6.79	−1.41
Yield/ha	1,743.08	652.99	1090.09***	10.56
Total output (Kg)	4,880.41	1,520.11	3360.30***	10.75
Output price/Kg (GHS)	1.46	1.31	0.15***	5.1
Total revenue (GHS)	2,642.00	850.08	1791.91***	10.17
Total cost of prod. (GHS)	584.98	414.91	170.07***	4.7
Gross margins/ha (GHS)	2,057.01	435.17	1621.84***	10.32

Note(s): *** 1% level of significance; **5% level of significance; *10% level of significance

Table 3. Farm characteristics of CF and NCF

Variables	Technical efficiency Coef.	Std. Err.	Contract farming Coef.	Std. Err.
Production ecology	0.017	0.015	0.100	0.172
Improved seed	−0.006	0.033	0.158	0.371
Gender	0.026	0.037	0.593	0.471
Age	0.000	0.001	0.015*	0.009
Educational level	−0.005***	0.002	0.040**	0.020
Farmer experience	0.001	0.001	−0.012	0.010
Wealth of farm HH	5.03E-06***	9.54E-07	3.04E-05**	1.33E-05
Household Size	−0.005*	0.003	−0.010	0.033
Total HH arable land	0.005	0.003	−0.158***	0.040
Rice farm size	0.018**	0.008	0.136	0.113
FBO membership	−0.036**	0.016	0.047	0.202
ISFM adoption	0.011	0.025	0.567**	0.272
1.Contract farming (CF)	0.273***	0.035		
Constant	1.479***	0.077	−3.387***	0.910
/athrho	−0.788***	0.206		
/lnsigma	−2.088***	0.061		
Rho	−0.657	0.117		
Sigma	0.124	0.008		
Lambda	−0.081	0.019		
Log likelihood	111.0336			
Wald test $\chi2$ (13)	429.39***			

LR test of independent equations $\chi2$ (1) 7.29***

Note(s): *** 1% level of significance; **5% level of significance; *10% level of significance

Table 4. Estimates of the endogenous treatment effect model of impact of CF on technical efficiency

The negative sign indicates a positive bias, suggesting that farmers with above-average TE have a higher probability of participating in CF.

The significant and positive determinants of TE are: wealth of household, rice farm size and CF. These imply wealth has significant effect on TE. Assets owned by farmers may assist them directly or indirectly in reducing costs of production and probably making them more technically efficient. These results are similar to that of Tchale (2009), who observed that asset ownership was a tool through which the farm's liquidity position was improved; hence increasing farm productivity through higher input access. Those with bigger rice farms are more technically efficient than those with smaller farm size, which is a similar result compared to Khai *et al.* (2011b); Dube *et al.* (2017). Farmers practicing CF are also more efficient than those not participating, which is in line with the contracting theory of Key *et al.* (1999). The results also agree with Sununtar *et al.* (2006); Men *et al.* (2013), who also established an increase in efficiency among contract farmers.

However, the significant and negative determinants of TE are: educational level, household size and farmer-based organizations (FBO) membership. This implies farmers who are more educated are less technically efficient which is in contrast with most literature (Huffman, 2001; Asadullah *et al.*, 2009; Javed *et al.*, 2010; Mariano *et al.*, 2010. This could be true because, from our experience, we realized most farmers who were educated were not regularly available on their farms as compared to the illiterate farmers who are always regular and managing their fields by themselves. They are able to detect deviations much earlier than the educated farmers who are not regular. The smaller households are also more technical efficient than those of larger households; this is in contrast with the work of Nargis *et al.* (2013). The smaller households may have better labour efficiency than the larger households.

FBO membership is negatively correlated with TE, which is in agreement with Kuwornu *et al.* (2013). This implies farmers who are members of FBOs are less technically efficient than their counterparts who are not members of any farmer-based group. This situation may be as a result of them spending more time in meetings with government and non-governmental institutions at the expense of their farms.

The significant and positive determinants of contract participation are: age of farmer, educational level, wealth and integrated soil fertility management (ISFM) adoption. The significant and negative factor influencing contract participation is total household arable land.

Age is positively correlated with contract participation and also positively correlated with social responsibilities and hence will have higher propensity to seek for support than their younger counterparts which agrees with findings of Adesiina *et al.* (1995); McNamara *et al.* (1991); Harper *et al.* (1990). The farmer who is more educated is more likely to participate in contract production than a farmer who is not educated because they may have better understanding of the concept and also better negotiation ability than their illiterate colleagues (Waller *et al.*, 1998; Caswell *et al.*, 2001). Wealthy households also have a better propensity to participate in contract production than poorer households probably because they are less risk-adverse (Mishra *et al.*, 2018a, b and c).

Mostly new technologies are capital-intensive and may be adopted by wealthy farmers who can afford (El Oster *et al.*, 1999); hence, the adoption of such technologies is influenced by wealth (Khanna, 2001). Size of farm labour is also positively correlated with participation in contracting which agrees with Kumar *et al.* (2018). This could be due to the fact that with contracting the farmers are supervised to implement all the agricultural practices to its optimum and hence will require more labour. Farmers who practice ISFM technology have a higher probability of participating in contract production which is in line with the work of Kumar *et al.* (2018). ISFM requires the use of improved seed and organic and inorganic fertilizers, which is made possible through contract arrangements. Farmers with bigger household arable land are less likely to participate in CF. In general, there are no observed consistent patterns of farm size acting as a constraint to agricultural technology adoption (Just *et al.*, 1983). The expected sign on the coefficient on farm size is indeterminate. Identified factors of CF participation to include: farmers' risk attitude, gender, yield, farm size and labour availability in their vegetable studies in China.

4.2 Impact of contract farming on allocative efficiency and its determinants

Results of the endogenous treatment effect model on impact of contract participation on AE and its determinants are presented in Table 5. The Wald test is significant indicating the goodness of fit of our endogenous treatment effect model. The Wald test of independence of the CF participation and AE equations indicate that we can reject the null hypothesis of no correlation between CF and AE. This implies CF is positively correlated with AE. The estimated ATE of participating in contract production is 0.23 of AE. The impact of CF on AE is about 0.23. This implies farmers participating in CF are 23% more allocatively efficient in their rice production than those not participating. The estimated correlation between the treatment assignment errors and the outcome errors is (−0.81) indicating that the unobservables that increased AE also tend to occur with the unobservables that encourage CF (self-selection occurred in CF participation). The negative sign indicates a positive bias, suggesting that farmers with above-average AE have a higher probability of participating in contracting.

The significant and positive determinants of AE are: rice farm size and contract farming. These imply households with bigger rice farms have a high probability of being more allocatively efficient than those with smaller rice fields.

The significant and positive determinants of contract participation are: age of farmer, educational level, wealth and ISFM adoption. The significant and negative factors influencing contract participation are: farmer experience in rice production and total

Variables	Allocative efficiency Coef.	Std. Err.	Contract farming Coef.	Std. Err.
Production ecology	−0.014	0.024	0.022	0.165
Improved seed	0.012	0.054	0.243	0.393
Gender	−0.004	0.059	0.419	0.396
Age	0.001	0.001	0.015*	0.009
Educational level	0.002	0.003	0.046**	0.019
Farmer experience	0.002	0.001	−0.018**	0.009
Wealth of farm HH	2.01E-06	1.49E-06	2.54E-05**	1.29E-05
Household size	−0.001	0.004	−0.002	0.032
Total HH arable land	0.005	0.005	−0.123***	0.037
Rice farm size	0.045***	0.013	0.069	0.095
FBO membership	0.026	0.027	−0.009	0.195
ISFM adoption	−0.010	0.040	0.699*	0.272
1.Contract farming (CF)	0.301***	0.031		
Constant	0.231**	0.123	−3.663***	0.894
/athrho	−1.133***	0.154		
/lnsigma	−1.606***	0.052		
Rho	−0.812	0.052		
Sigma	0.201	0.010		
Lambda	−0.163	0.017		
Log likelihood	−29.81			
Wald test $\chi2$ (13)	214.23***			

LR test of independent equations $\chi2$ (1) 22.53***

Note(s): *** 1% level of significance; **5% level of significance; *10% level of significance

Table 5. Estimates of the endogenous treatment effect model of impact of CF on allocative efficiency

household arable land. Farmer experience is negatively correlated with CF participation contrary to Foster and Rosenzweig (1995), who found that a new technology adoption is influenced positively with knowledge about management of the new technology. Farmers with bigger total household arable land are less likely to participate in contract.

4.3 Impact of contract farming on economic efficiency and its determinants

Results of the endogenous treatment effect model on impact of contract participation on EE and its determinants are presented in Table 6. From the results, the Wald test is highly significant indicating the goodness of fit of our endogenous treatment effect model. The Wald test of independence of the selection and outcome equations indicate that we can reject the null hypothesis of no correlation between CF and EE. This implies CF is positively correlated with EE. The estimated ATE of participating in contract production is 0.26 of the EE. The impact of CF on AE is about 0.26. This implies farmers participating in CF are about 26% more economically efficient in their rice production than those not participating. The estimated correlation between the treatment assignment errors and the outcome is (−0.86) indicating that the unobservables that increased AE also tend to occur with the unobservables that encourage contract participation (self-selection occurred in CF participation). The negative sign indicates a positive bias, suggesting that farmers with above-average EE have a higher probability of participating in contracting.

The significant and positive determinants of EE are: farmer experience, wealth, rice farm size and contract farming. These imply households with bigger rice farms are more economically efficient than those with smaller rice fields. Farmer rice production experienced influences EE positively. Farmers that are more experienced are likely to be more economically efficient compared to their less-experienced counterparts, perhaps because of their better skills, access to information and good farm planning (Dhungana *et al.*, 2004;

Variables	Economic efficiency Coef.	Std. Err.	Contract farming Coef.	Std. Err.
Production ecology	0.000	0.026	0.078	0.162
Improved seed	0.015	0.057	0.315	0.387
Gender	0.029	0.063	0.504	0.435
Age	0.000	0.001	0.015*	0.008
Educational level	−0.001	0.003	0.046**	0.019
Farmer experience	0.002*	0.001	−0.016*	0.009
Wealth of farm HH	0.000***	0.000	0.000	0.000
Household size	−0.004	0.005	−0.011	0.033
Total HH arable land	0.005	0.006	−0.122***	0.037
Rice farm size	0.056***	0.013	0.009	0.103
FBO membership	−0.008	0.028	0.041	0.194
ISFM adoption	0.009	0.042	0.629**	0.261
1.Contract farming (CF)	0.260***	0.038		
Constant	0.674***	0.131	−4.016***	0.874
/athrho	−1.300***	0.201		
/lnsigma	−1.546***	0.056		
Rho	−0.862	0.052		
Sigma	0.213	0.012		
Lambda	−0.184	0.020		
Log likelihood	−38.38			
Wald test $\chi2$ (13)	224.38***			

LR test of independent equations $\chi2$ (1) 28.13***
Note(s): *** 1% level of significance; **5% level of significance; *10% level of significance

Table 6. Estimates of the endogenous treatment effect model of impact of CF on economic efficiency

Balcombe *et al.*, 2007 and Khan *et al.*, 2010). Farmers' EE increases when they participate in contract production.

The significant and positive determinants of contract participation are: age of farmer, educational and ISFM adoption. The significant and negative factors influencing contract participation are: farmer agriculture experience and total household arable land. Farmer experience is negatively correlated with CF participation. Farmers with bigger household arable land are less likely to participate in CF.

5. Conclusion and recommendation

The results show that the impact of CF on TE is about 21%. This implies farmers participating in CF are more efficient in their rice production than those not participating. The significant and positive determinants of TE are: wealth of household, rice farm size and CF. However, the significant and negative determinants of TE are: educational level, household size and FBO membership. The significant and positive determinants of CF are: age of farmer, educational level, wealth and ISFM adoption. The significant and negative factor influencing CF is total household arable land.

The results show that the impact of CF on AE is about 23%. This implies farmers participating in CF are more allocatively efficient in their rice production than those not participating. The significant and positive determinants of AE are: rice farm size and CF. The significant and positive determinants of contract participation are: age of farmer, educational level, wealth and ISFM adoption. The significant and negative factors influencing contract participation are: farmer experience and total household arable land.

The results show that the impact of CF on AE is about 26%. This implies farmers participating in CF are more economically efficient in their rice production than those not participating. The significant and positive determinants of EE are: farmer experience, wealth, rice farm size and CF. However, the significant and negative determinants of EE are: fertilizer cost, labour cost, seed cost. The significant and positive determinants of CF are: age of farmer, educational level and ISFM. The significant and negative factors influencing CF are: farmer experience and total household arable land.

The results clearly establish that CF has positive impact on technical, allocative and economic efficiencies of rice producers. Farmers will be more efficient when they produce rice under production contracts. Policy directives to promote contract production will be in the right direction, as it will help farmers maximize their rice production businesses. The factors influencing TE positively and significantly are wealth, rice farm size and CF. We recommend that farmers should be encouraged to get involved in contract production. Wealthy farmers should also be encouraged to get into rice production. Older farmers should be targeted for adoption of CF as they have higher propensity to contract. Higher education is also positively correlated with adoption of CF, and hence, we recommend that more educated farmers should be targeted and also more effort should be put into sensitizing our illiterate farmers to see the need to contract. CF should also be encouraged as a means to promote the adoption of integrated soil fertility management practices (ISFM) technology. Enhanced efficiency will result in increased yields, income and gross margins of rice farmers. CF is a management strategy or tool worth practicing.

Notes

1. Self-selection bias arises in any situation in which individuals self-select themselves into a group, causing a biased sample with non-probability sampling.
2. The problem of endogeneity occurs when the independent variable is correlated with the term in a regression model.

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