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Does contract farming improve rice farmers' food security? Empirical evidence from Ghana

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Abstract

Purpose – In order to improve access to resources for smallholder farmers, efforts are being made to promote contract farming in Ghana. This is seen as a strategy to increase agricultural productivity of farmers, give better market access and guarantee adequate supply of raw materials to agro-based industries. However, the challenge is whether contract farming leads to improvement in food security status of farmers. The study therefore seeks to explore to what extent farmers' food security status is influenced by their participation in contract farming activities.

Design/methodology/approach – Using Cragg's double-hurdle model to analyse participation in contract farming, the authors control for selection bias using propensity score matching applied to a data set of 336 observations to examine the impact of contract farming on the food security levels of rice farmers in Ghana.

Findings – The results of this study show that yield of paddy and the wealth of the farmer are the main factors that influence the quantity of paddy rice to be contracted in contract farming arrangements. This study also finds that participation in contract farming will increase food security by 109%. In conclusion, contract farming has a significant positive impact on the farmers' food security status.

Originality/value – Agricultural policies and rural development initiatives supporting the promotion and expansion of contract farming should be pursued to persuade more farmers to produce under contract farming agreements.

Keywords Contract farming, Food security, Ghana, Impact, Participation, Rice

Paper type Research paper

1. Introduction

Agriculture is not just a way of life but an industry in Ghana; it provides employment predominantly in rural areas and also provides raw materials to the agriculture-based food industries. The timely and adequate quantity of good quality raw materials is a prerequisite for the smooth functioning of the agro-industries. It is this agriculture and industry relationship that has evolved into contract farming, which promises to provide a proper linkage between the farm and market. It also has the potential to promote high level of competition at the supply and market ends and minimize intermediaries to increase farmers' income, food security and employment. Contract farming in Ghana has been dominated by horticultural and cash crop outgrower schemes mainly for export. Nonetheless, many of these schemes have failed over time. There is, however, a new wave of contract farming in Ghana involving sorghum, paddy rice, maize and soy beans. This is due to agro-industrialization and increasing domestic demand for agricultural raw materials (Poku *et al.* 2018). Under a broad economic approach, "contract farming" generally is a form of supply chain governance

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used by firms to secure access to agricultural products, raw materials and supplies meeting their desired quality, quantity, location and timing specifications.

According to Acharya (2017), contract farming refers to a system where a processing or marketing firm purchases the harvests of independent farmers and the terms of the purchase are arranged in advance through forward contracts. The terms of the contract vary and usually specify how much produce the contractor will buy and what price they will pay for it. The contractor frequently provides credit inputs and technical advice. Contracting is primarily a way of allocating risk between producer and contractor; the former takes the risk of production and the latter the risk of marketing. A contract farming agreement is basically a joint venture between two parties, the farmer (owner or tenant) and the contractor (typically a local farmer or business companies). Contract farming is seen as a potential tool for reducing poverty, contributing to ruraldevelopment and employment and increasing food security. The ability of households and individuals to access food–one of the key aspects of "Food Security"–is an important welfare dimension. Food security is thus said to exist when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Development Report, 2007). Although food security is inherently multi-dimensional, one critical dimension is continued access to adequate food.

In the Kassena-Nankana Municipality of Ghana, a large number of the farmers are smallholders who are into the production of food crops such as rice, maize, millet, groundnuts, sorghum and vegetables (UNDP, 2010, p. 22). They are also involved in livestock rearing. Rice is cultivated in commercial quantities by these smallholder farmers at the Tono irrigation project and other smaller dugouts to feed small, medium and large-scale processing firms located in the Upper East, Northern and Ashanti regions of Ghana. These smallholders face several challenges including low yield, lack of credit, lack of access to productive assets, poor market linkage etc. However, one of the major constraints to increasing the benefits to these rice farmers is their inability to access profitable markets (IFPRI, 2007). Thus, facilitating market access for this smallholder farmers and enabling them to actively participate in the market systems is one of the key initiatives to pursue. There are some initiatives such as the Planting for Food and Jobs programme, One District One Factory, One District One Warehouse and One Village One Dam that are currently being implemented in Ghana to establish value chains for some food crops such as rice. These initiatives employ strategies such as outgrower or contract farming schemes and the development cooperatives. For the purpose of this paper, we focused on contract farming in Ghana.

The expansion in contract farming has generated some discussion on its welfare and economic benefits to smallholders, necessitating various studies into the phenomenon (Warning and Key, 2002). The proponents envision contract farming as a viable solution to numerous production challenges which could lead to increased yield and income, improved food security and poverty reduction (Eaton and Shepherd, 2001; Minot, 2007). But the sceptics on the other hand view contract farming as being potentially exploitative and subject to manipulation to cheat farmers by agribusiness firms to suit their interests (Little and Watts, 1994; Key and Runsten, 1999; Singh, 2007).

The paper contributes to empirical literature in two ways. First, it analyzes impact of contract farming and established the relationship between contract farming and food security of rice farmers. Again, it examines the extent to which farmers are willing to contract. It also provides recommendations for policy interventions aimed at promoting and expanding contract farming in Ghana. The rest of the paper is organized as follows. The next section reviews the theoretical relationship between contract farming and food security. Section three presents the research methodology employed in the study. Section four presents the results and discussion and in the final section, we present the conclusions and recommendation.

1.1 Rice value chain in Ghana

Rice is now the second most important food crop after maize in Ghana and its consumption is on the increase because of urbanization, population growth, increase household incomes and changes in consumer habits (MOFA, 2009). The annual rice production variations are largely due to the area (Ha) put under cultivation, rather than yield increases (ton/ha) (MOFA, 2016). Rice is cultivated both as a food and cash crop grown across Ghana but more importantly in the Northern, Upper East and Volta Regions of Ghana. The total national production is less than 400, 000 metric tonnes and meets just about 35% of the domestic rice demand. The 65% gap is met through imports. This does not only put pressure on Ghana's trade balance but also makes it vulnerable to global price increases and supply shortages in the rice market. With the current annual population growth rate of about 2%, increased household income and urbanization, it is estimated that per capita consumption of rice will increase significantly, and domestic demand will expand beyond one million tonnes. In order to satisfy such growing domestic demand and to ensure food security and reduction of the huge import bill, conscious efforts must be made to increase production and productivity of rice in Ghana.

2. Literature review

2.1 Theoretical foundation of contract farming

The theoretical framework of this research is based on the principal-agent (agency) and transaction costs theories. However, other theories were also reviewed and incorporated into the study. Agency theory and transaction costs are the two leading approaches which provide the theoretical basis for those other theories. Both theories view the firm as a legal entity that contracts outsiders (farmers, suppliers, aggregators and middlemen) and insiders (workers). Agency theory focuses on understanding the reasons for the existence of different types of contract arrangement and the payment mechanisms whilst transaction cost theory contributes to understand the changes in the food crop industry (Hobbs and Young, 2001).

The agency theory in addition to its focus on the inter-firm relationships, also looks at the strategic behaviour and intra-firm environment. It specifically relates to the principal problem of coping with asymmetric information, performance measurement and incentives.

The transaction costs theory on the other hand focus on asset specificity. Its main highlight is that all transactions between parties involve costs, known as transaction costs. These include the costs of finding a market, negotiating and signing a contract. The higher the asymmetric information, the higher the transaction costs. Despite its acceptance, it has been criticized for overlooking learning and innovations. In addition to the perspectives of agency and transaction cost theories is the convention theory that provides useful insights to this study. The idea behind the convention theory is its focus on the socio-economic, cultural, political and specific guidelines that regulate inter-firm relationships. Despite its deficiencies, convention theory was used in the study to review government's policies and laws regulating agribusiness activities in Ghana.

2.2 Conceptual framework

The conceptual framework for the study is informed by the agency theory and assesses the relationship that exists between firms and farmers considering the information asymmetry and uncertainties. In the agency relationship, the farmers are also required to conduct themselves in accordance with the goals of the firms. This theory further focuses on the agreement between these two parties and seeks to provide the most efficient information at the lowest cost.

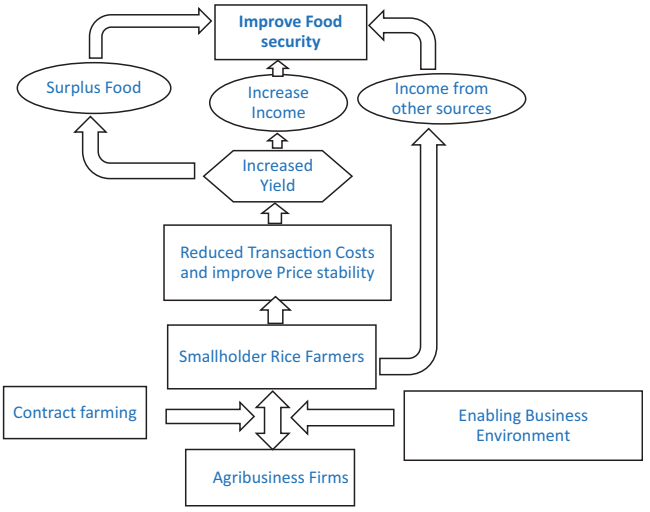
According to Christensen (1992), Little and Watts (1994), Eaton and Shepherd (2001), Simmons (2002) and Slangen *et al.*, (2008), contract farming helps farmers through improved access to markets, credits, inputs and better access to technology. Hence, it is anticipated that

contract farming brings together the strength of farmers to neutralize their individual constraints resulting in increased yields, increased incomes and ultimately leading to improve food security.

From the conceptual framework in Figure 1, it is expected that a reduction in information asymmetry and price stability between the agribusiness firms and smallholder rice farmers coupled with other factors such as prevailing government policies like One District One Factory programme, One Village One Dam initiative and Planting for Food and Jobs programme; risk management strategies like weather index insurance; physical factors and socio-economic characteristics of farmers will influence contract farming participation. Participation in contract farming will then result in new technology adoption, access to inputs, enhance agronomic practices, low labour cost, access to farm business planning services, access to markets and stable producer prices leading to productivity increases, increase income and food security. Also, the spillover of contract farming may lead to increases in yield of other crops and non-farm activities that the farmers engage in. Income from rice production, other farm and off-farm activities and surplus foods from emergency relief sources all contribute to the net food security situation of the farmer.

2.3 Empirical reviews

There exists a body of evidence on the impact of smallholder contract farming for export oriented high value commodities (Minot and Sawyer, 2016). However, there are some studies such as Maetens and Vande velde (2017), Ragasa *et al.* (2017), Bellemare (2010), Bidzakin *et al.* (2018) and Poku *et al.* (2018) that investigated the impact of contract farming in local food commodity chains. The analysis of these studies emphasized on the intermediate outcomes such as yield and for that matter income and technology adoption. This creates an evidence gap on its impact on farmers' ultimate outcomes such as food and nutritional security, poverty reduction, sustainable livelihoods, climate resilience etc. Therefore, there is the need to extend the impact of contract farming to farmers' food security. Few studies have examined the relationship between contract farming and farmers' food security. According to Minten *et al.* (2009), contract farming in the horticultural sector shortens lean periods.



Source(s): Author's framing

Figure 1. Conceptual framework of CF participation and its impact on food security

Bellemare and Novak (2017) also found out that contract farming improved producers' income and therefore reduce the hungry season. Soullier and Moustier (2018) found that contract farming reduced food insecurity by mitigating price seasonality. This paper sought to contribute to this body of evidence. The main aim of the paper was to examine the impact that contract farming had on farmers' food security in Ghana. Specifically, the paper sought to explore the determinants of participation in contract farming, determinants of proportion of production contracted representing extent and the impact of contract farming on food security. The hypothesis was that, contract engagements reduced farmers' food insecurity by increasing their incomes (Bellemare and Novak, 2017).

2.4 Growth of contract farming in Ghana and Sub-Saharan Africa

Contract farming is increasingly being used by major agricultural programs in Ghana by the government, development agencies and the private agribusiness firms. Some of these schemes include the following: the Planting for Food and Jobs program; the Agricultural Development and Value Chain Enhancement (ADVANCE) program; Market Oriented Agriculture Prorgram (MOAP), Competitive African Rice Initiative (CARI), Maximizing Rice and Key Enterprise in Target Sites (MARKETS) implemented by Christian Aid through its partner Youth Harvest Foundation Ghana (YHFG). There are also several private sector-led contract farming schemes, amongst them include: Masara N'Arziki Farmers Association, led by Wienco Ghana; Savannah Agricultural Trading Company limited (SATCO); Presbyterian Agricultural Station (PAS); Karaga Agribusines Centre, Shinkafa Buni by Avnash Industries; Akate Farms; Producers Common Marketing Platform (PROCOM) by Trade Aid Integrated; Sambay Enterprise etc.

In Sub-Saharan Africa, it is believed that contract farming is on the rise. Over the years, contract farming has become a useful income generating tool for smallholders in Africa. It has also been largely used as a rural development strategy by development projects with private sector involvement. However, several state-owned enterprises also use contract farming approaches to procure their raw materials. The proportion of contract farming is high in some developing countries (United Nations, 2009). There are evidence of contract farming in Madagascar, Malawi, Burkina Faso, Nigeria, South Africa and Zimbabwe depending upon the crop. According to Swinnen *et al.* (2007, almost 12% of the rural population in Mozambique are involved in contract farming. Also, over 50% of tea and sugar in Kenya are produced under contract farming arrangement. Again, contract farming is very successful in coffee and tobacco production (Bolwig *et al.*, 2009).

3. Methodology

3.1 The study area

This study was carried out in the Kassena-Nankana Municipality of Ghana. The Kassena-Nankana Municipality lies with the Guinea savanna woodlands. It is located approximately between latitude 11°10' and 10°3' North and longitude 10°1' West. It is one of the fifteen (15) local government administrative capitals in the Upper East region with Navrongo as the administrative capital. It shares boundaries to the north with Kassena-Nankana West and Burkina Faso, to the east with Bolgatanga Municipality, to the west with Builsa North District and to the South with West Mamprusi District in the Northern region. Agriculture is the mainstay of the municipal economy, employing over 60% of the economically active population. The main crops grown by these farmers are millet, sorghum, maize, rice, groundnuts, cowpea and dry season vegetables such as tomato, pepper and other leafy vegetables. They also keep livestock and poultry as part of the economic activities. Farming activities are mainly rain-fed. However, irrigation facilities at Tono irrigation project areas, smaller dams/dugouts and some other water bodies serve as sources of water for dry season farming.

3.2 Sampling and sample size

A multi-stage sampling technique was employed in selecting respondents for this study. In the first stage, out of the districts where rice contract farming takes place, Kassena-Nankana Municipality was selected on purpose because of the presence of many rice contract farming activities. In the second stage, based on the proportion of communities that undertake contract farming, four communities were purposively selected. They included Bonia, Korania, Ganni and Biu.

Third, rice farmers in the communities were stratified into two strata; contracted and non-contract farmers. The non-contract farmers were selected within communities of farmers under contractual rice production to ensure homogeneity of factors except contract farming. In the final stage, a total of 336 respondents (103 respondents under contract farming and 233 non-contract farmers) were selected using random sampling (Table 1).

3.3 Methods of analysis

3.3.1 Method of analysing determinants of participation in contract farming. 3.3.1.1 Cragg's double-hurdle model. The double-hurdle model (Cragg, 1971) was used to analyse the factors that influence farmers' decision to participate in contract farming and the intensity (quantities of production to contract). According to Greene (2005), the double-hurdle model is a generalization of the Tobit model, where the decision to participate and the level of participation are determined by two separate stochastic processes.

Whereas, in some aspects, parameterization of the double-hurdle model is similar to that of Heckman procedure, in that, two separate sets of parameters are obtained in both cases; the double-hurdle model is considered to be less restrictive. This is because in the Heckman model, non-participants will never participate under any circumstances. On the other hand, in the double-hurdle model, non-participants are considered as a corner solution in a utility maximizing model (Yami *et al.*, 2013). In the context of this study, the double-hurdle model assumes that the zero values reported in the first hurdle arise from smallholders' decision not to participate rice contract farming schemes, while those in the second hurdle come from farmers that would not have sold paddy rice due to their deliberate choice.

The double-hurdle model required the joint use of the Logit and the truncated regression models, where it is assumed that the decision to participate and intensity of participation in contract farming are determined by two separate stochastic processes. The discrete decision of whether to participate in contract farming arrangement is usually estimated with a probit and logit model. The dependent variable in the model to assess the determinants of participating in contract farming is binary assuming the value of 1 if a farmer participated and 0 otherwise. In this paper, the model of the first hurdle or participation decision equation is estimated with a logit model as:

Communities	Estimated population (Y)	Contracted farmers (CF)	Non-contracted (NCF)	Sample CF	Sample NCF	Total sample (z)
Bonia	510	115	395	18	63	81
Korania	580	150	430	24	69	93
Gani	320	90	230	14	37	51
Biu	690	295	395	47	64	111
Total	N = 2,100	650	1450	103	233	336

Source(s): Survey data, January 2019

Table 1. Sampled communities and respondents

$$P(X) = P(D = 1/X) = F(\beta_1 X_1 + \ldots \beta_i X_i) = F(X\beta) = e^{X\beta} \quad (1)$$

where D is a latent variable that takes the value1 if a farmer participated, and 0 if otherwise; X_i is a vector of independent variables (age, gender, education, experience etc), β is the parameter of interest to be estimated, and e is the error term.

3.3.1.2 Tobit model. The discrete decision of whether to participate in contract farming and the continuous decision of how much production to contract is estimated using a Tobit model. Thus, Tobit model captured the decisions of farmers to participate in contract farming and was censored at zero. Since the threshold for quantities to be contracted is zero (cannot be negative), the dependent latent variable is specified as an index function. Following Greene (2005), the Tobit model can thus be expressed as:

$$Y_i = \beta X_i + \varepsilon_i \quad (2)$$

$$Y_i = 1 \text{ if } Y_i > 0$$

$$Y_i = 0 \text{ if } Y_i \leq 0$$

The model assumes that a latent variable (Y_i) which is individual farmer's decision to participate in contract farming. β is a vector of parameters to be estimated, and X_i is a vector of independent variables influencing the farmers' level of participation in contract farming. The error term ε_i is assumed to be independent, normally distributed with zero mean and variance.

Following Wongnaa e al. (2019), the maximum likelihood estimation was employed to estimate the β_S based on the number of observations on the decision to participated in contract farming Y_i and X_i. This is essentially an estimation with censored normal regression model.

The log likelihood of the Tobit model is specified as:

$$\ln L = \sum_{y_i>0} -\frac{1}{2}\left[\log(2\pi) + \ln\sigma^2 + \frac{\left(y_{i-X_i'}\beta\right)^2}{\sigma^2}\right] + \sum_{y_i=0} \ln\left[\frac{1-\phi(X_i'\beta)}{\sigma}\right] \quad (3)$$

Hence, maximizing this likelihood function with respect to β and σ gives the description of the variables employed in these parameters. Table 2 presents a description of the variables in the model. Assuming the random error is independent and normally distributed across respondents, the expected Y for an observation drawn at random is:

$$E(Y) = \neq \Phi\left(\frac{X\beta}{\sigma}\right)X\beta + \sigma\phi\left(\frac{X\beta}{\sigma}\right) \quad (4)$$

Where Φ represents the normal distribution, ϕ represents the normal density function and σ represents the standard deviation. Moreover, the expected value of Y_i for observations above zero, referred to as (Y^*), is simply $X\beta$ plus the expected value of the truncated normal error terms (Greene 2005). Thus, the expected Y can be expressed as:

$$E(Y) = \neq \Phi\left(\frac{X\beta}{\sigma}\right)E(Y^*) \quad (5)$$

However, unlike linear models, the marginal effect or partial derivative for a given independent variable is nonlinear and thus not equal to β. The decomposition of this marginal

Variables	Description	Expected sign
Age	Age of the household head in years	+/−
Sex	Sex of HHH. (male = 1, female = 0)	−
Education	Education of HHH measured in years	+
HH size	Number of household members	+
Experience	Experience in rice production (number of years)	+/−
Rice farm size	Total size in acreage of a farmer's rice farm in ha	+
Yield	Yield of paddy (kg/ha)	+
Paddy price	Price the farmer receives from selling paddy rice in GHS	+
Credit	The amount per ha of inputs (improved seeds, fertilizer, pesticides) that a farmer received in GHS/Kg	+
Marketing cost	Cost of selling paddy rice (GHS/kg)	−
Farm location	Location of the farm where the farmer cultivates rice (1 for irrigation and 0 otherwise)	+
FBO member	Farmer base organization membership. Dummy variable (member of FBO = 1, otherwise = 0)	+
Assets	Total worth of farmer's household in GHS	+
Extension services	The number times a farmer receives extension service in a year	+

Table 2.
Variables employed in the study and their a prior expectations

effect that is obtained by considering the effect of a change in the *ith* variable of X on Y is expressed as:

$$\frac{\partial E(Y)}{\partial X_i} = \Phi\left(\frac{X\beta}{\sigma}\right)\left(\frac{\partial E(Y^*)}{\partial X_i}\right) + Y^*\left(\frac{\partial \Phi\left(\frac{X\beta}{\sigma}\right)}{\partial X_i}\right) \tag{6}$$

Intuitively, the total change in Y_i can be disaggregated into two parts: (1) the change in Y of the above bids, weighted by the probability of being above the zero bid and (2) the change in the probability of being above the zero bid, weighted by the expected value of Y if above the zero bid. Eqn (6) can be evaluated at the mean of the X_S, $\overline{X}$ with estimates of β and σ. The fraction of the total marginal effect due to the effect above the zero bid is:

$$\frac{\partial E\left(Y_i^*\right)}{\partial X_i} = 1 - \frac{X\beta\phi\left(\frac{X\beta}{\sigma}\right)}{\Phi\left(\frac{X\beta}{\sigma}\right)} - \frac{\phi\left(\frac{X\beta}{\sigma}\right)^2}{\Phi\left(\frac{X\beta}{\sigma}\right)^2} \tag{7}$$

The marginal effect, $\frac{\partial E(Y^*)}{\partial X_i}$ was estimated using Eqn (11) and the fraction of the total marginal effect above the zero bid, $\frac{\partial E(Y_i^*)}{\partial X_i}$ was also estimated using Eqn (12)

It is assumed in this paper that the discrete decision of rice farmers to participate in contract farming and the continuous decision of the proportion of paddy rice to contract are made simultaneously and that the same factors had the same effects on the two decisions. The Tobit model is able to combine the binary model and truncated models of Cragg's double hurdle model to obtain the joint coefficient, α, in case the two above-mentioned decisions are jointly made, which explains both the discrete decision to participate in contract farming schemes and the continuous decision of the quantities farmers are ready to contract.

To confirm the appropriateness of the Tobit model, it was tested against Cragg's model by estimating a logit, a truncated regression and a Tobit model with the same variables, and X_i

computed the succeeding likelihood ratio statistic (Katchova and Miranda, 2004; Greene 2005; Wiredu *et al.*, 2015; Asante *et al.*, 2018; and Wongnaa *et al.*, 2019)

$$\lambda = 2(\ln L_{\text{binarymodel}} + \ln L_{\text{truncated regression}} - \ln L_{\text{Tobit}}) \tag{8}$$

Where λ is distributed as chi-square with R degrees of freedom (R is the number of independent variables including a constant). The Tobit model will be rejected in favour of Cragg's model if λ exceeds the appropriate chi-square value.

3.3.2 Measurement of food security. Following Mubarak *et al.* (2020), rice farmers' food security was measured using the Household Food Insecurity Access Scale (HFIAS) score. The HFIAS is a nine-item food insecurity scale developed by US Agency for International Development's (USAID) Food and Nutrition Technical Assistance (FANTA) Project which was used to measure food insecurity. Based on the response to the nine questions and frequency of occurrence over the past 30 days, households are assigned a score that ranges from 0 (food secure) to 27 (severely food insecure). A higher HFIAS is indicative of poorer access to food and greater household food insecurity (Coates *et al.*, 2007). In this study, HFIAS is calculated as follows:

$$\text{HFIAS}(0-27) = (Q\_1a + \ Q\_2a + Q\_3a + Q\_4a + Q\_5a + Q\_6a + Q\_7a + Q\_8a + Q\_9a) \tag{9}$$

3.3.3 The impact evaluation framework. A valid measure of the impact of contract farming model would be to compare the outcomes (performance level- Food security indicator) of farmers receiving support with the presumed outcomes that the same farmers would have had if they did not get that support (Al-Zabir *et al.*, 2020). Assessing the impact of any intervention thus requires making an inference about the outcome that would have been observed had the program participants not participated. Following Heckman *et al.* (1997) and Smith and Todd (2001), let Y_1 be the mean of the outcome conditional on participation, that is the treatment group, and let Y_0 the outcome conditional on non-participation, that is the control group. The impact of participation in contract farming is the change in the mean outcome caused by participating in the rice contract agreement, which is given by:

$$Y = Y_1 - Y_0 \tag{10}$$

Where Y is the impact of contract farming participation on one of the outcome variables that is food security. Y_1 and Y_0 denote outcome of the respondents when they participated in the contract farming and the counterfactual, respectively. The average treatment effect (ATE) of contract farming participation can be calculated as:

$$\text{ATE} = E(\delta) = E(Y_1 - Y_0) \tag{11}$$

Where $E(\delta)$ represents the average or expected performance level. The impact of treatment on performance level of the farmers who participated in the contract farming (treated) can be estimated as

$$\text{ATT} = E(Y_1/D = 1) - E(Y_0/D = 1), \tag{12}$$

Where ATT represents average treatment effect on the treated and D denotes the contract farming participation indicator which equals one (1) if the farmer participated in the contract farming arrangement and zero (0). $E(Y0/D = 1)$ is the mean performance level of treated in absence of the treatment, that is, counterfactual performance level. In the case of non-participant (untreated or control) group of farmers, their average performance level can be estimated as:

$$\text{ATU} = E(Y_1 - Y_0/D = 0) \tag{13}$$

Where ATU is the average treatment effect on the untreated. The estimation of ATT and ATU clearly depends on the counterfactual levels of performance level of the two groups, treated and control $\{\mathrm{E}(Y_1/D/=1)$ and $(Y_1/D/=0)\}$ and, respectively, as explained above.

In a non-experimental study like this, it is impossible to assess the counterfactual performance level of the two groups of respondent contract farming participants (treated) and non-participants (untreated or control) groups. It is possible to use the performance level of non-participants as a counterfactual for participants or the treated. This may lead to a biased estimate of the impact (ATT) as a result of selection bias (Rosenbaum and Rubin, 1983) as follows:

$$\Delta = E(Y_1/D=1) - E(Y_0/D=1). \tag{14}$$

Through expansion and rearrangement,

$$\begin{aligned} \Delta &= E(Y_1/D=1) - E(Y_0/D=1) \\ &\quad + E(Y_1/D=1) - E(Y_0/D=0), \\ \Delta &= \mathrm{ATT} + E(Y_1/D=1) - E(Y_0/D=0), \\ \Delta &= \mathrm{ATT} + \mathrm{SB} \\ \mathrm{ATT} &= \Delta - \mathrm{SB} \end{aligned} \tag{15}$$

Where SB is selection bias which arises as a result of unobservable characteristics influencing selection of respondents into treatment and control groups, respectively. If SB = 0, then the difference between the average observed performance level of treated and control groups of farmers would be given as:

$$\mathrm{ATT} = E(Y/D=1) - (Y/D=0). \tag{16}$$

However, if SB is not equal to zero then there exists selection bias; thus, estimated ATT would not be the difference in the average observed performance level of the treated and untreated (non-participants).

The main problem of evaluating the treatment effect arises because for each farmer, only one of the potential outcomes either Y_1 or Y_0 can be observed, but Y_1 and Y_0 can never be observed for the same individual simultaneously. This leads to a missing-data problem, which is the heart of the impact assessment problem (Smith and Todd, 2005). The unobservable component in Eqn 1, be it Y_1 or Y_0, is called the counterfactual outcome. For the participants (treated group), their counterfactual would be the performance level in the absence of rice contract farming model. While for the non-participants (control or untreated group), their counterfactual would be the level of performance, had they participated in rice contract farming activities. Indeed, the challenge here is that it is difficult to assess counterfactuals, thus some studies used the performance level of the control group as counterfactual. This has been proved to result in biased estimates of the effect of the treatment. Therefore, in order to eliminate selection bias, there is the need to compare the performance levels of treated and control groups which are statistically identical (Rosenbaum and Rubin, 1983; Khandker *et al.*, 2010). Rosenbaum and Rubin (1983) suggested the use of propensity score matching (PSM) approach to deal with selection bias. The PSM approach is based on the idea that by matching the outcome (performance levels) of treated and control respondents who are similar in observable characteristics, selection bias would be eliminated. The PSM is used to correct for the estimation of effects, controlling for the existence of these confounding factors based on the idea that the bias is reduced when the

comparison is performed using treated and untreated or control respondents who are as similar as possible.

Based on the forgoing discussion and following Bannor *et al.* (2020) as well as Wongnaa and Babu (2020), PSM was employed in analysing the impact of contract farming on the food security status of rice farmers. PSM was chosen over other impact evaluation/assessment techniques because it assumes that all important household characteristics determining the impact of contract farming on the food security status of rice farmers are observable. The PSM method summarizes pre- participation characteristics into a single index known as the propensity score, which makes matching feasible. The propensity score is a conditional probability estimator, and any discrete choice model such as logit or probit can be used as they yield similar results (Caliendo and Kopeinig, 2008). Thus, the PSM approach follows two steps; first, either the logit or probit model is used to estimate the probability (propensity score) of contract farming participation, using observable characteristics which influence participation in the contract farming. In this study, the logit model was used and specified as:

$$\begin{aligned} P(X) &= P(D = 1/X) \\ &= F(\beta_1 X_1 + \ldots \beta_i X_i) \\ &= F(X\beta) \\ &= e^{X\beta} \end{aligned} \tag{17}$$

where $F(.)$ denotes response probability which strictly ranges between 0 and 1, X is a vector of all observable characteristics (covariates) which influence contract farming participation and β is the parameter of interest to be estimated.

This model predicts the probability (propensity score) of contract farming participation. Given that the propensity score is a balancing score, the probability of contract farming participation conditional on X will lead to distribution of farmers' covariates X, such that these covariates will be the same for treatment and control groups. Assuming that all information relevant to contract farming participation and performance level are observable, then the propensity score will produce valid matches which can be used to estimate impact (ATT) of contract farming participation on performance levels and variable inputs at the second stage. This is done by matching the two groups of respondents based on the predicted propensity scores as follows:

$$\text{ATT} = \{(E(Y_1/D = 1.\ E(PX))) - E(Y_0/D = 1.\ E(P(X)))\}, \tag{18}$$

Where $E(P(X))$ denote the expectation with respect to the distribution of the propensity score in the entire population and $E(Y_1/D = 1)$, $P(X))$, $E(Y_0/D = 1)$ are as defined in above.

There are three different matching algorithms which involve trade-offs in terms of bias and efficiency which are used to estimate ATT. These matching estimators are Nearest Neighbour, Radius and Kernel Matching methods and are all conditional on the propensity score. Nearest Neighbour Matching (NNM) selects the control group with the smallest distance in propensity score to the treated group (farmers who are involved in contract farming). Generally, this is done with replacement, and it works well once the distribution of the propensity score of both groups (treated and control) are similar. However, NNM may lead to poor matches when the nearest neighbours are far away. Radius Matching (RM) or Calliper involves all neighbours with a maximum propensity score distance. This is normally defined *a priori*, and it corresponds to the common support assumption. RM also helps to avoid poor matches which may arise through matching too distant neighbours (Smith and Todd, 2005). Kernel-based Matching (KM) was recommended by Heckman *et al.* (1998). This is a non-parametric estimator that includes all respondents of the underlying sample of control group and weighs more distant observed characteristics among both groups (treated and control) down, thus, reducing variance. Caliendo and Kopenig (2008) noted that poorer matches could

be obtained. The KM estimator of the ATT describes the mean difference in outcome while the matched outcome is given by the Kernel-weighted average of the outcome of the control group of farmers. After matching, the ATE is calculated as the average of the outcome differences between treated and matched controls (Dehejia and Wahba, 2002; Imbens, 2004)

The PSM model works under two assumptions, namely, the conditional independence assumption (CIA) and the common support or the balancing assumption. The conditional independence assumption postulates that all the covariates must be independent of participation. This means that the selection of farmers into both groups (treatment and control groups) is exclusively based on observable covariates X which influence the propensity score. The balancing assumption or the common support assumption (CSA) postulates that participation is shaped by pre-participation characteristics. Thus, this assumption rules out the phenomenon of perfect predictability of contract farming participation ($D = 1$) given covariates X. This ensures that farmers with identical observable characteristics or covariates (X) have a positive probability of belonging to a particular group Heckman *et al.* (1998).

The second analysis of this study is to investigate the factors that affect farmers' food security from contractual rice production. Regression analysis is one of the standard methods used to assess the effect of different factors on the farmers' household food security levels. In this study, the logit model was used to estimate probability of rice farmers' contract participation. Empirically, the impact of participation in contract farming on household food security (Y) can be expressed as a function of explanatory variables $(\mathcal{X}_i)$ and a participation dummy variable (R) specified as:

$$Y = \beta\mathcal{X}_i + \alpha R_i + \varepsilon_i \tag{10}$$

Where Y is food security, R_i is the participation dummy, 1 for contracted farmers and 0 for non-contract farmers. ε_i is the error term, β and α are coefficients of the parameters to be estimated. Table 2 presents the explanatory variables that were employed in estimation of the propensity scores

4. Results and discussions

4.1 Summary statistics of the variables

Table 3 shows the characteristics of respondents in terms of percentages and frequencies of various discrete variables. The results showed that 110 representing 32.74% of the farmers

Variables		Frequency	Percentage (%)
Participation:	Contracted	110	32.74
	Non-contracted	226	67.26
Gender:	Male	243	72.68
	Female	93	27.28
Education:	Educated	137	40.77
	Illiterate	199	59.23
Marital status:	Married	313	93.15
	Single	23	6.85
Credit:	Access	275	81.85
	No Access	61	18.15
Farm location:	Irrigated area	280	83.33
	Others	56	16.67
Extension contacts:	Access	328	97.62
	No access	8	2.38
FBO Membership:	Member	328	97.62
	No member	8	2.38

Source(s): Field data, 2019

Table 3. Distribution of socioeconomic characteristics of respondents

participated in contract farming whilst 226 (67.26%) did not. Also, majority of the farmers 72.68% are males while 27.68% were females meaning that rice farming is a male dominated activity. Furthermore, many of the farmers 83.33% had access to irrigation facilities because of the presence of the Tono irrigation project and other smaller dugouts while 16.67% had no access to irrigation. Majority of the respondents representing 59% had no formal education while 41% had attained different levels of formal education. More so, 83.33% had access to input credit while 18.15% had no access to credit. This may be due to government's planting for food and jobs programme which provides a 50% subsidy on agricultural inputs such as improved seeds, fertilizer and agrochemicals. Almost all contract farmers, 98% are members of farmer based organizations even though FBO membership was insignificant, which reflects the fact that organizing themselves in small groups is a prerequisite for contracting.

Table 4 presents *t*-test comparison of means for outcome variables according to participation in contract farming. Age, education, farm distance, size of rice farm, and average producer price of paddy rice, yield of paddy, credit , marketing cost and HFIAS score show significant differences between contracted and non-contract farmers. This suggests that participation of farmers in contract farming can be affected by these variables. The average age of the farmers is 45 years and the difference between the ages of contracted and their non-contracted counterparts is statistically significant at 1%. Similar finding was reported by Bidzakin *et al.* (2018). Contracted farmers travel longer distance, 5.45 km compared to 5.03 km for non-contracted farmers to their farms, this is highly significant at 1%. The results further reveal that contracted farmers cultivate significantly larger rice fields, 0.37 ha compared to 0.29 ha for non-contracted farmers, this is also highly significant at 1%. The contracted farmers harvest paddy of 2.2 mt/ha while their counterparts harvest 1.9 mt/ha and the difference is statistically significant at 5%.

Again, contracted farmers receive a slightly high producer price, Ghs 163.06 1 per 84 kg bag of paddy compared to Ghs 162.212 for non-contract farmers. This may be due to the bonuses processing and marketing firms pay for quality and timely delivery of products.

	Contract (N = 110)		Non-contract (N = 226)		All (336)		
Variables	Mean	Std error	Mean	Std error	Mean	Std error	t stat
Age	47.50	0.92	44.14	0.60	45.24	0.51	3.116***
Education	0.47	0.05	0.38	0.03	0.41	0.02	1.693*
HH size	5.49	0.17	5.22	0.12	5.31	0.10	1.254
Yield	2,206.91	144.94	1957.27	74.43	2039.00	69.15	1.699*
Farm Dist	5.45	0.09	5.03	0.05	5.16	0.05	4.409***
Experience	7.55	0.34	7.09	0.20	7.24	0.17	1.235
Farm size	0.37	0.02	0.29	0.01	0.32	0.01	3.343***
Av. Price	163.06	0.43	162.21	0.27	162.49	0.23	1.720*
Farm Inc	3431.85	249.41	3212.28	136.11	3284.17	122.89	0.840
Credit	474.64	23.67	370.13	10.46	404.34	10.78	4.687***
Market cost	184.04	12.06	162.78	6.23	169.74	5.77	1.733*
Farm loc	0.85	0.03	0.82	0.02	0.83	0.02	0.726
FBO mem	0.91	0.02	1.00	0.00	0.93	0.06	1.293
HFIAS	2.21	0.26	2.70	0.16	2.54	0.14	1.673*

Note(s): *significance at 10%; **significance at 5%; *** significance at 1%
Source(s): Field data, 2019

Table 4.
Mean comparison for outcome variables according to participation in CF

Furthermore, the results indicate that contracted farmers utilize more inputs such as fertilizer and improved seeds on credit (Ghs 474.633) compared to that of non-contracted farmers (Ghs 370.134). The difference in the amount of credit received is highly significant at 1%. This outcome could be attributed to fact that contracted farmers receive inputs on credit from contracting firms although both groups have equal access to inputs under the planting to food and jobs programme.

Also, the expenditure diffference about marketing cost, such as transportaion, handling charges, tax (council fees), showed that contract farmers pay some Ghs 21.26 5 more than the non-contracted farmers and the difference is statistically significant at 10%. These results confirm earlier revelation that contracted farmers travel longer distance (5.45 km) and will have to transport their paddy from their farms a longer to designated delivery centres. Finally, the food security measures show a significant difference between the HFIAS score of contracted and non-contracted at 10%. This implies that contract farmers are more food secure than their non- contracted counterparts.

4.2 Factors that influence participation and the extent of contract farming

The results of the probit, tobit and truncated regression models employed in determining the factors that influence farmers' discrete decision to participate in contract farming as well as the quantity of paddy rice to contract are presented in Table 5. The computed likelihood ratio statistic is 265. 36 which is well above the critical likelihood ratio value of 26.22. Since, the computed likelihood ratio is more than the tabulated likelihood ratio, we can reject the restricted (Tobit) model and infer that the unrestricted (Cragg's) model is better. Therefore, we can say that the Cragg's model better suits this paper than the tobit model. This also implies that the decisions about farmers' participation in contract farming and the quantities of paddy rice to contract are jointly made. Hence, subsequent discussions are based on the findings of the Cragg's model. The likelihood ratio statistic is statistically significant at 1% indicating that at least one of the regression coefficients in the model is not equal to zero. The results showed that farmers' participation in contract farming is influenced by yield of paddy and farm income.

The coefficient of yield of paddy is positively related to quantity of paddy contracted and is statistically significant at 1%. Specifically, an increase in the yield of a rice farmer by one kg/ha will increase the quantity that he/she will be willing to contract by 1.691. This is true as Table 4 also presents statistically significant relatively higher yields for contracted farmers. This implies that farmers will prefer to sell more of their produce at harvest through contract agreements. This is not surprising because the higher the yield, the more the farmers will seek participation in contract farming for enhanced prizing of their harvests through a presumed secure and profitable marketing channel. This confirmed the work of Bidzakin *et al.* (2018) that rice farmers engaged in contract farming are more production efficient and harvest higher yields. This is accounted for by the incentives provided by the contracting firms to engage in contract farming which contribute to optimizing yield. This result is also consistent with Ragasa *et al.* (2017) who revealed that contract participation led to improvement in yield. The findings of this paper about the

Variable	Sample	Treated	Control	Difference	S.E.	*T*-stat
HFIAS	Unmatched	1.9894	2.6296	−0.6403	0.3023	−2.12**
	ATT	1.8652	2.9548	−1.0896	0.3390	−3.21***

Note(s): SE denotes standard errors and ***significant at 1%, **significant at 5%, *significant at 10%
Source(s): Field Survey, 2019

Table 5. Effect of participation on in CF on farmers' food security

positive relationship of contract farming also confirms the work of Wang *et al.* (2014) who suggests that contract farming has a substantial influence on enhancing farm competence, productivity and incomes. The results also reveal that farm income is statistically significant at the 1% level and has a negative influence on quantity of paddy contracted. The result further show that as a farmer's wealth increases by Ghs 1, the quantity of paddy contracted will decrease by 0.470 (Table 6). This does not agree with the results in Table 4 that reports no significance even though there is a difference of about Ghs 2,206 in income between contracted and non-contracted farmers. This implies that farm income plays a lead role in deciding the quantity of paddy to contract in contract agreements. This finding suggests that farmer's financial endowment decreases the probability of participating in contract farming. This again reflects that contract farming helps less endowed farmers to cultivate cash crop such as rice. This finding corroborates Miglani (2016) who posits that as onion farmers' wealth increased, their likelihoods of contract farming participation decreased. It further revealed that farmers with low financial resources were more likely to produce under contract.

4.3 Food security level among rice farmers

The food security status among the rice farmers in the municipality is presented in Figure 2. The results from the study revealed that a majority 78% of the respondents were food secure and about 22% were food insecure. This clearly indicates that rice farmers in the Kassena-Nankana Municipality were food secure since over three-quarters of the respondents were food secure.

This result was inconsistent with the findings of Wiggins and Keats (2013) who reported that about 67% of the world's food insecure is found among smallholder farming household because smallholders are net buyers of food than seller of same. The result also contradicted the UNDP 2014 report that categorized Kassena-Nankana Municipality to be among the five

	Probit		Tobit		Truncated	
Participation	Coeff	SE	Coeff	SE	Coeff	SE
Age of farmer	0.027*	0.012	42.38*	18.13	−4.449	4.557
Sex	−0.792***	0.187	−1222.0***	296.9	45.48	72.40
Education	0.497**	0.172	709.8*	273.9	−58.07	64.93
Experience	0.010	0.027	−14.53	41.99	−6.843	9.868
Household size	0.017	0.056	70.66	90.32	16.69	24.40
Farm size	1.828*	0.886	2,300.67*	1225.7	−540.05	334.49
Farm distance	0.353***	0.111	330.7*	153.9	47.43	38.43
Farm location	−0.232	0.226	−377.3	374.1	−112.92	110.13
Extension contacts	0.053	0.449	−262.7	686.2	−180.25	157.69
Credit	−0.013	0.244	−317.3	394.5	−175.25	109.58
Yield of paddy	0.021**	0.001	3.208*	1.030	1.691***	0.307
Average price	0.044*	0.022	81.18*	33.74	9.363	8.528
Assets of farmer	−0.001***	0.000	−1.754***	0.554	−0.470***	0.162
Constant	−11.01***	3.596	−18033.7***	5596.4	−927.99	1447.07
Number of obs	336		336		110	
LR χ^2 (13)	77.43***		102.15***		1768.78***	
Pseudo R^2	0.1822		0.0451			
Log likelihood	−173.74		−1082.21		−775.79	
Likelihood ratio statistic	265.36					

Note(s): SE denotes standard errors and ***significant at 1%, **significant at 5%, *significant at 10%
Source(s): Field Survey, 2019

Table 6.
Determinants of participation in contract farming

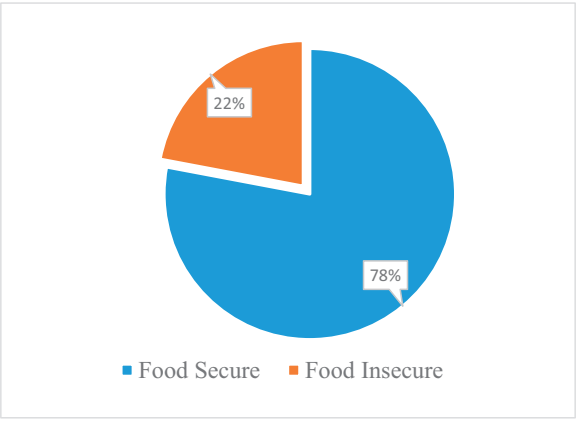


Figure 2.
Food security level among rice farmers

districts in Ghana that are identified with the highest proportion of households who are either severely or moderately food insecure.

4.4 The impact of contract farming on farmers' food security status

The PSM method was adopted to estimate the impact of contract farming on the food security status of rice farmers. The propensity scores (PS) were generated using the logit model. The results of the logit model are the same as the results in the double hurdle model and would be discussed in that section.

Table 6 presents the result of the balancing test between the covariates of contract and non-contract farmers. The non-significance of the coefficients and the low pseudo R^2 shows that the covariates between the two groups are actually balanced after matching (see Table 7).

We adopted the KM algorithm to estimate the ATT, which provides the impact of contract farming on the farmers' participation in contract farming. The results of the PSM indicated in Table 6 below showed that 216 respondents were used as the counterfactual. Using the HFIAS, rice farmers were classified into food secure and food insecure on the scale of 0–27. The score is expected to show by how much the proportion of the households reduce their mean scores by virtue of their participation in contract farming. The results of the KM show that the HFIAS of the contract farmers decreased significantly by 1.089. The relative effect on the HFIAS was significant at 1% level and reduced the proportion of the food security score by 109%, that is, a significant improvement in participants' food security level. This may be achieved through the increment in the revenues from the sale of paddy rice. Specifically, there is an increment in the total income by GHS 2007 using the KM algorithm. This outcome is consistent with the findings of Soullier and Moustier (2018) and Barthelemy *et al.* (2016) who observed that participation in contract farming had slight improvement in food security.

Sample	Ps R^2	LR χ^2	$p > \chi^2$	Mean bias	MedBias	B	R	Var
Unmatched	0.238	22.33	0.055	10.1	5.5	130.6*	1.12	22
Matched	0.326	17.30	0.241	8.1	6.1	136.1*	0.45*	44

Source(s): Author's estimations (2019)

Table 7.
PSM quality indicators before and after matching

5. Conclusion and policy implications

This study evaluated the impact of contract farming on the food security levels of farmers from rice contract production. The study used data collected from 336 farmers stratified by participation in contract farming. It used PSM to assess the impact of participating in contract schemes. It also used a double-hurdle model to analyse the factors that influence farmers' decision to participate in contract farming and the proportion of production to contract. In estimating the food security levels of the farmers, the results showed that majority (78%) of the farmers scored between 0 and 4 on the HFIAS and thus, were classified as food secure while 22% scored between 5 and 27 and hence, were classified as food insecure. The results of the propensity score matching showed that participating in contract farming had a positive and significant effect on farmers' food security. It improved the food security score by 109%. Contract farming had positive impact on food security, the results confirm the findings of Bellemare (2010) and Bellemare and Navak (2017).

The Cragg's double-hurdle model results relating to the determinants of farmers participation in contract farming as well as the quantity of paddy contracted revealed that these two joint decisions were influenced by almost the same set of factors. The results show that the factors that influence the quantity of paddy to contract in contract farming agreement are the yield of paddy rice and the farm income of the farmers. These factors significantly influence both the probability of participation and the quantity of paddy rice at the 1% level. The paper concludes that participation in contract farming improves the food security of participating farmers. Thus, facilitating access to high yielding technologies (improved seeds, fertilizers, agrochemicals) and technical support are crucial for optimizing yield, increased incomes and improved livelihoods for farmers. The implication of these findings is that contract farming can help increase productivity, sustainably supply raw materials to agro-based industries and improve food security.

Therefore, policies that will make it easier for farmers to participate in contract farming should be pursued. These include the recommendation that the government enacts a contract farming act to regulate agribusiness activities in Ghana in line with the industrialization agenda of One District One Factory and One Village One Dam. Also, Ghana agricultural policies need to consider promoting and expanding contract farming interventions by adequately providing incentives such as input subsidies, tax waivers and strengthening of farmer-based organisations' marketing skills. Finally, there should be supporting rural infrastructure that will make it easier for smallholder farmers to participate in contract farming. Improvements in road networks and irrigation schemes to ensure all year-round rice production is the very key in facilitating farmer participation in contractual agreements.

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