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Rice Marketing Outlets, Commercialization, and Welfare: Insights From Rural Ghana

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ABSTRACT

We investigated rice marketing outlets, commercialization, and welfare implications in rural Ghana. Primary data was gathered from 225 rural rice farmers. Fractional response, multinomial logistic, multivariate probit, and propensity score matching were estimated. Rice farmers in rural Ghana sell at farm gates, processing centers, local, district or regional capital markets. Rice marketing outlets are wholesalers, retailers and rice millers. About 62% of farmers produce rice mainly for sale, and 70% of rice produced in rural Ghana is sold. Majority of producers are high or medium commercialization rice farmers. Thus, rice commercialization (market participation) in rural Ghana is high. Credit, association membership, farm size, irrigated rice production, and commercial production enhance rice commercialization. However, rice commercialization reduces with education, household size, and distance to district capital. Welfare is highest for high commercialization rural rice farmers compared with low and medium commercialization farmers. Rice commercialization has positive implications on rural farmers' welfare.

KEYWORDS

Commercialization; fractional response regression; propensity score matching; rice marketing outlets; rural Ghana; welfare

Introduction

Rice production and marketing serve as a predominant source of income in Ghana (Donkoh, 2020), especially rural areas. Due to the increasing rice consumption in Ghana, its production has increased over the years. For instance, rice production increased from 44% in 2016 to 47% in 2017 (MoFA, 2017). Nevertheless, Ghana still imports rice to supplement local production (MoFA, 2017). Ghana government and non-governmental organizations (NGOs) have invested considerably in rice production to minimize importations. Also, rice farmers are encouraged to engage in

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high commercialization to boost production and productivity (Donkoh, 2020). Rice commercialization is expected to translate into poverty reduction and welfare enhancement in rural localities where majority of rice is produced.

In Ghana, rice is mostly cultivated in swampy areas because of insufficient irrigation dams (Amfo, Osei Mensah, et al., 2021). There is the need for a sustainable increase in rice production to meet the growing consumption in Ghana (Amfo, Osei Mensah, et al., 2021; Donkoh, 2020). Therefore, it is crucial to harmonize agricultural programmes/policies with national and global goals. For instance, agricultural programmes/policies aimed at increasing productivity should be synchronized with Sustainable Development Goals (SDGs) 1 and 2 (MoFA, 2017). This is because SDGs 1 and 2 aim at eradicating poverty and hunger by 2030 (MoFA, 2017). Therefore, they are crucial for the enhancement of food security and welfare of farmers in developing countries (Donkoh, 2020). Hence, choice of appropriate marketing outlets and agricultural commercialization are vital in improving agricultural production and productivity, and consequently, attaining SDGs 1 and 2. These would further enhance farmers' income, and thus, their welfare.

Food and Agriculture Sector Development Policy (FASDEP I and II), a key agricultural policy documents of Ghana, aims at enhancing commercial crop production, with the objective of improving farmers' income (MoFA, 2007). Agricultural commercialization involves the production of surplus farm produce and good postharvest handling practices like value addition (Kunze, 2003). Agricultural commercialization enhances food security, income, and welfare of rural households (Donkoh, 2020). Thus, there are government, NGO and donor organizations that promote agricultural commercialization in Ghana: Ghana Commercial Agricultural Project, Council for Scientific and Industrial Research, Ghana Grains Council, Presbyterian Agricultural Services, Resilience in Northern Ghana, National Seed Council, and Peasant Farmers Association, and programmes like Planting for Food and Jobs, and Planting for Export (Donkoh, 2020). These organizations and programmes train and build farmers' capacity to take agriculture as a business by aiming at commercial production and choice of appropriate marketing outlets.

Rural households in Ghana, mostly agrarians, continue to be the poor majority (GSS, 2018). For instance, in 2005/06, poverty in rural areas of Ghana was 43.7% as against 12.4% in urban areas; and in 2016/17, it was 39.5% in rural areas as against 7.8% in urban areas (GSS, 2018). This raises concerns about measures to reduce poverty, and raise the living standards and welfare of farmers in rural Ghana. Emerging arguments tend to call for agricultural commercialization. Thus, this study assesses the choice of

marketing outlets/options by rice farmers in rural Ghana, and the implications of commercialization on rural rice farmers' welfare.

In Ghana, rice and other crops are chiefly produced in rural areas. Meanwhile, Ghana's rural population continues to decline. For instance, Ghana's rural population was 50.65% in 2008, which declined to 47.23% in 2012, further declined to 44.59% in 2016, and 43.29% in 2019 (World Bank, 2019). This could be attributed to huge disparities in economic opportunities between rural and urban areas of Ghana, which often leads to rural-urban migration. Poverty, poor living standards and welfare are key developmental focus in rural areas of Ghana. There are 25,855,315 agricultural households with a population of 11,340,947 persons in Ghana (GSS, 2019). The population of agricultural households in rural areas of Ghana is 8,527,553 (75.20%) of which majority are into crop production (GSS, 2019). This indicates that agriculture, especially crop production, is the predominant source of livelihood in rural areas of Ghana. Therefore, agricultural development in Ghana is heavily linked to rural development. Likewise, rice is a major economic activity for rural folks in major rice producing regions/districts of Ghana (GSS, 2019). Hence, any intervention aimed at improving rice production is likely to boost the welfare of most rural households in major rice producing localities of Ghana. This calls for research on rice production and marketing in rural Ghana.

One way of reducing poverty and enhancing the living standards and welfare of rural folks is raising their awareness to engage in agricultural production as a business activity (Donkoh, 2020). For instance, choice of appropriate marketing outlets and commercialization could have welfare implications for rural folks in major rice producing communities. Thus, unlike most studies which focused on rice commercialization among farmers in general (such as Abdullah et al., 2019; Agwu, Anyanwu, & Mendie, 2012; Donkoh, 2020), this study narrowed down to rural folks, due to their keen involvement in rice production in the country.

As defined by FAO (2018), a marketing outlet, in this study, refers to an institution or agent through which rice is sold. Hence, it refers to places where farmers sell rice, and marketing agents they sell to. It entails the movement of goods (rice) from producers to consumers (Armestrong & Kotler, 2004). Reliable marketing outlets motivate farmers to boost output and shift from subsistence to commercial farming (Czinkota & Ronkainen, 2007).

Commercialization of agriculture could take place on the output side (increased market surplus) or input side (increased use of inputs) (Abdullah et al., 2019). In this study, rice commercialization refers to the sale of marketable surplus of rice (Martey, Al-Hassan, & Kuwornu, 2012) to meet household expenditure of farmers. Therefore, commercialization implies transition from subsistence-oriented rice production to market-

oriented production (Martey et al., 2012). Moving from subsistence to commercial production is vital for economic development, since its raises income levels, improves food security and welfare of farming households (Carletto, Corral, & Guelfi, 2017). However, commercialization affects people differently based on prevailing factors like socioeconomic status and institutional conditions (Abdullah et al., 2019). Thus, this study further analyzed the drivers of rice commercialization.

Many empirical studies have been conducted on marketing outlets and commercialization. Adams, Wongnaa, and Coleman (2021); Tura and Hamo (2018); Wosene, Ketema, and Ademe (2017); Melese, Goshu, and Tilahun (2017); Negeri (2017) assessed the determinants of market outlet choices by farmers. Moreover, Donkoh (2020); Abdullah et al. (2019); Carletto et al. (2017); Kabiti, Raidimi, Pfumayaramba, and Chauke (2016); Muriithi and Matz (2015); Hailua, Manjureb, and Aymutc (2015); Tufa, Bekele, and Zemedu (2014); Martey et al. (2012) assessed agricultural commercialization. Donkoh (2020) observed that rice commercialization in Ghana is positively influenced by sex, output, off-farm income, but negatively influenced by farm size, access to credit, and being a household head. Abdullah et al. (2019) reported that age, number of family members who assist in farm work, household size, vocational training, and farmer being landlord positively affect market participation. Kabiti et al. (2016) reported that farmers in Zimbabwe were moderately commercialized for both input and output sides. Martey et al. (2012) found that the degree of maize and cassava commercialization were 53% and 72% respectively. The study found the output price, farm size, access to extension services, distance to market and access to market information influence maize and cassava commercialization.

Nonetheless, majority of these studies focused on the determinants of agricultural commercialization. They also focused on rice commercialization among farmers in general. Furthermore, notwithstanding, the associated benefits of agricultural commercialization, rice commercialization in Ghana rather appears to be low. Rural folks are the major rice producers in developing countries, like Ghana, and poverty and poor welfare are rife in rural areas than urban areas. Thus, this study examines rural rice farmers' choice of marketing outlets in Ghana, and implications of rice commercialization on rural farmers' welfare. The specific research objectives are as follows:

1. To investigate the marketing outlets/options used by rural rice farmers in Ghana, and the determinants.
2. To examine the level of commercialization (market participation) by Ghana's rural rice farmers.
3. To investigate the determinants of rice commercialization.
4. To explore the impacts of commercialization on rural rice farmers' welfare in Ghana.

Materials and methods

Data, sampling and data collection

The study was conducted in rural areas of Northern, Ashanti and Upper East Regions of Ghana. These regions were selected due to their high levels of rice production. In each region, one major rice producing district was further sampled: Savelugu Municipal from Northern Region, Atwima Mponua District from Ashanti Region, and Kassena Nankana East District from Upper East Region. Rice production is a major source of livelihood for majority of rural folks in these districts (Amfo, Abdul-Rahaman, & Issaka, 2021).

Primary data was gathered from 225 rural rice farmers. GSS (2013) defines a rural area as a village/community with less than 5,000 population. Thus, only villages/communities with less than 5,000 inhabitants were sampled for the study. Multistage sampling technique was employed. In the first stage, lists of major rice-producing rural communities in Savelugu Municipal, Atwima Mponua District, and Kassena Nankana East District were obtained from the respective district level Ministry of Food and Agriculture offices. Five communities were randomly selected from each of the three districts. In the second stage, simple random sampling was employed in selecting 15 rice farmers from each of the 15 rural communities. This led to a total sample size of 225 rural rice farmers, constituting 75 from each of Northern (Savelugu Municipal), Ashanti (Atwima Mponua District), and Upper East Regions (Kassena Nankana East District).

A semi-structured questionnaire was used for the data collection through face-to-face interaction with rice farmers in November 2020. Six field assistants (agricultural extension officers) assisted in the data collection. These field assistants were indigenes of the respective study districts, and were, therefore, proficient in the local dialects (Dagbani, Asante Twi and Kassena Nankana in Savelugu Municipal, Atwima Mponua District, and Kassena Nankana East District respectively). Moreover, all the field assistants had experience in data collection. Nonetheless, the authors (researchers) had a thorough discussion of the survey questionnaire with the field assistants. The validity and reliability of the questionnaire were tested in a pilot survey. In this case, each field assistant administered two questionnaires to rice farmers. The actual data collection was carried out in the 15 sampled rural communities.

Ethical issues were considered. Enumerators sought the consent of respondents by explaining the rationale for the research before administering the questionnaires. The enumerators further assured the confidentiality of respondents' identity and information given. Moreover, the respondents were informed that participation in the survey was voluntary. The data

collection exercise took into account all Coronavirus (COVID-19) related restrictions. Thus, COVID-19 protocols—social distancing and wearing of face mask—were observed by enumerators and respondents during data collection.

Analytical framework

To examine the level of rice commercialization (market participation), the categorization given by Asuming-Brempong, Anarfi, Arthur, and Asante (2013) was adopted: low (<30% of rice output sold), medium (30–75% of rice output sold), and high (>75% of rice output sold). Determinants of rice commercialization were investigated using fractional response and multinomial logistic regressions. Propensity score matching (PSM) was used to explore the impacts of commercialization on rice farmers' welfare. Household consumption expenditure per capita per annum was used as a proxy for welfare.

Fractional response regression

Fractional regression model accommodates outcome variables that range from 0 to 1, such as proportions (Bayes, Bazan, & Garcia, 2012; Papke & Wooldridge, 1996; Xu & Long, 2005). The outcome variable in this study—proportion/share of rice output sold by a farmer—is continuous and bounded from 0 to 1. Linear regression models such as Tobit, truncated, hurdle and quantile regressions are inappropriate for this nature of outcome variable since they do not take into consideration the asymmetries between variables (Papke & Wooldridge, 1996; Wooldridge, 2010). Thus, fractional regression model was developed for estimating bounded continuous outcome variables; that is data bounded from 0 to 1 (Bayes et al., 2012; Papke & Wooldridge, 2008; Xu & Long, 2005). Unlike linear regression models whose predictions are not constrained from 0 to 1, predictions from fractional regression model are confined from 0 to 1. Fractional model is a generalized linear model which is suitable for estimating data restrained by upper (1) and lower (0) limits (Bayes et al., 2012; Wooldridge, 2010).

The outcome variable for the fractional response regression in this study was proportion of rice output sold by farmers. Primary data obtained through the field survey revealed that there were few rice farmers who did not sell rice at all while others sold all rice harvested in the 2018/2019 farming season (Table 4). Thus, proportion of rice sold by these farmers was 0% or 100% respectively. This resulted in an outcome variable that is greater than or equal to 0 and less than or equal to 1 $[0 \leq y \leq 1]$. Hence, the fractional regression was valid for the data (in lieu of beta regression whose outcome variable takes values between 0 and 1).

Fractional regression is a model of the mean of the outcome variable y conditional on covariates x, denoted by μ_x (StataCorp, 2015). Since y is in [0, 1], it must be ensured that μ_x is also in [0, 1]. This is done by using a probit or logit for μ_x (StataCorp, 2015). This study employed both probit and logistic fractional regressions. According to StataCorp (2015), log-likelihood function for fractional regression is expressed below:

$$lnL = \sum_{j=1}^{N} w_j y_j ln\left\{G\left(x_j'\beta\right)\right\} + w_j(1-y_i)\ ln\{1-G\ \left(x_j'\beta\right)\} \tag{1}$$

where N is sample size (225 rice farmers); y_j is the outcome variable (proportion of rice output sold); w_j is the optional weight; lnL is maximized. $G(.)$ could be:
where x_j are covariates for individual j, and ϕ is standard normal cumulative density function (StataCorp, 2015). Table 1 shows the variables used for the fractional response regression.

Fractional regression model	Functional form for G $\left(x_i'\beta\right)$
Probit	$\phi\ \left(x_j'\beta\right)$ (2)
Logit	$\exp\left(x_j'\beta\right)/\{1+\exp\left(x_j'\beta\right)\}$ (3)

Multinomial logistic regression

Multinomial logistic regression is suitable for categorical response variables with more than two outcomes, and the outcomes have no natural ordering (StataCorp, 2015). The response variable for the multinomial logistic regression is level of rice commercialization: 0 = low, 1 = medium, and 2 = high. Thus, there are three outcomes, 0, 1, 2, recorded in y. According to StataCorp (2015), multinomial logistic regression estimates a set of coefficients, $\beta^{(0)}$, $\beta^{(1)}$, *and* $\beta^{(2)}$, corresponding to each outcome:

$$\Pr(y=0) = \frac{e^{X\beta^{(0)}}}{e^{X\beta^{(0)}} + e^{X\beta^{(1)}} + e^{X\beta^{(2)}}} \tag{4}$$

$$\Pr(y=1) = \frac{e^{X\beta^{(1)}}}{e^{X\beta^{(0)}} + e^{X\beta^{(1)}} + e^{X\beta^{(2)}}} \tag{5}$$

$$\Pr(y=2) = \frac{e^{X\beta^{(2)}}}{e^{X\beta^{(0)}} + e^{X\beta^{(1)}} + e^{X\beta^{(2)}}} \tag{6}$$

Nonetheless, the model is unidentified since there are more than one solution to $\beta^{(0)}$, $\beta^{(1)}$, *and* $\beta^{(2)}$ which results in the same probabilities for $y=0$, $y=1$, and $y=2$. 0 = low rice commercialization was used as the base outcome. Thus, to identify the model, $\beta^{(0)}$ was arbitrarily set to 0. Hence, the remaining coefficients, $\beta^{(1)}$ (medium commercialization), and

Table 1. Variables used for the fractional response and multinomial logistic regressions.

Variable	Definition
Outcome variables	
Proportion of rice output sold	Fraction of total rice output sold [0, 1]
Level of rice commercialization	0 = low (<30% of rice output sold), 1 = medium (30–75% of rice output sold), 2 = high (>75% of rice output sold)
Predictor variables	
Sex	1 = male, 0 = female
Age	Years
Education	Years
Off-farm occupation	1 = yes, 0 = no
Household size	Number
Extension contact	1 = yes, 0 = no
Credit	1 = yes, 0 = no
FBO	1 = yes, 0 = no
Information sources	Number of information sources owned/used—radio, television, mobile phone and social media
Distance to district capital	Kilometers
Farm size	Hectares
Production method	1 = irrigated, 0 = rain-fed
Purpose of production	1 = commercial, 0 = subsistence

$\beta^{(2)}$ (high commercialization), measured changes in rice commercialization relative to $y = 0$ (low commercialization). Table 1 shows the variables used for the multinomial logistic regression.

Propensity Score Matching (PSM)

To estimate the impacts of commercialization on welfare, PSM compares differences in outcomes between treated group (high commercialization rice farmers) and comparison group (low/medium commercialization rice farmers). To assess average welfare impacts of rice commercialization, average Treatment Effect (ATE) compares average outcomes of the treated group with that of the control/comparison group. Nevertheless, a non-experimental estimation technique like Average Treatment Effect on the Treated (ATT) is needed. Rice commercialization is voluntary. Thus, there is potential for selection bias, where only outcomes of nonrandom subsample assigned to the treatment are observable. In this case, PSM is used to match high commercialization rice farmers and low or medium commercialization farmers who are similar in characteristics. Average Treatment Effect on the Untreated (ATU) estimates welfare impacts that commercialization would have had on rice farmers who did not commercialize rice (Heinrich, Maffioli, & Vázquez, 2010). Nearest neighbor matching method was used to estimate propensity scores (to match untreated/comparison and treated units).

Welfare impact of commercialization (treatment) on a rice farmer, i, is the difference between the potential outcome for the treatment and potential outcome in the absence of the treatment:

$$\delta_i = Y_{1i} - Y_{0i} \tag{7}$$

where δ_i is the welfare impact of rice commercialization, Y_{1i} and Y_{0i} are potential outcomes for a rice farmer in the presence and absence of the treatment respectively. Thus, the observed outcome Y for a rice farmer is Y_{1i} if he/she is high commercialization, and Y_{0i} if low or medium. The mean impact of commercialization, ATE, is expressed below:

$$ATE = E(\delta) = E(Y_1 - Y_0) \tag{8}$$

where E is the expected value. ATT is expressed below:

$$ATT = E(Y_1 - Y_0 |\ D = 1) \tag{9}$$

where D is a binary variable indicating treatment status of farmers. That is $D = 1$ for high commercialization rice farmers, and $D = 0$ for low or medium commercialization rice farmers. ATU is expressed below:

$$ATU = E(Y_1 - Y_0 |\ D = 0) \tag{10}$$

These parameters depend on the control group; and thus, unobservable. Therefore, ATT is rewritten as:

$$ATT = E(Y_1 |\ D = 1) - E(Y_0 |\ D = 1) \tag{11}$$

where the second term, $E(Y_0 |\ D = 1)$, is the average outcome that treated rice farmers would have obtained in the absence of treatment. The error term, $E(Y_0 |\ D = 0)$, is observable. This is the value of Y_0 for untreated individuals. Thus, the welfare impact of rice commercialization is estimated as follows:

$$\Delta = E(Y_1 |\ D = 1) - E(Y_0 |\ D = 0) \tag{12}$$

$$\Delta = E(Y_1 |\ D = 1) - E(Y_0 |\ D = 1) + E(Y_0 |\ D = 1) - E(Y_0 |\ D = 0) \tag{13}$$

$$\Delta = ATT + E(Y_0 |\ D = 1) - E(Y_0 |\ D = 0) \tag{14}$$

$$\Delta = ATT + SB \tag{15}$$

where the second term, SB, is selection bias (difference between treated and untreated outcomes in the absence of treatment). ATT is the difference between the mean observed outcomes for treated and untreated:

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

Results and discussion

Socioeconomic characteristics of rural rice farmers

Socioeconomic characteristics of rural rice farmers are illustrated in Table 2. More than half of low commercialization rural rice farmers were from Upper East Region, while majority of high commercialization were from Ashanti Region. Averagely, all the three regions of Ghana had reasonable proportions of low, medium and high commercialization rural farmers. Males formed majority of all the three categories of rice commercialization

farmers—more than 65% in each case. In Ghana, males are mostly household heads and the main bread winners for their respective families (Amfo, Osei Mensah, et al., 2021). Therefore, men mostly take decisions regarding the quantity of farm produce to sell. The average age for low, medium and high commercialization rice farmers was almost the same (45 years). Low commercialization farmers had the highest years of formal education, while medium commercialization farmers had the least. Less than 40% each of low, medium and high commercialization farmers had off-farm occupations, though high commercialization farmers recorded the highest.

Average number of household members for each of three categories of rice farmers is seven. High commercialization rural farmers recorded the highest average annual household income in the 2018/2019 farming season, while low commercialization farmers recorded the lowest. Low commercialization farmers reserve higher proportions of rice for household consumption, cultivation, and gift for loved ones (which is particularly common in Ghana). This reduces their income levels compared with high commercialization farmers who sell higher proportions of rice. More than half of high and low commercialization rural farmers had extension contacts in the 2018/2019 season, compared with less than half of medium commercialization farmers. All the low commercialization farmers obtained credits in the 2018/2019 season, compared with 20% and 30% of medium and high commercialization farmers respectively. This could be because low commercialization farmers may not have enough funds for agricultural production due to their low income status. Association membership of the three categories of rice farmers did not differ much, though high commercialization farmers recorded the highest.

Average number of information sources—radio, television, mobile phone and social media—owned/used by rural rice farmers was two. Distance to district capital was highest for low commercialization farmers, and lowest for high commercialization farmers. This indicates that high commercialization farmers reside closer to district capitals than low commercialization farmers. Farm size was highest for high commercialization farmers, and lowest for low commercialization farmers. This suggests that high commercialization farmers cultivate larger farms than low commercialization farmers. More than half of high commercialization farmers used irrigation for rice production, compared with about 25% and 40% of low and commercialization farmers respectively. Compared with rain-fed rice production, irrigation is capital intensive. Thus, it is likely that farmers who produce for commercial purpose would engage in irrigated rice cultivation.

Table 2 further shows socioeconomic characteristics of rural rice farmers on regional basis. The table reveals that rice production in Ghana is a male-dominated activity. Rice production in Ghana is labor intensive and

Table 2. Socioeconomic characteristics of rural rice farmers.

	Level of commercialization				Region				
Variable	Low ($n = 20$)	Medium ($n = 77$)	High ($n = 128$)	One-way ANOVA (F-statistic)	Northern ($n = 75$)	Ashanti ($n = 75$)	Upper East ($n = 75$)	One-way ANOVA (F-statistic)	Aggregate $N = 225$
Region	n.a.	n.a.	n.a.	8.48***	n.a.	n.a.	n.a.	n.a.	n.a.
Northern (%)	30.000	35.060	32.810	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ashanti (%)	15.000	22.080	42.970	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Upper East (%)	55.000	42.860	24.220	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sex (1 = male)	0.750	0.675	0.672	0.28	0.733	0.613	0.693	1.10	0.680
Age (years)	45.450	43.000	45.555	1.24	45.213	44.813	43.987	1.25	44.671
Education (years)	9.550	7.494	9.055	1.09	9.120	8.053	8.520	3.64***	8.564
Off-farm occupation (1 = yes)	0.250	0.221	0.398	5.80**	0.387	0.333	0.253	1.09	0.324
Household size	7.950	7.351	6.883	0.87	7.840	6.053	7.520	1.28	7.138
Annual income (US$)	1609.3	1750.1	3397.2	1.36*	2013.2	3938.5	2072.1	1.42**	2674.6
Extension contact (1 = yes)	0.550	0.442	0.672	6.40**	0.680	0.573	0.493	0.98	0.582
Credit (1 = yes)	0.100	0.208	0.305	5.18**	0.213	0.333	0.213	2.87*	0.253
FBO (1 = yes)	0.350	0.325	0.430	1.71	0.253	0.400	0.507	1.80	0.387
Radio (1 = yes)	0.400	0.636	0.656	3.09*	0.627	0.613	0.640	0.11	0.627
Television (1 = yes)	0.650	0.753	0.758	0.62	0.773	0.733	0.733	0.00	0.747
Mobile phone (1 = yes)	0.900	0.935	0.914	0.02	0.933	0.893	0.933	0.81	0.920
Social media (1 = yes)	0.250	0.143	0.188	0.00	0.227	0.120	0.187	1.14	0.178
Total information sources	2.200	2.481	2.516	0.99	2.560	2.373	2.493	0.39	2.476
Distance to district capital (kilometers)	21.250	12.597	7.594	27.11***	10.467	13.333	7.760	15.52***	10.520
Farm size (hectares)	0.825	1.148	2.136	2.69***	2.252	1.659	1.133	6.09***	1.681
Production method (1 = irrigated)	0.242	0.429	0.550	12.54***	0.000	0.000	1.000	669.00***	0.333

Note: n denotes number of observations. n.a. denotes not applicable. *, **, and *** denote statistical significance at 10%, 5%, and 1% respectively.

tedious due to inadequate farm machineries. Men are more likely to have the energy and resources for rice production than women. Married women usually assist their husbands in rice production. Averagely, a rice farmer is 45 years, and completed Class/Primary six. However, some rice farmers had up to tertiary education while others have no formal education. About one-third of rice farmers had off-farm economic activities. Rice farmers had about seven members in their households. This could be a source of family labor for rice production. For instance, children are mostly used in bird scaring on rice farms. Average annual household income of rice farmers was US$2600. About 60% of rice farmers had extension contacts in the 2018/2019 season. This is low considering the role of extension agents in educating farmers on new and improved production activities. A quarter of rice farmers obtained credit in the 2018/2019 farming season. Also, less than half of the farmers belonged to farmer associations.

Rural rice farmers owned/used an average of two sources of information. Average distance from farming communities to district capitals was 10 kilometers. Land area under rice cultivation is about one and half hectares. This indicates that rice farmers in the study location were predominantly smallholders. However, this is higher than Konja, Mabe, and Alhassan (2019); Mabe, Donkoh, and Al-Hassan (2018) who found average rice farm size in Ghana to be 0.959 and 1.052 hectares respectively. All the farmers from Northern and Ashanti Regions were under rain-fed rice production while those from Upper East were irrigated rice farmers. Rice production in Ghana is mainly rain-fed due to inadequate irrigation schemes. However, there are few irrigation schemes (dams) in the country (Amfo, Abdul-Rahaman, et al., 2021). Therefore, the authors sampled rice farmers from both rain-fed and irrigated rice farming areas/districts.

The one-way Analysis of Variance (ANOVA—*F*-statistic) shows statistically significant differences in regional distribution of commercialization, off-farm occupations, income, extension contact, credit accessibility, radio ownership, distance to district capital, farm size, production method, and purpose of production across the three levels of rice commercialization. Therefore, there are significant differences in these socioeconomic characteristics of rural rice farmers based on the level of commercialization. Thus, these socioeconomic characteristics could influence rice commercialization.

Rice marketing outlets in Ghana

Table 3 reports where rural farmers sell rice and marketing agents they sell to. Rural rice farmers sell at farm gate, processing centers, local, district or regional capital markets. About 70% of low commercialization farmers sell at farm gates and local markets. Considerable proportions of medium and

high commercialization farmers sell at farm gates, local markets and processing centers (over 20% in each case). The aggregate reveals that a quarter of rice farmers sell at farm gate (in the farm or at home). These farmer incurs no transportation cost. About one-third of farmers sell rice at local markets in their communities or nearby communities. A quarter of farmers sell rice at processing centers. Some marketing agents (wholesalers and retailers) buy rice at processing centers. Also, some marketing agents double as rice millers and buyers/traders. Few farmers (about 15%) sell rice at markets in district or regional capitals. This could be farmers residing closer to district or regional capitals, or large scale (high income) farmers who can afford to transport rice to markets in district or regional capitals. Most rice farmers prefer farm gates, local markets and processing centers due to low or no transportation cost. This reduces marketing cost which increases their net profit. However, buyers are likely to offer low prices for rice sold at these marketing outlets compared with those sold at district or regional markets.

Table 3 further reveals that majority of low commercialization rural farmers (about 95%) sell to wholesalers and retailers, and the remaining sell to rice millers. Exactly half of medium and high commercialization rural rice farmers sell to wholesalers. These farmers sell rice in large quantities; and therefore, prefer traders who buy in bulk (wholesalers). About 45% each of medium and high commercialization farmers sell to retailers and rice millers. No low commercialization rural farmer sell within their FBOs. For medium and high commercialization farmers, 1% and 5% sell in FBOs respectively. The aggregate reveals that half of rice farmers sell to wholesalers. Farmers may prefer wholesalers because of bulk purchase. Equal proportions of farmers sell rice to either retailers or rice millers (23% each). This could be rice farmers who sell in smaller quantities. Less than

Table 3. Marketing options for rural rice farmers in Ghana.

	Percentage (%) of rice farmers				
	Level of commercialization			One-way ANOVA	Aggregate
Marketing option	Low ($n = 15$)	Medium ($n = 77$)	High ($n = 128$)	(F-statistic)	($N = 220$)
Place of sale				1.89	
Farm gate	33.33	20.78	28.13		25.91
Local market	40.00	29.87	32.03		31.82
District capital market	6.67	11.69	8.59		9.55
Regional capital market	13.33	6.49	6.25		6.81
Processing center	6.67	31.17	25.00		25.91
Marketing outlet				1.03	
Wholesalers	46.67	50.65	50.00		50.00
Retailers	46.67	24.68	20.31		23.64
Rice millers	6.66	23.37	24.22		22.72
FBOs	0.00	1.30	5.47		3.64

Note: n denotes number of observations. $N = 220$ instead of 225 since five farmers did not sell rice in the 2018/2019 farming season.

5% of farmers belonged to FBOs which purchase rice from members and sell in bulk to traders. This could generate extra income for FBO members. The *F*-statistic shows that difference in marketing outlets is not statistically significant across the three categories of rice farmers. Thus, low, medium and high commercialization rural farmers did not differ significantly in the choice of marketing outlets.

Furthermore, Table 4 shows multivariate probit results for the determinants of marketing outlet choice by rice farmers in Ghana. The Wald chi-squared reveals that the model best fit the data. The sale of rice to wholesalers is significantly and positively influenced by education, income, FBO membership, distance to district capitals, farm size, irrigation, commercial production and proportion of rice sold (Table 4). Wholesalers usually move from one production community to the other to purchase rice in bulk from individual farmers and groups. In this case, they bear transportation cost and save farmers from the energy and time involved in transporting rice to the market. These make it convenient for most farmers to trade with wholesalers. The bulk purchase might entice farmers with high education. High income farmers normally cultivate rice on large scale due to access to production resources. Due to the bulk purchase, large scale farmers are more likely to trade with wholesalers than retailers and millers/processors. Farmers who belong to associations usually engage in group sales. This leads to bulk sales usually to wholesalers.

The result also shows that as the distance to district capitals increases, the probability of selling to wholesalers increases (Table 4). This is because wholesalers usually move to farming communities to purchase rice from farmers. It is common for such traders to move into farming villages farther away from district capitals to purchase rice in bulk. Farmers who produce rice under irrigation and commercial producers are usually profit-minded. Thus, such

Table 4. Multivariate probit results for the determinants of marketing outlets.

	Coefficients (*z*-values)		
Predictor variable	Wholesalers	Retailers	Millers/processors
Education (years)	0.058 (6.22)***	−0.028 (−1.72)*	0.014 (0.110)
Off-farm occupation (1 = yes)	−0.005 (−0.022)	0.017 (0.112)	0.099 (0.771)
Income (US$)	0.301 (2.30)**	1.273 (3.331)***	−5.909 (−0.088)
Extension contact (1 = yes)	1.009 (0.001)	0.273 (0.211)	0.272 (0.991)
Credit (1 = yes)	4.220 (0.764)	0.002 (4.91)***	0.047 (1.301)
FBO (1 = yes)	0.216 (2.12)**	−0.005 (−1.050)	0.069 (1.001)
Information sources (number)	0.091 (0.77)	−0.319 (−2.04)**	−0.005 (−1.50)
Distance to district capital (kilometers)	0.076 (1.969)*	0.101 (0.011)	−0.009 (−2.14)**
Farm size (hectares)	0.037 (1.79)*	−0.006 (−5.851)***	−0.006 (−2.851)**
Production method (1 = irrigated)	0.018 (3.170)***	−0.067 (−0.170)	−0.300 (−0.178)*
Purpose of production (1 = commercial)	0.117 (2.400)**	−0.210 (−2.55)**	−0.279 (−0.777)*
Proportion of rice sold (percentage)	0.031 (2.01)**	0.050 (1.420)	0.068 (1.425)
Constant	0.721 (4.906)***	0.822 (2.964)**	0.189 (0.230)
Wald chi-squared	166.710***	253.900***	291.750***
Log likelihood	−480.220	−401.700	−540.400

*, **, and *** denote statistical significance at 10%, 5%, and 1% respectively.

farmers sell large quantities/proportions of rice produced. This favors bulk sales to wholesalers.

Retailers usually purchase rice in smaller quantities and in most cases, farmers transport rice to them. Nevertheless, they offer higher prices than wholesalers. Income and credit increase the probability of selling rice to retailers (Table 4). High income farmers and those with access to credit could better afford the cost associated with transporting rice to retailers. However, education, access to information, farm size and commercial production reduce the probability of selling rice to retailers. Knowing the advantages of selling rice to wholesalers, most educated farmers might not trade with retailers. Farmers with access to information might be aware of other better marketing outlets relative to retailers. Large scale and commercial farmers produce and sell large quantities of rice. This favors the bulk sale of rice to wholesalers than retailers.

Also, distance to district capitals, farm size, irrigated production and commercial production reduce the probability of selling rice to millers/processors (Table 4). In most cases, rice millers/processors are in bigger towns such as district capitals and they serve farmers in nearby villages. Thus, living farther away from district capitals might reduce the probability of trading with millers/processors. Such farmers might sell rice to aggregators/wholesalers who purchase from villages. Large scale, irrigated and commercial producers usually produce and sell rice in large quantities. Thus, they are likely to sell to bulk buyers such as wholesalers instead of millers/processors.

Level of rice commercialization in rural Ghana

Table 5 illustrates the main purpose for rice cultivation. The *F*-statistic shows statistically significant differences in the purpose for rice cultivation across the three levels of commercialization and regions. All the low commercialization rural farmers produce rice on subsistence basis. These farmers cultivate rice predominantly for household consumption. However, most of them sell the surplus, largely when there is new harvest or financial crises. Conversely, all the high commercialization rural rice farmers produce mainly for sale. For medium commercialization farmers, only 15% produce mainly for sale, while the remaining 85% produce mainly for household consumption. Ashanti Region recorded the highest proportion of farmers who produce rice primarily for sale, while Upper East Region had the lowest. The aggregate reveals that 62% of farmers produce rice mainly for commercial purpose. Their main motive for production is to sell, though most of them reserve small proportions for household

Table 5. Main purpose for rice cultivation.

Level of commercialization and region of rice farmer	Number of observations	Purpose for rice production (%)		One-way ANOVA (F-statistic)
		Subsistence	Commercial	
Level of rice commercialization				
Low	20	100.0	0.0	
Medium	77	84.4	15.6	
High	128	0.0	100.0	593.42***
Region of Ghana rice farmer resides				
Northern	75	38.7	61.3	
Ashanti	75	21.3	78.7	
Upper East	75	53.3	46.7	17.46***
Aggregate data	225	37.8	62.2	

Table 6. Proportion of rice output sold.

Description	Mean	Standard deviation	Minimum	Maximum
Total output of rice (kilograms)	6,504.804	8,102.399	36	60,060
Whether farmer sold rice (1 = yes)	0.978	0.148	n.a.	n.a.
Quantity of rice sold (kilograms)	5,312.297	7,642.776	13.431	59,787
Proportion of rice output sold (percentage)	71.599	25.570	0.915	100

Note: n.a. denotes not applicable.

consumption. Conversely, 38% are subsistence rice farmers. They cultivate rice primarily for household consumption.

Table 6 shows rural rice farmers' market participation (proportion of rice output sold). Average rice output obtained by a farmer in the 2018/2019 farming season is 6,500 kg. Nonetheless, few farmers harvested over 60,000 kg of rice, while others harvested as low as less than 40 kg for the entire farming season. This huge discrepancies could be attributed to differences in farm size, soil fertility, type of seed cultivated, and timeliness and efficiency of agronomic practices (weeding, pests and diseases control, and fertilizer application). Furthermore, 98% of rural farmers sold rice in the 2018/2018 season (though Table 3 shows that 38% produced rice on subsistence basis). This suggests that majority of subsistence farmers sold rice.

Table 6 shows that about 70% of rice output obtained in the 2018/2019 farming season was sold. This indicates high level of rice commercialization in rural Ghana. However, the minimum shows that there were few outliers who sold less than 1% of their rice output. These were farmers who produced rice mainly for household consumption (and only sell the surplus), or those with large household sizes. Also, there were few outliers who sold all rice harvested. Such farmers did not reserve rice for household consumption, or for sowing in the 2019/2020 farming season. These were farmers who cultivate rice on commercial basis. The level of rice commercialization reported in this study is higher than that of Abdullah et al. (2019) who reported that 63.4% of rice farmers participate in commercialization.

Figure 1 illustrates the level of rice commercialization (market participation) by rural farmers. Over half of the respondents were high

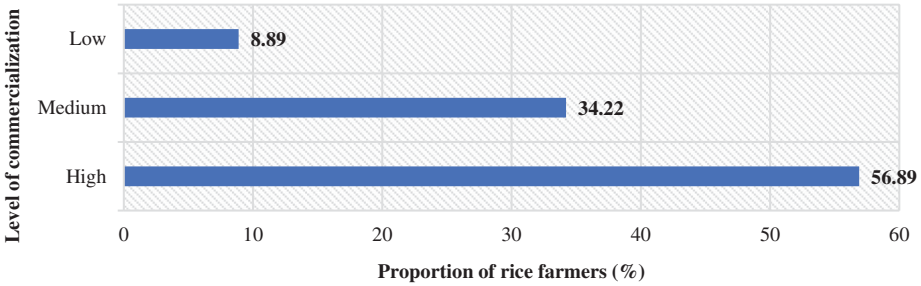

Figure 1. Level of commercialization by rice farmers in rural Ghana.

commercialization rice farmers. These are farmers who sold over 75% of rice output in the 2018/2019 season. Also, about 35% were medium commercialization rural rice farmers. They had 30–75% of their rice output sold. A little less than 10% were low commercialization farmers. These farmers sold less than 30% of their total rice output. Thus, despite small scale production, commercialization of rice production in rural Ghana is fairly high. This suggests that most farmers reserve lower proportions of rice for household consumption, and sell greater proportions. This is central in improving smallholder rice farmers' welfare. This is because smallholder commercialization is vital in income generation and poverty reduction (Abdullah et al., 2019; Gani & Adeoti, 2011).

Determinants of rice commercialization

Table 7 displays results from fractional response and multinomial logistic regressions for the determinants of rice commercialization. The Wald chi-squared is significant (at 1%) in the fractional response and multinomial logistic regressions. This indicates that the predictor variables jointly explain variations in rice commercialization. The pseudo R-squared in the fractional and multinomial regressions reveal that the predictor variables contribute about 22% and 78% of variations in rice commercialization respectively.

Age of farmer is significant (at 5%) and positive in the multinomial logistic regression (Table 7). This suggests that age has a positive association with high rice commercialization but negative association with low rice commercialization (base outcome). As a farmer's age increases, the probability of being a high commercialization farmer increases. Therefore, older rural rice farmers have higher levels of market participation than younger ones. This suggests that older farmers consider rice production as a business than younger ones. In Ghana, majority of the younger generation have the aspiration of obtaining white-collar jobs. This may adversely affect their desire toward farming (rice production). Thus, younger farmers may engage in rice production as a means of sustaining their households

Table 7. Determinants of rice commercialization.

	Fractional response estimations		Multinomial logistic regression (base outcome = low rice commercialization)	
Variable	Fractional probit regression	Fractional logistic regression	Medium rice commercialization	High rice commercialization
Sex (1 = male)	0.009 (0.14)	0.019 (0.18)	0.809 (0.56)	1.817 (1.12)
Age (years)	0.0002 (0.01)	0.0001 (−0.03)	0.055 (0.91)	0.151 (1.99)**
Education (years)	−0.008 (−1.72)*	−0.014 (−1.70)*	−0.126 (−1.26)	−0.118 (−0.96)
Off-farm occupation (1 = yes)	−0.021 (−0.32)	−0.038 (−0.34)	−0.578 (−0.37)	0.454 (0.26)
Household size	−0.011 (−1.42)	−0.016 (−1.20)	−0.531 (−1.92)*	−0.588 (−1.95)*
Extension contact (1 = yes)	0.037 (0.62)	0.058 (0.56)	1.421 (0.87)	2.020 (1.09)
Credit (1 = yes)	0.139 (1.71)*	0.235 (1.66)*	−0.908 (−0.35)	−0.626 (−0.23)
FBO (1 = yes)	0.129 (1.91)*	0.233 (2.01)**	3.275 (1.66)*	3.046 (1.37)
Information sources (number)	0.050 (1.55)	0.077 (1.36)	0.806 (0.82)	0.946 (0.88)
Distance to district capital (kilometers)	−0.056 (−5.52)***	−0.095 (−5.75)***	−1.103 (−3.15)***	−1.268 (−3.55)***
Farm size (hectares)	0.042 (1.44)	0.087 (1.66)*	0.354 (0.39)	0.884 (0.92)
Production method (1 = irrigated)	0.412 (4.70)***	0.692 (4.77)***	10.318 (2.80)***	11.518 (3.00)***
Purpose of production (1 = commercial)	0.784 (8.15)***	1.324 (8.09)***	25.465 (0.01)	49.125 (0.01)
Constant	0.776 (3.25)***	1.319 (3.37)***	24.794 (3.08)***	−0.759 (−0.01)
Number of observations	225	225	225	225
Wald chi-squared (13)	725.70***	665.61***	319.63***	319.63***
Pseudo R-squared	0.216	0.218	0.787	0.787
Log pseudo likelihood	−105.264	−105.048	−43.358	−43.358

*, **, and *** denote statistical significance at 10%, 5%, and 1% respectively. Figures in parenthesis are *z*-values.

while searching for other (white-collar or service sector) jobs. This finding agrees with Abdullah et al. (2019); Hailua et al. (2015); Agwu et al. (2012); Agwu and Ibeabuchi (2011) who reported positive relationship between age and crop commercialization. However, Randela, Alemu, and Groenewald (2008) reported otherwise.

Education is significant (at 10%) but negative in the fractional probit and logistic regressions. This implies that education reduces rice commercialization. In Ghana, majority of farmers have low or no formal education. Educated people are usually employed in the formal sector, and might engage in agricultural production as a secondary occupation. This reduces their reliance on agricultural income. Low rice commercialization among educated farmers could suggest that majority of them produce rice for household consumption, and depend on their primary occupations for other household expenditures. Conversely, farming is considered as a primary occupation for people with low formal education. Thus, they are more likely to depend chiefly on (rice) farming as a source of household income. Hence, farmers with lower education are more likely to sell higher proportions of their rice, and vice versa. This finding agrees with Abdullah et al. (2019); Musah, Bonsu, and Seini (2014) who found that education reduces market participation of farmers. However, this finding contradicts with Adeoti, Oluwatayo, and Soliu (2014); Gani and Adeoti (2011); Randela et al. (2008).

Household size is significant (at 10%) and negative in the multinomial logistic regression (Table 7). This means that rice commercialization

reduces with household size. Rural rice farmers with smaller households have higher probabilities of being medium or high commercialization farmers. As reported in Table 3, 38% of farmers produce rice on subsistence basis. The proportion of rice sold largely depends on household size. Therefore, it is likely that low commercialization rural farmers have many household members who consume greater portions of rice produced, leaving little for sale. This agrees with Siziba, Nyikahadzoi, Diagne, Fatunbi, and Adekunle (2011), but contradicts with Abdullah et al. (2019) who observed that household size increases market participation.

Credit accessibility is significant (at 10%) and positive in the fractional probit and logistic regressions. This means that rural farmers with access to credit have higher probabilities of selling greater portions of their rice. Rice production, like any other business venture, requires capital for expansion and efficient production to increase output. Farmers with access to financial support can better afford extra production cost involved in efficient and effective agronomic practices like weed, pests and diseases control, fertilizer application, and mechanization services. This increases rice output which leads to higher sales.

FBO membership is positive and significant in the fractional regression (Table 7). This implies that rural farmers who belong to FBOs have higher probabilities of selling higher proportions of rice compared with those who are not members of FBOs. Similarly, FBO membership is positive and significant in the multinomial regression for medium rice commercialization. This implies that farmers who belong to FBOs have higher probabilities of being medium commercialization farmers. Conversely, those who do not belong to FBOs have higher probabilities of being low commercialization farmers. Members of FBOs learn from one another. FBOs are the target for disseminating agricultural information by extension officers, NGOs and other stakeholders. These enhance the knowledge of FBO members, including rice commercialization.

Distance to district capital is negative and significant (at 1%) in the fractional regressions. This means that as distance from a rural farmer's community to district capital increases, the proportion of rice sold reduces. Likewise, distance to district capital is negative and significant (at 1%) in the multinomial regression for medium and high commercialization. This means that as the distance from a farmer's community to district capital increases, the probability of being a medium or high commercialization farmer reduces, while that of low commercialization rises. The foregoing suggests an inverse relationship between distance to district capitals and commercialization. Thus, it is likely that farmers residing in communities closer to district capitals have higher market participation compared with those staying farther away from district capitals. Communities closer to

district capitals are mostly bigger and more populated than those farther away. There is high human population in and around urban areas (district capitals) which increases nonagricultural land-use (Amfo & Ali, 2021). Hence, it is likely that only commercial and profit-minded farmers in such relatively populated centers cultivate rice and other crops. To improve productivity and efficiency, farmers in population centers apply inorganic fertilizers, herbicides, sow in rows, cultivate improved varieties, and plow the soil due to poor soil conditions (Amfo & Ali, 2021). These increase production cost. Thus, being profit-minded, farmers in such locations are compelled to sell greater proportions of farm produce (rice) to cater for the high production cost.

Farm size is positive and significant (at 10%) in the fractional regression (Table 7). This infers that as farm size increases, the proportion of rice output sold increases. Thus, rural farmers with larger rice farms are likely to sell higher quantities than those with smaller farms. Mostly, commercial and profit-minded farmers cultivate large hectares of rice farms. Also, farmers with large rice farms obtain enough outputs to feed their households and sell the excess.

Method of rice production is significant (at 1%) and positive in the fractional and multinomial regressions. The fractional regressions indicate that irrigation of rice farms increases commercialization in rural Ghana. Likewise, the multinomial regression indicates that irrigated rice farmers have higher likelihoods of being medium or high commercialization. However, rain-fed rice farmers are likely to be low commercialization. Thus, irrigated rural farmers are likely to sell greater proportions of rice than rain-fed rice farmers. Irrigation of rice farms involves extra cost. Farmers would have to sell greater quantities of rice to cover such cost. Therefore, in most cases, commercial and profit-minded farmers undertake irrigated rice production (Amfo, Abdul-Rahaman, et al., 2021).

There are two main motives for rice production: subsistence (production predominantly to feed one's household); and commercial (production predominantly for sale). Table 6 shows that rural farmers who produce mainly for commercial purpose sell higher proportions of rice outputs than those who produce on subsistence basis. Rural farmers who produce rice on subsistence basis feed their households, and only sell the surplus when there is a new harvest or financial crises. This reduces the proportion of rice sold by subsistence farmers compared with those who produce mainly for sale.

Impact of commercialization on rural rice farmers' welfare

Household consumption expenditure

Annual household consumption expenditure per capita was used as a proxy for rural rice farmers' welfare (Table 8). The one-way ANOVA reveals that

there are significant differences in the annual household expenditures among low, medium and high commercialization farmers, except medical care, transportation and social contribution. High commercialization rural farmers recorded the highest annual expenditures on food, clothing, education, communication, entertainment and asset maintenance. Food constituted about 70% of total annual household expenditure of rural rice farmers. Being poor (low income), rural farmers in Ghana focus predominantly on meeting their basic needs, like food, which forms greater proportion of their expenditure. This agrees with Amfo, Ansah, and Donkoh (2019) who observed that low-income (poor) households in Ghana spend 78% of their income on food. Also, Donkoh, Alhassan, and Nkegbe (2014) reported that food expenditure is more than half of household budget of the poor in Ghana. Education and savings (7% each) formed considerable proportions of rice farmers' annual expenditure. Expenditure on education might be low due to Ghana government's recent free Senior High School policy.

Average annual household consumption expenditure per capita is highest for high commercialization rural rice farmers (US$796). High per capita expenditure per annum depicts enhanced welfare status than low per capita expenditure (Donkoh, Ansah, Adzawla, & Amfo, 2017; Adzawla et al., 2016). This suggests that welfare of high commercialization farmers is higher than those of low and medium commercialization farmers. This could be attributed to higher income generated through greater market participation which enables high commercialization farmers to better take care of their needs compared with low and medium commercialization farmers.

Table 8. Annual household expenditure per capita of rural rice farmers.

	Average annual household expenditure (US$)					
	Level of commercialization					
Expenditure component	Low ($n = 20$)	Medium ($n = 77$)	High ($n = 128$)	One-way ANOVA (F-statistic)	Aggregate ($N = 225$)	Percentage share of total (%)
Food	3,444.35	2,005.27	4,050.40	1.47**	3,296.64	69.40
Clothing	50.34	67.46	123.35	7.74***	97.74	2.06
Medical care/health	185.02	245.30	233.24	0.98	233.08	4.91
Accommodation/housing	16.78	52.48	50.14	5.33***	47.43	1.00
Education	152.74	296.54	421.96	3.45***	352.72	7.42
Communication	33.29	41.42	64.64	7.10***	53.84	1.13
Transportation	107.79	105.16	101.12	1.07	103.10	2.17
Utility (water and electricity)	44.32	61.89	107.55	9.15***	85.72	1.80
Savings	77.05	506.42	220.95	7.28***	310.05	6.53
Social contributions	72.43	70.25	68.68	0.86	69.55	1.46
Entertainment	8.56	30.48	77.05	114.15***	48.33	1.02
Assets maintenance	12.41	33.75	70.98	18.48***	52.34	1.10
Total annual household consumption expenditure	4205.08	3516.42	5590.06	1.03	4750.54	n.a.
Average annual household consumption expenditure per capita	515.66	461.99	796.06	96.16***	656.81	n.a.

Note: n.a. denotes not applicable. ** and *** denote statistical significance at 5% and 1% respectively.

PSM estimation of the impacts of commercialization on rural rice farmers' welfare

To estimate PSM, low and medium rice commercialization were merged and coded zero while high commercialization was coded one. This yielded a binary response outcome for a probit regression (Appendix 1) used for estimating the PSM. The result was used to predict propensity scores for matching low/medium and high commercialization farmers. Observations with similar propensity scores were matched. This generated a subsample of respondents with similar pretreatment characteristics who only differ in commercialization levels (Appendix 2). Furthermore, a balancing test was run to check whether biases from observed characteristics have been eliminated after the matching (Appendix 3). For each covariate, there was a substantial level of bias reduction from the PSM procedure for both high (treated) and low/medium commercialization (control). The t-test bears witness to this bias reduction by showing that with the exception of distance to district capital and yield, there is no significant difference in the means of all the covariates in the model.

Appendix 4 is a graph of the common support region for low/medium and high commercialization after the matching. The graph shows propensity score distribution and common support for propensity score estimation. Given the substantial bias reduction, and that the two categories in the subsample are equal in every other aspect, except in commercialization, household expenditure per capita (welfare) were compared (Table 9). ATT estimates were generated to compare average outcomes of high commercialization with those of low/medium commercialization. This shows the average welfare impact of commercialization on rural rice farmers. The difference between the two classes of rice farmers—high commercialization (treated ATT) and low/medium commercialization (control ATT)—is positive and the t-statistic shows that it is significant (at 1%). Thus, commercialization has positive impact on rural rice farmers' welfare.

Production of rice mainly for sale improves rural farmers' income. Farmers who sell greater proportions of rice are more likely to generate higher income than those who produce mainly for consumption (and sell lower proportions). Higher income enables high commercialization rural farmers to better bear the cost of consumption expenditure compared with low commercialization ones. This improves the welfare of high commercialization rural farmers relative to low and medium commercialization ones.

Table 9. Impacts of commercialization on rural rice farmers' welfare.

Variable	Sample	Treated	Control	Difference	Standard error	*T*-statistic
Welfare (household expenditure per capita)	Unmatched	4648.978	2762.652	1886.326	110.606	17.050
	ATT	4614.039	2609.335	2004.703	238.915	8.390
	ATU	2788.558	4664.035	1875.477		
	ATE	1927.822				

Muriithi and Matz (2015) emphasized that market-oriented production enhances income than subsistence production. Thus, market-oriented production results in greater household consumption. Consistent with the above finding, Muriithi and Matz (2015); Tufa et al. (2014); Barrett et al. (2012); Bellemare (2012); Rao and Qaim (2011) observed that commercialization of farm produce enhances farmers' welfare (income and/or consumption expenditure). These studies concluded that commercialization reduces poverty among smallholders. Muriithi and Matz (2015); Tufa et al. (2014) asserted that commercialization is key in increasing smallholders' income and poverty reduction.

Conclusions and policy implications

This study used insights from rural Ghana to investigate marketing outlets and commercialization of rice, and its welfare implications. Rural rice farmers sell at farm gates, processing centers, and local, district or regional capital markets. Major rice marketing outlets are wholesalers, retailers and rice millers. About 62% of rural farmers produce rice mainly for sale, while 38% produce on subsistence basis. Also, 98% of rural farmers sold rice in the 2018/2018 farming season. About 70% of rural rice produced in the 2018/2019 season was sold. Majority of producers in rural Ghana are high or medium commercialization rice farmers. Thus, rice commercialization (market participation) in rural Ghana is high, despite small scale production. Credit, FBO membership, farm size, irrigated rice production, and commercial production enhance rice commercialization. However, rice commercialization reduces with education, household size, and distance to district capital. Welfare (consumption expenditure per capita) is highest for high commercialization rural rice farmers compared with low and medium commercialization ones. Rice commercialization (market participation) has positive implications on rural farmers' welfare.

To further increase rice commercialization (market participation), financial institutions such as banks should advance more credits to rural rice producers to expand their farms. Rural rice farmers should join FBOs. Government and NGOs interested in rice production should develop more irrigation schemes for rice production in rural localities. To improve rural rice farmers' welfare, they should shift from subsistence to commercial production.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix

Appendix 1. Probit regression used to estimate PSM.

Variable	Coefficient (robust standard error)
Sex	0.9360** (0.390)
Off-farm occupation	1.900*** (0.614)
Age	0.027* (0.015)
Household size	−0.030 (0.039)
Northern region	−2.449*** (0.473)
Upper East region	−3.457*** (0.578)
Extension contact	0.273 (0.344)
Credit	0.831* (0.455)
Distance to district capital	−0.316*** (0.040)
FBO	0.297 (0.352)
Farm size	0.333* (0.175)
Education	0.035 (0.025)
Constant	−4.137*** (1.589)
Observations	225
Mean (standard deviation) of dependent variable	0.5689 (0.463)
Pseudo R-squared	0.689
Chi-squared	113.749***
Akaike Information Criteria (AIC)	125.705
Bayesian Information Criteria (BIC)	176.947

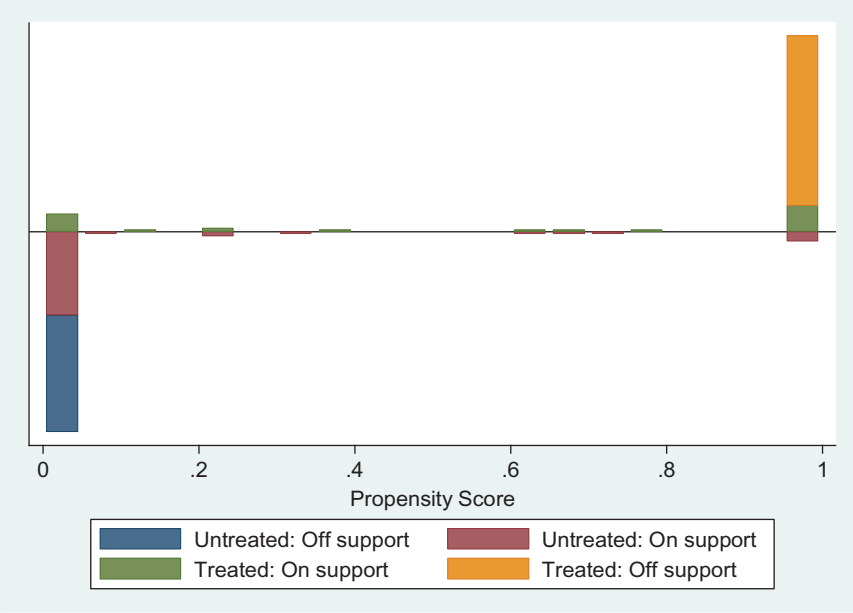
*, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.

Appendix 2. Subsample after PSM.

	Common Support		Total
Treatment assignment	Off support	On support	
Untreated	50	47	97
Treated	96	32	128
Total	146	79	225

Appendix 3. Balancing test after matching.

	Mean			
Variable	Treated	Control	% bias	*t*-Test
Sex	0.625	0.569	12.000	0.450
Off-farm occupation	0.344	0.331	2.700	0.100
Age	43.219	42.769	3.800	0.160
Household size	7.313	6.800	16.100	0.650
Northern Region	0.469	0.244	47.500	1.900*
Upper East Region	0.281	0.237	9.400	0.390
Extension contact	0.531	0.400	27.000	1.040
Credit	0.063	0.144	−19.000	−1.060
Distance to district capital	8.906	12.375	−62.400	−2.440**
FBO	0.344	0.375	−6.400	−0.260
Farm size	1.549	1.562	−1.000	−0.040
Education	7.969	8.150	−3.000	−0.130
Yield	7.881	8.355	−44.400	−1.900*
Pseudo R-squared	0.117			
LR chi-squared	10.420			
Mean bias	18.700			
Median bias	10.700			



Appendix 4. Propensity score distribution and common support for propensity score estimation.