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Research Article

Assessing Market Participation of Smallholder Cassava Farmers in Sekyere Central District of Ghana Using Vector Generalized Additive Ordered Models

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Abstract

Smallholder farmers theoretically produce and market their output to meet livelihood needs of the family under given set of resource constraints. In spite of numerous policy efforts to ensure that smallholder farmers in Ghana and rural districts in particular, exploit the economic potential of cassava production, many of them continue to produce for subsistence with limited participation in the markets. To assess and explain the levels at which smallholder cassava farmers participate in markets, the study applied the partial proportional odds model in the framework of Vector Generalized Additive model (VGAM), which comprehensively addresses conceptual, modelling and interpretational complexities implied by market participation (MP) theory. Data for the study were collected from 365 cassava farmers in Sekyere Central (SC) district of Ashanti region, Ghana. The results showed that only 32% of the farmers participated in the markets as Net sellers, while 45% and 23% participated as Autarkic producers and Net buyers respectively. The econometrics analysis revealed that household size, access to market information, age, education, market access, membership to famer or community organisation, off-farm income, farm income, livestock holdings, cassava output and cassava being cultivated as major crop, appeared statistically significant in explaining MP decisions. Five variables, namely income, livestock, produce, access to market information and cassava as major produce, failed the proportional odds assumption and entered the model unconstrained, producing regime specific estimates. These results are indicative of how conditional, on a given regime, farmers respond to changes in the factors that affect their MP decisions, in terms of intensity and direction. Farm level policies, that target cassava farm households' participation in markets should consider regime specific strategies.

Keywords

Market Participation, Cassava, Partial Ordered Models, Vector Generalised Additive Models, Sekyere Central District

1. Introduction

In Ghana, cassava is rated the most important root crop as it remains the main and cheapest source of staple food for many lower income households in the country. In 2022, Ghana produced about 25 million metric tons of cassava for both domestic and industrial consumption [1], and contributed to about 22% of Agricultural GDP in 2020 [1, 2]. The potential

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of cassava production to the economic development of Ghana still remains untapped. In Ghana, like many African countries, crop production and farming in general are predominantly handled by resource poor smallholder farm households. Majority of these farmers produce at subsistence levels, and hardly save substantial surplus for marketing purpose. Two major problems have saddled smallholder producers' capacities to improve productivity and yields. The first has to do with resources to mobilize appropriate inputs to optimize production; and the second relates to low level of market participation (MP) and commercialization to enable them to be seen and recognized as active players in the complex and unbalanced power structure of the agricultural supply chain and markets. These are evident in the recent observations made by the ministry of Trade and Industry and the Ghana Export Promotion Authority, that many agro-based industries in Ghana, including cassava processing industries operate under their production capacities [2], while farmers during glut seasons find it difficult to sell their produce at deserved prices. The incentives for smallholder farmers to effectively participate in the agricultural markets of developing countries are constrained by imperfect and structural barriers within the agricultural production and agribusiness systems. In such situations the resource poor farmer would hardly risk, and in effect take decisions that reflect the unobserved and observed costs and benefits that inform access to markets and productive assets [3].

Improving smallholder farmers access to markets, does not only strengthen agricultural value chain and rural employment, but contributes to food security, equitable distribution of income, forward and backward linkages and for national economic growth through multiply effects. Efforts on improving rural livelihood have directly centered on agricultural production technologies and physical infrastructure [4] which, though may indirectly affect transactions cost and transmission of market signals, smallholder farmers' livelihood and welfare improvements, to a larger extent, depend on their decisions to and how effectively they participate in agricultural markets. Barriers to market entry, in any form have significantly explained why many smallholder farmers have restrained from expanding their production thresholds [5-9]. Unlike farmers in developed countries, many in developing countries are beyond the reach of formal market institutions [10]. In the Sekyere enclave of the Ashanti region, cassava production has remained one of the major sources of staple food, but has not been exploited effectively, given its potential into more market-oriented and higher value-added produce that can feed the growing cassava markets for industrial purpose. In its strategy to improving rural economies, the government of Ghana and other stakeholders have embarked on productivity enhancement and commercial transformation of smallholder agriculture. Despite these efforts, Sekyere Central District like other rural districts, have many smallholder farmers who continue to grow cassava for subsistence, without conscious strategies to targeting the wider output market. As a result, commercialization of smallholder farming is much below the expectations and farming is still characterized by low productivity, low income and low degree of specialization [11, 9]. Understanding levels and factors that explain market participation for policy targeting cannot be underestimated for effective rural development strategies. Many studies especially in the developing countries, have as a result been conducted to explain smallholder farmers MP decisions from both theoretical and conceptual perspectives (see [3-5, 12-16]). Many others have solely focused on empirical investigations within different geographical contexts or specific crops of interest [17-20]; while few have combined empirical and methodological issues [9, 21-23]. In Ghana recent MP studies have concentrated on empirical investigations and many on cereals in the northern sector of the country [24-26] with limited studies in the southern and for root staple like cassava. Bosompem et al. [27] addressed MP in the cassava supply chain, but focused on value addition only. While these studies have made significant contributions to the MP literature, there exist mixed conclusions on the findings within and across countries, and among different crop types. Again, heterogeneity of factors faced by smallholder farmers and their methodological implications have often resulted in limited insights derived from such studies, and or making results incongruent with model structures used [28, 23, 26]. Based on theoretical models proposed by Boughton et al. and Barrett [14, 15], which posit that households' decision-making on production and consumption is non-separable in subsistence farming, and that subsistence farming households participate in markets as net sellers, autarkic or net buyers, effective market participation of smallholder cassava farmers should be viewed in terms of welfare gains or losses they derive from producing for the market [13, 15, 21]. In the MP literature however, many of the studies have focused on and attempted to explaining factors that determine smallholder participation in markets as sellers or not, and in some cases further explain the extent of participation by quantities of sale, with dearth of studies that have assessed MP within the effective participation order as either net sellers, autarkic or net buyers that reflect the levels of real welfare gains that output markets offer. The current study, taking into account the above conceptual, methodological and empirical gaps, sets to investigate and explain smallholder cassava farmers levels of participation in output markets regimes, defined by net seller, autarky and net buyer [15], in Sekyere Central district of Ashanti, using partial proportional odds analysis within the framework of vector generalised additive models (VGAM) developed by Yee [33, 34] and Yee and Hastie [35]. This framework in particular, addresses conceptual and methodological issues that have restricted parameter interpretational insights of many market participation (MP) studies that have used classical ordinary linear, binary, multinomial or ordered models. The rest of the paper is structured into 3 sections. Section 2 provides a brief description of data and the econometric modeling methodology used, while section 3 describes

the empirical analysis and results. Section 4 contains the concluding remarks.

2. Materials and Methods

The study focused on assessing smallholder cassava famers levels of MP and to explain their decisions to participate in a particular market regime. The methodological approaches used were based on household welfare theory [4, 9, 13-15] and implied modelling strategies applied in MP studies [4, 5, 9, 12, 13, 15, 29-32]. Market participation was defined based on smallholder household welfare theoretical propositions [4, 5, 9, 13, 23]. Sekyere Central District of Ashanti was used as the study area. The data analysis was carried out, using the Vector Generalised Linear/Additive Models (VGLM/VGAM) [29-31], which was implemented in R statistical software.

2.1. Study Area

The study was conducted in Sekyere Central District of Ashanti Region in Ghana. It is located at the northern part of the region, and shares boundaries with Mampong Municipal, Atebubu, Sekyere East, Sekyere South, and Eju-ra-Sekyeredumasi districts. The district was selected due to its production and market potential in cassava and other staple crops. The district covers an area of approximately 1,631.1 sq. km, located within longitudes 0.05 degrees and 1.30 degrees west and latitudes 6.55 degrees and 7.30 degrees north. It has about 150 settlements with about 70 percent being rural. The area has a bi-modal rainfall regime with an average annual rainfall of 1270mm. The major rainy season starts in April, with its major peak in May. The average annual temperature and relative humidity are, 27 ℃ and 72% respectively [36]. The district lies within the wet semi-equatorial forest zone; the soil is mainly sandy-loam. These climatic conditions have critical implications on agricultural production as majority of the farmers, about 65%, engage in rain-fed agriculture, with predominant crops being maize, cassava, plantain, beans and yam. The population of the district according to the 2021 population and housing census stands at 73,228; made up of 21,731 urban and 122,458 rural dwellers, with 36,490 and 36,738 males and females respectively [37].

2.2. Sampling and Description of Variables

A sample of 365 households were randomly selected from the study area. The sample covered Nsuta, Kwamang, Beposo and Afram plains enclaves of Sekyere Central district. Ten communities, were selected, through multi-stage random sampling procedure. The data was collected using a well-designed, open and closed ended questionnaires, which were administered through personal interviews. Based on economic theory and previous studies in the area of market participation and commercialization, variables selected to explain market participation decisions were grouped under household / demographic characteristics, resource endowment and production forms, accessibility to markets, accessibility to institutional services and household income status [23, 38-43]. In Table 1, variable names, description and measurement scale used are presented in columns one, two and three respectively.

Table 1. *Description of Variables.*

Variables	Description	Measurement
MktPart	Market participation	Rank ordered: Net seller=3, Autarky=2 Net buyer=1
Age	Age of respondents in years	Years
Income	Annual household income	Ghana cedi (Ghc)
OffIncome	Non farming income	Ghana cedi (GHc)
Education	Years of Education of household head	Years
HHsize	Household size	Number of people in the household
Livestock	Ownership of livestock	Number of livestock owned
Sex	Sex of household head	Dummy: Male = 1, Female = 0
Produce	Average annual harvest	Number of bags/kg
MajorProd	Cassava as major produced crop	Dummy: Yes=1, No=0
Member	Membership to farmer organisation	Dummy: Yes= 1, No= 0
ExtAccess	Access to extension services	Dummy: Yes = 1, No = 0
MktAccess	Access to market centres	Dummy: Yes = 1, No = 0

Variables	Description	Measurement
DistMkt	Distance to Market centres	Kilometers (km)
MktInfo	Access to market/price information	Dummy: Yes = 1, No = 0
FarmExp	Number of years in cassava farming	Years

2.3. Conceptual Framework and Model Specification

In general, varied methods have been applied in the analysis of MP based on a conceptual definition the researcher adopted. Two major blocks have dominated the literature; the two step selectivity models that analyze the discrete decision of market participation and the continuous decision of its intensity conditioned on participation decision [9, 13, 21, 26, 44] on one side as double hurdle model; and those that analyse the continuous decision of market participation intensity alone based on agricultural commercialization conceptualization in truncated modeling framework [25, 39, 45]. These lines have only focused on proportion of production sold during a production season, however based on theoretical models derived in Boughton et al. and Barrett [14, 15], households' decision-making on production and consumption is non-separable in subsistence farming, and that subsistence farming households participate in markets as net sellers, autarkic or net buyers. Thus, the level of participation in a market by a subsistence household is defined by production-consumption surplus or shortage, which is a function of transaction costs, household-specific characteristics and institutional factors. Muricho et al. [23] note that smallholder producers will not benefit by just a mere fact that they participate in the market but instead they should participate profitably as net sellers. Following, Bellamere and Barrett [13], they applied ordered probit to study maize market participation in Kenya. Technically, when viewed from the two step modelling conceptualizations (*the double hurdle*), MP outcomes in its three-regime specification suggests a form of cumulative structure inherent in the interpretation of ordered models; and of partial or generalized specifications where the behaviours at each level of the participation regimes are expected to vary. Following this conceptualization, the Vector Generalized Additive Models (VGAM) framework was utilized, given its the flexibility and robustness, to analyse MP of smallholder cassava farmers. The VGLM/VGAM structure of Yee [33], which admits varied distributional forms is adopted. Thus, given our categorical response variable Y of three ordered states, the distributions of these Y outcomes are modelled conditional on given selected X regressor variables in the form of specifications (1)-(4), (adopted and extracted from Abunyuwah [32] and Yee [34]).

$$f(\mathbf{y}|\mathbf{x};\mathrm{B}) = h(\mathbf{y}, \eta_1, \ldots\ldots \eta_M) \tag{1}$$

Where $h(.)$ is defined for some known function; B = $(B_1 B_2 \ldots B_M)$ is a $(p \times M)$ matrix of unknown regression coefficients; and η_j is the j^{th} linear predictor specified as:

$$\eta_j = \eta_j(\mathbf{x}) = \beta_j{}^{\mathrm{T}}\mathbf{x} = \sum_{k=1}^{p} \beta_{(j)k} x_k; \quad j = 1, \ldots M \tag{2}$$

In equation (2), $\mathrm{X} = (x_1, \ldots x_p)^{\mathrm{T}}$; models that include intercepts have $x_1 = 1$. In Yee [35], it is demonstrated that VGLMs expand GLMs by accommodating multiple linear predictors, and encompass models outside the narrow limits of the exponential family. Extending the VGLMs of equation (2) in VGAMs and to account for the parallelism assumption, equations (3) and (4) hold. In equation (4) in particular, the idea of 'constraints-on-the functions' are flexibly imposed.

$$\eta_j(\mathbf{x}) = \beta_{(j)1} + \sum_{k=2}^{p} f_{(j)k} x_k; \quad j = 1, \ldots M \tag{3}$$

$$\eta(\mathbf{x}) = \beta_1 + \sum_{k=2}^{p} f_k(x_k) = \mathrm{H}_1 \beta_1^* + \sum_{k=2}^{p} \mathrm{H}_k f_k^*(x_k); \tag{4}$$

where $\mathrm{H}_1, \mathrm{H}_2 \ldots \mathrm{H}_p$ are known full-column rank constraint matrices, f_k^* is a vector containing a possibly reduced set of component functions and β_1^* is a vector of unknown intercepts. Where no constraints are imposed at all, $\mathrm{H}_1 = \mathrm{H}_2 = \cdots = \mathrm{H}_p = \mathrm{I}_M$ and $\beta_{1=}^* \beta_1$. The X matrix in this framework ($\mathrm{X}_{\mathrm{VGL}}$) is thus constructed from X and H_k, using Kronecker product operations (see Yee [33] for examples). In the generalized ordered specifications, similar to (2) and (3) above, the regression coefficients, β_j, are estimated for each η_j category, while they appear equal for all η_j under the parallelism or proportional odds assumption which underlie the ordered models. Under circumstances where the proportional odds assumption is violated for some regressors, the partial ordered logit/probit models apply [46], which VGAM fits via constraint matrices specification as presented in equation (4). Model (4) was implemented via the cumulative link function, under VGLM/VGAM package in R statistical software [33, 34] after the *Brant* test of parallelism assumption failed for some variables (see Table 3).

3. Results and Discussions

3.1. Descriptive Statistics

In this section, we present descriptive statistics of the variables selected for the study (see Table 1). Ratio and interval variables are described with minimum, maximum, mean and standard deviations in Table 2, whilst categorical variables are summarized into frequencies and percentages in Table 3. From tables 2 and 3, in addition to the pooled data, the descriptive statistics are also presented according to the three-state market participation levels used, namely Net sellers, Autarky and Net buyers. Out of the 365 farmers interviewed, 116, 165 and 84 of them represented Net sellers, Autarky and Net buyers' groups respectively. The summary statistics from Table 2 show that average age of the respondents is 50.9 years. Similar to related studies, those who participate in cassava markets are relatively younger, with average age of 47 years (see [23, 38, 47, 48]). On average, household size of 6.58 estimated from the study appears comparatively higher than the 3.8 reported for the district from the 2021 national population census [37]. The Autarky and Net buyer groups recorded larger family sizes than the Net seller group. These findings are consistent with similar studies conducted in Kenya [23, 48]. Average incomes of farmers in the study area are relatively low, ranging from GHc 420 to GHc 2780 and GHc 130 to GHc 1825 for farm and non-farm incomes respectively. Within MP categories, Net sellers earned higher incomes than Autarky and Net buyers' groups with GHc 1100 (540.89), 898.0 (567.0) and 755 (820) respectively for farm (nonfarm) incomes. Similar to many rural and farming communities in Ghana and other developing countries, the results from Table 2 indicate that cassava farmers in the study area have lower levels of educational attainment. Measured in years, educational levels of the respondents were 8.58, 7.78 and 6.48 for Net sellers, Autarky and Net buyers' groups respectively, with average educational attainment score of 6.78 years for the pooled data. This finding compares with 6.67, 5.49, 6.28 and 7.56 of Tirra et al. [48] in Kenya, Kyaw et al. [47] in Central Dry Zone of Myanmar, Okoye et al. [8] in Madagascar and Muricho et al. [23] in Kenya. Given the important role of education in production, technology adoption and marketing decisions of households, it is implied that there exists a constrained scope for MP decision space.

Table 2. *Descriptive Statistics of Continuous Variables.*

Parti Group	Net Sellers			Autarky			Net Buyers			Pooled Data		
Variables	Mean (Std.D)	Min	Max	Mean (Std.D)	Min	Max	Mean (Std.D)	Min	Max	Mean (Std.D)	Min	Max
Age	46.69 (3.84)	37	56	53.40 (4.34)	47	63	49.9 (7.3)	39	60	50.49 (4.84)	37	63
HHsize	5.58 (2.36)	02	10	7.350 (2.60)	04	15	8.78 (2.6)	03	14	6.58 (3.56)	02	15
Income	1100 (245.8)	470	2780	898.0 (189.8)	496	1480	755 (155.8)	420	1080	855 (245.8)	420	2780
OffIncome	540.89 (136.7)	150	865	567.0 (114.7)	130	850	820 (161.7)	290	1825	586.89 (148.7)	130	1825
Education	7.78 (2.54)	00	15	6.48 (1.84)	00	13	8.58 (1.94)	00	13	6.78 (2.84)	00	15
DistMkt	6.76 (2.23)	01	10	6.41 (2.00)	01	14	5.70 (2.23)	01	10	6.42 (2.23)	01	14
Livestock	29.00 (8.80)	06	49	25.50 (6.40)	09	47	27 (6.80)	12	43	27 (8.80)	06	49
Produce	27.63 (6.70)	14	46	17.76 (17.76)	08	36	14.6 (4.7)	06	26	19.6 (7.70)	06	46
FarmExp	11.26 (3.56)	01	20	15.5 (4.76)	02	30	9.6 (3.96)	01	18	12.46 (4.56)	01	30

Source: Field survey, 2023.

From Table 2, respondents on average travel for 6.42 kilometers to market centres. Net sellers travel marginally higher than Autarky and Net buyer groups, averaging 6.76, 6.41 and 5.70 respectively. The results further revealed that all households reared livestock alongside crop production. The numbers ranged between 06 and 49 with mean stock size of 27 for the pooled data; while ranges 06-49, 09-47 and 12-43 were respectively recorded for Net sellers, Autarky and Net buyers. Livestock play significant role in MP decisions as it provides alternative source of income and / or animal protein source for the family. Cassava production levels recorded for Net sellers, Autarky, Net buyers and the Pooled data were 2700.3kg, 1700.76kg, 1460.00 kg and 1960.00kg in that order. Finally, from Table 2, experience levels in farming of respondents are presented in the last row of the table. The mean farming experience in years was esti-

mated at 12.46 for the pooled data, while Net buyers recorded minimum years with an average of 9.6 years.

Table 3. Descriptive Statistics of Categorical Variables.

Participation Group		Net Sellers		Autarky		Net Buyers		Pooled Data	
Variables	Category	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Sex	Males=1	85	73.1	106	64.2	57	67.0	248	67.9
	Female=0	31	26.9	59	35.8	27	33.0	117	32.1
MajorProd	Yes=1	102	88.3	137	83.0	23	27.4	262	71.8
	No=0	14	11.7	28	17.0	61	72.6	103	28.2
ExtAccess	Yes=1	77	67.0	125	75.6	49	52.8	253	69.3
	No=0	39	33.0	40	24.4	35	41.2	112	30.7
MktAccess	Yes=1	110	95.7	92	55.4	69	82.1	272	74.5
	No=0	06	04.3	73	44.6	15	17.9	93	25.5
MktInfo	Yes=1	98	85.2	105	63.6	71	84.5	274	75.0
	No=0	18	14.8	60	36.4	13	15.5	91	25.0
MemberAsso	Yes=1	74	63.5	100	60.2	45	53.6	219	60.0
	No=0	42	36.5	65	39.8	39	46.4	146	40.0

Source: Field survey, 2023

With respect to Table 3, as expected and in line with similar studies, males dominated cassava farming households as heads with 71.8 percent representation. About 88 percent (262) of the farmers produced cassava as their major crop (MajorProd). Majority of the farmers (69.3%) had access to extension services; distributed among Net sellers, Autarky and Net buyers' groups as 67, 75.60 and 52.8 percentages. High level of extension access compares well with Kyaw et al. [47], but contradicts that of Abunyuwah et al. [38] and Gebremedhin and Jaleta [49]. Similar pattern was also observed for access to market. About 272 respondents (74.5%) indicated that they did have access to market centres without any serious constraints. Among market participation groups however, it was observed that only 55.4% of the Autarky group had no constraints in accessing markets, which distantly compares to 95.7% of Net sellers and 82.2% of Net buyers' groups. It was also observed that access to information on markets and prices were relatively high, as 75% of the respondents indicated they had access to marketing and price information. Again, Autarky group had relatively lower access (63%) compared to 85 and 84 percentages for the Net sellers and Net buyers' groups respectively. These observations contradict studies by Kyaw et al. [47] and Gebremedhin and Jalata [49] and support the findings of Muricho et al. [23]. The results from Table 3 further show that fairly large proportion (60%) of the respondents belong to community or farmer-based associations in the study area. Net sellers' group has higher representation of members who belong to associations, followed by Autarky and Net buyers' groups.

3.2. Econometrics Analysis

In this section, the results and analysis of the main study objective, explaining MP decisions of smallholder cassava farmers in Sekyere Central district of the Ashanti region are presented. Following Abunyuwah [31], and as elaborated in section 2, to apply the ordinal logistic/probit regression model the validity of the parallel line or proportional odds assumption must be established. Using R statistical software, the Brant test which jointly tests all the variables as well as a test for each variable separately to see whether all or any variable violates the proportional odds assumption was used in the evaluation. Results from the Brant test are presented in Table 4. From the table, variables selected for the analysis are presented in column one, while columns two, three and four contain the chi-square values, degree of freedom and their corresponding probability values respectively. For the omnibus and each of the variables, the null hypothesis states that the parallel regression assumption holds. The statistics indicate that the proportional odds assumption for the model as whole (Omnibus) is violated, with chi-square value of 69.65 and p-value of 0.000. Indeed,

five variables contributed to the overall failure of the model to pass the proportional odds assumption. The five variables, namely; Income, Livestk, Produce, MktInfo and MajorProd defined for income from farming activities, quantity of livestock held, production level of cassava, access to market information and whether cassava was considered as the major crop of the farmer respectively (see Table 1), individually failed to pass the parallel line regression assumption. With the exception of Income and MktInfo for which the null was rejected under 5% level of significance, it was rejected under 1% level of significance for each of the remaining three variables. When the parallel lines assumption is violated, and the basic ordered model is used, the coefficients of the affected variables and the model in general may give incorrect, incomplete or misleading results [31]. Another option is to use multinomial logistic regression model (Glogit) in general. This however results in estimation of many parameters which make interpretation of results confusing and loss of ordinal quality of the dependent variable. As a result, the partial proportional odds (PPO) model which provides a substantially better fit to the data than the ordered logit model does while at the same time being much more parsimonious than other alternatives [31, 32], was used.

Table 4. *Brant test of parallel regression assumption.*

Variable	Chi-square	df	Probability
Omnibus (model)	69.65	15	0.000***
HHsize	0.46	1	0.510
Age	0.26	1	0.614
Sex	0.78	1	0.322
Education	0.62	1	0.394
Income	4.54	1	0.033**
OffIncome	0.23	1	0.632
Livestk	43.13	1	0.000***
Produce	12.66	1	0.000***
MajorProd	27.54	1	0.000***
MktAccess	1.47	1	0.207
MktDist	0.66	1	0.388
FarmExp	1.31	1	0.212
ExtAccess	0.68	1	0.380
MktInfo	4.72	1	0.030**
Member	1.53	1	0.201

Note: *, **, *** indicate 10%, 5%, 1% level of significance, respectively.

In addition to the conclusion drawn from the brant test in support of the application of the partial proportional odds model (PPO), the goodness of fit of the model was evaluated in comparison with the ordered logit (Ologit) and generalised ordered logit model (Gologit) specifications using the *Akaike's* Information Criterion (AIC) and the likelihood ratio test, given the structure of equations (3) and (4) as nested. In Table 5, the AIC values of 259.727, 218.876 and 213.655 are respectively presented for Ologit, Gologit and the PPO models. As expected, the LR test, for comparing the PPO and the Ologit, gave a chi-square value of 43.075 (p-value=0.000), which is highly significant. However, the results for the comparison between the Pologit and the Gologit appeared insignificant with LR chi-square value of 15.321 (p-value=0.113). These support the choice for the partial proportional odds (PPO) model since it had the smallest AIC value; and significantly improved on the Ologit model with five additional parameters while no significant improvement could be achieved when the unconstrained ordered logit (Gologit) model was estimated (see Table 5).

Table 5. *Akaike's information criterion for models.*

Model	Observations	Df-AIC	LR	AIC	LR chi-sqr
Ologit	365	17	05	259.727	39.479 (0.000)
Gologit	365	32	10	218.876	15.321 (0.113)
PPO	365	22	-	213.655	-

Source: Author's computation

3.3. Results of Partial Proportional Odds Model

In this sub-section, results of the PPO model are presented in Table 6. The explanatory variables are presented in column one, while their corresponding estimated coefficients, standard errors, z-scores and p-values are presented in columns two, three, four and five respectively. The last column of Table 6 displays the odds ratio, which is used to interpret the intensity of effects of the explanatory variables on the level of market participation regimes.

The results are interpreted in a two-dimensional rank-order categories, given the three level MP groups defined for the dependent variable; namely, 'Net sellers group (NSell)', 'Autarky group (Autky)' and 'Net buyers group (NBuy)'. The references are done by considering the current category and the least coded categories as the base group, when viewed in terms of binary logit or probit model [31, 32]. Consequently, NBuy category was made the base MP category as it was assigned the least code score of 1 (see Table 1). In discussing PPO results as in Table 6, four issues are of interpretational interest; the statistical significance, the signs of the coefficients, the intensity of the effects or the size of the odds ratio/marginal effects, and the regime/category specific coefficients and their odd ratios/marginal effects which result from the variables that failed to pass the proportional odds assumption. In respect of the later, two regime specific estimates ensue, given the three-category rank-ordered dependent variable of this study. However, only estimates for the variables that violated the parallel lines assumption are reported in Table 6 as Reg. 1 and Reg. 2 for regimes one and two respectively. Thus, for variables that passed the parallelism assumption, same estimates hold across all the regimes, and as such were not tagged Reg. 1 and Reg. 2. As indicated above, regime 1 which uses NBuy as its base category and compared with Autky and NSell, has its specific estimates to cover those denoted as Reg. 1 and all of the variables that passed the parallel lines assumption. Likewise, results of variables denoted as Reg. 2 and all of the non-regime specific variables constitute regime 2 estimates, which references NBuy and Autky together as base and contrasted with NSell category. The signs of the coefficients provide an indication of how likely or otherwise a respondent in regime 1 or regime 2 will be in the Autky and NSell or NSell categories respectively.

The results from Table 6 show that many of the explanatory variables appeared statistically significant, at least, under 10% level of significance. Eleven (11) of the fifteen variables, namely; HHsize, MktInfo, Age, Education, MktAccess, Member, OffIncome, FarmIncome, Livestk, Produce and MajorProd appeared statistically significant, while Sex, MktDistance, FarmExp, and ExtAccess variables were insignificant in explaining MP decisions.

Again, as presented in Table 6, a total of 20 parameters (excluding the constants) were estimated after constraining those variables that did not violate the proportional odds assumption. Out of the ten variables that passed the proportional odds assumption six, namely; HHsize, Age, Education, MktAccess, Member and OffIncome appeared statistically significant, while Sex, MktDistance, FarmExp and ExtAccess were insignificant in explaining MP decisions of the respondents. The results further show that HHsize, Age, Education, MktDistance, FarmExp and OffIncome had negative coefficients, while Sex, MktAccess, Member, OffIncome had positive coefficients. These imply that increases in the numbers or values of the variables that have negative coefficients will result in less likelihood of a respondent belonging to Autky or Nsell MP regimes compared to NBuy regime, while a higher likelihood holds for variables with positive coefficients when increases in their values occur. For instance, HHsize, Age, Education and OffIncome appeared significant with negative coefficients and odd ratios of 0.4763015, 0.7854917, 0.7652391 and 0.9937043 respectively, which imply that respondents of larger households, who are relatively aged, of higher levels of education and higher off-farm incomes have lower odds of being in Nsell or Autky regimes. Thus, smaller sized households, in this case, are more likely (about 2.0995 times) to be in Autarky (self-sufficient) or Net sellers' regimes. This result compares to Muricho et al. [23], where larger household sizes negatively affected the probability of households being net sellers in their study of smallholder maize farmers MP in Kenya.

Table 6. *Partial Proportional Odds Model Results.*

Variables	Coefficients	Std. Error	z value	Pr(>|z|)	Odds Ratio
(Intercept): Reg 1	6.5772451	1.1671763	5.635	0.0050214 ***	-
(Intercept): Reg 2	2.1258046	1.1403568	1.865	0.0854363 *	-
HHsize	-0.7303349	0.0906968	-8.052	0.0000081***	0.4763015
Age	-0.2414463	0.0545348	-4.427	0.0000095***	0.7854917
Sex	0.1041405	0.3883325	0.268	0.7885470	1.1097684
Education	-0.267567	0.0831471	-3.218	0.0012290 **	0.7652391

Variables	Coefficients	Std. Error	z value	Pr(>|z|)	Odds Ratio
MktAccess	0.8065226	0.4290325	1.886	0.0601300 *	2.2401048
MktDistance	-0.0913380	0.0919729	-0.993	0.32066	0.9127093
FarmExp	-0.0156610	0.0410017	-0.382	0.70249	0.9844610
ExtAccess	0.0764840	0.4140534	0.185	0.85345	1.0794849
Membership	0.7246316	0.3735714	1.940	0.05241*	2.0639706
OffIncome	-0.0063165	0.0015253	-4.141	0.0000035***	0.9937043
MktInfo: Reg. 1	-0.8180632	0.4225533	-1.936	0.05548*	0.4412855
MktInfo: Reg. 2	0.9768632	0.4520422	2.161	0.01248**	2.656111
FarmIncome: Reg. 1	0.009737	0.0015412	6.296	0.0000030 ***	1.0097509
FarmIncome: Reg. 2	0.004618	0.0009556	4.834	0.0000013 ***	1.0046295
Livestk: Reg. 1	0.1796470	0.0349418	5.141	0.0000270 ***	1.1967949
Livestk: Reg. 2	0.076917	0.0290454	2.648	0.0080920 **	1.0786243
Produce: Reg. 1	0.6525921	0.1151058	5.669	0.0000028 ***	1.9202962
Produce: Reg. 2	0.2217830	0.0403560	5.496	0.0000038 ***	1.2483004
MajorProduce: Reg. 1	2.1121099	0.3530519	5.982	0.0000054 ***	8.265663
MajorProduce: Reg. 2	0.6870075	0.1543118	4.452	0.0000546 ***	1.9877582

Note: *10%, **5%, ***1% indicate significance levels.

Similar observations were also made in other studies [9, 47, 49], while findings reported by Konja and Mabe [26] and Bosompem et al. [27] who conducted their studies in Ghana, contradict the findings in this study. For age, as expected, the results compare to findings of many similar studies, as younger farmers tend to be more commercial oriented [8]. Contrary, with respect to the sign of the education variable mixed results abound in the MP literature. Our results indicate that respondents with higher level of education are less likely to participate in the markets as Autky or NSell. While conceptually unexpected, similar observations are found in the MP literature [8, 9, 48]. Many others, found positive effect of education on MP [23, 27, 38, 47, 49]. Membership to farmer and community-based associations and levels of off -farm income have expected direction of influence on MP regimes. Membership to association increases the likelihood of a cassava farmer to participate in the market as Net seller or Autarky compared to Net buyer. Thus, association members are about 2.04 times more likely to participate in markets as Autarky or Net sellers, than non-members. As expected, this result is supported by many previous studies [8, 9, 23, 26]. With regards to off-farm income, the results indicate that household heads who earn more from non-farming engagements are less likely, though marginal (0.993 times), to participate in cassava markets as Net sellers. This observation is consistent with results reported in other studies [9, 23, 27], but contradicts those of Andaregie et al. and Ola and Menapace [20, 50]. As stated above, although Sex, MktDistance, FarmExp and ExtAccess did not appear significant in explaining MP decisions in this study, the sex, distance to market and access to extension services variables had expected signs which compare to findings of many MP studies [20, 23, 27, 38, 47]. While it is expected that experienced farmers would operate at relatively higher efficiency levels and would have established marketing links, to positively affect MP decisions, the results of this study, similar to Haile et al. and Konja and Mabe [9, 26], indicate otherwise which contradict those of Okoye et al. and Bosompem et al. [8, 27]. Market participation is fundamentally a function of market accessibility, and as expected the results of this study show that farmers who have access to markets are more likely (2.40 times) to participate in the markets as Net sellers than those who had limited access.

The results for the variables that failed the proportional odds assumption are presented at the second half of Table 6. These address the restrictive and constrained parameter estimates and interpretations of ordered models under the proportional odds assumption where same effects apply across categories (see references, [32, 33, 51]). From Table 6, all the three regime specific estimates for the five variables (resulting in ten parameter estimates) appeared significant, at least, under 10% level of significance. Again, with the exception of the estimate for MktInfo variable for regime one (Reg. 1), all others had positive coefficients. As expected, one of the critical insights that are deduced from the PPO models is observed with the MktInfo variable. Under regime one, that is,

comparing Net buyers' category to Autarky and Net sellers categories, the results (coefficient = -0.8180632; Odd ratio = 0.44128) imply that farmers who have access to market information are less likely to produce for Autarky (self-sufficiency) or for Net sales (0.44128 times) than those with limited access to market information. However, results of the same variable for regime two (Reg. 2) indicate a switch in intensity and direction of influence. Thus, with a positive coefficient (0.9768632) and the associated odd ratio of 2.656, it means that farmers who have higher access to market information are more likely and of higher intensity to be drawn towards Net seller MP category from Autarky group. This observation is consistent with theory; and in this case, the PPO better explains the MP conceptualizations where participation is usually defined in binary category. That is, holding other factors constant, it is expected that households with enough market information will tend to efficiently participate in the market, either as a net buyer or net seller from the position of autarky, but for welfare improvements and market rewards, they will be more vigorous, when it is towards the net seller regime. This finding in general is consistent with majority of previous studies [23, 26, 47]. The results for the four remaining variables, indicate that all of them maintained their direction of influence, but with differing intensity from one regime to the other. For instance, higher production levels, as expected and in line with many previous researches, had positive effects on market participation regimes, but varied from regime one to two. The results indicate that a unit increase in produce (a bag of 100kg) for a farmer in NBuy regime will be 1.921 times more likely to move to Autky/NSell regimes, while same change in produce will result in 1.248 times likelihood for moving from NBuy/Autky to NSell regimes. Similar observations hold for Income, Livestk and MajorProd. The conclusions from the PPO model for these variables conform to the general observations found in the literature [8, 9, 20, 23, 26, 27].

4. Conclusions

The study assessed levels of MP by cassava farmers in Sekyere Central district of Ghana using partial ordered logit model, based on household choice theory and its implied welfare and profitability embedded measure of MP regimes. Based on these, the study provided extensive and deeper methodological insights, especially in the interpretation of regime specific effects of the regressors specified in the structure of partial ordered regression model. The results showed that, relatively few farmers, about 32%, participate in the markets with gains (as net sellers). Thus, out of the 365 farmers interviewed, 116 (31.8%), 165 (45.2%) and 84 (23%) of them participated in the market as Net sellers, Autarkic producers and Net buyers' respectively. The econometrics analysis revealed that variables defined for household size, access to market information, age, education, market access, membership to famer or community organisation, off-farm income, farm income, livestock holdings, total output of cassava in the previous production season and cassava being cultivated as major crop, appeared statistically significant, while those for sex, distance to market centres, farming experience and access to extension services were insignificant in explaining MP decisions of cassava farmers in the Sekyere Central district. Following the outcome of the brant test, five of the variables which failed to pass the proportional odds assumption entered the model unconstrained. The significant coefficients of the regime specific variables, further give insights into how conditional on their current regimes, farming households on average respond to changes in factors that affect their MP decisions with differing intensity. Farm level policies, that target cassava farm households' participation into the market should therefore consider regime specific strategies and measures. Again, given the high percentage (68%) of farmers who do not participate in the cassava market profitably, increased efforts to enhance production, improve accessibility especially to market and market information, and to have a review of current extension strategies are recommended to ensure that smallholder cassava farm households effectively access the full potential of cassava supply chain.

Abbreviations

GDP	Gross Domestic Product
GHc	Ghana Cedi
MP	Market Participation
PPO	Partial Proportional Odds
VGLM/VGAM	Vector Generalised Linear/Additive Models

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Author Contributions

Isaac Abunyuwah is the sole author. The author read and approved the final manuscript.

Data Availability Statement

Data used for this work is a primary data that was collected by the Author. Available at request.

Conflicts of Interest

The author declares no conflicts of interest.

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