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Impact of digital financial inclusion on the participation in farmer-based organisations, structured market and off-farm work in Ghana

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Abstract

This paper examines the impact of mobile money account ownership on farmers' participation in farmer-based organisations (FBOs), structured market and off-farm work. Relying on recursive bivariate probit model, our results reveal that owning a mobile money account increases the likelihood of farmers' participating in an FBO, structured market and off-farm work by 15.4%, 33.3% and 37.5%, respectively. Furthermore, mobile money account ownership is influenced by socioeconomic and institutional factors as well as the presence of mobile money vendors within a community. Our finding calls for sustained efforts to deepen digital financial inclusion for increased participation in FBOs, structured market and off-farm work.

KEYWORDS

mobile money, recursive bivariate probit, smallholder maize farmers, southern Ghana

1 | INTRODUCTION

This article shines light on the impact of the adoption of mobile money account on the decision to participate in farmer-based organisations (FBOs), structured market and off-farm work in Ghana. Mobile money transactions have gained traction globally. For instance, the Groupe Speciale Mobile Association (2022) indicates that the volume of mobile money transactions in 2021 stood at US \$1 trillion, with an estimated 1.35 billion registered accounts in 2021 (Groupe Speciale Mobile Association, 2022). Sub-Saharan Africa (SSA) countries recorded 183 million registered active accounts with 697.7 billion transactional value in 2021. In Ghana, in 2018 mobile money transactions accrued a total value of 223.2 billion Ghana cedis (Atta-Ankomah, 2022; Bank of Ghana, 2019). These statistics point

to the immense adoption and contribution of mobile money to digital financial inclusion, and ultimately how the surge and increased use of mobile money can positively impact economic sectors in society. Indeed, studies show that mobile money positively impacts poverty reduction (Aziz & Naima, 2021), accumulation of wealth (Célerier & Matray, 2019) and growth in incomes (Zhang & Posso, 2019). Mobile money transactions have also received attention among farmers in transacting businesses (Kikulwe et al., 2014; Murendo et al., 2018; Sekabira & Qaim, 2017). For instance, Parlasca et al. (2022) showed that over 82% of farmers in Kenya use mobile money. There is, however, an uneven penetration of the adoption of mobile money across countries in SSA, and even within countries, there is differential access to mobile money accounts. Where rural locations appear to be disadvantaged.

This article advances an argument that mobile money account ownership positively impacts the decision to join FBOs and participation in structured market and off-farm work. This argument is inspired by the limited works that have examined the impact of mobile money account ownership on the three streams of interconnected literature (the decision to participate in FBOs, structured market and off-farm work). We find strands of literature that examine the impact of mobile money in silos. For instance, studies (Kikulwe et al., 2014; Sekabira & Qaim, 2017; Yao et al., 2022) have considered the impact of mobile money on market participation, the impact of mobile money on off-farm work (Sekabira & Qaim, 2017). However, in the extant literature, there appears to be no evidence about the impact of the ownership of mobile money on the decision to participate in FBOs. To the best of our knowledge, this study appears to be the first to examine the impact of mobile money on smallholder farmers' decision to join FBOs and participate in structured markets and off-farm work in Ghana. The related literature has extensively examined the impact of mobile money on household welfare outcomes mainly through the pathway of remittances (Kikulwe et al., 2014; Yao et al., 2022). The extant literature shows that mobile money has positive impacts on consumption, food security, income and farm profit (Kikulwe et al., 2014; Li et al., 2020; Sekabira & Qaim, 2017; Suri & Jack, 2016). It is well documented that mobile money brings efficiency in market transactions and money transfers particularly for the unbanked. However, paucity of information exists on the real impacts in developing countries, especially covering smallholder farmers (Kikulwe et al., 2014; Nakasone et al., 2014). The few literatures that attempt to examine this thin area remain skewed towards Eastern Africa, especially Kenya and Uganda (Jack & Suri, 2014; Kikulwe et al., 2014; Munyegera & Matsumoto, 2016; Murendo & Wollni, 2016; Parlasca et al., 2022; Sekabira & Qaim, 2017).

In the case of Ghana, limited attempts have been made to understand the impact of mobile money adoption on farmers' welfare outcomes, leading to an unbalanced literature on digital financial inclusion skewed towards Eastern Africa. Awunyo-Vitor (2016) earlier examined the drivers of mobile money services among maize farmers in Ghana. Asravor et al. (2022) recently examined the factors that drive mobile money adoption and its intensity in Ghana. Abdul-Rahaman and Abdulai (2022) assessed the impact of mobile money adoption on input use and agricultural output among rice farmers in northern Ghana, while Peprah, Koomson, et al. (2020) assessed the impact of mobile money on smallholder farmers' productivity in Ghana. The literature so far on Ghana lacks explicit studies that examine the impact of mobile money adoption on participation in structured market, decision to join FBOs and the participation in off-farm work.

Our study contributes to the three interconnected streams of literature by showing the impact of mobile money account ownership on the participation in FBOs, off-farm work and structured market. Generally, we find that studies that examine the impact of mobile money adoption on agricultural welfare outcomes are limited in SSA (Asravor et al., 2022; Kikulwe et al., 2014; Kirui et al., 2013; Peprah, Oteng, & Sebu, 2020). To the best of our knowledge, this study is the first to introduce another pathway for the impact of mobile money ownership on the decision to participate in FBO activities. We find the pathway useful because government and donors continue to encourage participation in FBOs, especially with regard to the implementation of new agricultural programme interventions. However, the extent to which mobile money promotes participation in FBOs appears under-researched even though it has important policy implications for academia and practice. Our study introduces a new pathway about the impact of mobile money on the decision to participate in FBO activities. This remains essential for three reasons. First, we note that belonging to FBOs enables members to access high-end markets, where such markets may find it easier to make

payments for the produce supplied through official FBO mobile money accounts. The FBOs may intend also to make payments to their members through their mobile money accounts, by cutting off the direct engagements with formal financial institutions that appear to have limited reach in remote locations. For instance, a close study by Sekabira and Qaim (2017) examined the impact of mobile money on agricultural marketing and off-farm in Uganda, where they showed that mobile money users were able to market their produce to high-end supermarkets relative to the local market. Secondly, FBOs and their members may have formal accounts with financial institutions that are linked to the mobile money accounts. Hence, the ownership of mobile money accounts can be linked to financial institutions' bank accounts and vice versa, thereby deepening digital transactions and financial inclusion. Finally, given the benefits of collective action, FBOs are able to negotiate for reduced unit prices of agricultural inputs when they make bulk purchases. The acquisition of agricultural inputs can be made through mobile money transactions; hence, we find the direct link between the adoption of mobile money accounts and the decision to join FBOs, but this is conspicuously missing in the related literature.

We find that the few studies that attempt to examine the impact of mobile money adoption on smallholder welfare outcomes tend to focus on cash crops even though cereals are major staple crops within SSA. Parlasca et al. (2022) observed that most impact studies on mobile money examined cash crop farmers; hence, such findings cannot be used to generalise for the broader farming population. Maize is an important staple crop across most African countries including Ghana; hence, there is the need to focus on how mobile money adoption plays out among cereal crop farmers. We note that while our study focuses on Ghana, the surge in the adoption of mobile money appears to be growing rapidly in SSA; thus, our study has direct relevance for countries with similar socio-demographic settings in the subregion.

Overall, highlighting the impact of mobile money adoption on market participation, the decision to join FBOs and structured markets is beneficial in policy design and programme implementation that targets deepening digital financial inclusion among farmers, while taking into account the socio-economic determinants that influence the adoption of mobile money accounts in Africa.

The introduction is next followed by conceptual and empirical framework underpinning the study. Section 3 presents the study site, variables selection and summary statistics. The penultimate section (Section 4) presents the results and discussions within the related body of literature. The final section concludes and offers policy-worthy recommendations that can guide sustainable agricultural production.

2 | CONCEPTUAL AND EMPIRICAL FRAMEWORK

The aim of this study is to examine how farmers' decisions to own a mobile money account are related to their participation in FBOs, structured markets and off-farm work. Farmers' participation in FBOs, structured markets and off-farm work is influenced by various socioeconomic factors, including mobile money account ownership (Bekele, 2022; Tay et al., 2022). The awareness of farmers about the benefits of FBOs, structured markets and off-farm work, coupled with owning a mobile money account, can boost their chances of participating in these activities. Figure 1 below shows the pathway between owning a mobile money account and the decision to join FBOs, structured market and off-farm work.

FBO is defined as a collective of smallholder farmers, who come together either in formal or informal arrangements, established common pool resources (human, material and financial) for collective action. Among some of the main benefits of membership of FBOs include enhanced access to market information, better market access (good market niche for agricultural produce), uniform prices for farm produce and improved bargaining power (Dary & Grashuis, 2021; Francesconi & Wouterse, 2015). Supermarkets find it easy to deal with FBOs relative to individual farmers. It appears not to be cost effective to deal with individual farmers compared to FBOs. Indeed, Sekabira and Qaim (2017) showed that mobile money enhanced access to high-end supermarkets in Uganda. Agricultural produce supplied by FBOs to supermarkets can be paid via the FBO's bank account which may be linked to the FBO's mobile

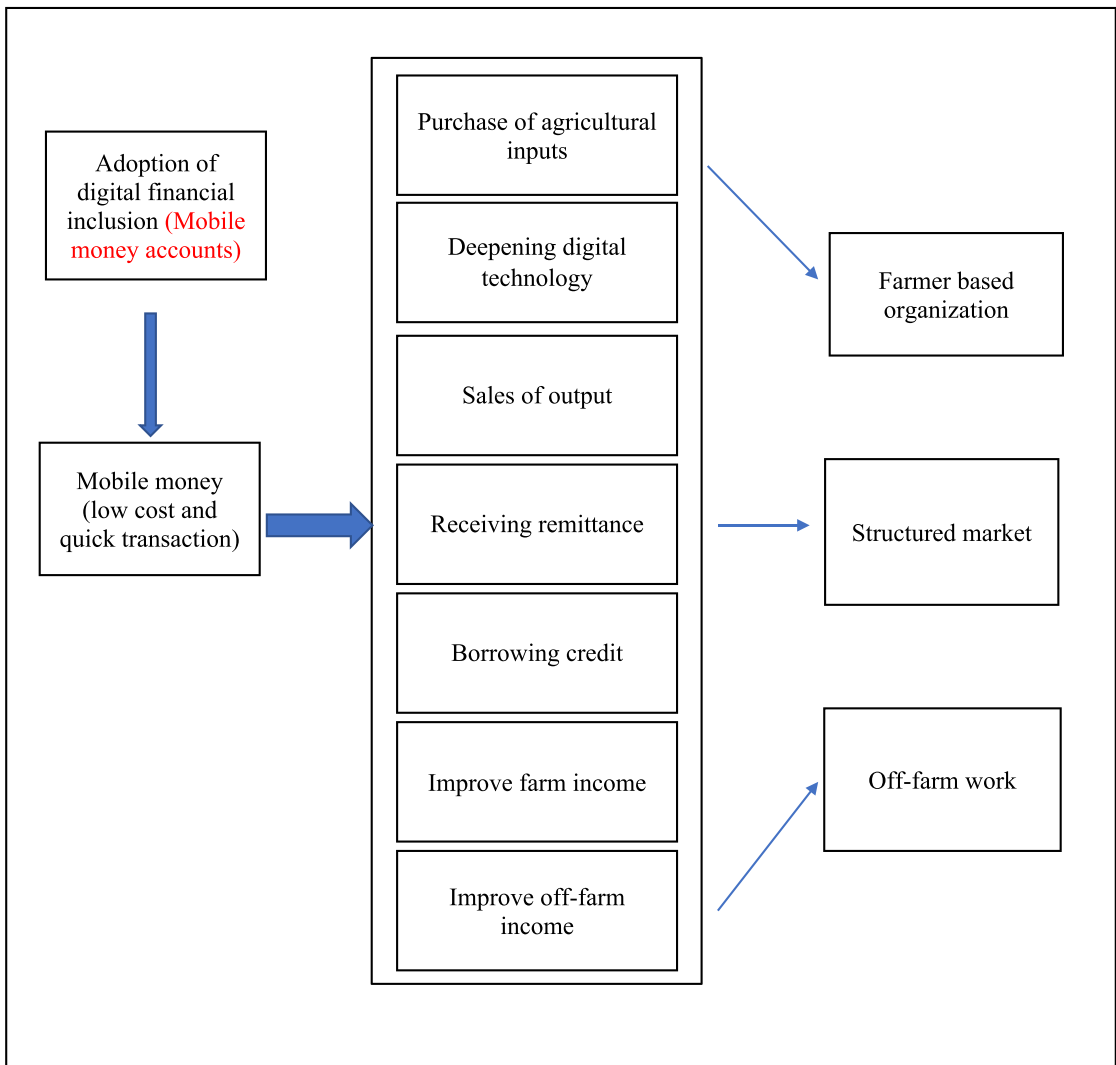


FIGURE 1 Pathways of mobile money impact on FBO, structured market and off-farm work. Source: Author's construct, 2023. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

money account. This can hasten transactions and cut down transactional costs associated with physical interface transaction costs and time. We note that in remote areas, easy mobility is a challenge because of inefficient transportation systems. Francesconi and Wouterse (2015) argued that the success of FBOs partly depends on the risk-sharing mechanisms and efficiency-enhancing devices which may include digital financial inclusion. Efficient FBOs entice members to join.

In this study, a structured market is defined to be a market characterised by participants such as aggregators, off-takers and processors who conduct trade through well-established systems that ensure equitable pricing, efficient sales and distribution, embedded in a system that ensures reliable information dissemination. It is characterised by aggregators, who assemble the farm produce at centralised points, while off-takers pick up the aggregated far, produce and make it available to processors for processing and eventually to final consumers. These markets often feature centralised clearinghouses that mitigate counterparty risk and facilitate smooth trade settlement.

Mobile money account influences farmer's participation in structured markets through a direct window where value chain actors such as producers, aggregators, processors and transporters use the mobile money accounts to transact business (Issahaku et al., 2018). This is predicated on the fact that structured markets are well-structured with established systems; therefore, the high-level informality that pertains in open-spaced markets appears less in structured markets. Therefore, the use of mobile money accounts as a medium of financial transactions is enhanced. Value chain actors are able to reduce transactional costs and, hence, become more profitable. There is a high risk involved in carrying bulk money around transacting business; hence, mobile digital wallets afford the above-mentioned value chain actors involved in the maize value chain the opportunity to easily transact business.

Off-farm income refers to the portion of income earned by farm households that is derived from sources outside of the farm. This includes income from nonfarm wages, salaries, pensions, remittances and petty trading earned by farm families (Aron, 2017). As farmers become more efficient through the use of mobile money accounts in their transactions, they begin to operate farming as a business, and therefore, they are able to invest money from off-farm activities into farming and vice versa. Mobile money account ownership is a welfare-enhancing mechanism where money remitted as well as credit borrowed can be transferred onto mobile money accounts which eventually improves production efficiency in both farming and off-farm activities (Twumasi Baffour et al., 2021), thereby facilitating both farm and off-farm business diversification portfolios. Evidence in Mozambique shows that mobile money reduces transaction costs on remittances (Batista & Vicente, 2020). The related literature (Kikulwe et al., 2014; Murendo et al., 2018; Sekabira & Qaim, 2017) establishes the impact of mobile money on off-farm market.

Figure 1 summarises the pathways of the adoption of mobile money accounts by smallholder farmers to include the purchase of agricultural inputs, sales of agricultural produce, purchase of technologies (thus deepening of digital financial inclusion), borrowing credit, receiving of remittances and increases in farm and off-farm income.

If the potential profits outweigh the costs, farmers are more likely to prioritise the benefits of owning a mobile money account. Therefore, the decision to own a mobile money account and participate in FBOs, structured markets and off-farm work can be seen as a binary choice. The decision to own a mobile money account can be represented by two options: either own account ($d_1 = 1$) or not own ($d_1 = 0$). Similarly, farmers' participation in FBOs, structured markets and off-farm work can be denoted as ($h_1 = 1$) and their non-participation as ($h_1 = 0$).

To achieve the aim of this paper, a recursive bivariate probit (RBP) model was employed drawing on previous research (see Greene, 2018; Ma, Renwick, et al., 2018; Ma & Zhu, 2021). This model effectively addresses endogeneity problems stemming from both observed and unobserved variables and allows for unbiased parameter estimates (Greene, 2018; Ma, Renwick, et al., 2018; Ma & Zhu, 2021). Unlike other models, such as the PSM (Propensity Score Matching), which do not consider unobserved factors and are not limited to binary outcomes (Prah et al., 2023; Zheng, 2023), the RBP model used in this study addresses these issues and is more effective in achieving unbiased parameter estimates. As per Chang and Mishra's (2008) approach, we examine whether there exists a joint decision-making process, particularly considering the endogeneity of owning a mobile money account. To properly identify the RBP model, we need a suitable instrument that can explain the likelihood of owning a mobile money account but is uncorrelated with the outcome variable (i.e., FBOs, structured markets and off-farm work). Taking cues from Deng et al. (2019) and Ma, Renwick, et al. (2018), this study utilised the presence of mobile money vendors within farmers' villages as the instrumental variable. Our hypothesis was that this variable would impact the decision to own a mobile money account but not influence the decision to participate in FBOs, structured markets and off-farm work (Amadu et al., 2020; Li et al., 2019; Ma & Zhu, 2021). We, therefore, specified the RBP model as

$$d_1^* = \alpha X' + \mu \quad \text{where } d_1 = \begin{cases} 1 & \text{if } d_1^* > 0 \\ 0 & \text{if } d_1^* \leq 0 \end{cases} \quad (1)$$

$$h_1^* = \psi d_1^* + \eta W' + \varpi \quad \text{where } h_1 = \begin{cases} 1 & \text{if } h_1^* > 0 \\ 0 & \text{if } h_1^* \leq 0 \end{cases} \quad (2)$$

where d_1^* and h_1^* represent latent variables and indicate the likelihood of owning a mobile money account and the decision to participate in FBOs, structured markets and off-farm work, respectively. The variable d_1^* is considered to display endogeneity in the h_1^* model. The variables d_1 and h_1 signify the observed choices (either 0 or 1), while X and W are exogenous factors, and α and η are vectors of unknown coefficients to be estimated. The variables μ and ϖ are residuals that are assumed to have a joint normal distribution with $N \sim (0, 1)$ and a correlation parameter equal to ρ (Cameron & Trivedi, 2010). A statistically significant parameter of $\rho\mu\varpi$ would suggest that there is a correlation between the unobserved factors that affect the ownership of mobile money account and the participation in FBO, structured market and off-farm work. This would indicate that the decision to own a mobile money account is endogenous and that farmers' choices regarding ownership and participation are jointly affected by these unobserved factors such as motivations (Ma, Abdulai, & Goetz, 2018). In this study, we utilised the full information maximum likelihood (FIML) procedure, which is more efficient in handling endogeneity issues compared to the two-stage instrumental variable estimation method (Wooldridge, 2010). Our dependent variable was the binary ownership status of mobile money accounts among farmers, and we also included a binary indicator of their participation in FBOs, structured markets and off-farm work.

We selected the explanatory variables for our empirical model based on a review of literature on mobile money account ownership and participation in FBOs, structured markets and off-farm work. These variables include age, gender, education, household size, farm size, total asset value, farm distance and district dummies (Anang et al., 2020; Anarfo & Abor, 2020; Asongu et al., 2019; Bekele, 2022; Emara & Moheildin, 2021; Nkegbe et al., 2022).

Based on Chiburis et al. (2012), we further estimated the treatment effect of owing a mobile money account on participation in FBO, structured market and off-farm work. Average treatment effect on the treated can be written as

$$ATT = \frac{\sum_{i=1}^{n_{d_1}} [\Pr(G_{ik} = 1)|d_1 = 1] - \Pr(G_{ik} = 0|d_1 = 1)]}{n_{d_1}} \quad (3)$$

where n_{d_1} represents the sample size for the treated, $\Pr(G_{ik} = 1)|d_1 = 1$ denotes the predicted outcome variable probability for farmers-owned mobile money accounts in an observed context and $\Pr(G_{ik} = 0|d_1 = 1)$ shows the predicted probability that a farmer-owned mobile money account (in a counterfactual context) will not participate in the outcome variables (i.e., FBO, structured market and off-farm work).

3 | STUDY SITE, VARIABLES SELECTION AND SUMMARY STATISTICS

The study collected data from smallholder maize farmers in the Brong-Ahafo Region of Ghana between September and December 2021. A multistage sampling technique was used to select 1440 farmers, with 480 farmers selected from each of the three districts—Kintampo South, Kintampo North and Jaman. The first stage involved selecting Brong-Ahafo, one of the leading maize-producing regions in Ghana, purposively. The second stage involved selecting the three districts based on their significant maize production. The third stage involved the random selection of five communities from each district, resulting in a total of 96 sampled farmers. The selection of communities was based on the size of farmland or the number of maize farmers in each community. The final sample size was 1431 maize farmers due to incomplete responses. The structured questionnaire used in the data collection gathered information on farmers' attributes, farm level, institutional factors, digital financial inclusion variables and maize production within the study area.

Table 1 shows the variables used in the model and presents the summary statistics of the entire sample. Among the maize farmers surveyed, 48% owned a mobile money account. The participation rates in FBOs, structured markets and off-farm work were on average 55%, 46% and 68%, respectively. Most maize farmers (78%) were male, and

TABLE 1 Definitions and summary statistics of the full sample.

Variables	Measurement	Expected sign	Source	Mean	Std. Dev.
Age	Age of respondent in years	+/-	(Anarfo & Abor, 2020)	47.6	10.6
Sex	1 if respondent is male and 0 = female	+/-	Soekarno et al. (2020); Huang et al., 2021; Tay et al., 2022)	0.78	0.34
Education	Education of respondent in years	+	(Bede Uzoma et al., 2020; Tay et al., 2022)	6.3	5.1
Household size	Number of household members	+	(Anang et al., 2020; Nkegbe et al., 2022)	6.7	3.3
Farm size	Farm size of respondent in acres	+	(Meier zu Selhausen, 2016)	5.2	4.3
Farm distance	Distance from respondent homestead to the nearest farm in kilometres	-	(Nkegbe et al., 2022)	6.7	4.4
Asset value	Total value of asset in Ghana cedis	+	(Meier zu Selhausen, 2016; Ngwako et al., 2021)	6582.32	4979.07
Extension contact	1 if respondent had extension contact and 0 = otherwise	+	(Oladele, 2015)	0.58	0.50
Credit access	1 if respondent had credit access and 0 = otherwise	+	(Alhassan et al., 2020; Sekyi et al., 2017)	0.76	0.43
Kintampo North	1 if respondent from Kintampo North and 0 = otherwise	+	(Bekele, 2022; Ma et al., 2018; Ma & Zhu, 2021)	0.30	0.10
Jaman North	1 if respondent from Jaman North and 0 = otherwise	+	(Bekele, 2022; Ma, Abdulai, & Goetz, 2018; Ma & Zhu, 2021)	0.28	0.22
Kintampo South	1 if respondent from Kintampo South and 0 = otherwise	+	(Bekele, 2022; Ma, Abdulai, & Goetz, 2018; Ma & Zhu, 2021)	0.41	0.21
Mobile money vendor	1 if there is a mobile money vendor located within the village and 0 = otherwise	+	(Aziz & Naima, 2021)	0.25	0.13
FBO membership	1 if respondent belongs to farmer-based organisation and 0 = otherwise			0.55	0.49
Structured market	1 if respondent had structured market access and 0 = otherwise			0.46	0.48

(Continues)

TABLE 1 (Continued)

Variables	Measurement	Expected sign	Source	Mean	Std. Dev.
Off-farm work	1 if respondent engages in off-farm work and 0 = otherwise			0.68	0.46
Mobile money account	1 if respondent owns mobile money and 0 = otherwise			0.48	0.37

their average age was 47.6 years. The average household size was 6.7, and the average farm size was 5.2 acres. The average number of years of schooling for a maize farmer was 6.3, which is quite high for making informed decisions about participation. On average, a typical maize farmer had a total asset value of GH¢ 6582.32/US \$1 117.54,¹ which could be crucial in influencing participation. The average farm distance was 6.7 km, which may play a crucial role in participating in the outcome variables during maize production. About 76% had credit access, and 58% had contact with an extension officer, which could potentially affect their participation in the outcome variables. The district dummies indicate that 41% of the full sample came from Kintampo South.

Table 2 provides a comprehensive comparison of the average differences between maize farmers who own mobile money accounts and those who do not. The analysis shows that among both owners and non-owners of mobile money accounts who participated in FBO, structured markets and off-farm work during maize production, the majority were male. Also, the owners of mobile money accounts who participated in FBO, structured markets and off-farm work tended to be younger than non-owners, which suggests that there may be selection bias due to unobserved variables. It is also noted that younger farmers are generally more risk-takers and less conservative than older ones. On average, participants and non-participants of FBO, structured markets and off-farm work who were owners and non-owners of mobile money accounts had similar household sizes. Participants who owned mobile money accounts had higher years of education than non-participants, while non-participants who owned mobile money accounts had higher asset values than non-participants who did not own mobile money accounts. However, among participants and non-participants who did not own mobile money accounts, the reverse was observed. Participants who owned mobile money accounts tended to cultivate larger farm sizes than non-participants, and this was also observed among non-owners of mobile money accounts. Interestingly, most owners of mobile money accounts who were participants had greater access to credit and extension services than non-owners. Additionally, participants and non-participants who owned mobile money accounts travelled shorter distances to their farms compared to non-participants who did not own mobile money accounts. This suggests that farm distance may influence participation in FBO, structured markets and off-farm work. It is important to note that both participants and non-participants who were owners and non-owners of mobile money accounts did not have vendors located within their communities, which could affect their decision to own a mobile money account.

4 | RESULTS AND DISCUSSIONS

4.1 | Diagnostics of RBP model

Table 3 displays the results of the RBP model estimation, which examines the determinants of mobile money account ownership and its impact on maize farmers' decision to participate in FBO, structured market and off-farm work. The

¹The exchange rate stood at US \$1 at GH¢ 5.89.

TABLE 2 Descriptive statistics of mobile money account ownership by farmer-based organisation, structured market and off-farm work.

Variables	Owned mobile money					
	FBO		Structured market		Off-farm work	
	Participants Mean	Non-participants Mean	Participants Mean	Non-participants Mean	Participants Mean	Non-participants Mean
Age	46.6 (11.1)	47.5 (10.7)	46.9 (11)	47.2 (10.6)	45.5 (10.2)	49.5 (11.6)
Sex	0.83 (0.36)	0.88 (0.31)	0.87 (0.33)	0.86 (0.34)	0.88 (0.32)	0.83 (0.37)
Education	6.9 (5.2)	5.7 (5.3)	7.8 (5.3)	5.6 (4.2)	6.9 (5.3)	5.2 (4.2)
Household size	6.8 (3.4)	6.2 (3)	6.4 (2.9)	6.6 (3.8)	5.9 (2.6)	7.5 (3.9)
Farm size (acre)	5.5 (3.6)	4.6 (2.6)	4.9 (3.2)	5.4 (3.1)	5.5 (4.3)	4.4 (2.5)
Farm distance	5.5 (3.2)	6.8 (4.0)	5.1 (3.9)	6.5 (3.9)	5.1 (3.4)	6.3 (3.7)
Asset value (GH¢)	5383.19 (4702.74)	8813.65 (4644.57)	6911.47 (4669.54)	6688.01 (4687.03)	6798.71 (4522.89)	7815.59 (4926.57)
Extension contact	0.69 (0.46)	0.50 (0.33)	0.61 (0.48)	0.59 (0.49)	0.58 (0.49)	0.65 (0.47)
Credit access	0.72 (0.44)	0.56 (0.39)	0.62 (0.48)	0.76 (0.42)	0.80 (0.39)	0.59 (0.49)
Kintampo North	0.32 (0.12)	0.34 (0.13)	0.34 (0.13)	0.33 (0.12)	0.31 (0.11)	0.36 (0.16)
Jaman North	0.39 (0.2)	0.25 (0.16)	0.35 (0.14)	0.34 (0.11)	0.37 (0.16)	0.28 (0.18)
Kintampo South	0.24	0.43	0.32	0.42	0.35	0.37

(Continues)

TABLE 2 (Continued)

Variables	Owned mobile money			
	Structured market		Off-farm work	
	Participants Mean	Non-participants Mean	Participants Mean	Non-participants Mean
	(0.16)	(0.25)	(0.11)	(0.22)
			(0.15)	(0.16)
Mobile money vendor	0.32 (0.14)	0.22 (0.11)	0.21 (0.12)	0.20 (0.1)
			0.19 (0.1)	0.22 (0.12)
Observations	278	247	334	191
			326	199

Note: Standard deviation in parenthesis.

TABLE 2 (Continued)

Variables	Do not own mobile money			
	Structured market		Off-farm work	
	Participants Mean	Non-participants Mean	Participants Mean	Non-participants Mean
	(10.6)	(10.3)	(10.9)	(10.2)
Age	47.9 (10.6)	47.8 (10.3)	47.7 (10.9)	47.9 (10.2)
				48.5 (10.8)
Sex	0.85 (0.35)	0.89 (0.3)	0.85 (0.35)	0.88 (0.32)
				0.87 (0.33)
Education	6.7 (5.9)	5.6 (5.5)	6.5 (5.9)	5.5 (3.5)
				6.9 (5.9)
				4.9 (3.3)
Household size	6.6 (3.2)	6.7 (3.3)	6.5 (3.3)	6.7 (3.8)
				6.4 (3.0)
Farm size (acre)	4.8 (3.7)	4.6 (3.2)	5.2 (3.5)	4.3 (3.8)
				4.7 (3.8)
				4.5 (3.7)
Farm distance	5.9 (4.2)	6.4 (3.6)	6.8 (4.4)	5.8 (3.6)
				6.4 (4.2)
				5.6 (3.2)

TABLE 2 (Continued)

Variables	Do not own mobile money					
	FBO		Structured market		Off-farm work	
	Participants Mean	Non-participants Mean	Participants Mean	Non-participants Mean	Participants Mean	Non-participants Mean
Asset value (GHC)	6665.14 (5534.15)	5510.43 (4670.49)	5998.38 (4907.42)	6301.91 (5289.03)	6021.65 (4938)	6579.45 (5676.25)
Extension contact	0.59 (0.42)	0.56 (0.49)	0.60 (0.48)	0.56 (0.49)	0.59 (0.49)	0.53 (0.5)
Credit access	0.66 (0.32)	0.56 (0.49)	0.66 (0.47)	0.86 (0.34)	0.78 (0.41)	0.82 (0.39)
Kintampo North	0.29 (0.19)	0.26 (0.17)	0.35 (0.14)	0.23 (0.15)	0.27 (0.17)	0.29 (0.19)
Jaman North	0.3 (0.19)	0.18 (0.13)	0.33 (0.12)	0.19 (0.14)	0.27 (0.18)	0.19 (0.13)
Kintampo South	0.4 (0.2)	0.45 (0.29)	0.35 (0.16)	0.47 (0.34)	0.43 (0.25)	0.41 (0.22)
Mobile money vendor	0.18 (0.12)	0.19 (0.23)	0.21 (0.11)	0.18 (0.21)	0.18 (0.14)	0.21 (0.11)
Observations	508	398	319	587	640	266

Note: Standard deviation in parenthesis.
Source: Field data, 2021.

TABLE 3 Impact of mobile money account ownership on FBO, structured market and off-farm work.

Variables	Model 1		Model 2		Model 3	
	Mobile money Ownership dy/dx	FBO dy/dx	Mobile money Ownership dy/dx	Structured market dy/dx	Mobile money Ownership dy/dx	Off-farm work dy/dx
Mobile money ownership		0.078*** (0.018)		0.024*** (0.007)		0.038*** (0.011)
Age	−0.126 (0.079)	0.017** (0.008)	−0.123 (0.078)	0.028 (0.098)	−0.203*** (0.049)	−0.015* (0.007)
Sex	−0.080* (0.048)	−0.012 (0.054)	−0.086* (0.047)	−0.047 (0.049)	−0.077 (0.048)	0.038 (0.048)
Education	0.098*** (0.030)	0.062* (0.033)	0.097*** (0.028)	0.069** (0.031)	0.094*** (0.028)	0.055* (0.033)
Household size	0.002 (0.037)	0.010 (0.038)	0.003 (0.036)	−0.064 (0.041)	0.005 (0.036)	−0.013*** (0.004)
Farm size (acre)	0.051* (0.030)	−0.049 (0.031)	0.055* (0.029)	0.014*** (0.005)	0.052*** (0.019)	0.046 (0.032)
Farm distance	−0.071*** (0.023)	−0.098*** (0.021)	−0.063*** (0.024)	−0.085*** (0.020)	−0.072*** (0.022)	−0.010 (0.022)
Asset value (GH¢)	0.016 (0.012)	0.024** (0.012)	−0.011 (0.012)	0.019 (0.021)	0.014 (0.012)	0.019*** (0.005)
Extension contacts	0.187*** (0.057)	0.014 (0.033)	0.026** (0.012)	0.003 (0.031)	0.127*** (0.034)	0.032*** (0.012)
Credit access	0.125*** (0.035)	0.019** (0.008)	0.134*** (0.035)	0.018*** (0.003)	0.136*** (0.044)	0.091* (0.053)
Kintampo North	0.133*** (0.044)	−0.012 (0.067)	0.139*** (0.044)	0.026 (0.031)	0.179*** (0.051)	0.014*** (0.005)
Kintampo South	−0.044 (0.043)	0.019*** (0.005)	−0.042 (0.043)	−0.257*** (0.073)	−0.047 (0.043)	0.094** (0.042)
Mobile money vendor	0.049* (0.027)		0.045 (0.029)		0.066*** (0.026)	
Observations	1431		1431		1431	
Wald chi2(26)	211.16***		223.70***		181.29***	
rho p	−0.371*** (0.048)		−0.672*** (0.249)		−0.500*** (0.176)	
Wald test of rho = 0: chi2 (1)	48.29		11.16***		22.27***	
ATT	0.154*** (0.029)		0.333*** (0.125)		0.375*** (0.129)	
Log likelihood	−703.70		−801.27		−981.78	

Note: Standard errors are in parenthesis. Jaman North used as based group.

*At 10%.

**At 5%.

***At 1%.

Source: Field data, 2021.

Wald test of rho suggests that models 1, 2 and 3 are statistically significant at the 1% level, indicating that maize farmers' likelihood of owning a mobile money account is strongly linked to their inclination to participate in FBO, structured market and off-farm work through unobserved factors not included in the models. This implies that unobserved factors not captured in the models may influence maize farmers' decision to own a mobile money account and participate in FBO, structured market and off-farm work during maize production. Thus, farmers' decisions to own a mobile money account and participate in FBO, structured market and off-farm work are interdependent. Further, the results from models 1, 2 and 3 show a significant influence of the selection bias due to unobserved factors, as indicated by the rho ρ . The correlation of the three error terms suggests that the probability of participating in one variable is dependent on the probability of the others. The negative correlation parameters suggest that maize farmers have a low probability of participating in FBO, structured market and off-farm work. Additionally, the Wald chi-square tests confirm the joint significance of all the parameters in explaining the respective outcome variables. The findings are consistent with Ma and Zhu (2021), Chagwiza et al. (2016) and Chiburis et al. (2012).

4.2 | Factors influencing ownership of mobile money account

Table 3 displays the marginal effects of the factors affecting mobile money account ownership in columns 2, 4 and 6. As the same explanatory variables influence the decision to own mobile money account in all three models, they are discussed simultaneously. The results of the coefficients are presented in Table A1 in the Appendix. The results demonstrate that education, age, farm size, credit access, farm distance, extension contact, presence of mobile money vendor located within the village and districts are significant determinants of mobile money account ownership among maize farmers in Ghana. Specifically, education has a positive and significant effect on the likelihood of owning a mobile money account. This finding is consistent with previous studies such as Emara and Moheildin (2021) in the Middle East and Africa, who found that education increases the probability of owning a mobile money account due to farmers' better understanding of the benefits of using this technology. These findings are consistent with other studies such as Tay et al. (2022) and Bede Uzoma et al. (2020) who found that wealth and education increase the probability of owning a mobile money account. Additionally, farm size, which is often used as a proxy for wealth, also has a positive and significant influence on the probability of owning a mobile money account. Meier zu Selhausen (2016) also found similar results, suggesting that farmers with more resources, such as larger landholdings, may perceive greater gains from using mobile money accounts to receive payments from anyone around the world. On the other hand, the results suggest that age and gender have negative effects on the likelihood of owning a mobile money account. Older farmers are less likely to own a mobile money account, which may be due to their conservative approach towards digital technologies. Furthermore, male farmers are less likely to own a mobile money account, which is in line with the finding of Soekarno et al. (2020) that in Indonesia, females are more likely to use digital platforms such as the Internet and social media. This aligns with the findings of Huang et al. (2021) and Tay et al. (2022).

The proximity of the nearest farm to the farmer's home negatively and significantly affects the likelihood of owning a mobile money account. Longer distances discourage farmers from owning mobile money accounts by 7.1%, possibly because farmers who travel longer distances may incur higher transportation costs and fees. On the other hand, there is a positive relationship between extension contact and ownership of mobile money accounts. Additional meetings with extension officers lead to an 18.7% increase in the likelihood of owning a mobile money account. Extension agents typically raise awareness and educate farmers on new technologies that could improve their maize production. This agrees with the findings of Oladele (2015) opined positive relationship between ICT and extension agents in South Africa. Access to credit has a positive and significant impact on the likelihood of owning a mobile money account. An increase in credit access by farmers increases the likelihood of owning a mobile money account by 12.5%. Credit access plays a vital role in crop production, and with such accessibility, farmers may be

motivated to obtain a mobile money account since most credits are given through electronic payment. Furthermore, compared to farmers in the Jaman District, those in the Kintampo North District are more likely to have mobile money accounts. This is possibly due to the availability and accessibility of mobile money vendors within their villages, which could reduce transaction costs. The distance to mobile money vendors from farmers' homes has a positive and significant effect on their decision to own a mobile money account. Therefore, the closer the mobile money vendor is to the farmer, the higher the likelihood of owning an account. This finding is consistent with a study by Aziz and Naima (2021) that reported similar results for farmers in Bangladesh.

4.3 | Impact of mobile money account ownership on participation in FBOs, structured market and off-farm work

The results of the impact of participation in FBO, structured market and off-farm work on maize production in Ghana are presented in Table 3. The analysis reveals a significant positive impact of owning a mobile money account on farmers' decision to participate in FBO, structured market and off-farm work. These results are consistent with previous studies by (Aziz & Naima, 2021; Li et al., 2020; Lu et al., 2021), who indicate a positive influence of mobile money on farmers' participation in various agricultural activities. In recent times, the increased adoption of mobile banking and e-payment services has played a significant role in expanding digital financial inclusion in developing nations. For instance, Li et al. (2020) discovered that digital financial inclusion has facilitated the growth of financial inclusion by enabling households to engage in online shopping and digital payments in China. Evidence suggests that developing countries with greater digital financial inclusion can effectively reduce poverty and achieve a higher financial inclusion rate in society (Aziz & Naima, 2021).

The outcomes presented in columns 3, 5 and 7 of Table 3 were impacted by other various factors. As the same set of explanatory variables impacted these outcomes, we discuss them collectively. Our study revealed that the age of farmers had divergent impacts on the likelihood of participating in FBO and off-farm work. Specifically, we found that an additional year of age had a positive and significant impact on the probability of participating in FBO, increasing by 1.7 percentage points. However, the same increase in age had a negative and significant impact on the probability of engaging in off-farm work, decreasing by 1.5 percentage points. This suggests that as farmers age, they may experience a decline in physical strength and stamina, limiting their ability to engage in multiple economic activities. Consequently, older farmers may be more likely to join FBO, which can provide them with productive resources to enhance their maize production. This finding is consistent with previous research (Ma, Renwick, et al., 2018; Mojo et al., 2017).

The education of farmers had a positive and significant impact on their likelihood to participate in all three outcome variables. Each additional year of education increased the probability of participating in FBOs, structured markets and off-farm work by 6.2%, 6.9% and 5.5%, respectively. Educated farmers are likely to be better informed and knowledgeable, enabling them to make informed decisions about these variables. This aligns with the findings of Nkegbe et al. (2022) and Bekele (2022), who reported that educated farmers are more likely to participate in FBOs, structured markets and off-farm work. The negative and significant impact of household size suggests that an additional household member decreases the likelihood of farmers participating in off-farm work. This is not surprising because a larger family size may indicate a greater availability of labour to assist with family businesses such as maize production. Furthermore, the size of the farm had a positive and significant impact on the decision of farmers to participate in structured markets. This is consistent with the results of previous studies which indicate that participation in structured markets could provide benefits such as information on market prices and available buyers, leading to increased participation as farm size increases (Anang et al., 2020; Ngwako et al., 2021; Nkegbe et al., 2022).

Distance from farmer's home to the farm had a negative and significant impact on participation in FBO and structured market during maize production. This is likely due to the costs associated with participating in FBOs and structured markets, such as dues and transaction costs, which may discourage participation (Nkegbe et al., 2022). Farmers' asset value had a positive and significant impact on participation in all three outcomes. Assets

are a proxy for resource endowment and wealth and indicate long-term household economic status and perpetual income, which impact participation (Ngwako et al., 2021). This finding is consistent with Meier zu Selhausen's (2016) study in Uganda, which found that farmers with more resources, such as land, were more likely to participate in FBOs and off-farm work due to the higher perceived gains. Additionally, contact with extension officers tended to impact off-farm work participation, suggesting that farmers who communicate with extension officers during maize production are more likely to engage in off-farm activities, particularly off-season crop production. Similar finding was observed in Ethiopia (Shumeta & D'Haese, 2016; Woldeyohanes et al., 2017) and in Ghana (Nkegbe et al., 2022; Osarfo et al., 2016). The participation of farmers in FBO, structured market and off-farm work was positively and significantly impacted by credit access. Farmers who had credit access were 1.9, 1.8 and 9.1 percentage points more likely to participate in FBO, structured market and off-farm work, respectively. This could be because credit provides farmers with the means to afford productive resources and participate in economic activities (Alhassan et al., 2020; Sekyi et al., 2017), as well as social groups and markets that aim to improve their welfare (Nkegbe et al., 2022; Woldeyohanes et al., 2017). In comparison to the Jaman District, farmers in the Kintampo South and North districts were more likely to participate in off-farm work by 9.4 and 1.4 percentage points, respectively. However, farmers in the Kintampo South were less likely to participate in structured market due to the complex nature of the market and relatively high market tolls in their villages.

4.4 | Average treatment effects results

We utilised Chiburis et al. (2012) approach to estimate the average treatment effects and provide a better understanding of the impact of mobile money account ownership on farmers' participation in FBO, structured market and off-farm work. This approach involved bootstrapping to reduce the sampling noise from the sample, resulting in an ATT estimate that accounts for selection bias, given that owners and non-owners of mobile money accounts differ significantly in observed and unobserved factors. This approach allowed for a more accurate assessment of the impact of mobile money account ownership on farmers' participation in various economic activities. According to the results presented in Table 3, we found that owning a mobile money account increases the likelihood of farmers' participation in FBOs, structured market and off-farm work by 15.4%, 33.3% and 37.5%, respectively, regardless of the deviation from the RBP model estimates. The deviations may arise from the different methods used in assessing various parameters. The marginal effects of owning a mobile money account measure the likelihood of farmers' participation in FBO, structured market and off-farm work when they decide to own a mobile money account. In contrast, the ATT estimates the causal effect of farmers' participation in FBO, structured market and off-farm work on owning a mobile money account. These findings align with the works of Ma, Abdulai, et al. (2018) and Ma and Zhu (2021).

5 | CONCLUSION AND POLICY RECOMMENDATIONS

This paper examined the impact of digital financial inclusion proxied by mobile money account ownership on the decision of smallholder maize farmers to participate in FBOs, structured market and off-farm work in Ghana. So far, the account on the adoption of mobile money impact on the participation in FBOs, structured market and off-farm work remains rare in the literature on digital finance covering Ghana and by implication most countries in SSA. Relying on recursive bivariate probit model, we find that there is a significant positive impact of owning a mobile money account and farmers' decision to participate in FBOs, structured market and off-farm work. Specifically, we find that owning a mobile money account increases the likelihood of farmers' participating in FBOs, structured market and off-farm work by 15.4%, 33.3% and 37.5%, respectively. The results reveal that mobile money account ownership among maize farmers is influenced by socioeconomic factors (age, education, farm size), institutional factors (credit access, extension contact) and the presence of mobile money vendor located within the village and district.

Our findings suggest that maize farmers' likelihood of owning a mobile money account is strongly linked to their inclination to participate in FBOs, structured market and off-farm work. This calls for sustained efforts to widen digital financial inclusion given the positive dividends on the participation in FBOs, structured market and off-farm work. Ghana's central bank—Bank of Ghana and the apex body of rural banks—(ARB Apex Bank Limited) should encourage financial products that can be linked to mobile money accounts and vice-versa (to bank accounts) to foster digital financial inclusion. Consideration could be made to further reduce the electronic levy (e-levy) on digital financial transactions to widen and consolidate digital financial inclusion. Government can consider tax waivers for the mobile network operators (MNOs) that extend telecommunication services to the rural areas to foster digital financial inclusion. Additionally, agricultural extension and advisory services are encouraged to target increased education that widens and deepens the adoption of money accounts in the maize agricultural value chain activities for increased welfare.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Google Drive at https://drive.google.com/drive/folders/12IIQ9-G_g1vWIMoonAJgDtg6f9_NkseT?usp=share_link.

ETHICS STATEMENT

This research was performed on humans and the needed informed consent was obtained from all participants.

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APPENDIX A

TABLE A1 Recursive bivariate model of impact of mobile ownership on FBO, SM and OFW.

Variables	Model 1		Model 2		Model 3	
	MMO Coefficients	FBO Coefficients	MMO Coefficients	SM Coefficients	MMO Coefficients	OFW Coefficients
Mobile money ownership		0.426*** (0.021)		0.334*** (0.027)		0.389*** (0.190)
Age	−0.392 (0.245)	0.495** (0.248)	−0.385 (0.245)	0.084 (0.290)	−0.813*** (0.245)	−0.445* (0.242)
Sex	−0.250* (0.149)	−0.033 (0.153)	−0.270* (0.148)	−0.141 (0.146)	−0.240 (0.151)	0.118 (0.147)
Education	0.306*** (0.094)	−0.178* (0.099)	0.302*** (0.089)	0.205** (0.096)	0.294*** (0.090)	0.168 (0.103)
Household size	0.008 (0.115)	0.027 (0.108)	0.009 (0.113)	−0.191 (0.118)	0.017 (0.113)	−0.416*** (0.126)
Farm size	0.158* (0.092)	−0.140 (0.092)	0.172* (0.090)	0.077 (0.093)	0.161*** (0.048)	0.142 (0.100)
Farm distance	−0.222*** (0.071)	−0.281*** (0.062)	−0.195** (0.076)	−0.253*** (0.060)	−0.225*** (0.071)	−0.030 (0.067)
Asset value (GH¢)	0.051 (0.037)	0.070* (0.036)	−0.058 (0.037)	−0.058* (0.034)	−0.042 (0.037)	0.096*** (0.036)
Extension contact	0.460*** (0.102)	0.040 (0.093)	0.180** (0.089)	0.039 (0.094)	0.107*** (0.041)	0.048*** (0.017)
Credit access	0.388*** (0.112)	0.558** (0.229)	0.418*** (0.111)	0.560*** (0.107)	0.396*** (0.110)	0.279* (0.167)
Kintampo North	0.414*** (0.140)	−0.036 (0.192)	0.434*** (0.139)	0.417 (0.344)	0.422*** (0.140)	−0.438*** (0.147)
Kintampo South	−0.137 (0.134)	0.530*** (0.146)	−0.131 (0.133)	−0.767*** (0.199)	−0.145 (0.133)	0.290** (0.129)
Mobile money vendor	0.153* (0.086)		0.141 (0.090)		0.205** (0.082)	
Constant	0.586*** (0.140)	0.893*** (0.107)	0.781** (0.337)	0.234*** (0.042)	0.669*** (0.234)	−0.144*** (0.054)

Note: Standard errors are in parenthesis. Jaman North used as based group.

*At 10%.

**At 5%.

***At 1%.

Source: Field data, 2021.