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Gendered distributional impacts of ownership of mobile money account on farm input expenditures: A micro perspective from rural maize farmers in Ghana

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Abstract

This article investigates the distributional impact of mobile money account ownership on farm input expenditures among maize farmers in southern Ghana. Using cross-sectional data from 1044 farm households, we employed an instrumental variable quantile regression to account for endogeneity and selection bias. We find that socioeconomic, spatial location, and institutional factors significantly influence male and female-headed household decisions to own mobile money accounts. The empirics show that male-headed households spend more on fertilizer and pesticide relative to female-headed households. Mobile money account ownership increases fertilizer expenditure in male-headed households more than female-headed households. Male-headed families with mobile money accounts spend 13.9% and 6.5% more on fertilizer at the 40th and 60th quantiles. High 80th quantile female-headed households spend 4.3% more on fertilizer. For male-headed households, farming experience and education positively influence mobile money account ownership on fertilizer expenditure, while off-farm activity at the 40th quantile positively influences female-headed households. Our results distill useful policy implications that call for concerted efforts targeted at digital financial inclusion with an eye to bridging differential gender gaps.

KEYWORDS

female-headed household, fertilizer, instrumental variable quantile regression, male-headed household, pesticide

JEL CLASSIFICATION

C21, C26, F65, Q12

1 | INTRODUCTION

Digital financial inclusion and access remain topical, especially in sub-Saharan Africa (SSA) (Koomson et al., 2021). The apparent benefits of mobile money account ownership (digital finance) are not in doubt, but the question of interrogating the extent to which the adoption of digital finance impacts on agricultural inputs purchases remain thin, and even thinner regarding the gendered impacts. This article answers the research question: What is the distributional impact of the ownership of mobile money account on agricultural input expenditures from a gendered perspective? We find the research question worth probing, because despite the growing mobile money account adoption in SSA, gender disparities and rural gaps are evident (Demirgüç-Kunt et al., 2018). Kantar (2019) found that 32% of Bangladeshi women relative to 56% men use digital payments. Digital financial access has increased, however the spotlight on differential access has received less attention (Yesmin et al., 2019). Indeed, Demirguc-Kunt et al. (2018) and Afawubo et al. (2020) found that women are more excluded from the digital financial sector. Koomson et al. (2021) examined mobile money account uptake on idiosyncratic shocks in five African nations and found gender gaps. Males in Kenya are 8% more likely to own mobile money accounts than females. In Ghana, Rwanda, and Uganda, gender discrepancies grow 10%, 11%, and 16%. Koomson et al. (2021) pointed to differences in rural–urban mobile money adoption despite growing penetration. Due to rising acceptance along agricultural value chains, mobile money adoption is reducing the rural–urban gap. For instance, globally, an estimated 15% of farmers in remote communities receive digital payments for the sale of agricultural products. Essentially, mobile money reduces the inconveniencies, costs, risks, and inefficiencies involved in the conventional payments (Demirgüç-Kunt et al., 2018). For example, in Ghana, Kenya, and Zambia, the share of smallholder farmers receiving digital cash payments is double the average for the global north and an appreciable proportion (40%) of individuals transact digital payments on registered mobile money accounts (Demirgüç-Kunt et al., 2018). Yet, the impact of mobile money adoption remains sparing in the extant literature covering Ghana and the existing account appear largely anecdotal. Even more compelling is the lack of gendered perspectives on the impact of digital finance on agricultural inputs expenditures. The objectives of this article are in three folds: to determine factors that influence the ownership of mobile money accounts, to investigate the gendered distributional impact of mobile money ownership on agricultural fertilizer expenditures, and pesticide expenditures.

Addressing the above research objectives remain important because most of the literature on the impact of mobile money adoption is replete in Eastern Africa, specifically Kenya, a frontier for mobile money inception and adoption (Jack & Suri, 2011, Jack & Suri, 2014; Kikulwe et al., 2014). There is a dearth in the literature concerning Ghana. Even though mobile money was introduced as far back as 2009. Mobile money transactions, however, continue to be used as a substantial means of payment particularly among the unbanked, especially in remote areas of the country. Few studies in Ghana have attempted to understand the impact of mobile money account adoption on the agricultural sector. For instance, Peprah et al. (2020) assessed the impact of mobile money adoption on wealth, welfare, and farm output among smallholder farmers in Ghana's Central Region. Apiors and Suzuki (2018) examined the effects of mobile money adoption on individuals' productive activities and payments focusing on Ghana's Ashanti Region. Asravor et al. (2022) examined factors that influence mobile money adoption among smallholder farmers in rural Ghana.

Specifically, our article contributes in three ways: First, we provide pragmatic insights on the impact of mobile money adoption on farm input expenditures, focusing on a gendered perspective, which has largely been overlooked (Ankrah, 2022; Jack & Suri, 2011, 2014; Kikulwe et al., 2014). Ignoring gendered impacts can result in policies that are not gender-sensitive, hindering the optimal benefits of digital financial inclusion. Second, we offer a micro-perspective on mobile money adoption and agricultural input expenditures, a focus largely missed in the existing literature. Efficient use of agricultural supplies, particularly through digital financial tools, significantly increases farmers' output. Our findings inform policy on how mobile money aids smallholder farmers in accessing finance, farm inputs, and improving productivity. Additionally, we suggest targeted policies or interventions to enhance agricultural input utilization among smallholder maize farmers through mobile money account ownership. A final novelty in our study lies with the estimation rigor, where for the first time, to the best of our knowledge, an instrumental variable quantile regression is employed to estimate the gendered distributional impact of mobile money adoption of agricultural input use in Ghana. Our study is embedded in a positivism research paradigm that is deeply rooted in a quantitative approach.

The rest of the article proceeds as follows: the ensuing section presents a background of the related literature, to give readers a contextual perspective. The section is next followed by Section 3 that gives an overview of the conceptual framework that embeds the study, next is the study's methodology. This is followed by the results and discussions. A final section concludes and offers policy recommendations worth targeting by specific stakeholders in fostering digital financial inclusion in Ghana, and by implication SSA.

2 | BACKGROUND/REVIEW OF RELATED LITERATURE

Donovan (2012) defines mobile money as financial services provided through cell phones, encompassing mobile payments, banking, and finance, including insurance, credit, and savings. It plays a crucial role in closing financial exclusion gaps, with nearly 1 billion unbanked individuals gaining access via mobile phones, leading to significant digital financial inclusion

(Koomson et al., 2020; Pénicaud & Katakam, 2019). Global mobile money transactions surpassed $1 trillion in 2021, with 1.35 billion people enrolled (Groupe Speciale Mobile Association, 2022). In Ghana, mobile money transactions totaled 223.2 billion cedis in 2019 (Bank of Ghana, 2019). Studies identify factors influencing mobile money adoption, as education level, age, residential area, and standard of living (Mbiti & Weil, 2011). Factors like ease of use, perceived risk, security, and social factors also play crucial roles (Sayid et al., 2012).

Research on Ghana (Osei-Assibey, 2015) and elsewhere (Ismail & Masinge, 2011) underscores cost, skills, trust, and user-friendliness as critical factors to adoption. Household education levels impact adoption in Ghana (Baffour et al., 2021), with advertising and higher education influencing adoption among smallholder farmers (Peprah et al., 2020). Mobile money accounts have notably benefited the agricultural sector across most African economies (Aker et al., 2016; Jack & Suri, 2014; Ky et al., 2018; Munyegera & Matsumoto, 2016), enhancing household welfare through increased consumption and savings during emergencies (Ky et al., 2018). In Ghana, mobile money adoption improves smallholder farmers' welfare and agricultural output (Afawubo et al., 2020; Aron, 2017; Peprah et al., 2020). Studies highlight how mobile money facilitates higher agricultural input use, income levels, and market access (Abdul-Rahaman & Abdulai, 2022; Batista & Vicente, 2020; Kikulwe et al., 2014). Tabetando et al. (2022) found significant increases in farm income and agricultural inputs through mobile money adoption in rural Uganda.

Despite these advancements, research gaps persist regarding the gendered impact of mobile money adoption on agricultural inputs. Our study aims to address this gap, hypothesizing differential effects on males and females. By examining mobile money's role in enhancing access to agricultural inputs in Ghana, our research contributes to understanding its broader implications for smallholder productivity. This study is relevant to the debate as to whether, mobile money adoption reduces impulse buying, and encourages savings, that essentially facilitate farming households to make increased purchases of agricultural inputs (fertilizers and pesticides), and overall contributes to improved welfare outcomes.

3 | THEORETICAL AND CONCEPTUAL FRAMEWORK FOR MOBILE MONEY OWNERSHIP, MOBILE SAVINGS, FLEXIBILITY OF TRANSACTIONS, AND AGRICULTURAL INVESTMENTS

Our conceptual framework is predicated against the backdrop that differential access exists regarding access to productive resources including financial capital (Ankrah, 2022; Ankrah et al., 2020; Asante, Addai, et al., 2023; Asante, Puskur, et al., 2023). Cultural restrictions, economic capital, social status, and women's limited access to mobile phones (Asante, Addai, et al., 2023; Asante, Puskur, et al., 2023; Bailur & Masiero, 2017) have long been discussed. Our theory is based on resources and appropriation theory, where Dijk (2005) argues that structural inequalities exist in societies due to unequal resource allocation, causes, and differential access to technologies, including financial digital technologies. Overall, unequal resource distribution reinforces structural inequalities through unequal participation. Demographic (age, religion, marital status, and gender) and positional (educational level, employment position, job kind, and household size) differences often affect the digital divide. Livingstone and Helsper (2007) found that access and use affect inequality. Based on recent literature on digital inclusion framework (Thomas et al., 2020), we address three interrelated components of digital financial inclusion: drivers of mobile money adoption and drivers of the distributional impact of mobile money account ownership on fertilizer expenditures. The influence of mobile money account adoption on agriculture input (fertilizers and pesticides) spending.

We focus our conceptual framings along these lines: First, liquid cash in the hands of any economic agent increases impulse buying on daily items (Aiolfi et al., 2022). This statement is contextual and not general, especially in Ghana, where cash-rich people spend on unbudgeted products. Mobile money payment methods in the global north have been linked to impulsive buying (Zhang et al., 2022). However, mobile money accounts, especially those which allow the mobile money user to save, increases spending on less frequent items in the case of Ghana. This is because the mobile money account offers a savings incentive (Ahmad et al., 2020; Batista & Vicente, 2020; Suri & Jack, 2016). The situation is not the same in other contexts. For instance, according to Batista and Vicente (2020) and Suri and Jack (2016), farmers with mobile money accounts save more and buy nonfrequent products and services, including agricultural inputs.

Thus, mobile money accounts could improve agricultural investments by increasing agro-chemical use (fertilizers and pesticides). However, due to gender disparities, mobile money account adoption remains gendered. Farmers may simply get remittances and borrow credit with mobile money accounts. Second, since a mobile money account makes it easier to get to the market with less cash, remote farmers who buy their inputs from urban centers may feel more comfortable traveling using mobile money accounts to buy more fertilizer and pesticides than those without (Aron, 2017; Asravor et al., 2022; Jack & Suri, 2014). This implies that mobile money makes financial transactions safe. However, other digital financial transaction vulnerabilities have been found, such as mobile money scams (Andoh et al., 2018). Overall, digital finance is safer than cash transactions.

In all, the reduction in purchases of regular items, savings, and safety conduits provided by mobile money accounts could drive investments in agricultural inputs. Consequently, higher economic returns (increased crop outputs and profits) will be attained by farmers who own mobile money accounts (see Figure 1). This study hypothesizes that mobile money users buy more agricultural inputs and make more money. When agricultural input sales and purchases become more structured (Ankrah, 2022) there may be other economic effects. Beyond the agricultural inputs market, local economies may see commercial transaction reorganizations. Visiting commercial and rural banks for financial transactions is down. Mobile money accounts can link to bank accounts back and forth. Mobile money wallets offer savings interest, making them a bank for individuals. Overall, the economic effects include increased e-commerce and a cashless local economy. When more farmers use mobile money and realize its benefits, other farmers in the community are encouraged to adopt, boosting adoption scale and intensity. Cultural and geographic aspects of the journey are intriguing. In areas with high maize output, mobile money accounts may be used to access more inputs.

4 | MATERIALS AND METHODS

4.1 | Study area

Our study collected data from smallholder maize farm households in Ghana's Brong-Ahafo Region between September and December 2021. The region covers land area of 39,558 km^2, the second largest region. It exhibits diverse vegetative cover, including forests, transitional areas, and savannah, representing the southern, middle, and northern parts of the region, respectively.

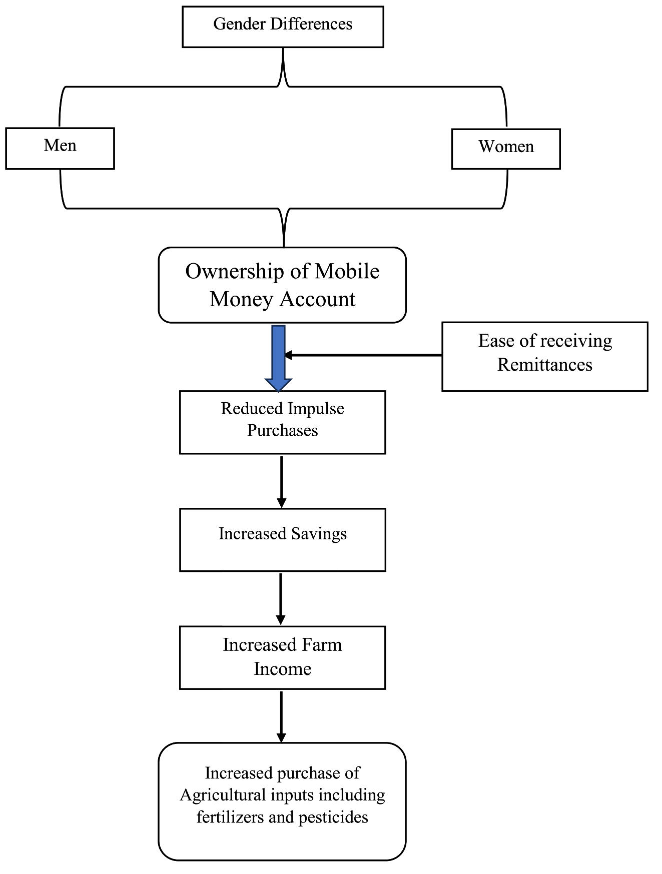

FIGURE 1 Pathways of mobile money account ownership impact on agricultural inputs use. *Source*: Author's construct (2023). [Colour figure can be viewed at wileyonlinelibrary.com]

The region experiences a bimodal rainfall pattern, with an average annual total rainfall ranging from 1088 to 1197 mm (GSS, 2021). Agriculture serves as the primary economic activity, engaging 69.1% of the population. The cultivation of various food crops such as maize, yams, cassava, and other root crops is particularly prominent. It plays a significant role in maize production, contributing 29% to the national production (Amanor, 2013; Boafo & Lyons, 2021; Prah et al., 2023).

We adopted a positivism approach and utilized a quantitative research design to establish a causal relationship between mobile money account ownership and farm input expenditure. Our study combined primary data and secondary information. Primary data were collected using structured questionnaire translated into the local dialects of maize farmers, covering personal characteristics, plot-level data, institutional factors, mobile money variables, and maize production. Secondary information was obtained from the Ministry of Food and Agriculture. A multi-stage sampling technique was used to select 1044 farm households: 348 from each of the three districts—Kintampo South, Kintampo North, and Kobeda. Brong-Ahafo, a leading maize-producing region, was purposively selected in the first stage. Three districts were then chosen based on their substantial maize production, followed by a random selection of six communities per district. This resulted in a sample of 1044 maize farmers, including 562 male-headed and 482 female-headed households. Data analysis was conducted using the STATA software.

4.2 | Empirical strategy

Various methods used to assess the impact of mobile money on farming households' welfare include propensity score matching (PSM) (Kikulwe et al., 2014; Munyegera & Matsumoto, 2016; Peprah et al., 2020), randomized control trials (RCTs) (Aker et al., 2016; Batista & Vicente, 2020), and instrumental variables (IV) approaches (Koomson et al., 2021). PSM uses variables to match treated and untreated groups, which may overestimate impacts. RCTs estimate well but are expensive. IV regression controls endogeneity, important in agricultural practice and technology adoption impact studies (Ogundari, 2022). Instrumental quantile regression (IVQR) addresses endogeneity and unobserved motivations for distributional impacts (Asante, Puskur, et al., 2023; Asante, Addai, et al., 2023; Lu & Kandilov, 2021; Ma et al., 2020; Zhu, 2020).

To investigate the distributional impacts of owning a mobile money account on farm input expenditures, we employed IVQR (Asante, Addai, et al., 2023; Asante, Puskur, et al., 2023). While conditional (Lu & Kandilov, 2021) and unconditional (Khanal et al., 2018; Ma et al., 2020) quantile regression models exist, they assume exogeneity of all covariates, which is inappropriate when the treatment variable may be endogenous. Ownership of a mobile money account can be endogenous due to household head self-selection based on socioeconomic status and technology access (Hubler & Hartje, 2016; Ma et al., 2020; Min et al., 2020). Previous research highlights that neglecting endogeneity can bias estimates and compromise analysis reliability (Ma & Zheng, 2022).

The output of the IVQR model, which presents the τth quantile of the outcome variable (either fertilizer or pesticide expenditure), is a linear function of the treatment variable (O), the set of explanatory variables (W'), and a disturbance term (ϖ), specified as:

$$\ln(Q_i) = q(O, W', \varpi) = \delta_\tau O + \beta_\tau W' + \varpi \quad (1)$$

where $q(.)$, conditional τth quantile function strictly increasing in τ; O, ownership status (1 if household head own mobile money account ad 0 for otherwise); W', vector of the exogenous variables; δ_τ and β_τ, parameters to be estimated at the quantile τ; and ϖ, random disturbance term assumed to be normally distributed.

Following previous studies (see Ma & Zheng, 2022; Hubler & Hartje, 2016; Min et al., 2020), we employed the rational maximization framework to ascertain the linear function of ownership of mobile money account. The framework postulated that an ith household head is potentially to own mobile money account if the expected benefit exceeds the cost. Suppose we consider the utilities obtained from owning a mobile money account (U_{O}) and not owning (U_{NO}). A farm head will choose to own a mobile money account if the utility of owning one is greater than zero, that is, $O_i^* = U_{\mathrm{O}} - U_{\mathrm{NO}} > 0$. Since O_i^* is a latent variable and can be observed (O_i) as:

$$O_i^* = \alpha_\tau W' + \psi_\tau V + \mu$$
$$O_i = \begin{cases} 0 \text{ if } O_i^* > 0 \\ \cdot \\ \cdot \\ 0 \text{ if } O_i^* \leq 0 \end{cases} \quad (2)$$

where O_i^* and O_i, unobserved and observed variables indicating the probability of owing mobile money account, respectively. W' is defined in previous equations; V, instrumental variable (IV), α_τ and ψ_τ, coefficients to be estimated; and μ, disturbance term assumed normal distribution.

In this study, we used the ownership of a mobile money account by household neighbors as an IV. The variable took a value of 1 if a farm household's neighbor owned a mobile money account, and 0 otherwise. The selection of the IV was based on theoretical and empirical literature (Ma & Zheng, 2022; Ma et al., 2020) because of information spillover and peer pressure associated with ownership of mobile money account. To assess the validity of the IV, we conducted both a falsification test (Asante, Addai, et al., 2023; Di Falco et al., 2011) and a Pearson correlation analysis (Ma & Zheng, 2022). The results in Table A3 indicated that the IV had a significant influence on the ownership of a mobile money account but no significant effect on the outcome variables (i.e., fertilizer and pesticide expenditure). Additionally, the results in Table A4 showed that the IV was significantly correlated with the ownership of a mobile money account but not correlated with the two outcome variables. Furthermore, Cragg–Donald F-statistic and the Kleibergen–Paap rk Wald statistic provide evidence of rejecting the null hypothesis of weak instrument (Table A5). We concluded that the IV was suitable and effective, and proceeded to estimate the models.

The quantile regression model is based on moment conditions which can be specified as:

$$\tau = p\{Q \leq \propto_\tau O + \beta_\tau W' + \varpi | W', V\} \tag{3}$$

Based on the uncertainty assumptions (see Mitra et al., 2015), we simplified the objective function as:

$$\min_{\alpha_\tau, \beta_\tau, Q_\tau, \psi_\tau} E\left(\mathrm{p}_\tau\left[Q - \alpha_\tau O - \beta_\tau W' - \psi_\tau V\right]\right) \tag{4}$$

To obtain the IVQR estimator, we solved the minimization program in Equation (4). Our implementation of the estimator followed the procedure developed by Kwak (2010).

To select the explanatory variables for our empirical model, we reviewed theoretical and empirical literature on the relationship between mobile money ownership and farm input expenditure. We included the following variables: age (Ma & Zheng, 2022), education (Ma et al., 2020; Salazar & Rand, 2020), household size (Ma et al., 2020), farm size (Mojo et al., 2017), asset value (Ma & Zheng, 2022; Ma, Abdulai, & Ma, 2018; Ma, Renwick, et al., 2018), farm distance (Shumeta & D'Haeseb, 2016), pest and disease experience (Ma & Zheng, 2022), membership in farmer-based organizations (FBOs) (Addai et al., 2022), off-farm activities (Abebaw & Haile, 2013), and location (Ma & Zheng, 2022).

5 | EMPIRICAL RESULTS AND DISCUSSIONS

5.1 | Descriptive statistics

Table 1 presents the definitions and measurements of the variables. Average fertilizer and pesticide expenditures are GH¢ 122.23/hectare and GH¢ 29.24/hectare, respectively. This is higher than the national average expenditure in Ghana. For instance, Sasu (2022) indicated that the average expenditure on fertilizers was GH¢ 101/hectare in 2021. Anang et al. (2021) asserted that farmers in Ghana spent an average of GH¢ 148 on crop protection and soil fertility management. Among the sampled farmers, 37.8% owned mobile money accounts. This is a relatively low adoption rate of mobile money compared with 44.3% of farmers in Ghana using mobile money (Esoko, 2017; World Bank, 2023). Most household heads (89.6%) are men with a mean age of 47.4 years and about 22 years of experience in maize production. The results suggest that household heads are economically active with in-depth knowledge of maize production. On average, the household heads have spent 6 years in education with a family size of 7.

TABLE 1 Definition and summary statistics of variables.

		Full sample	
Variables	**Measurement**	**Mean**	***SD***
Fertilizer	Total fertilizer expenditure in GH¢/hectare	122.23	43.56
Pesticide	Total pesticide expenditure in GH¢/hectare	29.24	17.71
Mobile money	1 if a farm household head owns mobile money, 0 = otherwise	0.378	0.485
Gender	1 if a farm household head is male, 0 = otherwise	0.896	0.306
Age	Age of farm household head in years	47.422	10.44
Education	Education of farm household head in years	6.117	5.47
Household size	Number of household members	6.624	3.252
Experience	Farming experience of farm household head in years	21.829	12.296
Asset value	Total value of farm household asset in GH¢	5987.38	4988.97
Farm size	Farm size of farm household head in hectare	4.783	4.825
Land ownership	1 if a farm household head owned land, 0 = otherwise	0.684	0.477
Off-farm activity	1 if a farm household head engaged in off farm activity and 0 = otherwise	0.671	0.470
Pest and disease experience	1 if a farm household head experienced pest and disease, 0 = otherwise	0.576	0.494
Credit access	1 if a farm household head had credit access and 0 = otherwise	0.759	0.428
FBO membership	1 if a farm household head belongs to farmer-based organization, 0 = otherwise	0.540	0.499
Extension contact	1 if a farm household head had extension contact, 0 = otherwise	0.594	0.491
Market access	1 if a farm household head had market access, 0 = otherwise	0.342	0.475
Market distance	Distance from household head's homestead to the nearest agricultural market in kilometer.	6.767	4.412
Kintampo North	1 if a farm household head from Kintampo North District, 0 = otherwise.	0.31	0.107
Kintampo South	1 if a farm household head from Kintampo South District, 0 = otherwise.	0.412	0.216
Kobeda	1 if a farm household head from Kobeda South District, 0 = otherwise.	0.269	0.079
Neighbor status	1 if farm household's neighbors used mobile money, 0 = otherwise	0.691	0.462

Abbreviation: FBO, farmer-based organizations.
Source: Field data (2021).

The finding is higher than the national average household size of 4. This implies that the education status of the household head is more likely to influence the ownership of mobile money accounts. Higher family size could imply that household heads are endowed with labor for maize production. While 68.4% of the household head owned land, 67.1% engaged in off-farm activity. The average asset value and farm size of household head were GH¢ 5989.38 and 4.78 hectares, respectively. Fifty-eight percent of the household heads indicated that they experienced pest and diseases with only 34.2% contacts extension officers. Most household heads (54%) joined farmer-based organizations (FBOs) where 75.9% had credit access to support maize production. Only 34.2% of the sampled households had market access with the mean distance to the nearest agricultural market being 6.7 kilometers. Majority (69.1%) of the households neighbor owned mobile money with 41.2% of households located in Kintampo South.

Table 2 presents the average differences in fertilizer and pesticide expenditures between male and female-headed households with or without mobile money accounts. Male-headed households generally spend more on both inputs compared to female-headed households. There were no significant differences in education, experience, household size, or land ownership between the two groups. Male-headed households owning mobile money accounts operate larger farms (5.3 hectares) compared to nonowners (4.6 hectares), whereas female-headed households owning mobile money accounts operate farms of 3.7 hectares, significantly larger than nonowners (3.06 hectares). Statistically significant differences were observed in asset value, off-farm activities, extension contacts, credit access, and pest and disease experiences between mobile money owners and nonowners in both male and female-headed households. These findings suggest that mobile money account ownership influences various socioeconomic factors and farm management practices differently between male and female-headed households. However, it is important to note that these comparisons may not fully capture the complex relationships between mobile money account ownership and farm input expenditures. Addressing the endogeneity of mobile money account ownership is crucial to accurately assess its heterogeneous effects on agricultural practices and household welfare.

5.2 | Determinants of ownership of mobile money account

Table 3 presents the factors influencing farmers' decisions of owing mobile money account. Using the probit model, the results reveal that the McFadden pseudo R^2 appropriately predicted the variations in dependent variable. The likelihood ratio test was also statistical different from zero suggesting a best fit of the model. According to Asante, Addai, et al. (2023) and Asante, Puskur, et al. (2023), marginal effects give us a better picture of the magnitude of the explanatory variables than coefficients; hence, we used the marginal effects for the interpretations of our results. We find that neighbor status positively and significantly influenced both male- and female-headed household decisions to own mobile money account. This suggests that the male and female heads are 16.2% and 16.5% more likely to own mobile money account, respectively. A plausible explanation could be that spatial factors often play a significant role in determining the ownership of mobile money accounts. Specifically, farmers are often influenced by their observations of positive experiences among neighboring farmers, which serves as a motivation to adopt mobile money accounts (Ma & Zheng, 2022). Education has a positive and significant influence on the likelihood of owning mobile money account for the sampled farmer groups. Thus, an additional year in education results in 9.8% and 6.9% increase in male and female

TABLE 2 Average differences between mobile money account owners and nonowners by gender.

	Male-headed farm household (N = 562)			Female-headed farm household (N = 482)		
	Mobile money account owners	Nonmobile money account owners		Mobile money owners	Nonmobile money account owners	
Variables	**Mean**	**Mean**	**Mean diff.**	**Mean**	**Mean**	**Mean diff.**
Fertilizer	131.42 (40.91)	115.54 (43.8)	15.88***	127.93 (46.43)	123.43 (44.12)	4.5**
Pesticide	38.57 (7.6)	36.36 (7.0)	2.20***	35.75 (6.3)	34.04 (11.0)	1.71
Age	46.49 (11.1)	48.14 (10.4)	1.64**	46.2 (8.1)	47.65 (8.2)	1.45
Education	6.14 (5.7)	6.15 (5.3)	0.01	5.98 (3.2)	5.68 (5.2)	−0.29
Household size	6.52 (3.0)	6.86 (3.3)	0.33	6.06 (3.1)	5.60 (3.3)	−0.45
Experience	22.70 (11.2)	22.07 (12.8)	0.63	20.33 (11.3)	15.6 (11.7)	4.73
Asset value	5893.90 (466.6)	5711.71 (632.6)	182.1***	2670.76 (328.9)	1910.91 (198.6)	759.85***
Farm size	5.3 (4.2)	4.69 (4.9)	−0.68**	3.7 (2.4)	3.06 (1.3)	−0.72*
Land ownership	0.697 (0.46)	0.721 (0.45)	−0.02	0.666 (0.47)	0.610 (0.48)	0.05
Off-farm activity	0.646 (0.47)	0.688 (0.46)	−0.04**	0.584 (0.49)	0.758 (0.42)	−0.17**
Pest and disease experience	0.682 (0.46)	0.522 (0.49)	0.16***	0.508 (0.45)	0.677 (0.48)	−0.17***
Credit access	0.697 (0.46)	0.596 (0.41)	0.10***	0.667 (0.47)	0.424 (0.37)	0.23***
FBO membership	0.50 (0.49)	0.534 (0.49)	−0.03	0.661 (0.45)	0.758 (0.43)	−0.10
Extension contact	0.640 (0.47)	0.565 (0.49)	0.07**	0.676 (0.47)	0.482 (0.50)	0.19**
Market access	0.433 (0.49)	0.250 (0.43)	0.18***	0.520 (0.5)	0.418 (0.49)	0.14
Market distance	7.39 (4.7)	6.09 (3.7)	1.3***	8.41 (4.9)	7.46 (5.7)	0.94
Kintampo North	0.357 (0.14)	0.26 (0.14)	0.09***	0.334 (0.12)	0.163 (0.37)	0.17***
Kintampo South	0.376 (0.17)	0.243 (0.42)	0.13**	0.408 (0.10)	0.311 (0.46)	0.09
Kobeda	0.115 (0.31)	0.230 (0.15)	−0.11	0.145 (0.35)	0.179 (0.13)	−0.03
Neighbor status	0.812 (0.39)	0.63 (0.48)	0.18***	0.75 (0.43)	0.524 (0.50)	0.22***

Note: *, **, and *** denotes 10%, 5%, and 1% significance level.
Abbreviation: FBO, farmer-based organizations.
Source: Field data (2021).

TABLE 3 Determinants of ownership of mobile money account.

	Male-headed farm household		Female-headed farm household	
Variables	**Coefficient**	**Marginal effect**	**Coefficient**	**Marginal effect**
Age	−0.079** (0.039)	−0.028** (0.014)	0.203 (0.216)	0.080 (0.084)
Education	0.273** (0.127)	0.098** (0.045)	0.178** (0.076)	0.069** (0.029)
Household size	−0.158 (0.157)	−0.056 (0.056)	0.388 (0.654)	0.152 (0.258)
Experience	0.014* (0.007)	0.005* (0.003)	−0.002 (0.052)	−0.001 (0.020)
Farm size	0.380*** (0.116)	0.136*** (0.042)	0.110 (0.088)	−0.043 (0.035)
Market distance	0.034 (0.086)	0.012 (0.031)	0.117** (0.052)	0.046** (0.020)
Asset value	0.092* (0.048)	0.033* (0.017)	−0.255 (0.389)	−0.100 (0.154)
Land ownership	−0.062 (0.132)	−0.022 (0.048)	0.282 (0.172)	0.062 (0.043)
Extension contact	−0.048 (0.129)	−0.017 (0.046)	0.540*** (0.206)	0.089*** (0.010)
Off-farm activity	−0.142 (0.143)	−0.052 (0.052)	−0.286** (0.119)	−0.083** (0.015)
Credit access	0.301* (0.159)	0.111* (0.060)	0.240 (0.840)	0.094 (0.332)
FBO membership	−0.147 (0.129)	−0.053 (0.046)	0.130** (0.064)	0.046** (0.019)
Market access	0.277** (0.138)	0.100** (0.051)	0.781 (0.966)	0.298 (0.350)
Pest and disease experience	0.247 (0.167)	0.087 (0.068)	0.790 (0.621)	0.302 (0.223)
Neighbor status	0.472*** (0.138)	0.162*** (0.045)	0.419*** (0.160)	0.165*** (0.023)
Kintampo North	0.053*** (0.019)	0.022*** (0.007)	−0.184 (0.118)	−0.522 (0.191)
Kintampo South	−0.240 (0.185)	−0.082 (0.061)	−0.098 (0.106)	−0.034 (0.030)
Constant	0.205*** (0.045)		−0.906*** (0.279)	
N	562		482	
LR $\chi^2(17)$	109.92***		146.13***	
McFadden pseudo R^2	0.1512		0.4381	
Log likelihood	−308.470		−295.85	

Note: *, **, and *** denotes 10%, 5%, and 1% significance level. The Kobeda district is used as the reference group.
Abbreviation: FBO, farmer-based organizations.
Source: Field data (2021).

household heads' probability of mobile money account ownership, respectively. Farmers with high education are more inclined to use mobile phones to perform transactions.

From column 3 of Table 3, the marginal effect of age, farming experience, farm size, asset value, credit access, and market access indicate significant influence on male-headed household probability to own a mobile money account. An increase in age of the male head by 1 year, he is less propelled to own mobile money account by 2.8% compared with younger head. Mostly older farmers are more conservative to use technologies. Younger generations tend to be more technological savvy and comfortable with digital tools and technologies. Older men in male-headed households likely have greater exposure and familiarity with technology, facilitating easier adoption of mobile money services. Conversely, women in female-headed households, facing barriers such as digital literacy and technology access in Africa (Rahman & Connor, 2022a), may find age less influential in mobile money adoption.

Farm size significantly increases the likelihood of owning a mobile money account, suggesting that larger farms may engage more in financial transactions such as purchasing inputs, paying labor, and selling crops, making mobile money a convenient and cost-effective payment option. Asset value positively influences mobile money ownership, with a 3.3% higher likelihood for each increase in asset value. Male-headed households with higher asset values are more likely to own mobile money accounts, possibly using mobile phones for calls and financial transactions. Access to credit shows a significant positive effect, indicating 11.1% higher likelihood of mobile money ownership among farmers with better credit access. This suggests that financially included farmers are more likely to use mobile money for savings, insurance, and remittances. Market access similarly increases the likelihood of mobile money ownership by 10% among male-headed farmers, likely due to lower transaction costs associated with mobile money services in accessible markets. Moreover, relative to the Kobeda District (reference group), farmers located in the Kintampo North are 2.2% more likely to own mobile money account. This confirms the geographical difference where Kintampo North District may have better mobile network coverage than Kobeda District, which would make it easier for farmers to access mobile money services.

The last column of Table 3 (female-headed household), presents a significant positive effect of market distance on the probability of owning mobile money account suggests that female-headed farmers are more likely to own mobile money accounts when they are located further away from the nearest agricultural markets. This implies that farmers are 4.6% more likely to own mobile money accounts which is due to the high transaction costs associated with transporting produce to the agricultural market, hence, encouraging farmers to use mobile money services. The results show that an additional contact with extension agents increases the probability of mobile money account ownership by 8.9%. Extension contacts provide farmers with first-hand knowledge of digital tools and educate them on the effectiveness of using mobile money accounts to track their farm expenditures. Female-headed households engaged in off-farm activity are less likely to own mobile money account, as indicated by the significant negative effect between off-farm activity and the probability of money account ownership. Female-headed households who are engaged in off-farm activities may have alternative means of accessing financial services, such as through formal employment or other sources of income, hence may reduce their need for mobile money services. Being a member of an FBO positively and significantly influence the likelihood of owing mobile money account. This means that farmers who join FBOs are 4.6% more likely to own mobile money account. This is because FBOs can help to raise awareness of the benefits of mobile money accounts. In particular, FBOs can use mobile money services to facilitate group savings and lending, which can help their members to access credit for agricultural inputs or other needs.

5.3 | Distributional impacts of ownership of mobile money account on fertilizer expenditure

Table 4 presents that having a mobile money account significantly increases fertilizer expenditure among the two groups of farmers, but the magnitudes of this impact are higher for male-headed household than female-headed households. This suggests that male-headed households with mobile money accounts tend to spend 13.9% and 6.5% more on fertilizer at the 40th and 60th quantiles, respectively. On the other hand, female-headed households at the highest 80th quantile demonstrated a 4.3% increase in fertilizer expenditure. Ownership of a mobile money account helps farmers improve their application of moderately priced fertilizer to increase maize productivity. Farmers who spend less money on fertilizer can increase their spending through mobile money accounts, which also facilitates farmers' transactions on the fertilizer market. The findings of Yuan et al. (2021), who found that mobile money services increase the use of chemical fertilizer in China, are consistent with the finding of the upsurge effect of owning a mobile money account on fertilizer expenditure.

To provide a more comprehensive analysis, we estimated the impact of owing mobile money account on fertilizer expenditure using the endogenous treatment regression (ETR) model. The ETR model is effective in addressing selection bias issues that arise from observed and unobserved factors (Ma et al., 2020). Table A1 results indicate that ownership of a mobile money account has a positive and statistically significant impact on fertilizer expenditure. However, using a mean-based approach, such as the ETR model, may only provide a narrow understanding of the linkage between ownership of a mobile money account and fertilizer expenditure. In contrast, the IVQR model estimation provides more significant insights.

The results reveal that age has a negative and statistically significant impact on fertilizer expenditure at the 20th, 40th, and 60th quantiles for female-headed households. Our results indicate that for every 1-year increase in age, fertilizer expenditure decreases from 9.9% to 12.1%. Conversely, farming experience has a positive and statistically significant impact on fertilizer expenditure across all quantiles for both male and female farmers. Our findings suggest that as farmers accumulate more farming experience with age; enhance farm management skills, which enable them to increase fertilizer expenditure. This result aligns with Hassen (2018), who found that older farmers tend to use less mineral fertilizer in Ethiopia. Education has a statistically significant positive impact on fertilizer expenditure at all quantiles except 20th quantile for male-headed households, but decreases at the lowest 40th quantile for female-headed households. Interestingly, female-headed households spend 6.3% more on fertilizers at the 80th quantile compared to their male counterparts, although this difference is not statistically significant. Education appears to enable farmers to increase fertilizer expenditure within the recommended rate to enhance maize productivity. Household size has a negative and statistically significant coefficient in the female-headed household column of Table 4. Specifically, an additional household member decreases fertilizer expenditure by 4.9%–9.7% from the lowest 20th to the highest 80th quantile. This finding is consistent with that of Croppenstedt et al. (2003) for Ethiopia, which showed that households with larger member sizes are less likely to encounter labor shortages during the busy farming season, allowing them to use fertilizers more intensively and achieve higher farm productivity. Asset value such as agricultural machines and livestock, is positively associated with increased expenditure on fertilizers. Thus, increasing fertilizer expenditure by 32% at the 80th quantile for male-headed households. However, for female-headed households, asset value only increased fertilizer expenditure by 11.2%, 12.8%, and 11% at the 20th, 40th, and 60th quantiles, respectively. This difference is because assets can be converted into cash to purchase fertilizers, which can improve farm productivity. Similarly, farm size has a positive and statistically significant coefficient on increased fertilizer expenditure, indicating that for each additional hectare, farmers tend to spend 19.7% and 8.5% more on fertilizer expenditure at the lowest 20th and highest 80th quantiles for male and female-headed households, respectively. Larger farms typically require higher farm expenses, such as purchasing more fertilizers to improve maize yields.

Extension contact has a significant and positive impact on fertilizer expenditure at all selected quantiles for female-headed households, but only at the highest 60th quantile for male-headed households. These results underscore the significant role of technical training in helping

TABLE 4 Distributional impact of ownership of mobile money account on fertilizer expenditure.

Variables	Male-headed household				Female-headed household			
	20th	40th	60th	80th	20th	40th	60th	80th
Mobile money account	0.020	0.139***	0.065**	0.010	0.039	0.098	0.029*	0.043***
	(0.045)	(0.043)	(0.028)	(0.012)	(0.064)	(0.122)	(0.017)	(0.010)
Age	0.003	0.084	0.275	0.004	−0.091***	−0.099**	−0.121*	0.443
	(0.135)	(0.129)	(0.233)	(0.036)	(0.023)	(0.044)	(0.064)	(0.364)
Education	0.028	0.088**	0.188***	0.024**	0.037	−0.187*	−0.071	0.063***
	(0.038)	(0.037)	(0.066)	(0.010)	(0.050)	(0.096)	(0.138)	(0.007)
Household size	0.001	−0.012	−0.065	−0.015	−0.097***	−0.049***	−0.087***	−0.050***
	(0.054)	(0.051)	(0.093)	(0.014)	(0.007)	(0.014)	(0.020)	(0.012)
Experience	0.062**	0.068**	0.083**	0.010	0.025***	0.015	0.050***	0.037***
	(0.021)	(0.028)	(0.040)	(0.012)	(0.006)	(0.011)	(0.016)	(0.009)
Farm size	0.197***	0.214***	0.098	0.013	0.863***	−0.175	0.183	0.085***
	(0.040)	(0.038)	(0.069)	(0.011)	(0.068)	(0.131)	(0.188)	(0.011)
Market distance	0.023	0.005	−0.033	−0.005	−0.053	−0.038	0.023	−0.289
	(0.029)	(0.027)	(0.050)	(0.008)	(0.045)	(0.087)	(0.125)	(0.710)
Asset value	0.014	−0.082	0.041	0.320***	0.112***	0.128***	0.110*	−0.031
	(0.017)	(0.160)	(0.029)	(0.110)	(0.021)	(0.041)	(0.059)	(0.034)
Land ownership	−0.043	0.041	−0.003	−0.004	−0.184*	0.189	−0.110	0.068
	(0.045)	(0.043)	(0.077)	(0.012)	(0.107)	(0.204)	(0.293)	(0.167)
Extension contact	0.004	0.043	0.141*	−0.007	0.121***	0.711***	0.108***	0.996***
	(0.043)	(0.041)	(0.074)	(0.011)	(0.009)	(0.189)	(0.027)	(0.154)
Off-farm activity	0.005	−0.042	−0.018	−0.009	−0.085	0.422**	0.326	−0.671***
	(0.047)	(0.045)	(0.081)	(0.013)	(0.101)	(0.193)	(0.277)	(0.158)

TABLE 4 (Continued)

	Male-headed household				Female-headed household			
Variables	**20th**	**40th**	**60th**	**80th**	**20th**	**40th**	**60th**	**80th**
Credit access	−0.073	−0.115**	−0.104	0.035**	0.125*	0.620***	0.765***	0.302***
	(0.056)	(0.053)	(0.096)	(0.015)	(0.071)	(0.136)	(0.195)	(0.111)
FBO membership	0.010	0.055	0.022	0.046***	0.008	0.188	0.146	0.878***
	(0.044)	(0.042)	(0.075)	(0.012)	(0.073)	(0.140)	(0.201)	(0.114)
Market access	0.092*	0.103**	0.044	−0.017	0.687***	0.062	0.561*	0.121***
	(0.048)	(0.046)	(0.084)	(0.013)	(0.107)	(0.205)	(0.294)	(0.167)
Pest and disease experience	0.178	0.258	0.230	0.018	0.200	0.105	0.095	0.231
	(0.440)	(0.420)	(0.760)	(0.012)	(0.760)	(0.146)	(0.209)	(0.191)
Kintampo North	0.132**	0.225***	0.121	0.039**	0.034***	0.034	0.094***	0.128***
	(0.067)	(0.064)	(0.116)	(0.018)	(0.010)	(0.209)	(0.030)	(0.017)
Kintampo South	−0.023	0.091	0.129	0.036**	−0.046***	0.136	−0.246	−0.043**
	(0.058)	(0.056)	(0.100)	(0.015)	(0.010)	(0.202)	(0.290)	(0.016)
Constant	3.945***	3.751***	3.065***	5.001***	10.536***	10.707***	11.898***	2.341
	(0.506)	(0.483)	(0.874)	(0.134)	(1.012)	(1.941)	(2.789)	(1.586)

Note: *, ** and *** denotes 10%, 5% and 1% significance level. The Kobeda was used as the reference group.
Abbreviation: FBO, farmer-based organizations.
Source: Field data (2021).

farmers increase fertilizer use. For female-headed household, off-farm activity reveals a positive significant impact on fertilizer expenditure at the 40th quantile but a negative impact at the highest 80th quantile. This suggests that involvement in off-farm work creates a source of income for households, which tends to increase fertilizer expenditure. The impact of credit access on fertilizer expenditure varies depending on the gender of the household head. For female-headed households, credit access has a significant positive impact on fertilizer expenditure across all quantiles. However, for male-headed households, credit access has a negative impact on fertilizer expenditure at the lowest 40th quantile. A possible explanation could be the fact that at the 40th quantile, male-headed households may have reached a certain level of financial stability and may not require credit to purchase fertilizers. At the highest 80th quantile, being a member of an FBO impacted fertilizer expenditure positively among the two groups of farmers. FBOs can help their members to negotiate better prices for fertilizers which may increase expenditure by purchasing in bulk. This can result in cost savings for individual farmers, particularly for those who are able to purchase fertilizer in bulk. For both farmer groups, market access has a significant and positive impact on fertilizer expenditure, particularly at the lowest 20th quantile. Market access can increase farmers' income, which can enable them to invest more in fertilizers. Compared with maize farmers in the Kobeda District, those in Kintampo North spend significantly more on fertilizers (ranging from 3% to 22%) across all quantiles for both groups, while those in Kintampo South spend 3.6% more on fertilizers at the highest 80th quantile for male-headed households, and 4.6% and 4.3% less on fertilizer at the lowest 20th and highest 80th quantiles for female-headed households, respectively. One possible reason is that Kintampo North may have more favorable soil conditions and intensive farming practices, which may require more fertilizer inputs to achieve higher yields. This also confirms the geographical difference regarding input use in crop production.

5.4 | Distributional impacts of ownership of mobile money account on pesticide expenditure

Table 5 presents the results of the distributional impacts on pesticide expenditure. Among male-headed households in the lowest 20th quantile, owning a mobile money account significantly increases pesticide expenditure by 18%. This may be because male farmers with the lowest pesticide expenditure tend to apply pesticides inadequately, and they use the mobile money account to purchase more pesticides as a yield-increasing input. However, for female-headed households in the higher 60th and 80th quantiles, owning a mobile money account significantly decreases pesticide expenditure by 24% and 18%, respectively. This suggests that for farmers with a high level of pesticide expenditure, the mobile money account provides them with the opportunity to purchase pesticides at lower transaction costs. The finding of a negative relationship between mobile money ownership and pesticide expenditure is upheld by Zhao et al. (2021) findings in China.

We estimated the impact of owning a mobile money account on pesticide expenditure using the ETR model. The results, presented in Table A2, indicate a positive and statistically significant impact of ownership of a mobile money account on pesticide expenditure. These findings provide additional evidence to support the effectiveness of the IVQR model estimation in understanding the relationship between ownership of a mobile money account and pesticide expenditure.

TABLE 5 Distributional impact of ownership of mobile money account on pesticide expenditure.

	Male-headed farm household				Female-headed farm household			
Variables	**20th**	**40th**	**60th**	**80th**	**20th**	**40th**	**60th**	**80th**
Mobile money account	0.167***	0.261***	0.018	0.108**	−0.087	−0.152	−0.238**	−0.177***
	(0.048)	(0.095)	(0.038)	(0.050)	(0.075)	(0.103)	(0.094)	(0.049)
Age	0.013***	0.023***	0.014	0.029	0.412	0.063*	0.102***	0.075***
	(0.005)	(0.008)	(0.115)	(0.151)	(0.264)	(0.035)	(0.032)	(0.017)
Education	0.005	0.040***	−0.002	0.070***	−0.013	−0.133	−0.092	0.071*
	(0.010)	(0.008)	(0.033)	(0.043)	(0.061)	(0.083)	(0.076)	(0.040)
Household size	−0.097***	−0.036	−0.008	0.021	−0.232***	−0.435***	0.044***	0.047***
	(0.014)	(0.114)	(0.046)	(0.060)	(0.079)	(0.107)	(0.009)	(0.005)
Farming Experience	0.013**	0.024***	−0.020	0.021	0.013	0.010	0.011	−0.030
	(0.006)	(0.004)	(0.022)	(0.039)	(0.070)	(0.009)	(0.008)	(0.041)
Farm size	0.032***	0.028***	0.002	−0.006	0.033	−0.108	0.092**	0.007
	(0.011)	(0.008)	(0.034)	(0.045)	(0.079)	(0.108)	(0.039)	(0.052)
Market distance	−0.054***	−0.036***	−0.011	0.022	0.019	0.040	−0.057	0.032
	(0.007)	(0.009)	(0.025)	(0.032)	(0.048)	(0.066)	(0.060)	(0.031)
Asset value	0.018***	0.047***	−0.012	−0.017	−0.019	0.010	0.190***	−0.007
	(0.004)	(0.013)	(0.014)	(0.019)	(0.024)	(0.033)	(0.030)	(0.016)
Land ownership	0.047	0.053	−0.021	0.054	0.056	−0.133	−0.197	0.064
	(0.120)	(0.190)	(0.038)	(0.050)	(0.114)	(0.155)	(0.141)	(0.290)
Extension contact	0.026**	0.039	−0.014	−0.052***	0.040***	−0.171	−0.102	−0.094***
	(0.011)	(0.091)	(0.036)	(0.018)	(0.011)	(0.144)	(0.131)	(0.029)
Off-farm activity	−0.031**	0.016*	−0.003	0.017	0.168	0.182	0.104	0.332***
	(0.013)	(0.009)	(0.040)	(0.053)	(0.117)	(0.160)	(0.146)	(0.077)

(Continues)

TABLE 5 (Continued)

	Male-headed farm household				Female-headed farm household			
Variables	**20th**	**40th**	**60th**	**80th**	**20th**	**40th**	**60th**	**80th**
Credit access	0.110***	0.028**	−0.019	0.380***	0.149*	0.155	0.217**	0.278***
	(0.015)	(0.010)	(0.048)	(0.062)	(0.079)	(0.107)	(0.098)	(0.051)
FBO membership	0.072	−0.016*	−0.021	−0.060***	0.092	0.057	0.094	−0.135**
	(0.120)	(0.009)	(0.037)	(0.019)	(0.089)	(0.121)	(0.110)	(0.058)
Market access	0.046	−0.026	−0.021	0.016	−0.166	−0.232	−0.186	−0.030
	(0.130)	(0.100)	(0.041)	(0.054)	(0.111)	(0.151)	(0.138)	(0.073)
Pest and disease experience	0.020*	0.044***	0.015	0.006	0.293***	0.184*	0.199**	0.377***
	(0.012)	(0.015)	(0.038)	(0.049)	(0.078)	(0.106)	(0.097)	(0.051)
Kintampo North	−0.022	0.029**	−0.002	−0.042	0.301**	0.281*	0.259*	0.136*
	(0.018)	(0.011)	(0.057)	(0.075)	(0.112)	(0.153)	(0.140)	(0.073)
Kintampo South	0.041***	0.091***	0.066	0.024	−0.405***	0.546***	0.653***	−0.679***
	(0.016)	(0.029)	(0.050)	(0.065)	(0.105)	(0.143)	(0.130)	(0.069)
Constant	3.497***	5.107***	3.487***	3.700***	2.325*	2.125	0.703	1.406*
	(1.305)	(1.715)	(0.433)	(0.567)	(1.178)	(1.603)	(1.465)	(0.769)

Note: *, ** and *** denote 10%, 5% and 1% significance level. The Kobeda was used as the reference group.
Abbreviation: FBO, farmer-based organizations.
Source: Field data (2021).

Our results reveal that pesticide expenditure differs between older male-headed and female-headed households. We found that as age increases at the 20th and 40th quantiles, male-headed households spend 1.3%–2.3% more on pesticides, while at the 40th, 60th, and 80th quantiles, female-headed households spend 6.3%–10.2% more on pesticides. This phenomenon may be attributed to older male farmers possessing greater knowledge and experience in pest management, allowing them to use pesticides more efficiently and effectively. Our finding is consistent with the finding of Yang et al. (2019), who asserted that men in China are inclined to spend less on pesticides. Education variables show a positive and statistically significant impact on pesticide expenditure at the 40th and 80th quantiles for male-headed households. This suggests that additional year in education results in a 4%–7% increase in pesticide expenditure.

Similarly, for female-headed households, we observed a 7.1% surge in pesticide expenditure at the highest 80th quantile as the years of education increased. This finding underscores the crucial role of education in pesticide usage. This is consistent with the conclusion drawn by Salazar and Rand (2020) for Vietnam, but it contrasts with the findings of Jallow et al. (2017) for Kuwait. Farming experience and farm size of male-headed households have a positive and significant impact on pesticide expenditure at the lowest 20th and 40th quantiles. Male farmers with more years of farming experience spend around 1.3%–2.4% more on pesticide expenditure, while an additional acre leads to a 2.8% increase in pesticide expenditure. However, these variables do not have a significant impact on pesticide expenditure for female-headed households. At the lowest 20th quantile, both male and female-headed households observe a negative significant impact on pesticide expenditure if they have additional household members. This suggests that households with more members are labor endowed to assist in farm operations, hence tend to spend less on pesticides. However, at the highest 60th and 80th quantiles, only female-headed households spend from 4.4% to 4.7% more on pesticides, indicating that female-headed households with small households are more inclined to spend more to control pests. The distance from male-headed households to the nearest agricultural market has a negative significant impact on pesticide expenditure. Specifically, a longer distance to the market decreases pesticide expenditure by 5.4% and 3.6% at the 20th and 40th quantiles, respectively. This finding suggests that longer distances to the market tend to discourage farmers' farm operations, leading to lower pesticide expenditure (Ma, Abdulai, & Ma, 2018; Rahman & Chima, 2018). Asset value variable has a positive and significant impact on pesticide expenditure for both male- and female-headed households but at different quantiles. Specifically, for male-headed households, the asset value variable has a positive and significant impact on pesticide expenditure at the 20th and 40th quantiles. Meanwhile, for female-headed households, the asset value has a positive and significant impact on pesticide expenditure at a higher 60th quantile. The possession of higher asset value can provide households with more resources to invest in farming operations, such as acquiring pesticides, resulting in higher pesticide expenditure (Ma & Zheng, 2022).

Extension contact has a significant positive impact on pesticide expenditure for both male- and female-headed households, but the effect differs at different quantiles. Extension contact significantly increases pesticide expenditure by 2.6% and 4% for male and female-headed households, at the lowest 20th quantile, respectively. However, at the highest 80th quantile, farmers reduce pesticide expenditure by 5.2% and 9.4% for male and female-headed households, respectively. Studies (Lin et al., 2022; Jallow et al., 2017; Rahman & Connor, 2022b) highlighted the importance of extension services in reducing pesticide use. For example, Rahman and Connor (2022b) found that farmers who received extension services in Bangladesh were less likely to overuse pesticides. Farmers, especially male-headed farmers, involved in other activities aside farming tend to spend 3.1% less on pesticides at the lowest 20th quantile, but their pesticide expenditure increases by 1.6% at the 40th quantile. However, for female-headed households, the results show that more is spent on pesticides at the highest 80th quantile. Participation in off-farm activities may affect the time available for farm operations, consequently, farmers with the expectation of generating more income may divert part of the income to increase pesticide expenditure. Moreover, credit access has a positive significant impact on pesticide expenditure for both male-headed and female-headed households, with an increase observed at both the lowest and highest quantiles. At the 80th quantile, female and male-headed farmers increase pesticide expenditure by 27.8% and 38%, respectively. The importance of agricultural credit in increasing pesticide use has been reported in previous studies (Afawubo et al., 2020; Aziz & Naima, 2021; Kikulwe et al., 2014).

Membership in FBOs had a negative and significant impact on pesticide expenditure, but only at certain quantiles. For example, male-headed households recorded a negative and significant impact on pesticide expenditure at the 40th and 80th quantiles. For female-headed households, membership in FBOs has a negative and significant impact on pesticide expenditure only at the highest 80th quantile. Such FBOs may promote alternative pest management methods which could lower pesticide expenditure (Abebaw & Haile, 2013). Male farmers who have experienced pest and disease prevalence tends to spend from 2% to 4.4% more on pesticides at the 20th and 40th quantiles.

However, for female-headed households, pesticide expenditure is higher across all quantiles. The application of pesticides can help farmers prevent pests and disease prevalence to sustain crop productivity. Therefore, pest and disease experiences are associated with higher expenditure on pesticides. Relative to the reference category (Kobeda), male-headed households producing maize in Kintampo South spend around 9.1% more at the lowest quantile. Additionally, female-headed households growing maize in both Kintampo North and South spend more across all quantiles. This finding confirms the existence of spatial differences in pest management strategies, resulting in higher pesticide expenditure in certain locations.

6 | CONCLUSIONS AND POLICY RECOMMENDATIONS

Digital financial inclusion has driven widespread adoption of mobile money accounts in the global south, benefiting sectors such as agriculture. However, disparities persist, particularly disadvantaging women in accessing productive resources. This article examines the gendered impact of mobile money account ownership on agricultural inputs, specifically fertilizer and pesticides, filling a gap in literature on economic benefits. To account for endogeneity and selection bias stemming from unobserved factors, we employed an instrumental variable quantile regression to analyze the distributional impacts of ownership of a mobile money account on farm input expenditures using cross-sectional data from 1044 farm households.

Our findings reveal that education, farming experience, farm size, asset value, credit access, and market distance significantly influence the likelihood of male-headed households owning mobile money accounts. In contrast, female-headed households are more likely to adopt mobile money accounts when located farther from agricultural markets. Factors such as market distance, extension contacts, and membership in farmer-based organizations also positively impact mobile money adoption. However, female household heads engaged in off-farm activities are less likely to own mobile money accounts. These results underline the need for gender-specific targeting in policy interventions to enhance mobile money adoption among both male and female-headed households, considering their distinct influencing factors. Targeting education, farming experience, farm size, asset value, loan access, and market proximity can effectively promote mobile money account ownership among male-headed households.

Our study reveals significant differences in the impact of mobile money adoption on fertilizer and pesticide expenditures between male and female-headed households. Specifically, male-headed households allocate more spending to fertilizers and pesticides compared with female-headed households. The impact of mobile money ownership shows a notable increase in fertilizer expenditure for both groups, with a higher differential impact observed among male-headed households. For instance, male-headed households with mobile money accounts increase fertilizer spending by 13.9% and 6.5% at the 40th and 60th quantiles, respectively, while female-headed households at the 80th quantile show a 4.3% increase in fertilizer expenditure. These results suggest that male-headed household's purchases of more fertilizers, may translate into higher yields and profit. Thus, better welfare outcomes relative to females. It is therefore important to target bridging this gap, to improve the productivity of female-headed farmers.

The distributional impact of mobile money account ownership on fertilizer expenditure is positively and significantly influenced by farming experience, education for male-headed households, whereas female-headed households are significantly positively influenced by off-farm activity at the 40th quantile but a negative impact at the highest 80th quantile. We found that asset value, extension contact, credit access had a positive and significant impact on pesticide expenditure for both male-headed and female-headed households but at different quantiles. These results suggest that male- and female-headed households are influenced by different factors in driving the adoption of mobile money accounts of fertilizer purchases.

Our study reveals distributional differences in the impact of mobile money account adoption on pesticide purchases between male and female-headed households. Among male-headed households, owning a mobile money account significantly increases pesticide expenditure by 18% in the lowest 20th quantile. In contrast, for female-headed households at the 60th and 80th quantiles, owning a mobile money account decreases pesticide expenditure by 24% and 18%, respectively, indicating reduced transaction costs for high-spending farmers. Education, age, extension contacts, and asset value positively influence pesticide expenditure for both genders, highlighting areas for targeted improvement. Conversely, membership in farmer-based organizations and household size negatively impacts pesticide expenditure, suggesting policy targets to reduce pesticide use.

We recommend policymakers and financial institutions transition from gender-neutral to targeted gender-responsive policies that enhance access to mobile money accounts. These should address entrenched gender disparities in digital financial inclusion, aiming to enhance agricultural production through increased access to and expenditure on agricultural inputs. Specific measures include gender-focused initiatives like financial literacy training, capacity-building workshops, and tailored agricultural extension services. These efforts are crucial to empower female-headed households in accessing mobile money accounts and credit.

Our study highlights the gendered impacts of mobile money adoption on agricultural input expenditures, offering insights into persistent gender disparities in Ghana and SSA. Also, we acknowledge the absence of multiple suitable instruments to account for instrument validity. Our findings underscore the need for targeted policies to promote digital financial inclusion, aiming to narrow these gaps and foster sustainable agricultural production. Future research should consider longitudinal data to better understand the long-term effects of mobile money adoption and explore innovative methodologies such as using neighbors' mobile money account proportions as instruments in similar analyses. These steps could provide a more robust foundation for policymaking and interventions in digital financial inclusion.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX A

TABLE A1 Impact of ownership of mobile money account on fertilizer expenditure among gender.

Variables	Male-head farm household ETR estimates Selection	Fertilizer expenditure	Female-head farm household ETR estimates Selection	Fertilizer expenditure
Mobile money account		0.062***		0.068***
		(0.015)		(0.010)
Age	−0.799**	0.023	−0.029	−0.015
	(0.391)	(0.116)	(0.020)	(0.017)
Education	0.271**	0.081**	0.043	0.018
	(0.127)	(0.032)	(0.031)	(0.012)
Household size	−0.156	0.027	−0.018	−0.040**
	(0.157)	(0.043)	(0.052)	(0.020)
Farming experience	0.014*	0.006***	0.005	−0.021
	(0.007)	(0.002)	(0.018)	(0.007)
Farm size	0.380***	0.133***	0.824***	0.105
	(0.116)	(0.037)	(0.285)	(0.099)
Market distance	0.035	−0.001	0.278	0.183***
	(0.086)	(0.023)	(0.190)	(0.069)
Asset value	0.093*	0.012	0.167	−0.018
	(0.049)	(0.014)	(0.106)	(0.041)
Land ownership	−0.065	−0.052	−0.277	−0.050
	(0.133)	(0.035)	(0.351)	(0.128)
Extension contact	0.046***	0.048	0.473	0.037
	(0.012)	(0.034)	(0.366)	(0.133)
Off farm activity	−0.137	−0.038	−0.821**	0.133
	(0.144)	(0.038)	(0.369)	(0.130)
Credit access	0.303*	0.116**	0.211	0.279**
	(0.159)	(0.047)	(0.361)	(0.118)
FBO membership	−0.149	0.043	0.123	0.087
	(0.129)	(0.035)	(0.340)	(0.126)
Market access	0.277**	0.052	0.104	−0.224
	(0.138)	(0.040)	(0.370)	(0.137)
Pest and disease experience	0.247*	0.172***	0.750**	0.238*
	(0.137)	(0.040)	(0.367)	(0.131)
Kintampo North	0.532***	0.143**	−0.124	−0.039
	(0.189)	(0.063)	(0.439)	(0.146)

TABLE A1 (Continued)

Variables	Male-head farm household ETR estimates Selection	Fertilizer expenditure	Female-head farm household ETR estimates Selection	Fertilizer expenditure
Kintampo South	−0.243	0.026	−0.516	−0.325**
	(0.186)	(0.046)	(0.409)	(0.148)
Neighbor status	0.469***		0.499**	
	(0.139)		(0.198)	
Constant	2.074		−2.855*	5.088***
	(1.456)		(1.590)	(0.562)
Wald $\chi^2(17)$	130.66***		78.03***	
Log likelihood	−538.610		−194.638	
rho	−0.057		−0.950***	
	(0.259)		(0.035)	
sigma	0.364***		0.470***	
	(0.011)		(0.043)	
Lambda	0.021		0.446	
	(0.094)		(0.053)	
LR test	18.912***		9.80***	

Note: *, ** and *** denote 10%, 5% and 1% significance level. The Kobeda was used as the reference group.
Abbreviations: ETR, endogenous treatment regression; FBO, farmer-based organization.
Source: Field data (2021).

TABLE A2 Impact of ownership of mobile money account on pesticide expenditure among gender.

	Male-head farm household		Female-head farm household	
	ETR estimates		ETR estimates	
Variables	Selection	Pesticide expenditure	Selection	Pesticide expenditure
Mobile money account		0.070***		0.124***
		(0.026)		(0.018)
Age	−0.795**	0.044	0.419**	0.193**
	(0.392)	(0.056)	(0.192)	(0.084)
Education	0.273**	−0.012	0.172***	0.098
	(0.127)	(0.016)	(0.063)	(0.177)
Household size	−0.158	−0.018	0.124*	−0.855***
	(0.157)	(0.021)	(0.064)	(0.272)
Farming experience	0.014*	−0.021	−0.077*	0.160
	(0.007)	(0.037)	(0.042)	(0.216)
Farm size	0.380***	0.007	−0.313	−0.274
	(0.116)	(0.018)	(0.898)	(2.467)
Market distance	0.034	0.005	0.114**	0.169
	(0.086)	(0.011)	(0.045)	(0.162)
Asset value	−0.092*	−0.010	−0.217	0.223
	(0.048)	(0.007)	(0.284)	(0.777)
Land ownership	−0.063	0.013	0.121	−0.217
	(0.133)	(0.017)	(0.137)	(0.385)
Ext contact	−0.047	−0.004	0.444***	0.263
	(0.130)	(0.016)	(0.169)	(0.348)
Off farm activity	−0.142	0.012	−0.269***	−0.331
	(0.143)	(0.019)	(0.094)	(0.358)
Credit access	0.301*	0.026	0.423	0.402
	(0.159)	(0.023)	(0.842)	(0.256)
FBO membership	−0.147	−0.003	0.124**	0.484*
	(0.129)	(0.017)	(0.055)	(0.262)
Market access	0.277**	−0.021	−0.057	−0.769**
	(0.138)	(0.020)	(0.787)	(0.386)
Pest and disease experienced	0.246*	0.013	0.123**	0.672**
	(0.137)	(0.019)	(0.056)	(0.274)
Kintampo North	0.530***	−0.031	0.121***	6.229
	(0.189)	(0.030)	(0.091)	(3.942)
Kintampo South	−0.239	0.012	−0.115	−0.137***
	(0.186)	(0.023)	(0.092)	(0.038)

TABLE A2 (Continued)

Variables	Male-head farm household		Female-head farm household	
	ETR estimates		ETR estimates	
	Selection	Pesticide expenditure	Selection	Pesticide expenditure
Neighbor status	0.472*** (0.138)		0.060*** (0.023)	
Constant	2.050 (1.456)	3.472***(0.217)		
Wald χ^2(17)	131.51***		93.99***	
Log likelihood	−136.912		−273.48	
rho	−0.011 (0.248)		−0.944*** (0.039)	
sigma	0.178*** (0.053)		0.765***(0.075)	
Lambda	−0.024 (0.044)		0.723 (0.091)	
LR test	20.92***		13.06***	

Note: *, ** and *** denote 10%, 5% and 1% significance level. The Kobeda was used as the reference group.
Abbreviations: ETR, endogenous treatment regression; FBO, farmer-based organizations.
Source: Field data (2021).

TABLE A3 Falsification test estimates.

Instrument	Ownership of mobile money account (0/1)	Fertilizer expenditure	Pesticide expenditure
Neighbor status	0.562*** (0.089)	11.332 (13.642)	0.811 (0.576)
Constant	−0.632*** (0.075)	109.633*** (28.773)	35.801*** (4.554)
Model diagnosis	$\chi^2 = 40.91$***; pseudo $R^2 = 0.290$	F-test = 2.21; $p = .139$; $R^2 = 0.551$	F-test = 1.98; $p = .160$; $R^2 = 0.$
Sample size	1044	617	617

Note: *, ** and *** denotes 10%, 5% and 1% significance level.

TABLE A4 Instrument testing using Pearson's correlation test.

IV	Outcome variables	Correlation	*p*-Value
Neighbor status	Ownership of mobile money account	0.1946***	.0000
Neighbor status	Fertilizer expenditure	0.0150	.9874
Neighbor status	Pesticide expenditure	0.0316	.3078

***$p < .01$.

TABLE A5 Validity testing of instrument using generalized method of moments-IV.

Variable	Fertilizer expenditure Coefficient (*SE*)	Pesticide expenditure Coefficient (*SE*)
Control variables	Yes	Yes
Neighbor status (IV)	19.08 (23.40)	0.811 (0.576)
Constant	32.264 (47.64)	35.801*** (4.554)
Sample size	1044	1044
Cragg–Donald	χ^2 (1) = 16.38 (*p*-value = .001)	χ^2 (1) = 16.43 (*p*-value = .001)
Kleibergen–Paap rk Wald statistic	χ^2 (1) = 17.57 (*p*-value = .000)	χ^2 (1) = 16.19 (*p*-value = .001)

Note: *, ** and *** denotes 10%, 5% and 1% significance level.