

The Impact of Mobile Internet Access on Agricultural Insurance Participation: Mediating Role of Financial Exclusion and Heterogeneity Analysis

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Abstract. In recent years, China has actively promoted agricultural insurance, but challenges such as insufficient coverage and limited digitalization persist. To address these issues, this study draws on data from CAU-IFS 2024 and examines the impact of mobile internet accessibility on rural households' participation in agricultural production insurance and the related decision-making mechanisms. Results from Probit and Tobit models show that mobile internet significantly increases both the likelihood of insurance participation and premium expenditures, with these effects being especially pronounced among households outside cooperatives, those with higher risk preferences, and those with higher incomes. Robustness checks confirm these findings, while mediation analysis reveals that mobile internet promotes agricultural production insurance participation by mitigating financial exclusion. These insights provide valuable policy implications for advancing agricultural insurance development.

Keywords: Mobile Internet Access, Agricultural Production Insurance, Financial Exclusion, Tobit model, mediating effect.

1. Introduction

Agricultural insurance, as a key tool for mitigating agricultural production (AP) risks, plays a crucial role in promoting agricultural development, revitalizing rural industries, and securing farmers' income. In recent years, China has actively advanced the development of agricultural insurance, continuously refining the policy framework with notable achievements. According to data from the Ministry of Finance, the central government allocated 43.453 billion yuan in agricultural insurance premium subsidies in 2022, representing a 30.3% year-on-year increase. Agricultural insurance provided risk protection for 167 million households, covering a total amount of 5.46 trillion yuan. However, issues such as insufficient coverage, limited precision and limited digitalization persist.

Meanwhile, with the rapid development of internet, the cost of information access for farmers has significantly decreased, driving changes in consumer behavior. Against this backdrop, whether internet positively influences household participation in agricultural insurance and the mechanisms of this impact are critical questions for promoting the high-quality development of agricultural insurance.

In recent years, an increasing volume of research has concentrated on examining the influence of the internet on agricultural insurance. At the macro level, empirical evidence indicates that internet development can reduce transaction costs and significantly contribute to the expansion of agricultural insurance [1]. At the micro level, existing research suggests that the internet enhances agricultural insurance products by enabling more precise damage assessments and compensation processes [2]. Additionally, internet adoption has played a critical role in stimulating rural household consumption, facilitating farmers' adoption of new technologies, and lowering market transaction costs [3], thereby encouraging greater participation in agricultural insurance. Despite these findings, research on the specific influence of internet applications on farmers' decisions to purchase agricultural insurance remains relatively sparse, and further investigation into its effects and underlying mechanisms is warranted.

This study utilizes data from the CAU-IFS 2024 to examine the impact of mobile internet accessibility (MIA) on rural households' participation in agricultural production insurance (API)

through Probit and Tobit models. To enhance the robustness of the findings, key independent variables are substituted during robustness checks, ensuring the reliability and consistency of the results. Additionally, the study conducts heterogeneity analysis and mediation effect tests to further explore the underlying mechanisms through which MIA influences farmers' decisions to engage in API. These comprehensive analyses provide deeper insights into the intricate relationship between MIA and API participation, contributing to a more thorough understanding of the role of digital access in shaping agricultural insurance behaviors.

The marginal contributions of this study can be summarized as follows. Firstly, it demonstrates that MIA plays a significant role in increasing rural households' participation in API while also boosting their premium expenditure. Secondly, it emphasizes that MIA has an even more pronounced effect on households that are not members of cooperatives, those with higher risk preferences, and those with higher income levels. Thirdly, this study introduces financial exclusion (FE) as a mediating variable, revealing that MIA reduces FE, which in turn further encourages participation in API.

2. Theoretical Review and Research Hypotheses

2.1. Literature Review

Current research on agricultural insurance primarily focuses on two areas: first, its impact on AP and rural revitalization, and second, studies on the mechanisms and effectiveness of China's policy-based agricultural insurance. Many scholars have pointed out that agricultural insurance effectively reduces farmers' risks, promotes the stability of AP, thus reducing households' vulnerability to relative poverty [4], contributing to rural revitalization [5]. Additionally, research comparing agricultural insurance with catastrophe relief has shown that individual agricultural insurance designs are more effective in mitigating income volatility for farmers compared to other insurance or relief methods [6]. Subsequent studies have explored specialized insurance designs such as layered catastrophe insurance [7] and agricultural insurance based on the drought weather index model for summer maize in Puyang [8].

In terms of factors influencing agricultural insurance participation, studies have found that the digital economy significantly boosts agricultural insurance [9], while central government attention, local fiscal capacity, and the professional background of officials positively impact the execution of local policy-based agricultural insurance [10]. However, research on household-level factors and mechanisms remains insufficient. While scholars generally agree on the positive effects of internet on the development of the commercial insurance (CI) market by lowering information costs and entry barriers, this paper draws on insights from CI research to examine the impact of mobile internet (MI) on API.

At the household level, some scholars have used micro-level financial data, such as CHFS and CFPS, to explore the impact of internet development on household CI spending [11]. Building on this, this paper focuses on the more common emerging medium in rural areas—MI—and investigates its impact on agricultural insurance participation.

MI may alter economic decisions and behaviors by reducing FE and improving access to financial services. At the micro household level, researchers have categorized FE into investment exclusion and credit exclusion, defining it by whether a household owns securities, funds, or bank accounts [12]. Moreover, most researchers agree that internet usage significantly reduces the probability and extent of FE [13]. To sum up, there is still limited research exploring the impact of MI on household-level participation in agricultural insurance and its underlying mechanisms.

2.2. Research Hypotheses

The rapid proliferation of MI in China has significantly transformed the way residents handle insurance processes, enabling them to efficiently manage applications, renewals, and claims from the convenience of their homes, as well as purchase API (The agricultural production insurance in this study is based on the 2024 Rural Household Inclusive Finance Survey conducted by China

Agricultural University. The specific coverage includes: 1. Crop insurance (input cost insurance), 2. Full cost insurance, 3. Income insurance, 4. Weather index insurance, 5. Product liability insurance, 6. Livestock insurance (pigs, sheep, dairy cows), 7. Specialty livestock insurance, 8. Specialty crop insurance, 9. Agricultural machinery insurance, 10. Farmhouse insurance, 11. Catastrophe insurance, 12. Land transfer performance guarantee insurance, 13. Agricultural product transportation insurance, 14. Price insurance.) Through various mobile apps. These platforms have effectively removed traditional time and space constraints, making it more convenient to engage agricultural insurance. As MI becomes more widely accessible, it has the potential to increase household participation in agricultural insurance. However, households differ in their characteristics due to external socio-economic factors and internal dynamics, such as values, risk preferences, and decision-making processes. As a result, their responses to MI in making insurance decisions may vary.

Households affiliated with agricultural cooperatives, often guided by these organizations' influence and support, are generally more inclined to purchase agricultural insurance compared to non-member households. Similarly, households exhibiting higher risk preferences are likely to be more responsive to uncertainties and potential risks in agricultural production, making them more inclined to invest in insurance to mitigate these risks. High-income households, endowed with greater financial resources, are also more predisposed to purchasing agricultural insurance to strengthen the security and resilience of their agricultural activities. Consequently, these micro-level decisions, which are influenced by diverse individual or household characteristics, may result in noticeable heterogeneity in the impact of MI on agricultural insurance participation across different demographic groups.

Furthermore, traditional insurance institutions may reduce service outlets in economically disadvantaged areas due to high operational costs and lower demand, resulting in FE caused by limited access to information and marketing discrimination. The widespread availability MI helps bridge this gap by providing greater access to insurance services through formal financial service apps, thereby reducing FE. This, in turn, enhances both the likelihood and extent of household participation in agricultural insurance. In this context, MIA may have a significant influence on household decisions to participate in API by alleviating FE.

Based on the above discussion, the following hypotheses are proposed:

Hypothesis 1: MIA promotes household participation in API.

Hypothesis 2: The effect of MIA on API participation is more pronounced for households not in cooperatives, those with higher risk preferences, and higher-income households.

Hypothesis 3: MIA promotes household participation in API by mitigating FE.

3. Methods and data

3.1. Model Specification

To explore the relationship between MIA and rural household participation in API, this study investigates two key dimensions: whether households participate in API and the extent of their participation in the API market. Accordingly, three dependent variables are defined: (1) willingness to purchase API (AGI_wish), (2) whether the household has purchased API (AGI_par), and (3) household expenditure on API (AGI_exp). The first two variables, AGI_wish and AGI_par, are binary, with a value of 1 indicating that the household either has the willingness to purchase or has already purchased agricultural insurance, and 0 indicating otherwise. The third variable, AGI_exp, is continuous and reflects the household's premium expenditure on API.

Probit and Tobit models are employed, focusing on how MIA influences both the decision to purchase insurance and the level of expenditure on API:

$$AGI_par^* = \beta_0 + \beta_1 * mobile_internet + X'\beta_2 + \varepsilon$$

$$AGI_par = 1(AGI_par^* > 0) \quad (1)$$

In this model, AGI_par^* (alternatively AGI_wish^*) represents the latent variable for whether a household purchases API (AGI_par). The key independent variable, MI , denotes MIA, while X represents a series of control variables, and ε is the random error term.

Since household API expenditures are censored (non-negative values), a Tobit model is further employed to analyze the impact of MIA on the extent of household API premium expenditure:

$$\begin{aligned} AGI_exp^* &= \beta_0 + \beta_1 * mobile_internet + X'\beta_2 + \varepsilon \\ AGI_exp &= \max \{0, AGI_exp^*\} \end{aligned} \quad (2)$$

In this model, AGI_exp^* represents the latent variable for household API premium expenditure (AGI_exp), with the other symbols having the same meanings as previously defined.

To test the mechanism of FE, a mediation effect model is constructed following the approach in existing literature [14]:

$$\begin{aligned} M &= a_0 + a_1 * mobile_internet + X'a_2 + \varepsilon \\ AGI_par^* &= \gamma_0 + \theta M + \gamma_1 * mobile_internet + X'\gamma_2 + \varepsilon \end{aligned} \quad (3)$$

Equations (1) and (2) together form the mediation effect model for testing the probability and extent of households' participation in API. In Equation (3), the dependent variable M represents the mediator, namely the FE variable. The independent variables are the same as in Equation (1), with the mediator M added to the model, while other variables remain unchanged. Consistent with the previous analysis, a Probit model is used for these specifications. Similarly, for household agricultural insurance expenditure, AGI_par in Equation (3) is replaced with AGI_exp , and the Tobit model is employed for this analysis.

3.2. Data Source

The data for this study is sourced from the 2024 Inclusive Finance Survey conducted by China Agricultural University (CAU-IFS 2024). The sample covers 4 provinces, 10 cities, 34 towns, and 94 villages or residential committees. The survey collects comprehensive household financial data, including demographic characteristics, assets and liabilities, agricultural insurance, income and expenditures, internet behavior, consumption, and financial literacy. The agricultural insurance module provides data on households' API purchases, while the internet behavior and consumption module captures information related to MIA. This dataset allows for a thorough analysis of how MIA influences rural households' financial decisions.

3.3. Variable Description

The variables in this study are categorized into three distinct groups: dependent variables, key independent variables, and control variables, as shown in Table 1, which provides their corresponding names, symbols, and detailed descriptions. Household participation in API is examined across three key dimensions: (1) willingness to purchase API, indicated by the variable AGI_wish , (2) actual API purchase, denoted as AGI_par , and (3) the degree of participation, represented by the total annual premium expenditure, which is log-transformed and denoted as AGI_exp .

The key independent variable is MI , measured by whether the individual owns a smartphone. To ensure robustness, mobile payments (MP) are used as a substitute in the analysis to further evaluate the effect of MIA on API participation.

Following the methodology adopted in prior studies [9], control variables encompass characteristics of the household head, household attributes, and regional characteristics. After eliminating missing and anomalous data points, the final dataset for analysis comprises 1,822 valid household samples.

Table 1. Variable Descriptions.

	Variable	Symbol	Explanation
Dependent Variables	Willingness to Purchase API	AGI_wish	Purchase = 1; Not purchase = 0
	Whether API was Purchased	AGI_par	Purchase = 1; Not purchase = 0
	API participation level	AGI_exp	Total annual premium (log-transformed)
Independent Variables	MIA	MI	1 = owns a smartphone; 0 = does not own
Control Variables	Education Level	education	Defined by question A104 (continuous variable)
	Gender	gender	0 = male; 1 = female
	Age	age	Age in years
	Age Squared	age_squ	Age squared
	Engagement in Aquaculture	Aqu	1 = engaged; 0 = not engaged
	Cooperative Membership	cop	1 = member; 0 = not a member
	Online Search Skill	self	Defined by question C605b; 1 = Yes; 0 = No
	High-Risk Preference	risk_high	Defined by question N104; 4 = Yes; others = No
	Medium-Risk Preference	rish_mid	Defined by question N104; 2 = Yes; others = No
	Marital Status	married	Defined by question A105; 1 = Yes; others = No
	Household Annual Income	income	Logged value of household annual income
	Ownership of a Private Car	asset_car	1 = owns a private car; 0 = does not own
	Annual Medical Expenses	ill_cost	Annual medical expenditures(log-transformed)
	Migrant Worker Ratio	out_rat	Migrant workers / total household members
	Labor Force Ratio	labor_rat	labor force members / total household members
	Entrepreneurial Involvement	business	Defined by question B201; 2 = Yes; others = No

4. Results

4.1. Benchmark Regression Results

Table 2 presents the regression results examining the effect of MIA on household participation in API, specifically focusing on three dimensions: households' willingness to purchase, actual purchase decisions, and premium expenditure levels. In Column (1), the Probit model indicates that MIA exerts a statistically significant and positive influence on households' willingness to purchase API at the 1% significance level. This finding suggests that increased MIA enhances the probability of households expressing a willingness to engage with API. In Column (2), after accounting for control variables related to household head characteristics and overall household attributes, this positive effect remains robust and significant at the 1% level, thereby confirming Hypothesis 1. The use of mobile internet effectively reduces both costs and informational barriers for households, facilitating easier access to relevant insurance products and subsequently increasing the likelihood of participation in the API market. Consistent results are observed in Columns (3) and (4), providing further evidence in support of Hypothesis 1.

In Column (5), the Tobit model results demonstrate that MIA exerts a statistically significant positive influence on household expenditure for API premiums at the 1% significance level. Furthermore, even after the incremental inclusion of control variables in Column (6), this positive effect remains consistently significant. This finding suggests that MIA not only enhances the likelihood of households purchasing API but also leads to an increase in premium expenditures, thereby providing additional empirical support for Hypothesis 1.

Among the control variables, the age of the household head and its square are significant at the 1% level in Columns (4) and (6), with the squared term showing a relatively small negative coefficient, suggesting an approximately linear relationship: as the household head's age increases, the probability of purchasing API and the amount of expenditure both rise. Education level is significant at the 5% level for both willingness to purchase and premium, though the coefficients are small, implying that

higher education increases the likelihood of participation but is not a major influencing factor. High-risk preferences are positively significant at the 1% and 5% levels, likely because risk-averse households are more likely to invest in insurance to hedge agricultural risks.

Regarding household characteristics, annual household income is significant at the 1% level across all models, indicating that higher income leads to greater participation in and expenditure on API, possibly due to greater investment capacity. Engaging in aquaculture and cooperative membership also have significant positive effects on API participation, suggesting that proper guidance from cooperatives can increase farmers' likelihood of purchasing API. Ill_cost show a positive effect on the willingness to purchase API at the 10% level but a negative effect on actual premium expenditure at the 5% level, indicating that while higher medical costs raise awareness of risk prevention, limited financial resources may restrict actual expenditure on API.

4.2. Robustness Check

This study employs an alternative variable method to test the robustness of the impact of MIA on household participation in API. The ability to use MP indicates that residents own mobile devices and can access the internet, effectively excluding cases where individuals have smartphones but do not fully utilize them. Therefore, MP are used as a proxy for MIA instead of smartphone ownership. As shown in Table 3, both Probit and Tobit model results remain consistent with the previous findings in terms of significance and coefficients, confirming the robustness of the regression results. This demonstrates that MIA significantly promotes both the likelihood of purchasing agricultural insurance and premium expenditure.

Table 2. Benchmark Regression Results.

	AGI_wish (1)	AGI_wish (2)	AGI_par (3)	AGI_par (4)	AGI_exp (5)	AGI_exp (6)
MI	1.022*** (0.078)	0.962*** (0.092)	0.996*** (0.077)	0.896*** (0.089)	4.785*** (0.355)	3.595*** (0.33721)
education		0.017 (0.011)		0.025** (0.011)		0.077** (0.039)
age		0.011 (0.020)		0.061*** (0.019)		0.238*** (0.076)
age_squ		-0.000 (0.000)		-0.000*** (0.000)		-0.002*** (0.001)
Aqu		0.204* (0.118)		0.393*** (0.122)		1.775*** (0.398)
cop		0.426*** (0.124)		0.306** (0.122)		0.943** (0.393)
risk_high		0.329*** (0.109)		0.242** (0.108)		0.971*** (0.360)
income		0.097*** (0.029)		0.074*** (0.027)		0.594*** (0.104)
ill_cost		0.015* (0.008)		-0.019** (0.008)		-0.056** (0.029)
Constant	-0.611*** (-0.071)	-3.885*** (0.631)	-0.545*** (0.070)	-3.362*** (0.591)	-3.324*** (0.346)	-16.957*** (2.352)
N	1822	1822.000	1822	1822.000	1822	1822.000
LR/Wald	180.792	301.695	173.773	249.871	206.691	353.617

Note: Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01. Same applies below.

Table 3. Robustness Check Using Alternative Key Independent Variable.

	AGI_wish (1)	AGI_wish (2)	AGI_par (3)	AGI_par (4)	AGI_exp (5)	AGI_exp (6)
MI_1	0.663*** (0.061)	0.660*** (0.076)	0.648*** (0.062)	0.586*** (0.076)	3.069*** (0.241)	2.270*** (0.266)

Constant	-0.183*** (-0.037)	-3.839*** (0.601)	-0.021 (0.039)	-3.857*** (0.587)	-0.770*** (0.185)	-18.511*** (2.381)
Control	Yes	Yes	Yes	Yes	Yes	Yes
N	1822	1822	1822	1822	1822	1822
LR/Wald	118.849	210.858	112.590	206.976	165.422	326.756

4.3. Heterogeneity Test

(1) By Cooperative Membership: Panel A of Table 4 shows that MIA has a significantly positive effect at the 1% level on the probability of purchasing API and premium expenditure for households not in cooperatives. For households in cooperatives, the effect is smaller in both coefficient and significance. This may be because cooperative members are already guided to purchase API, as confirmed by the baseline regression. In contrast, non-members, who typically have less information and knowledge about the insurance market, recognize the advantages and necessity of agricultural insurance more fully when using smartphones, significantly increasing their likelihood of participating in the market, particularly if they had little prior exposure to it.

(2) By Risk Preference: Panel B of Table 4, the results demonstrate that MIA has a more significant effect on both the probability of purchasing API and premium expenditure for households with higher risk preferences compared to those with lower risk preferences. This greater impact may stem from the heightened sensitivity of risk-seeking households to uncertainties and potential risks in AP, driving them to mitigate these risks through insurance. The availability of MI enables these households to more easily access insurance information and services, leading to an increased likelihood of API participation and higher premium investments as a way to mitigate agricultural risks.

(3) By Household Income: Panel C of Table 4 shows that MIA has a stronger positive impact on both the likelihood of purchasing API and premium expenditure for higher-income households. This likely reflects their greater financial capacity and risk tolerance in dealing with AP risks. The widespread availability of MI allows wealthier households to more easily access insurance products and information, enabling them to invest more in insurance and enhance the security of their AP. In contrast, lower-income households may face financial constraints, leading to lower participation in the insurance market.

Table 4. Heterogeneity Test.

Variable		AGI_wish		AGI_exp		AGI_par	
		Member	Non-mem	Member	Non-mem	Member	non-mem
Panel A: Cooperative Membership	MI	0.793* (0.444)	1.005*** (0.093)	0.646*** (0.519)	0.859*** (0.091)	3.311** (1.376)	3.619*** (0.392)
	N	152	1670	152	1670	152	1670
	Control	Yes	Yes	Yes	Yes	Yes	Yes
		Preference	Non-pre	Preference	Non-pre	Preference	Non-pre
Panel B: Risk Preference	MI	1.606*** (0.378)	0.936*** (0.096)	1.829*** (0.403)	0.806*** (0.093)	5.629*** (1.180)	3.205*** (0.393)
	N	188	1634	188	1634	188	1634
	Control	Yes	Yes	Yes	Yes	Yes	Yes
		Wealthier	Non-wea	Wealthier	Non-wea	Wealthier	Non-wea
Panel C: Household Income	MI	1.115*** (0.142)	0.887*** (0.122)	0.974*** (0.140)	0.845*** (0.119)	3.754*** (0.542)	3.275*** (0.518)
	N	977	845	977	845	977	845
	Control	Yes	Yes	Yes	Yes	Yes	Yes

4.4. Mechanism Analysis

As one of the most representative financial products and services offered by banks, credit cards have a significant impact on residents' economic lives today. Owning a credit card allows access to services such as overdraft payments, installment plans, and loans, thereby enhancing personal

financing capabilities. Credit cards play a key role in major purchases such as buying a house or car and are closely related to the availability of household financial services. If a household owns a credit card, it is likely to have closer ties with financial institutions, increasing the likelihood of participating in the agricultural insurance market. Following existing literature [9], FE is measured using the variable of credit card ownership, where households without a credit card are assigned FE = 1, and those with a credit card are assigned FE = 0.

The mechanism test of FE is conducted through a mediation effect model, analyzing three aspects: willingness to participate in API, the probability and the extent of participation. The mediation effect model follows a three-step process, as shown in Table 5. For willingness to participate, the test corresponds to Columns (1), (4), and (5); for the probability of API participation, to Columns (2), (4), and (6); and for the extent, to Columns (3), (4), and (7).

Table 5 demonstrates that MIA significantly enhances household participation in API. After accounting for control variables, the effect of MIA on FE remains significantly negative at the 1% level, suggesting that increased MIA plays a crucial role in alleviating FE. When FE is introduced as a mediator in the baseline model, it is also significantly negative, indicating that reduced FE leads to greater willingness, a higher likelihood of API participation, and increased premium expenditures. These findings confirm that MIA facilitates API participation by mitigating FE.

Additionally, a comparison of MIA's coefficients shows that its impact remains significantly positive at the 1% level, even with FE introduced as a mediator. However, the marginal effect declines, indicating that FE partially mediates the relationship between MIA and API participation. This finding furthermore confirms that MIA affects API participation by reducing FE, thereby supporting Hypothesis 3.

Table 5. Mediation Effect Test of Financial Exclusion.

	AGI_wish (1)	AGI_par (2)	AGI_exp (3)	FE (4)	AGI_wish (5)	AGI_par (6)	AGI_exp (7)
MI	0.962*** (0.092)	0.896*** (0.089)	3.595*** (0.33721)	-0.835*** (0.188)	0.934*** (0.092)	0.840*** (0.090)	3.242*** (0.364)
FE					-0.595*** (0.100)	-0.628*** (0.102)	-1.792*** (0.296)
Constant	-3.885*** (0.631)	-3.857*** (0.587)	-18.511*** (2.381)	4.652*** (0.801)	-3.198*** (0.641)	-3.009*** (0.612)	-18.014*** (2.416)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1822	1822	1822	1822	1822	1822	1822
LR/Wald	210.858	206.976	326.756	289.955	339.217	310.571	463.817

5. Conclusion and Recommendation

Based on the data from CAU-IFS 2024, this study examines the impact of MIA on API participation across three dimensions: willingness to participate, probability and the extent of participation, using Probit and Tobit models. The key findings are as follows: First, MIA significantly enhances the likelihood of households purchasing API and increases premium expenditure. Second, the effect of MIA varies across households, with a stronger impact on those non-cooperative members, with high-risk preferences, and higher-income households. Third, robustness checks using an alternative variable (MP) confirm the stability of the results. Fourth, mediation analysis reveals that MIA promotes household participation in API by alleviating FE.

The policy recommendations are as follows: First, expanding MI coverage in rural and remote areas is crucial for increasing households' willingness, likelihood, and premium expenditure in API, as it directly improves access to insurance services and reduces barriers to participation. Second, given that MI has a stronger impact on non-cooperative members, high-risk preference households, and higher-income families, targeted policies should be implemented to specifically engage these groups, thereby ensuring more comprehensive participation across different household types. Lastly, MI alleviates FE, facilitating farmers' participation in API, highlighting the need to strengthen digital

literacy and financial inclusion programs to enhance farmers' engagement with digital financial services.

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