

Integrating Agricultural Technology Adoption and Financial Inclusion as a Strategy to Improve Micro-Scale Farm Productivity in Rural Areas of South Sumatra

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Abstract: Micro-scale farming faces various constraints in improving productivity, particularly in relation to farmers' ability to adopt technology and access financing that meets their business needs. Agricultural technology can improve the efficiency of input use, access to information, farm management, and decision-making. However, technology adoption among smallholder farmers is still influenced by digital literacy, infrastructure, economic conditions, and institutional factors. On the other hand, access to credit can improve farm productivity and technical efficiency by enabling farmers to obtain production inputs and make productive investments. This study aims to: (1) analyze the effect of agricultural technology adoption on micro-scale farm productivity; and (2) analyze the effect of financial inclusion access on micro-scale farm productivity. The study employs a quantitative explanatory approach using multiple linear regression analysis. A total of 300 farm observations are used as simulated data to demonstrate the proposed analytical framework; therefore, the numerical results do not represent findings from an actual field survey. The independent variables consist of an agricultural technology adoption index and a financial inclusion access index, while farm productivity serves as the dependent variable. Farmers' age, education level, and land area are included as control variables. The results indicate that agricultural technology adoption and financial inclusion access have positive and statistically significant effects on farm productivity. The model explains a substantial proportion of the variation in productivity and provides an initial basis for further empirical investigation into the role of technology and financing in micro-scale farming. These findings are illustrative in nature and should be validated using primary data collected from farmers.

Keywords: *Agricultural Technology Adoption, Financial Inclusion, Agricultural Financing, Productivity, Micro-Scale Farmers, Rural Areas.*

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I. INTRODUCTION

➤ Research Problem

Micro-scale farming constitutes an important component of rural economies; however, improvements in farm productivity remain constrained by limited access to capital, technology, information, markets, and financial services. These limitations may hinder farmers from investing in production inputs and technologies required to improve production efficiency. In agricultural development, productivity improvement therefore depends not only on the availability of technology but also on farmers' ability to

access the resources necessary to utilize technology effectively (Balana et al., 2022; Regassa, Degnet, & Melesse, 2023).

The development of agricultural technology, particularly information and communication technology, offers opportunities to improve production processes and farm decision-making. Technologies used by farmers may include access to price information, social media for marketing, marketplaces, agricultural applications, digital payments, farm record-keeping systems, mechanization, and production technologies. However, the adoption of digital

technology among smallholder farmers in Indonesia remains uneven. Satria et al. (2025) reported that digital literacy, internet and electricity infrastructure, economic conditions, and institutional factors constitute important barriers to the adoption of digital agricultural technology.

A study conducted by the Asian Development Bank involving 149 farmers in Yogyakarta and Central Java showed that the use of digital technology has increased, although adoption levels vary according to the type of technology. Social media was more widely used than e-commerce platforms and farm management applications (ADB, 2024). This condition indicates that technologies with potential economic benefits may not necessarily be widely adopted if they are not aligned with farmers' capacities, needs, and farm conditions.

In addition to technology, financing is an important factor influencing farm production and investment decisions. Access to credit can enable farmers to purchase seeds, fertilizers, equipment, machinery, and other productive inputs while reducing liquidity constraints that limit investment decisions. Empirical evidence from Indonesia suggests that access to credit can improve farm productivity and technical efficiency, while access to different sources of financing is also associated with horticultural production risks (Haryanto et al., 2023; Wulandari et al., 2021).

The relationship between financing and technology adoption has also received support from international research. Regassa et al. (2023) found that access to credit can increase both the likelihood and intensity of agricultural technology adoption, particularly when credit is used to finance agricultural inputs and among households facing liquidity constraints. Similarly, Balana et al. (2022) demonstrated that both demand-side and supply-side credit constraints may hinder investment among smallholder farmers.

The development of financial technology (fintech) has created new alternatives for agricultural financing. Rufaidah et al. (2023) reported that fintech has the potential to expand access to financial services in the Indonesian agricultural sector. However, challenges remain regarding literacy, access, platform sustainability, and the suitability of financing models for agricultural characteristics. Karyani et al. (2024) also identified financing technology as an alternative mechanism for supporting agricultural product financing, although the design and sustainability of financing platforms require careful consideration.

These conditions indicate the existence of two complementary streams of knowledge. The first stream positions technology adoption as a factor that can improve efficiency, access to information, marketing, and farmers' decision-making processes. The second stream positions financial inclusion and access to credit as factors that enable farmers to obtain productive inputs and make productive investments. In the Indonesian context, both streams have received empirical support; however, evidence specifically focusing on micro-scale farmers in rural areas of South

Sumatra remains limited and requires further investigation using primary data (Satria et al., 2025; Wulandari et al., 2021).

This study focuses on two main objectives: examining the effect of agricultural technology adoption on productivity and analyzing the effect of financial inclusion access on productivity. This focus is intended to establish a clear empirical baseline regarding the contribution of each factor before subsequent research develops more complex models concerning the interaction between technology, financing, agricultural fintech, and rural institutions.

Based on the existing state of the art, the research gap lies in the continuing separation between discussions of technology and financing, the limited evidence concerning micro-scale farmers, and the need for more contextual evidence regarding the relationship between these two factors and farm productivity in rural areas of Indonesia. Studies on technology have largely emphasized adoption determinants and barriers to digitalization, whereas studies on financing have primarily examined access to credit, investment, and farm performance. Therefore, this study focuses on examining the direct effects of agricultural technology adoption and financial inclusion access on productivity as an empirical basis for developing subsequent research models (Regassa et al., 2023; Satria et al., 2025).

The novelty of this study lies in the simultaneous examination of two determinants of micro-scale farm productivity, namely agricultural technology adoption and financial inclusion access, with a particular focus on rural areas in South Sumatra. The study estimates the contribution of each variable to productivity while controlling for farmer and farm characteristics. This approach provides an empirical baseline for future research concerning the integration of agricultural digitalization and financing.

The urgency of this study is based on the need to ensure that agricultural modernization and digitalization are accompanied by improvements in farmers' economic capacity. The availability of technology without the financial capacity to purchase equipment, production inputs, connectivity, or maintenance services may limit its effective utilization. Conversely, financing without improvements in productive capacity may not necessarily result in sustainable productivity growth. Digitalization barriers related to economic conditions, infrastructure, and knowledge further reinforce the need to examine technology and financial inclusion simultaneously in agricultural development (Satria et al., 2025; Rufaidah et al., 2023).

Accordingly, this study aims to: (1) analyze the effect of agricultural technology adoption on micro-scale farm productivity; and (2) analyze the effect of financial inclusion access on micro-scale farm productivity.

➤ *Hypotheses*

- H1: Agricultural technology adoption has a positive effect on micro-scale farm productivity.

- H2: Financial inclusion access has a positive effect on micro-scale farm productivity.

II. RESEARCH METHODOLOGY

➤ Research Design

This study employs a quantitative explanatory approach to examine the relationships between agricultural technology adoption, financial inclusion access, and farm productivity. The unit of analysis consists of farmers or micro-scale farming households located in rural areas. Multiple linear regression analysis is employed to estimate the effects of the two main independent variables on farm productivity while controlling for relevant farmer and farm characteristics.

➤ Population and Sample

The empirical research design targets a sample of 300 micro-scale farmers. Sampling may be conducted using a multistage sampling approach involving the selection of districts, sub-districts, villages, and subsequently individual farmers. Respondents are selected based on the following criteria: they own and manage a farming business, have actively engaged in agricultural production for at least one production season, reside in rural areas, and are familiar with the technologies used in their farming activities.

➤ Operationalization of Variables

Table 1 Operationalization of Variables

Variable	Indicators	Measurement
X1. Agricultural Technology Adoption	Access to price information; social media use; marketplace/e-commerce utilization; agricultural applications; digital payments; machinery/equipment; digital record-keeping; production technology	1–5 scale
X2. Financial Inclusion	Bank account ownership; access to credit; ease of obtaining financing; financing requirements; access to financial institutions; loan amount/credit limit; repayment schedule; financing costs	1–5 scale
Y. Farm Productivity	Output per unit of land area	tons/ha or kg/ha
Control Variables	Age; education; land area	Years and hectares

The technology adoption index and financial inclusion index can be constructed from indicator scores aggregated into composite indices. A 1–5 scale allows the level of technology use or financial access to be measured consistently. Productivity should preferably be measured using an objective indicator such as tons/ha or kg/ha. When different commodities are involved, the value of production per hectare can be used as an alternative measure (Wulandari et al., 2021).

➤ Data Analysis Techniques

The analysis begins with descriptive statistics to describe the characteristics of the respondents and the distribution of the variables. If the research instrument uses a questionnaire, the validity and reliability of the indicators are tested before constructing the indices. Hypothesis testing is conducted using multiple linear regression. The coefficient β_1 is used to test H1, while β_2 is used to test H2.

➤ Model Assumption Tests

Model diagnostics include an examination of residuals, multicollinearity, and heteroscedasticity. Multicollinearity can be assessed using the Variance Inflation Factor (VIF) and tolerance values, while heteroscedasticity can be examined using the Breusch–Pagan or White test. If heteroscedasticity is detected, robust standard errors can be employed.

III. RESULTS AND DISCUSSION

A total of 300 synthetic observations were used to demonstrate the analytical procedure. These data are not based on a field survey and do not represent the actual conditions of farmers in South Sumatra. Therefore, all numerical results presented in this section should be replaced with findings from primary data before the manuscript is used as an empirical research article.

Table 2 Descriptive Statistics of the Simulated Data

Variable	Mean	SD
Technology Adoption	3.25	0.75
Financial Inclusion Access	3.03	0.82
Age	46.76	9.86
Education	10.37	3.19
Land Area (ha)	0.82	0.48
Productivity (tons/ha)	4.49	0.81

Table 3 Multiple Linear Regression Results from the Simulated Data

Variable	Coefficient	p-value	Interpretation
Constant	1.188	0.000	Significant
Technology Adoption	0.619	0.000	Significant
Financial Inclusion Access	0.444	0.000	Significant
Age	-0.011	0.001	Significant
Education	0.038	0.000	Significant
Land Area	0.090	0.204	Not significant

$$R^2 = 0.532; \text{Adjusted } R^2 = 0.524; F = 65.68; p < 0.001.$$

➤ *Effect of Technology Adoption on Productivity*

The coefficient of technology adoption in the simulated data is 0.619, with a p-value of 0.000. The positive coefficient indicates that an increase in the technology adoption score is associated with higher productivity after controlling for age, education, and land area. Thus, H1 is supported by the results.

Substantively, this relationship can be explained by the ability of technology to facilitate access to information, support production and marketing decisions, and improve farm management efficiency. This finding is consistent with studies highlighting the potential of digital technology to improve agricultural performance, although its effectiveness depends on farmers' literacy and the availability of supporting infrastructure (Satria et al., 2025; ADB, 2024).

This interpretation should be limited to the statistical relationship observed in the simulated data. Technology does not automatically increase productivity across all commodities, as its impact may depend on technological suitability, users' capabilities, infrastructure quality, and the intensity of technology utilization. Therefore, field data should distinguish between merely owning or having access to technology and actually using it in production activities.

➤ *Effect of Financial Inclusion Access on Productivity*

The coefficient of financial inclusion access in the simulated data is 0.444, with a p-value of 0.000. The positive coefficient indicates that an increase in financial inclusion access is associated with higher productivity after controlling for the other variables in the model. Therefore, H2 is supported by the results.

From an economic perspective, access to financing can alleviate liquidity constraints, enabling farmers to purchase production inputs, undertake farm maintenance, utilize equipment, and make investments that support production. This finding is consistent with evidence suggesting that access to credit can improve agricultural productivity and farm efficiency in Indonesia (Heliyon, 2023; Wulandari et al., 2021).

Financial access should not be measured solely by account ownership or whether farmers have previously received credit. In agricultural activities, the quality of financial access also includes the ease of obtaining financing, the adequacy of the financing limit relative to farmers' needs, repayment schedules that are compatible with production cycles, affordability of financing costs, and farmers' ability to meet the required conditions. Such an approach provides a

more comprehensive representation of the quality of financial inclusion (Rufaidah et al., 2023).

➤ *Integrated Discussion*

The results indicate that both technology adoption and financial inclusion are positively associated with productivity. Technology can support access to information and improve efficiency, while financing provides farmers with the economic capacity to obtain production inputs and undertake productive investments. Literature concerning credit access and technology adoption also indicates that liquidity constraints may be one of the barriers to the adoption of productive technologies (Regassa et al., 2023; Balana et al., 2022).

For small-scale farmers, these findings suggest that productivity-enhancement policies need to address two dimensions simultaneously: the capacity to adopt technology and the ability to access appropriate financing. However, because the numerical results are based on simulated data, these findings cannot yet be interpreted as causal evidence for farmers in South Sumatra.

IV. FURTHER DISCUSSION

➤ *Policy Implications*

If the results of the field study confirm H1 and H2, productivity-enhancement programs could focus on strengthening farmers' capacity to adopt technology and expanding access to financing that is appropriate to the characteristics of agricultural enterprises (Pusvita et al, 2026). Technology programs should be accompanied by training and infrastructure support, while financing schemes should consider production cycles, repayment capacity, and farmers' investment needs (Satria et al., 2025; Rufaidah et al., 2023).

➤ *Implications for the Research Roadmap*

This study can serve as a baseline for subsequent research. After the direct effects of technology adoption and financial inclusion have been tested using field data, future studies could extend the analysis by examining the interaction between technology and financing, agricultural fintech (agri-fintech), and the role of Village-Owned Enterprises (BUMDes) as intermediaries connecting farmers with financial services, technology, and markets. The literature on agricultural fintech in Indonesia highlights these opportunities while also emphasizing the importance of access, financial literacy, governance, and the sustainability of financing models (Rufaidah et al., 2023; Karyani et al., 2024).

V. CONCLUSION

In accordance with Objectives 1 and 2, the findings indicate that agricultural technology adoption and access to financial inclusion are positively associated with the productivity of small-scale farming enterprises. First, technology adoption has a positive and statistically significant effect, thereby supporting H1. This relationship is consistent with the literature identifying technology as a means of improving efficiency, access to information, marketing, and decision-making, although its utilization is influenced by farmers' literacy and supporting infrastructure.

Second, access to financial inclusion has a positive and statistically significant effect, thereby supporting H2. Access to financing can help alleviate liquidity constraints and enable farmers to obtain production inputs and undertake productive investments, consistent with empirical evidence regarding the relationship between credit access and agricultural performance in Indonesia (Heliyon, 2023; Wulandari et al., 2021; Hermawati et al, 2025; Hermawati et al, 2025a; Hermawati et al, 2024; Hermawati et al, 2025b).

Nevertheless, because the analysis presented in this study is based on simulated data, the findings should be regarded as methodological demonstrations rather than empirical evidence of causal relationships among farmers in South Sumatra. Further validation using primary field data is therefore required before the findings can be generalized to the target population.

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