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ACCESS TO CREDIT AND FARM PRODUCTIVITY: HETEROGENEOUS EFFECTS ACROSS CREDIT SOURCES IN INDONESIA

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Abstract

Background: Seasonal horticultural farmers in Indonesia face high production risks, seasonal cash flow constraints, and limited access to productive financing despite the sector's importance for rural income and high-value agricultural supplies.
Purpose: This study examines the impact of credit access on the economic productivity of seasonal horticultural farmers, with particular emphasis on heterogeneous effects across credit sources.
Design/methodology/approach: This study distinguishes informal credit, formal nonbank credit, and formal bank credit using nationally representative microdata from the 2018 Horticulture Cost Structure Survey covering 41, 167 farmers. Inverse probability-weighted regression adjustment (IPWRA) is applied to estimate the average treatment effect on the treated, while propensity score matching (PSM) is used as a robustness check.
Findings/Results: Credit access significantly improves farm productivity, but the magnitude differs by source type. Formal bank credit generates the largest and most robust productivity gains, followed by formal non-bank credit, while informal credit shows no statistically robust effect after selection adjustment. However, only 5.2% of farmers have access to credit.
Conclusion: Expanding suitable formal credit can unlock substantial productivity in the horticulture sector.
Originality/value: This study provides source-specific evidence of the impact of agricultural credit using nationally representative horticultural data.

Keywords: credit access, farm productivity, horticulture, Indonesia, IPWRA

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INTRODUCTION

Seasonal horticultural crops play an important role in Indonesia's agricultural economy as a source of farm households' income and as suppliers of high-value commodities for domestic markets. The 2023 Agricultural Census recorded 17.6 million farmers engaged in seasonal horticultural crop production (BPS, 2024). Despite this importance, the subsector is exposed to weather variability, pest and disease outbreaks, input price fluctuations, and output market instability (Wulandari et al. 2021). These risks make timely financing crucial because horticultural production generally requires intensive working capital before revenue realization.

Therefore, access to farm credit is a key determinant of production performance. Credit enables farmers to purchase seeds, fertilizers, pesticides, labor, and other inputs at the right time, thereby supporting more efficient production and technology adoption (Haryanto et al. 2023; Khan and Kim, 2025; Reyes et al. 2023). Conversely, limited access to credit may reduce input use and productivity, particularly in capital-intensive horticulture.

However, financial inclusion among seasonal horticultural farmers is low. Only 5.2% of farmers reported accessing any form of credit, indicating a substantial gap between financing needs and actual credit participation. This suggests that many farmers may depend on internal funds, informal arrangements, or reduced input use, even when external financing could potentially improve their productivity. The low credit participation rate is particularly important because it implies that the issue is not only whether credit improves productivity, but also which financing channels can be made accessible to farmers who are currently excluded from productive agricultural financing.

Empirical studies show that credit access can improve agricultural outcomes by facilitating input use, technology adoption, farm efficiency, and farm income (Effendy et al. 2019; Haryanto et al. 2023; Iski et al. 2016; Wulandari et al. 2021). In the Indonesian context, Iski et al. (2016) found that formal credit positively affected production and income among Arabica coffee farmers, whereas access to credit was influenced by farmer characteristics and institutional interactions. Other studies indicate that credit access is shaped by demographic, socioeconomic, and institutional factors, such as age, education, asset ownership, farmer group membership, and extension services (Khan & Kim, 2025; Purwanti et al. 2023; Puryantoro et al. 2024). These findings imply that credit access is not randomly distributed, and selection mechanisms must be considered when estimating its productivity effect.

Despite the growing body of literature, two gaps remain. First, Indonesian studies on credit and productivity have mostly examined staple food crops or estate crops (Alwarritzi et al. 2015; Effendy et al. 2019; Haryanto et al. 2023; Tothmihaly & Ingram, 2019), while evidence on seasonal horticultural farmers is scarce. This gap is relevant because horticultural farming tends to be more capital-intensive and vulnerable to production and price risks.

Second, previous studies often treat credit as an aggregate category or focus on formal bank credits. In practice, farmers obtain financing from different sources, including informal credit from individuals, formal non-bank credit from cooperatives or other financial institutions, and formal bank credit from banks. These sources differ in terms of accessibility, collateral requirements, loan size, repayment flexibility, and monitoring mechanisms (Salmiah et al. 2019; Wulandari et al. 2021); thus, their productivity effects may differ.

In Indonesia, formal agricultural lending is influenced by institutional and regulatory requirements. Banks generally apply risk-based screening, documentation, and collateral requirements to safeguard their financial stability (Feryanto, 2017). While these requirements are important, they may exclude smallholder farmers who lack formal land documents or sufficient collateral (Burhansyah, 2021), creating a financing gap despite the potential productivity returns from credit-financed investment.

Against this background, this study examines the impact of credit access on the economic productivity of seasonal horticultural farmers in Indonesia, with explicit attention to heterogeneity across credit sources. This study addresses two questions: first, whether the determinants of credit access differ across informal credit, formal non-bank credit, and formal bank credit; and second, how access to these credit sources affects farmers' economic productivity. Based on rural finance theory and previous empirical evidence, this study proposes two testable hypotheses: H1, farmers' access

to credit differs systematically across credit sources because each source applies different screening, collateral, and institutional requirements; and H2, formal bank credit generates higher productivity gains than informal credit because it is more likely to provide larger, more structured, and investment-oriented financing. This study contributes to the literature by using nationally representative horticultural microdata, distinguishing credit sources, and estimating source-specific productivity effects using IPWRA, with PSM as a robustness check.

METHODS

This study uses microdata from the 2018 Horticulture Cost Structure Survey (SOUH) conducted by Statistics Indonesia (BPS). The survey provides nationally representative information on input use, production costs, farm characteristics, farmer demographics, credit access, and production outcomes of horticultural farmers in Indonesia. The sample consisted of 41,167 seasonal horticulture farmers, including 2,140 credit users and 39,027 noncredit users. Sampling weights were applied to maintain the national representativeness. Economic productivity, measured as the production value from the last harvest per hectare and expressed in logarithmic form, was used as the outcome variable because horticultural commodities are reported in various physical units. The treatment variable is access to credit, which is classified into informal credit, formal non-bank credit, and formal bank credit types. The control variables include farmer, household, farm, institutional, input-use, financial constraint, and regional characteristics, as summarized in Table 1.

Table 1. Description of research variables

Research Variables	Description	Mean	S.D.
Productivity	The production value from the last harvest is expressed in million rupiahs per hectare.	9.586	13.506
Log productivity	Productivity in logarithmic form	15.583	1.077
Gender	Binary variables were coded as 1 for women and 0 for men.	0.097	0.296
Age	Age of farmers in years.	46.828	11.720
Education Level	The categorical variable of the level of education completed consisted of no education or only completing primary school (reference category = 1), completing high school (junior or senior) (=2), and completing a university degree (= 3).	1.412	0.543
Position in the household	The binary variable is coded as 1 for household heads and 0 for non-heads.	0.932	0.251
Number of farmers in the household	The binary variable was coded as 1 for more than two farmers and 0 for two or fewer farmers.	0.042	0.200
Farm scale	The binary variable was coded as 1 for two hectares or more and 0 for less than two hectares of land.	0.001	0.026
Land ownership status	A binary variable was coded as 1 for landowners and 0 for non-landowners.	0.929	0.257
Partnership or contract farming	A binary variable was coded as 1 for having a contract and 0 otherwise.	0.009	0.094
Access to agricultural extension services	Binary variables were coded as 1 for access and 0 for no access.	0.143	0.350
Access to credit	Binary variables were coded as 1 for access and 0 for no access.	0.052	0.222
Financial difficulties	A binary variable was coded as 1 for farm funding difficulties and 0 otherwise.	0.580	0.494
Land ownership document	Possession of a document as proof of land ownership, consisting of not having a category (reference=1), having other than certificate documents category (2), and having a land certificate (3).	2.049	0.851
Certified seed use	A binary variable was coded as 1 for certified seed users and 0 for non-certified seed users.	0.522	0.500
Regional Dummy	The binary variable was coded as 1 for Java and 0 for non-Java.	0.174	0.379

Note: S.D. refers to standard deviation

The empirical analysis was conducted in five steps. First, the SOUH microdata were restricted to seasonal horticultural farmers and cleaned to ensure consistency in credit status, land area, production value, and farmer-level characteristics of the farmers. Second, descriptive statistics were used to describe the extent of credit participation, distribution of credit sources, and the main constraints reported by farmers who did not access bank credit. Third, probit models were estimated to identify the determinants of overall credit access and each credit source. Fourth, the IPWRA was applied to estimate the productivity effect of credit access after adjusting for observable differences between credit users and non-users. Fifth, PSM and post-estimation diagnostics were used to assess the robustness and validity of estimates.

The selection of control variables follows the rural finance and farm productivity literature, which emphasizes that credit access is influenced by household resources, farm assets, institutional linkages, and location. Gender, age, education, and household position are characteristics that may affect financial literacy, bargaining power, and lender screening. Farm scale, land ownership, and land documents represent productive assets and collateral capacity. Extension access, contract farming, farmer group membership, and government assistance capture institutional connections that may reduce information asymmetry between farmers and lenders. Certified seed use and regional location were included because input quality and market infrastructure may influence both credit access and productivity.

Credit adoption is modelled as a binary decision in which farmers choose whether to access credit based on observable characteristics. The latent propensity to access credit is specified as:

$$I_i^* = Z_i'\gamma + \mu_i,\ I_i = \begin{cases} 1\ if\ I_i^* > 0 \\ 0\ otherwise \end{cases} \quad (1)$$

where the latent variable represents the propensity to access credit, the error term is assumed to be normally distributed, and the observed credit status equals one when the latent propensity exceeds the normalized threshold. Following Marschak (1974), the probability of adopting credit is expressed as:

$$pr(I_i=1|\ Z_i) = pr\ (I^*_i>0) = pr\ (\mu_i>-Z_i'\ \gamma) = 1-F(-Z_i'\ \gamma) \quad (2)$$

where credit access is a binary outcome, the explanatory variables include observable farmer and farm characteristics, F denotes the standard normal cumulative distribution function, and the estimated coefficients are used to identify the determinants of credit access.

This probit specification is grounded in the random utility framework and the credit rationing theory. Farmers are assumed to seek credit when the expected benefit of external financing exceeds its perceived cost, and lenders allocate credit based on observable information and risk assessments. In Equations 1 and 2, the credit variable is estimated separately for overall, informal, formal non-bank, and formal bank credits. The vector of explanatory variables included gender, age, education, household labor, farm scale, land ownership, contract farming, certified seed use, extension access, government assistance, financial difficulty, land documentation, farmer group membership, and regional location of the farmer. Estimating separate models by credit source is important because informal lenders, cooperatives, and banks may use different screening mechanisms and serve farmers with different characteristics.

Accordingly, source-specific probit models are used to test H1 by assessing whether farmer, farm, institutional, and regional factors influence access differently across informal, formal non-bank, and formal bank credit. The subsequent IPWRA and PSM estimations are used to test H2 by comparing the productivity effects of each credit source relative to noncredit users.

Estimation of The Average Reatment Effect of Credit Access on Productivity Inverse-Probability-Weighted Regression Adjustment (IPWRA) Estimator

Seasonal horticulture encompasses diverse commodities with varying physical units, complicating the construction of a standardized yield measure. Therefore, this study used economic productivity, defined as production value per hectare, to allow comparisons across crops.

Because credit access is not randomly assigned and credit users differ from non-users, ordinary least squares (OLS) may produce biased estimates. IPWRA is used to estimate the average treatment effect on the treated (ATT) by combining a treatment and an outcome model to reduce selection bias from observable covariates (Cattaneo, 2010; Rosenbaum & Rubin, 1983).

IPWRA was selected because of its doubly robust property: the estimator remains consistent if either the treatment or outcome model is correctly specified (Wooldridge, 2007). It also retains the full sample through probability weighting, unlike matching approaches that may discard unmatched observations (Hirano et al. 2003; Rubin, 2003).

In this study, the treatment model estimates the probability that a farmer accesses credit, while the outcome model estimates the log of economic productivity, conditional on the treatment status and observed covariates. The same covariate set was used to maintain consistency between treatment assignment and outcome equations. The ATT is the main parameter of interest because the study focuses on productivity gains among farmers who accessed credit compared to those who did not. This parameter is more relevant for policy evaluation than a population-wide effect because existing credit programs first affect current and potential credit users who meet minimum eligibility conditions.

Estimation Procedure

The IPWRA estimation involves three steps. First, a probit model estimates the probability of receiving treatment based on the observed covariates, generating a propensity score for each farmer (Rosenbaum & Rubin, 1983).

Second, inverse probability weights were constructed. For ATE estimation, the weights are defined as:

$$w_i = \frac{I_i}{\hat{p}(X_i)} + \frac{1-I_i}{1-\hat{p}(X_i)} \qquad (3)$$

For ATT estimation, treated observations received unit weight, whereas control observations were weighted by the odds ratio based on the estimated propensity score. Separate outcome regressions are then estimated for the treatment and control groups:

$$E[Y_i|T_i = t, X_i] = m_t(X_i; \beta_t), \;\; t \in \{0,1\} \quad (4)$$

where the outcome variable is economic productivity in logarithmic form, and the conditional mean function adjusts for observable differences between treated and control farmers.

$$\hat{Y}_i(1) = m_1(X_i; \beta_1), \quad \hat{Y}_i(0) = m_0(X_i; \beta_0) \quad (5)$$

The ATT is computed as:

$$\widehat{ATT} = \frac{1}{N_1}\sum_{i;T_i=1}\left(\hat{Y}_i(1) - \hat{Y}_i(0)\right) \quad (6)$$

where ATT captures the average productivity difference between credit users and comparable non-users (Cattaneo, 2010).

The validity of the IPWRA relies on conditional independence and common support. Covariate balance was assessed using standardized differences and variance ratios (Rubin, 2001), while common support was assessed using propensity score distributions (Caliendo & Kopeinig, 2008). Observations with propensity scores exceeding the 95th percentile were trimmed to reduce instability from extreme weights; the results were not significantly affected (Crump et al. 2009).

Propensity Score Matching (PSM) As Robustness Check

PSM is used as a robustness check by matching credit users with non-users who have similar observable characteristics based on propensity scores estimated from a probit model (Rosenbaum & Rubin, 1983).

$$p(X_i)=pr(D_i=1|\, X_i) \quad (7)$$

where the propensity score represents the probability of accessing credit, conditional on observable characteristics. The matching procedures include nearest-neighbor matching with a caliper or radius threshold and kernel matching.

The effects are reported as the average treatment effect (ATE) and the average treatment effect on the treatment (ATT), which are defined as follows:

$$ATE=E(Y_{1i} \mid p(X_i))-E(Y_{0i} \mid p(X_i)) \quad (8)$$

$$ATT=E(Y_{1i} \mid D_i=1,p(X_i))-E(Y_{0i} \mid D_i=1,p(X_i)) \quad (9)$$

where the potential outcomes represent productivity under credit use and non-use. The consistency between the IPWRA and PSM results was used to assess the robustness of the estimated effects of credit.

For each credit source, credit users are compared with non-credit users rather than with users of other credit sources. This design allows the estimated effect

to capture the productivity difference associated with accessing a particular credit source relative to not accessing credit. The PSM results are not treated as the main estimates because matching may lose observations and is more sensitive to the choice of matching algorithm. However, similar signs and significance across IPWRA and PSM provide additional evidence that the estimated effects are not driven solely by one method.

RESULTS

The Role of Credit For Horticulture Farmers

Access to adequate and timely financing is a central issue in seasonal horticulture because production requires continuous investment in seeds, fertilizers, pesticides, and hired labor before revenue realization. Therefore, financing constraints may reduce input intensity, weaken farmers' ability to respond to shocks, and lower productivity.

Figure 1 shows that 41.45% of seasonal horticultural farmers experience farm funding difficulties. This proportion indicates that liquidity constraints are widespread and provides an empirical basis for examining whether credit access improves productivity. Figures 1 and 2 summarize the context of this analysis. Figure 1 shows the extent of farm funding difficulties, while Figure 2 shows that among credit users, 53.42% obtain loans from banks, 20.7% from formal nonbank institutions, and 25.88% from informal sources. These patterns support the need for a source-specific analysis. The descriptive results also show that the role of credit in horticulture differs from a simple question of access versus non-access to credit. Although bank credit accounts for the largest share of credit users, the overall credit-participation rate remains very low. This means that bank credit appears to be dominant among those who enter the credit market, but most horticultural farmers remain outside financing channels. This finding contrasts with the context in which informal credit dominates smallholder finance and suggests that the main policy issue in seasonal horticulture is not merely substituting informal finance with formal finance but expanding entry into productive credit markets while preserving the features that make formal credit useful for investment.

Compared with previous studies on food or estate crops, the financing problem in horticulture may be more binding because production cycles require intensive and timely input. Haryanto et al. (2023) show that credit sources matter for farm performance among secondary food crop farmers, while Wulandari et al. (2021) emphasize the role of access to finance in reducing horticultural production risk. The present findings complement these studies by showing that, even in a nationally representative horticultural sample, credit access remains scarce and is differentiated by the source.

Table 2 reports the main reasons for not accessing bank credit in our sample. The largest barriers are the lack of collateral (33.37%) and procedural complexity (32.15%), while high-interest rates are cited by only 6.20% of farmers. This pattern suggests that non-price barriers are more binding than borrowing costs, consistent with evidence that smallholder farmers often rely on more flexible financing when formal procedures are difficult to satisfy (Hafid et al. 2025).

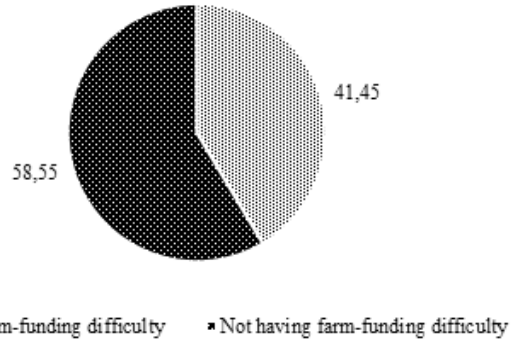

Figure 1. Distribution of farmers by farm-funding difficulty

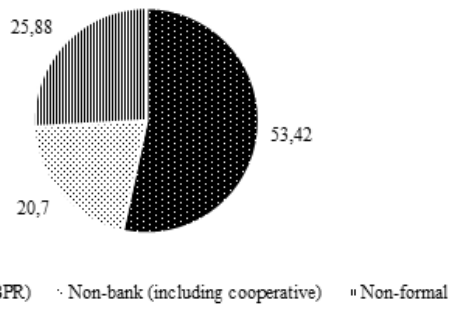

Figure 2. Distribution of farmers who access credit by credit source

Table 2. Main reasons for not accessing bank credit among farmers

Main reason	Percentage (%)
Do not know the procedure	8.90
Procedure complexity	32.15
Do not have collateral	33.37
High interest rate	6.20
Long distance to bank location	8.04
Other reasons	20.25

These findings indicate that the key challenges are not only credit affordability but also institutional accessibility issues. Collateral requirements, documentation, and complex procedures may limit access to productive bank credit, particularly for farmers without formal land certificates or sufficient administrative capacity to obtain them.

From a policy perspective, the descriptive evidence points to the importance of simplifying credit procedures, improving alternative collateral mechanisms, and strengthening linkages between extension services and financial institutions. These measures are relevant because the productivity gains documented later are strongest for formal credit, especially bank credit.

These barriers help explain why credit programs that focus only on lowering interest rates may have limited effects if farmers remain unable to meet documentation, collateral, or procedural requirements. This evidence is consistent with the broader rural credit literature, which argues that asymmetric information and collateral constraints may cause formal lenders to ration credit even when borrowers have potentially profitable investment opportunities (Besley, 1994; Stiglitz & Weiss, 1981). Thus, the descriptive evidence provides an important bridge between observed financing constraints and the econometric results on bank credit productivity effects.

Determinants of Credit Access and Implications For Treatment Assignment

Credit access is shaped by farmer, farm, and institutional characteristics, which may also influence productivity. Identifying these determinants is therefore necessary to understand financial inclusion patterns and to support the selection-on-observables strategy used in the impact analysis.

Table 3 shows that the determinants of credit access differ across the sources. Gender, age, education, household labor, land ownership, contract farming, certified seed use, extension services, government assistance, financial difficulties, land documents, farmer group membership, and regional location are associated with credit access in various ways.

Individual characteristics showed source-specific patterns in the present study. Female farmers are less likely to access overall and informal credit, while age increases access to formal non-bank and bank credits but reduces reliance on informal credits. Higher education is negatively associated with informal credit and positively associated with bank credit, indicating sorting across credit markets.

Farm- and asset-related variables are particularly relevant for obtaining formal credit. Land ownership and land documents are strongly associated with bank credit, reflecting the role of collateral and formal documentation in bank screening. Possession of a land certificate increases the likelihood of bank credit access, suggesting that formalized land rights matter more than ownership status does.

Institutional linkages are also important in this regard. Access to extension services consistently increases the probability of obtaining all types of credit, whereas farmer group membership is significant, mainly for bank credit. These findings suggest that institutional networks help reduce information barriers and facilitate interaction with formal lenders.

Financial difficulties increase the likelihood of seeking credit, especially informal credit, while farmers in Java are more likely to access bank credit. Overall, the results confirm that credit access is nonrandom and justify the use of IPWRA and PSM to estimate productivity effects after adjusting for observable differences in the groups. The source-specific determinants reported in Table 3 are consistent with, but also extend to, previous evidence. Similar to Iski et al. (2016), the results indicate that farmer characteristics and institutional interactions

influence access to formal agricultural credit in the study area. However, this study shows that these determinants do not operate uniformly across credit sources. For example, extension access increases the likelihood of accessing all forms of credit, but farmer group membership is significant mainly for bank credit. This suggests that banks may place greater value on formal organizational networks, whereas informal lenders may rely more on personal relationships and local knowledge.

Table 3. Determinants of credit access (probit model estimation results)

Farmer characteristics	Overall credit	Informal credit	Formal non-bank credit	Bank credit
Gender (female)	-0.210**	-0.235**	-0.050	-0.206
	(0.096)	(0.118)	(0.137)	(0.136)
Age	0.027*	-0.048**	0.055**	0.060***
	(0.016)	(0.019)	(0.026)	(0.020)
Age2/100	-0.000*	0.000**	-0.001**	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
High school education	0.039	-0.125*	0.106	0.069
	(0.057)	(0.072)	(0.093)	(0.069)
Diploma/University	0.227	-0.937***	0.059	0.431**
	(0.187)	(0.164)	(0.222)	(0.208)
Number of farmers in the same household (more than 2 farmers)	-0.468***	-0.342**	-0.127	-0.583***
	(0.117)	(0.135)	(0.159)	(0.153)
Position in household (head)	0.050	0.019	-0.008	0.074
	(0.110)	(0.167)	(0.155)	(0.145)
Farm scale (more than 2 hectares)	-0.101	-	-0.327	0.212
	(0.326)		(0.425)	(0.321)
Land ownership status (owned)	-0.430***	-0.123	-0.324**	-0.487***
	(0.076)	(0.111)	(0.134)	(0.088)
Contract farming (having contract)	-0.309**	-0.935***	-1.175***	-0.008
	(0.154)	(0.340)	(0.319)	(0.166)
Certified seed (user)	-0.162***	-0.118*	-0.250***	-0.084
	(0.054)	(0.068)	(0.075)	(0.067)
Access to extension services (having access)	0.441***	0.368***	0.332***	0.334***
	(0.069)	(0.093)	(0.108)	(0.082)
Government assistance (recipient)	-0.130**	-0.129	-0.039	-0.115
	(0.059)	(0.080)	(0.094)	(0.072)
Financial difficulties (experienced)	0.517***	0.795***	0.160	0.410***
	(0.062)	(0.088)	(0.099)	(0.075)
Other proof of land ownership document	0.094	-0.078	0.070	0.187***
	(0.060)	(0.091)	(0.096)	(0.072)
Having a land certificate	0.187***	-0.059	0.106	0.298***
	(0.059)	(0.085)	(0.089)	(0.072)
Farmer group membership (member)	0.055	-0.026	-0.016	0.098**
	(0.035)	(0.046)	(0.060)	(0.042)
Java	0.218***	-0.093	0.132	0.314***
	(0.052)	(0.080)	(0.081)	(0.062)
Constant	-2.005***	-1.044**	-3.104***	-3.187***
	(0.389)	(0.467)	(0.629)	(0.485)
Number of observations	41,167	41,167	41,167	41,167
Pseudo R-squared	0.066	0.094	0.032	0.069

Note: Farm scale was excluded from the informal credit model because all observations accessing informal credit operated on less than two hectares of land. The robust standard errors are given in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Survey weights were applied to the estimation

The role of land documentation also supports the argument that formal credit access is strongly linked to collateral and administrative eligibility. This finding is consistent with Burhansyah (2021) and Feryanto (2017), who emphasized the institutional constraints in agricultural financing. Simultaneously, the negative coefficient of land ownership status in several models indicates that ownership is insufficient. Formal proof of ownership is more relevant for bank screening than nominal ownership status. This distinction is important for managerial and policy interpretation because improving land certification, borrower records, and credit documentation may be more effective than assuming that all landowners are automatically eligible for bank loans.

The Java dummy further highlights regional inequality in accessing formal financing. Farmers in Java are more likely to access overall and bank credit, reflecting better financial infrastructure, denser markets, and lower transaction costs. This result contrasts with informal credit, where regional location is insignificant. This pattern implies that informal credit may fill local liquidity needs in areas where formal institutions are less accessible, but it may not provide the same capacity to finance productivity-enhancing investments. Overall, these source-specific differences support H1, indicating that farmers access different credit sources through distinct eligibility, screening, and institutional mechanisms.

Average Treatment Effects of Credit Access On Economic Productivity

This section estimates the productivity effects of credit access using ATT. Because productivity is expressed in logarithmic form, the estimated effects can be interpreted as proportional changes in economic productivity. IPWRA was used as the main estimator, with PSM as a robustness check.

Table 4 shows that credit access generally improves productivity, but the effect varies by source. Formal bank credit produces the largest and most consistent gains with an IPWRA estimate of 0.192. Using the standard interpretation for semi-log models, namely exp(coefficient) - 1 (Halvorsen & Palmquist, 1980), this corresponds to an approximate productivity gain of 21.2% for the treated farmers.

Formal non-bank credit also has a positive and statistically significant effect, with an IPWRA estimate of 0.128, indicating that cooperatives and other formal non-bank lenders support productive-input use. However, the effect is smaller than that of bank credit, suggesting differences in loan size, repayment terms, and institutional capacity.

Informal credit shows a positive but statistically insignificant IPWRA estimate, although PSM produces significant coefficients. This difference suggests that the apparent productivity gains from informal credit may be sensitive to model specifications and partly reflect the selection effects. Informal credit may be more useful for short-term liquidity management than financing productivity-enhancing investments.

For overall credit, the IPWRA estimate is 0.183 and is statistically significant, implying meaningful productivity gains among credit users. However, the disaggregated results show that this aggregate effect is mainly driven by formal credit, particularly bank credit. The results highlight that credit is not a homogeneous input variable. Formal bank credit appears to be better suited for financing input-intensive horticultural production because it may provide larger loan amounts, longer repayment periods, and stronger monitoring than informal credit sources.

Table 4. Average treatment effect of credit access on economic productivity

Type of credit (vs non-credit)	IPWRA	PSM (nearest-neighbor and caliper)
Informal credit	0.117	0.194***
Formal non-bank	0.128**	0.186***
Formal bank credit	0.192***	0.195***
Overall credit	0.183***	0.165***

Note: ATT was measured in log form. ***significant at 1 percent; ** at 5 percent; *at 10 percent. Survey weights were applied in the estimation.

These findings are consistent with rural finance theory, which emphasizes that information asymmetry, limited collateral, and borrower screening shape access to formal credit (Besley, 1994; Stiglitz and Weiss, 1981). In the Indonesian context, prudential requirements may protect financial stability but can also restrict access for smallholders who lack formal collateral to borrow.

Thus, the key policy challenge is to expand well-regulated formal agricultural finance without weakening the risk management. Improving documentation, alternative collateral mechanisms, and risk-based credit appraisal could help more horticultural farmers access the credit types that generate the strongest productivity gains.

The stronger effect of bank credit is consistent with Wulandari et al. (2021), who found that formal bank financing is associated with improved technical efficiency in Indonesian horticulture. This also supports Haryanto et al. (2023), who reported that formal credit generates larger performance gains than informal credit does among crop farmers. This study extends these findings by distinguishing formal nonbank credit from bank credit and estimating source-specific effects using IPWRA. The results indicate that not all formal finance has the same productivity effect: formal non-bank credit is beneficial, but bank credit remains the most powerful channel for productivity improvement. The insignificant IPWRA effect of informal credit contrasts with some studies that find positive associations between informal borrowing and farm outcomes. One possible explanation is that informal loans are often smaller, more flexible, and more accessible, but they may be used to address urgent liquidity needs rather than to finance investments in improved inputs or technology improvements. In contrast, bank credit may provide larger loans and more structured repayment periods, making it better suited for financing input-intensive horticultural production. This interpretation is consistent with the observed difference between IPWRA and PSM for informal credit: once observable selection is more fully adjusted, the informal credit effect statistically weakens.

The findings also complement those of Iski et al. (2016), who showed that formal credit improves production and income among Arabica coffee farmers. However, while that study focused on formal credit for a specific commodity and location, the present study examines a broader national sample of seasonal horticultural farmers and compares multiple sources of credit. This wider scope shows that the productivity contribution of credit depends not only on whether farmers borrow but also on the loan's institutional source. Therefore, agricultural credit policy should not treat credit as a homogeneous input.

Overall, the stability of the formal credit effects across the IPWRA and PSM supports the results' credibility. The findings suggest that the institutional source of credit shapes both access and productivity outcomes, with formal bank credit providing the strongest productivity-enhancing effect. These results support H2, showing that formal bank credit generates the strongest and most robust productivity gains, whereas informal credit loses its statistical significance under the doubly robust IPWRA specification.

The Validity of The IPWRA Estimation Results

The validity of the IPWRA estimates depends on conditional independence and common support. Figure 3 shows a substantial overlap in the propensity score distributions between the treatment and control groups, indicating that comparable observations exist across the relevant range of credit access probabilities.

Table 5 shows that covariate balance improved after the weights were applied. The weighted standardized differences were below the commonly used threshold of 0.25, and the variance ratios were close to one for observed covariates. These diagnostics indicate that the observable characteristics were sufficiently balanced after adjustment.

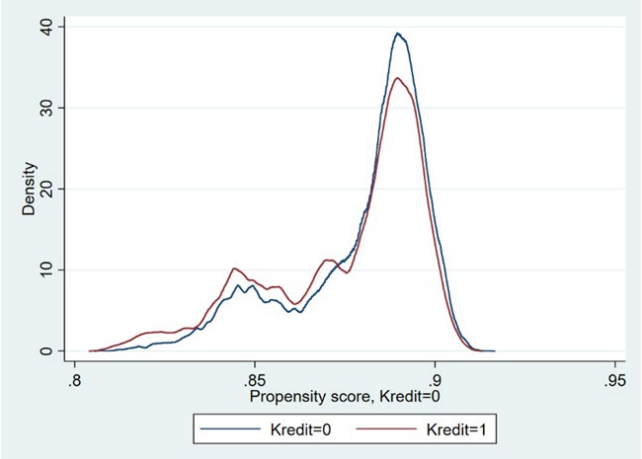

Figure 3. Density plot of propensity score by credit access (credit vs non-credit)

Table 5. Covariate balance summary (credit vs non-credit)

Covariate	Standardized Difference (raw)	Standardized Difference (weighted)	Variance Ratio (raw)	Variance Ratio (weighted)
Gender	-0.036	-0.033	0.882	0.892
Age	-0.116	-0.072	0.895	0.911
Education	0.045	0.018	1.015	1.006
Farmer Group	0.163	0.007	1.152	0.965
Land certificate	-0.059	-0.045	0.939	0.953
Other land document	0.044	0.009	1.018	1.004
Jawa	0.067	0.020	1.098	1.026
Number of Treated Observation	2,670	12,384	2,670	12,384
Number of Control Observation	26,702	16,988	26,702	16,988
Number of Observation	29,372	29,372	29,372	29,372

Together, the overlap and balance diagnostics support the validity of the IPWRA estimates and strengthen the interpretation of the productivity effects reported in Table 4. These diagnostic results are important because the credibility of the IPWRA depends on the existence of comparable treated and untreated observations. The low standardized differences after weighing indicate that the main observable differences between credit users and non-users were reduced after matching the groups. Although this does not eliminate the possibility of unobserved heterogeneity, it strengthens the confidence that the estimated effects are not merely driven by observable differences in farmer characteristics, farm assets, institutional access, or regional location.

Managerial Implications

These findings have several managerial implications for financial and agricultural institutions and public agencies involved in rural finance. For banks, the large productivity effect of formal bank credit indicates that horticultural farmers can be a productive lending segment when credit appraisal is designed based on the characteristics of seasonal agriculture. Bank managers should not evaluate horticultural farmers based only on conventional collateral and fixed-income criteria. Instead, loan assessment can incorporate farm history, crop cycles, input needs, farmer group participation, extension records, and transaction information. This would allow banks to maintain prudent lending while identifying farmers with viable production prospects.

For cooperatives and formal nonbank lenders, the positive effect of formal nonbank credit suggests an important complementary role for cooperatives. These institutions are closer to farmers and may better understand local production conditions; however, their productivity impact appears to be smaller than that of banks. Managerially, cooperatives and microfinance institutions can improve their role by linking loans more directly to productive input packages, farm planning, and repayment schedules that follow harvest cycles. Partnerships with input suppliers, farmer groups, and extension officers may help ensure that credit is used for productivity-enhancing purposes rather than only for short-term liquidity.

For government agencies and regulators, the evidence suggests that financial inclusion programs should explicitly address non-price barriers. The main obstacles to bank credit are collateral requirements and procedural complexity, not high interest rates. Therefore, managerial interventions should focus on simplifying loan procedures, improving farmer documentation, strengthening credit guarantee mechanisms, and supporting alternative credit assessment tools. Programs such as land certification, farmer registration, and extension services should be integrated with agricultural finance systems so that farmers' production records can support creditworthiness assessments.

For extension services and farmer groups, the results show that institutional linkages matter for credit access in the study area. Extension officers and farmer group leaders can act as intermediaries between the farmers and lenders. They can help farmers prepare production plans, document input use, understand loan requirements, and improve repayment discipline. This role is particularly important for smallholders who may have viable farm operations but limited experience with formal banking procedures.

For farmers, the findings imply that access to more productive credit depends not only on the demand for funds but also on their readiness to meet institutional requirements. Farmers need to improve their farm records, maintain land and business documentation, participate in farmer groups, and use credit for productive inputs. Better financial management at the farm level can increase the likelihood of accessing formal credit and strengthen the productivity benefits of borrowing.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study examines the role of credit access in shaping the economic productivity of seasonal horticultural farmers in Indonesia, with particular attention to differences across credit sources. Using nationally representative microdata and a selection-on-observables framework, this study applies IPWRA and PSM to estimate the productivity effects of credit access.

The findings show that credit access significantly improves productivity, but the magnitude differs by the source. Formal bank credit generates the largest and most robust productivity gains, followed by formal non-bank credit, while informal credit does not show a statistically robust effect after selection adjustment. Simultaneously, only 5.2% of farmers access credit, indicating a large gap between the potential benefits of credit and its actual availability. These findings support previous evidence on the positive role of formal credit in farm performance (Haryanto et al. 2023; Wulandari et al. 2021; Iski et al. 2016), while showing that credit-source heterogeneity matters for productivity outcomes in emerging market agricultural finance.

These results imply that expanding access to appropriate formal credit, particularly bank credit, could unlock substantial productivity gains in the horticulture subsector. However, this requires addressing structural barriers such as collateral requirements, procedural complexity, and limited institutional linkages.

Recommendations

The policy priority is to improve access to productive formal credit while preserving prudential stability. Credit programs should focus less on interest rate subsidies and more on reducing non-price barriers, including simplified procedures, clearer documentation requirements, and credit appraisal methods suited to seasonal horticulture. Risk-sharing mechanisms, such as credit guarantees, can support bank lending to horticultural farmers, especially when they are aligned with productivity-enhancing investments. Land certification programs should also be complemented by borrower information systems and alternative credit assessment tools to ensure that farmers without conventional collateral are not automatically excluded from the program. Institutional coordination is also important. Linking extension services, farmer groups, farmer registries, and financial institutions can reduce information asymmetry and help farmers navigate formal credit procedures to obtain loans in the future. Informal and non-bank lenders may still provide short-term liquidity; however, policies should create pathways for farmers to gradually access more productive formal finance.

This study has several limitations. First, the use of IPWRA and PSM addresses selection based on observable characteristics but cannot fully eliminate bias from unobserved factors such as managerial ability, risk preference, and social capital. Second, credit is measured as access rather than loan size, maturity, interest rate, repayment conditions, or borrowing purpose. Third, the analysis focuses on productivity and does not examine long-term outcomes, such as income stability, risk management, or sustainability. Future research could use panel data, instrumental variables, and loan-level information to examine these mechanisms in greater depth.

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