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Institutional Type, Food Security Index, and Rural Banks Performance: Evidence from Java and Sumatera

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Abstract

This study examines how institutional type, Islamic versus conventional rural banks, and regional food security jointly affect Indonesian rural bank performance, and whether institutional type moderates this relationship. Using an unbalanced panel of 1,130 rural banks, 1,008 conventional and 122 Islamic, in Java and Sumatra, 2019-2024, with 6,769-6,775 observations, financial data from OJK, Otoritas Jasa Keuangan, were merged with district-level Food Security Index, IKP, from Badan Pangan Nasional. Random Effects regression with clustered standard errors was estimated in Stata, guided by Breusch-Pagan LM and Hausman tests, with moderation visualized via margins. IKP is positively associated with non-performing loans, especially in Java, and negatively with return on assets. Islamic Rural Banks show a lower-risk, lower-return profile than conventional banks at average IKP and are less exposed to credit risk rising with IKP in Java, ending up safer across most Java districts. A similar, weaker pattern appears for profitability in Sumatra. Rural bank performance in Indonesia is jointly shaped by institutional type and regional food security, but channel and direction differ between Java and Sumatra, neither is a uniform determinant. The correlational design and Random Effects estimator, necessitated by time-invariant institutional status, limit causal interpretation and testing of loan-level mechanisms. This study documents a region-specific food-security-performance relationship in Islamic banking, informing OJK and rural bank strategy, and shows how interaction-term specification shapes institutional-type interpretation.

Keywords: Regional Food Security Index, Islamic Rural Banks, Rural Banks, Credit Risk, Profitability

INTRODUCTION

Conventional Rural Banks (Bank Perekonomian Rakyat/BPR) and Islamic Rural Banks (Bank Perekonomian Rakyat Syariah/BPRS) are central to Indonesia's financial inclusion system, serving groups such as smallholder farmers and micro-entrepreneurs which commercial banks often do not reach (Ismail et al., 2024; Putra et al., 2026). Conventional Rural Banks (RBs) and its Islamic counterpart, Islamic Rural Banks (IRBs), operate under different principles. RBs uses conventional interest-based intermediation, whereas IRBs follow profit-and-loss-sharing arrangements consistent with Islamic finance. Existing Indonesian studies of their efficiency and financial performance are largely descriptive and treat institutional type as an independent determinant (Endri et al., 2022; Wasiaturrahma et al., 2020). They therefore leave unresolved whether institutional type systematically shapes these institutions' responses to structural conditions in their operating environments.

Regional food security is one such condition. Agriculture remains structurally important across many Indonesian regional economies, and RBs/IRBs are well positioned to finance agriculture-related micro and small enterprises. A growing international literature links financial inclusion to household and national-level food security (Arshad, 2022; Baborska et al., 2020; Yasmin &

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Setiastuti, 2023). Access to savings, credit, and formal financial services helps households' smooth consumption and invest in productive assets (Ahmed & Ambinakudige, 2025; Astuti & Hartono, 2023; Boltana et al., 2023). Institutional-level studies rarely run the arrow backwards. We know little about whether food security conditions in a district feed into rural bank profitability and non-performing loans.

This gap matters because food security is both a household attribute and a regional structural condition. It shapes client creditworthiness, agricultural income volatility, and consequently loan portfolio quality (Bekoe et al., 2025; Bjornlund et al., 2022). In food-insecure regions, rural households and micro-enterprises may face more frequent income shocks and repayment difficulties, increase non-performing loans and reduce bank profitability. Multidimensional food security frameworks emphasize the connection between economic access and food outcomes (Ashraf & Javed, 2023; Clapp et al., 2022; Jackson & Holm, 2024; Montesclaros, 2021). However, to the best of the authors' knowledge, no prior study has explicitly examined the relationship between a formal food security index and bank-level outcomes in the Indonesian context.
yet Indonesian evidence linking a formal food security index to bank-level outcomes remains very scarce.

A second unsolved issue is whether this relationship differs between RBs and IRBs. Profit-and-loss-sharing structures, distinct governance mechanisms, and religiously grounded lending screens may cause Islamic financial institutions to take risks differently from conventional institutions (Abdeljawad et al., 2024; El Mokdad & Awdeh, 2025; Ghenimi et al., 2024). Evidence from the Middle East and North Africa suggests that Islamic banks may be more resilient to macroeconomic shocks (Ghenimi et al., 2024) and less exposed to credit risk (Abdeljawad et al., 2024). Indonesian evidence likewise identifies comparable but distinct stability dynamics across the two systems (Mawardi et al., 2024). If more IRBs clients rely on small agricultural businesses, changes in regional food security may affect IRBs performance more strongly than RBs performance, either negative or positive.

This study addresses both gaps by modeling rural bank performance, measured by Return on Assets (ROA), and credit risk, measured by the Non-Performing Loan ratio (NPL), as functions of institutional type (RBs and IRBs), the district/city-level Food Security Index (Indeks Ketahanan Pangan, IKP), and their interaction. The panel covers rural banks in Java and Sumatra, which together contain most of Indonesia's rice-harvested area and rural bank population (Badan Pusat Statistik, 2025). The study raises three main research questions. First, do ROA and NPL differ systematically between RBs and IRBs? Second, does district/city-level food security affect rural bank performance and risk? Third, does institutional type moderate this relationship? By answering these questions, the study complements household and macro-level research on financial inclusion and food security (Atta-Aidoo et al., 2024; Funke et al., 2024; Lin et al., 2022; Tan et al., 2024) and extends sharia–conventional comparisons by conditioning institutional effects on a region-specific structural variable (Sulaeman et al., 2025).

Literature Review and Hypotheses Development

Grand Theory: Risk-Sharing Paradigm and Multidimensional Conceptualization of Food Security

Islamic rural banking differs from conventional banking through profit-and-loss-sharing (PLS) contracts, such as mudharabah and musyarakah, which distribute risk between financiers and entrepreneurs rather than generating fixed returns (Sutrisno & Widarjono, 2022). This risk-sharing structure can promote more equitable financing and strengthen resilience by aligning the interests of banks and borrowers. Although PLS financing may promote equitable and resilient outcomes, it also increases information asymmetry and monitoring costs, affecting credit risk and

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profitability (Danlami et al., 2022). Evidence from Indonesian IRBs further shows that these effects depend on regional, institutional, regulatory, and market conditions (Widarjono et al., 2022). Accordingly, institutional type is expected to produce distinct risk–return profiles whose magnitude varies across operating environments.

This contextual dependence provides the link to the second theoretical pillar which is the multidimensional conceptualization of food security. This approach treats district-level food security as a multidimensional construct encompassing availability, access, utilization, and stability (Simelane & Worth, 2020). Because regional food security may diverge from household conditions, the Food Security Index (Indeks Ketahanan Pangan/IKP) captures the broader economic and agricultural environment rather than individual borrower creditworthiness. Together, the risk-sharing and food-security perspectives suggest that institutional effects on rural bank performance are conditioned by the regional context in which lending occurs.

Financial Inclusion and Food Security

Extensive evidence links financial inclusion to food security at household and national levels. Cross-country analysis shows a significant positive association in developing countries (Arshad, 2022), while Indonesian household evidence links access to savings and credit with greater dietary diversity (Astuti & Hartono, 2023). Baborska et al. (2020) similarly find that financial inclusion improves subjective food security in low- and middle-income countries, and Yasmin & Setiastuti (2023) that this relationship extends across developing and developed economies but varies with shocks such as COVID-19. More recent contributions refine the channel through which this relationship operates. Financial inclusion and bank stability jointly support agricultural productivity, suggesting that institutional stability matters alongside access (Bekoe et al., 2025).

Research from China likewise associates digital inclusive finance with multidimensional food security (Tan et al., 2024) and agricultural resilience (Lin et al., 2022), while Funke et al. (2024) and Atta-Aidoo et al. (2024) identify related channels through financial literacy and mobile money in rural Nigeria and post-conflict Burundi. Food security itself is now understood as multidimensional. Clapp et al. (2022) propose a six-dimensional framework that includes agency and sustainability. Jackson & Holm (2024)) and Ashraf & Javed (2023) similarly emphasize social, economic, and institutional dimensions. Bjornlund et al. (2022) and Montesclaros (2021) further argue that persistent food insecurity reflects structural and institutional weaknesses rather than temporary shocks. This study therefore treats food security as a structural regional condition rather than an outcome.

Credit and Agricultural Household Resilience

A related literature focuses specifically on credit access. Microfinance credit increases household calorie intake among rural Ethiopian borrowers (Boltana et al., 2023), while agricultural credit improves food security among marginal farmers in environmentally vulnerable areas of Bangladesh, conditional on repayment design (Ahmed & Ambinakudige, 2025). Sulaeman et al. (2025), using Indonesian provincial panel data, find that agricultural financing from both Islamic and conventional banks improves food security nationally. Their study provides the most direct precedent for linking Indonesia's dual banking system to food security outcomes, although its analysis is conducted at the aggregate provincial level rather than the individual bank level, a gap that this study addresses.

Rural Banks and Islamic Rural Banks Performance Determinants

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Institutional research consistently identifies internal financial ratios as determinants of rural bank profitability and risk. Capital adequacy, operational efficiency, liquidity, and asset size significantly affect profitability and loan quality in Indonesian rural banks, including IRBs (Baroroh, 2023; Endri et al., 2022; Ismail et al., 2024; Putra et al., 2026; Wasiaturrahma et al., 2020). These studies, however, largely treat performance as a function of internal bank characteristics, without incorporating a regional structural variable such as food security.

A separate strand of literature does incorporate regional or national macroeconomic conditions explicitly as determinants of RBs/IRBs performance, establishing that such regional-level effects are analytically salient. Earlier study by Fakhrunnas & Imron (2019), using panel data from 21 Islamic rural banks representing 21 Indonesian provinces (2013–2017), found that regional economic growth significantly affects profitability, indicating that Islamic rural bank performance depends partly on the economic growth trajectory of its home province. Further evidence remains mixed. Fakhrunnas (2020) identifies a long-run association of regional inflation and economic growth with IRBs financing, but only among larger institutions. By contrast, regional growth is insignificant for conventional BPR bankruptcy risk after controlling for internal ratios (Nisa et al., 2025), while national inflation increases BPRS non-performing financing in both the short and long run, with no significant long-run GDP effect (Inayati & Pertiwi, 2025). Thus, inflation appears more robust than growth, supporting the use of IKP as a potentially sharper indicator of local conditions affecting rural bank portfolios.

Hypotheses Development

The theoretical and empirical literature reviewed above supports two categories of directional prediction, namely the effects of institutional type and regional food security on rural bank performance and risk, together with their interaction. Hypotheses that we propose in this study are:

H_{1a}. Regional food security (IKP) is positively associated with rural bank profitability.
H_{1b}. Regional food security (IKP) is negatively associated with rural bank credit risk.
H_{2a}. Sharia status is negatively associated with rural bank credit risk.
H_{2b}. Sharia status is positively associated with rural bank profitability.
H_{3a}. The positive effect of IKP on profitability is stronger for IRBs than for RBs.
H_{3b}. The negative effect of IKP on credit risk is stronger for IRBs than for RBs.

METHOD

This study uses secondary panel data for BPR and BPRS operating in Java and Sumatra from 2019 to 2024. Together, these islands account for most of Indonesia's rice-harvested area and rural bank population (Badan Pusat Statistik, 2025). Bank-level data come from financial statements published by Otoritas Jasa Keuangan (OJK) in their website. Annual district/city-level Food Security Index (IKP) data come from Badan Pangan Nasional. The IKP's construction is a composite index spanning three pillars (availability, economic access, and utilization), aggregating district-level indicators, including per-capita consumption relative to production, poverty incidence, household food-expenditure share, infrastructure access, female educational attainment, health-service availability, child stunting prevalence, and life expectancy — combined using expert-judgement-derived weights and normalized to a 0–100 scale (Badan Pangan Nasional, 2023). This data is matched to each bank-year observation using the bank's district or city of domicile.

The empirical analysis uses a Random Effect panel model with an interaction term:

$$Y_{it} = \alpha + \beta_1 IKP_{kt} + \beta_2 SYA_i + \beta_3 (IKP_{kt} X\ SYA_i) + \mathrm{X}_{it}\theta + u_i + \varepsilon_{it}$$

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where Y_{it} is ROA for profitability or NPL for credit risk of bank i in year t, estimated as two separate models. Although there is terminology differs, NPL for conventional credit, NPF for Islamic financing, both ratios are constructed under a common OJK asset-quality classification architecture comprising five collectibility tiers, governed by POJK No. 33/POJK.03/2018 for BPR and POJK No. 29/POJK.03/2019 for BPRS respectively. IKP_{kt} is the Food Security Index of district/city k in year t. SYA_i is a time-invariant dummy equal to 1 for IRBs and 0 for RBs. X_{it} is a vector of bank-level controls which are log of total assets, CAR, BOPO, and cash ratio. Where u_i is a bank-specific random effect assumed to be uncorrelated with the regressors under the Random Effects estimation, and ε_{it} is the error term, with standard errors clustered at the bank level. β_3, the coefficient on the interaction term, is the primary test of H_3.

Because the Hausman test rejects the Random Effects assumption in all six models, we additionally estimate a Correlated Random Effects (Mundlak, 1978) specification as a robustness check. Each baseline model is augmented with bank-level means of the time-varying regressors (IKP, CAR, BOPO, CR, Log Assets, and IKP × SYA). A joint Wald test on these bank-mean terms serves as the Mundlak-form analogue of the Hausman test. Rejection indicates that the time-varying regressors are correlated with the unobserved bank effect. Results are reported in Table 6.

All six models use random-effects estimation because the time-invariant SYA indicator would be absorbed by bank fixed effects, preventing direct tests of H_{1a} and H_{1b}. The Breusch–Pagan Lagrange Multiplier test confirms bank-level heterogeneity and rejects pooled OLS. Separate ROA and NPL models are estimated for the combined Java–Sumatra sample and for each island, yielding six specifications. Given the limited number of IRBs in Sumatra, those estimates are interpreted cautiously as robustness evidence. All panel regressions were estimated using Stata version 15.0. Table 1 exhibit variable definition and data source.

Table 1. Variables and Data Sources

Variable	Definition	Symbol	Expected sign (ROA)	Expected sign (NPL)	Hypothesis	Source
Dependent variables						
Profitability: Return on Assets	Ratio of net profit to total assets, measuring rural bank profitability	ROA	n/a	n/a	—	OJK
Credit Risk: Non-Performing Loan	Ratio of non-performing loans to total financing, measuring rural bank credit risk	NPL	n/a	n/a	—	OJK
Main independent variable						

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Food Security Index	District/city-level food security index, constructed from indicators of food availability, access, and utilization	IKP	(+)	(−)	H_{1a}/H_{2b}	Badan Pangan Nasional
Moderating variable						
Sharia status	Dummy variable equal to 1 if the rural bank is BPRS (Islamic), 0 if BPR (conventional)	SYA	(+)	(−)	H1b / H1a	OJK
Interaction term						
Food Security × Sharia	Interaction between the district/city-level food security index and sharia status	IKP×SYA	(+)	(−)	H3a / H3b	Authors' calculation
Control variables (no formal hypothesis)						
Capital Adequacy Ratio	Ratio of capital to risk-weighted assets	CAR	(+)	(−)	—	OJK
Operational Efficiency	Ratio of operating expenses to operating income	BOPO	(−)	(+)	—	OJK
Cash Ratio	Ratio of liquid assets to short-term liabilities	CR	(+)	(−)	—	OJK
Bank Size	Natural logarithm of total assets	Log Asset	(+)	(−)	—	OJK

Note: Expected signs for IKP, SYA, and IKP×SYA correspond directly to H1a–H3b. Control variables carry conventional literature-based expectations but are not the subject of formal hypotheses in this study; their inclusion is to isolate the effect of the focal and moderating variables. All ratio variables are winsorized at the 1st–99th percentile prior to estimation. Source: OJK (Otoritas Jasa Keuangan) and Badan Pangan Nasional, 2019–2024.

RESULT AND DISCUSSIONS

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Result

Descriptive Statistic

The merged OJK–IKP dataset initially formed a balanced panel of 1,130 rural banks, 1,008 RB and 122 IRBs, observed annually from 2019 to 2024, yielding 6,780 bank-year observations. Sixteen erroneous or definitionally invalid bank-year cells were set to missing at the variable level rather than removed as complete rows, so that affected observations remain available in specifications where the required variables are non-missing, producing an unbalanced estimation sample of 6,769–6,775 observations depending on which variables are missing. Before estimation, ROA, NPL, KPMM, BOPO, and CR were winsorised at the 1st and 99th percentiles to limit outlier influence without further sample loss.

Table 2. Descriptive Statistic

	Mean	Standard Deviation	Min	Max	Count
ROA	2.093	4.144	-19.040	14.980	6779
NPL	8.718	8.357	0.000	43.450	6773
SYA(1 = IRBs, 0 = RBs)	0.108	0.310	0.000	1.000	6780
IKP	81.799	6.344	37.670	94.200	6780
CAR	46.013	34.858	2.830	199.280	6780
BOPO	90.107	26.831	28.090	240.040	6780
CR	28.676	29.785	3.720	218.950	6776
Log Asset	17.728	1.219	9.887	23.140	6780
Observations	6780				

Table 2 presents descriptive statistics for the cleaned and winsorised full sample. Mean ROA is 2.09%, with standard deviation of 4.14% and range between -19.04% and 14.98%. While for NPL, average NPL is 8.72% with range between 0% and 43.45%, underscoring substantial heterogeneity across Indonesia's rural banks. The regional food security index averages 81.80 with lowest value is 37.67 is Mentawai Island regency in 2021 while the highest is Salatiga Regency in 2023. This wide range indicates generally high food security alongside meaningful cross-district variation. Islamic rural banks account for 10.8% of bank-year observations, consistent with their comparatively limited presence in the national RBs/IRBs sector.

Addressing Assumption Violations

The moderating role of institutional type is captured through an interaction between IKP and SYA, with IKP mean-centered before constructing the interaction term. This specification ensures that the coefficient on SYA represents the performance differential between Islamic and conventional rural banks at the sample-mean level of IKP, which is representative of the districts in which the sampled banks operate (Dawson, 2014). Mean-centering also serves a diagnostic purpose. Given that the uncentered food security index has a sample mean far from zero, an interaction term based on the raw index would be highly collinear with the institutional-type indicator. Mean-centering mitigates this source of multicollinearity, as supported by the correlation matrix (Table 3), which reports a pairwise correlation of −0.231 between SYA and the interaction term. This result indicates that multicollinearity is unlikely to materially reduce the precision of the reported estimates. In addition, all models use bank-level clustered standard errors, providing heteroskedasticity and autocorrelation-consistent inference by allowing arbitrary within-bank

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error correlation across the six annual observations without imposing a specific autocorrelation structure (Flynn & Wang, 2025; Munyepwa et al., 2026).

Table 3. Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) SYA	1						
(2) IKP	-0.0853***	1					
(3) IKP x SYA	-0.231***	0.332***	1				
(4) CAR	-0.152***	0.0458***	0.0307*	1			
(5) BOPO	-0.00263	0.0443***	0.0344**	0.0510***	1		
(6) CR	0.0760***	-0.0312*	-0.0524***	0.500***	0.123***	1	
(7) Log Assets	0.0529***	0.0476***	0.0188	-0.432***	-0.249***	-0.333***	1

Coefficients above 0.80 in absolute value indicate potential multicollinearity concerns.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Food Security, Institutional Type, and Profitability

Table 4 reports Random Effects estimates for return on assets across the full sample and the two geographic subsamples. The regional IKP carries a small but statistically significant negative coefficient on ROA in the full sample and in Java, indicating that higher regional food security is associated with modestly lower profitability. In economic terms, a one-standard-deviation increase in IKP is associated with a decline in ROA of 0.14 percentage points in the full sample, equivalent to 6.7% change of the sample mean return on assets, and 0.11 percentage points in Java, equivalent to 5.4% change of the Java-specific mean. Institutional type or SYA in estimation is significantly associated with ROA in the full sample and, most prominently, in Sumatra. In the full sample, IRBs exhibit ROA 0.35 percentage points lower than RBs at mean regional food security, a differential equivalent to 16.6% of the full-sample mean return on assets. This differential is far more pronounced in Sumatra, where IRBs significantly underperform RBs by 1.04 percentage points, a magnitude equivalent to 51.9% of the Sumatra-specific mean ROA.

Table 4. Random Effect Panel Regression Result for Profitability
Dependent Variable: ROA

Variable	Full Sample	Jawa	Sumatera
IKP	-0.0222**	-0.0213**	-0.0202
	(0.0088)	*(0.0100)*	*(0.0127)*
SYA	-0.3479*	-0.0512	-1.0364***
	(0.1783)	*(0.2279)*	*(0.2323)*
IKP x SYA	0.0265	-0.0453	0.0776*
	(0.0308)	*(0.0418)*	*(0.0448)*
CAR	0.0115***	0.0116***	0.0143*
	(0.0029)	*(0.0032)*	*(0.0078)*
BOPO	-0.1061***	-0.1064***	-0.1081***

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Variable	Full Sample	Jawa	Sumatera
	(0.0044)	*(0.0049)*	*(0.0096)*
CR	0.0104***	0.0090***	0.0147*
	(0.0029)	*(0.0032)*	*(0.0077)*
Log Asset	0.1472**	0.1440*	0.1590
	(0.0734)	*(0.0821)*	*(0.1668)*
Constant	10.0761***	10.1032***	9.7326**
	(1.7831)	*(1.7980)*	*(4.2005)*
Observations	6775	5149	1626
Banks	1130	859	271
R-squared (overall)	0.562	0.567	0.554
Wald chi2	956.17	760.63	248.70

Standard errors in parentheses.
Standard errors clustered at bank level.
** p < 0.10, ** p < 0.05, *** p < 0.01*

The interaction is positive and significant at 10% in the Sumatra model. In practical terms, IRBs underperform RBs in profitability across nearly the entire observed range of regional food security in Sumatra, with the performance gap narrowing but not reversing except among a small number of districts with exceptionally high food security. The interaction term is not statistically significant in either the full sample or Java. Across all three specifications, the control variables behave consistently with theoretical expectations. CAR is positively and associated with ROA throughout, while BOPO carries a negative and highly significant coefficient in all three specifications. Liquidity (CR) and bank size (log assets) are also positively associated with ROA, significantly so in the full sample and Java.

Food Security, Institution Type, and Credit Risk

Table 5 reports Random Effects estimates for non-performing loans across the full sample and the two geographic subsamples. The regional IKP is positively and significantly associated with NPL across the full sample and in Java specifically, indicating that higher regional food security predicts elevated, rather than reduced, credit risk. The corresponding relationship in Sumatra is considerably weaker and only marginally significant. In economic terms, a one-standard-deviation increase in IKP is associated with a 1.16 percentage point increase in NPL in the full sample, equivalent to 13.3% of the sample mean NPL ratio, and a 1.57 percentage-point increase in Java, equivalent to 16.9% of the Java-specific mean. These magnitudes are considerably larger in relative terms than the corresponding food-security effects on profitability reported in Section, indicating that the counter-hypothesized relationship between regional food security and bank performance operates primarily through the credit-risk channel rather than through profitability directly.

Table 5. Random Effect Panel Regression Result for Credit Risk
Dependent Variable: NPL

Variable	Full Sample	Jawa	Sumatera
IKP	0.1827***	0.2932***	0.0361*

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Variable	Full Sample	Jawa	Sumatera
	(0.0210)	*(0.0340)*	*(0.0202)*
SYA	-1.0100**	-1.3074***	0.5894
	(0.4662)	*(0.5060)*	*(0.9514)*
IKP x SYA	-0.0686	-0.2225***	0.1088
	(0.0583)	*(0.0830)*	*(0.0826)*
CAR	0.0020	0.0040	-0.0272**
	(0.0072)	*(0.0085)*	*(0.0107)*
BOPO	0.1012***	0.1002***	0.1035***
	(0.0086)	*(0.0099)*	*(0.0152)*
CR	-0.0126*	-0.0141*	-0.0102
	(0.0072)	*(0.0086)*	*(0.0082)*
Log Assets	-0.7570***	-1.0163***	-0.2757
	(0.1525)	*(0.1882)*	*(0.2074)*
Constant	-1.5475	-5.5656	1.0054
	(3.2689)	*(4.3465)*	*(4.0038)*
Observations	6769	5143	1626
Banks	1130	859	271
R-squared (overall)	0.166	0.163	0.211
Wald chi2	277.07	242.72	81.26

Standard errors in parentheses.
Standard errors clustered at bank level.
** p < 0.10, ** p < 0.05, *** p < 0.01*

SYA is significantly associated with NPL in both the full sample and Java. At the average level of regional food security, IRBs have lower credit risk than RBs. Their NPL ratio is 1.01 percentage points lower in the full sample and 1.31 percentage points lower in Java, equivalent to 11.6% and 14.1% of the respective mean NPL ratios. No significant difference is found in Sumatra. Combined with the lower profitability reported in Section 4.1.3, these findings suggest that IRBs generally exhibit a lower risk, lower-return profile at typical levels of regional food security. IKP x SYA is negative and highly significant in the Java model, indicating that the sensitivity of credit risk to regional food security conditions is substantially attenuated for IRBs relative to RBs (see Robustness Check below, where this result attenuates under an alternative specification). This moderation is not statistically significant in either the full sample or Sumatra. Post-estimation margins reveal that the predicted NPL lines for RBs and IRBs in Java intersects are at an IKP value of approximately 76.6, below the Java regional mean of 82.5. Figure 1 shows this condition. Below IKP value 76.6, IRBs are predicted to carry higher credit risk than BPR, above it, encompassing the majority of Java's districts given the regional mean, the relationship reverses and BPRS exhibit lower predicted credit risk, with confidence intervals for the two institutional types remaining clearly separated in the vicinity of the sample mean. Among the controls, BOPO is again the

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strongest predictor, positively and significantly associated with NPL across all three specifications. Log Assets is negatively associated with NPL in the full sample and Java but not in Sumatra, consistent with economies of scale in credit risk management. CR is negatively associated with NPL in the full sample and Java ($p < 0.10$), while CAR shows no significant effect except in Sumatra, where it is unexpectedly negative.

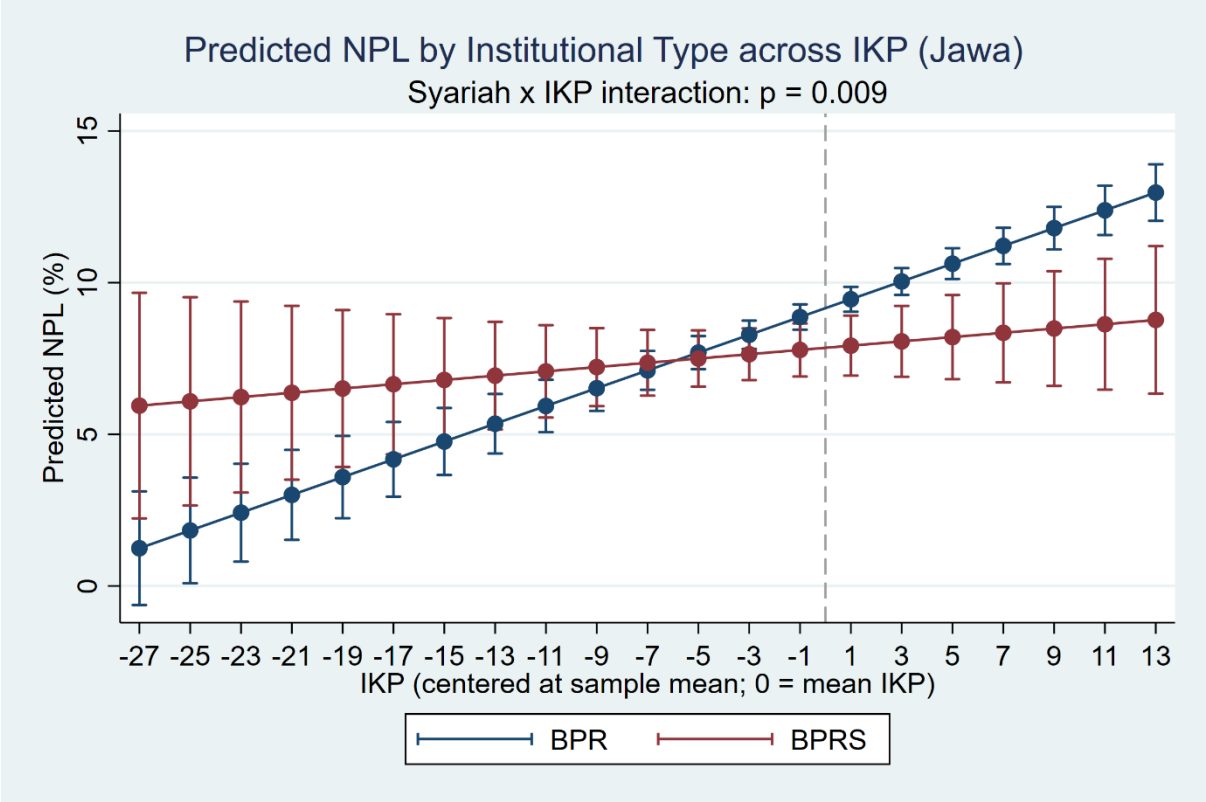

Figure 1. Predicted Non-Performing Loans by Institutional Type across the Food Security Index (Java)

Robustness Check

Table 6. Correlated Random Effects (Mundlak) Robustness Check

Variable	ROA Full	ROA Jawa	ROA Sumatera	NPL Full	NPL Jawa	NPL Sumatera
IKP	−0.0279***	−0.0434**	−0.0186*	0.2120***	0.4378***	0.0215
	(0.0096)	(0.0168)	(0.0102)	(0.0301)	(0.0480)	(0.0263)
SYA	−0.3010	0.0657	−1.3000***	−0.5234	−0.9343*	0.9054
	(0.2188)	(0.2702)	(0.2872)	(0.4878)	(0.5215)	(1.1354)
IKP × SYA	−0.0142	−0.1273	0.0529	−0.0325	−0.2876*	0.1828*
	(0.0506)	(0.0955)	(0.0514)	(0.0868)	(0.1533)	(0.0998)
CAR	0.0131***	0.0116**	0.0222**	−0.0094	−0.0072	−0.0310**
	(0.0043)	(0.0047)	(0.0110)	(0.0087)	(0.0101)	(0.0130)
BOPO	−0.0967***	−0.0955***	−0.1023***	0.0994***	0.0977***	0.0985***
	(0.0049)	(0.0055)	(0.0103)	(0.0091)	(0.0105)	(0.0167)
CR	0.0132***	0.0137***	0.0079	−0.0089	−0.0089	−0.0012
	(0.0034)	(0.0038)	(0.0075)	(0.0082)	(0.0098)	(0.0084)
Log Asset	0.3512**	0.2355	0.7686**	−0.3904	−0.6095	−0.2927
	(0.1645)	(0.1891)	(0.3233)	(0.3325)	(0.4454)	(0.3224)
Mean IKP	0.0089	0.0324	−0.0208	−0.1004**	−0.3555***	0.0452

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	(0.0173)	(0.0200)	(0.0317)	(0.0401)	(0.0614)	(0.0403)
Mean CAR	−0.0085*	−0.0035	−0.0278**	0.0437***	0.0391**	0.0259
	(0.0051)	(0.0056)	(0.0107)	(0.0134)	(0.0163)	(0.0183)
Mean BOPO	−0.0404***	−0.0422***	−0.0335***	0.0242*	0.0199	0.0385
	(0.0061)	(0.0070)	(0.0103)	(0.0147)	(0.0162)	(0.0290)
Mean CR	−0.0065	−0.0117**	0.0225***	−0.0309**	−0.0356**	−0.0612**
	(0.0043)	(0.0049)	(0.0076)	(0.0136)	(0.0157)	(0.0249)
Mean Log Asset	−0.5188***	−0.3556*	−1.0616***	−0.2952	−0.4638	0.0940
	(0.1660)	(0.1861)	(0.3152)	(0.3804)	(0.5065)	(0.4650)
Mean IKP × SYA	0.0869	0.1191	0.1038*	−0.1206	0.1493	−0.3322**
	(0.0627)	(0.1165)	(0.0540)	(0.1186)	(0.1955)	(0.1535)
Constant	18.6131***	17.1490***	22.1546***	0.2045	10.8018*	−5.5409
	(2.0516)	(1.7677)	(4.8630)	(4.5539)	(5.9351)	(8.0496)
Observations	6,775	5,149	1,626	6,769	5,143	1,626
Banks	1,130	859	271	1,130	859	271
R-squared (overall)	0.581	0.590	0.588	0.178	0.184	0.235
Wald $\chi^2(13)$	1460.11	1213.27	570.85	319.65	305.76	143.63
Joint Wald test, $\chi^2(6)$	61.97	55.69	30.60	29.74	48.10	16.67
Joint Wald test p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0106

Standard errors clustered at bank level in parentheses. Each model augments the baseline Random Effects specification with bank-level means of the time-varying regressors (IKP, CAR, BOPO, CR, Log Assets, and IKP × SYA), following Mundlak (1978). The joint Wald test on the six bank-mean terms is the Mundlak-form analogue of the Hausman test.
* p < 0.10, ** p < 0.05, *** p < 0.01

Table 6 reports the Correlated Random Effects robustness check. The joint Wald test on the six bank-mean terms is significant in all six models ($\chi^2(6)$ ranging from 16.67 to 61.97, $p < 0.05$ in all models and $p < 0.0001$ in five of six), confirming the Hausman rejection. The time-varying regressors are indeed correlated with the unobserved bank effect. The main effect of IKP on both ROA and NPL remains stable in sign and, if anything, strengthens under this specification, for example the IKP coefficient in the Java NPL model rises from 0.2932 in the baseline Random Effects model to 0.4378 here. The main effect of institutional type (SYA) and the IKP × SYA interaction terms, however, attenuate. Most notably, the interaction term in the Java NPL model, the basis for our central crossover-point finding, falls from $p = 0.007$ under the baseline Random Effects specification (coefficient −0.2225) to $p = 0.061$ here (coefficient −0.2876). The interaction term supporting H_{3a} in the Sumatra ROA model, only marginally significant at baseline ($p = 0.083$), loses significance entirely ($p = 0.303$). The main SYA effects in the full-sample ROA and NPL models likewise lose significance ($p = 0.169$ and $p = 0.283$, respectively), while remaining strongly significant in the Sumatra ROA model (coefficient −1.3000, $p < 0.001$ in both specifications).

To consolidate the findings reported across Tables 4 through 6, Table 7 summarizes the decision for each hypothesis, incorporating both the baseline Random Effects results and their sensitivity to the Correlated Random Effects robustness check.

Table 7. Summary of Hypothesis Testing Result

Hypothesis	Statement	Decision
H1a	IKP positively associated with profitability	Not Supported (negative, significant in Full and Java)

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H1b	IKP negatively associated with credit risk	Not Supported (positive, significant in Full and Java — the study's central counter-hypothesized finding)
H2a	Sharia status negatively associated with credit risk	Partially Supported (significant in Full and Java under baseline RE; attenuates to non-significance in Full sample and marginal significance in Java under CRE robustness check)
H2b	Sharia status positively associated with profitability	Not Supported (negative; significant and opposite-signed in Sumatra)
H3a	IKP's positive effect on profitability stronger for IRBs	Not Supported (marginal at baseline in Sumatra only, p = 0.083; not robust to CRE, p = 0.302)
H3b	IKP's negative effect on credit risk stronger for IRBs	Partially Supported (significant in Java under baseline RE, p = 0.007; weakens to marginal significance under CRE, p = 0.061)

Discussion

The positive association between regional food security and credit risk differs from the conventional expectation that improved food security should reduce borrower default risk. A plausible explanation is that rural banks lend more extensively to food-secure districts because these areas appear less risky. Over time, however, greater lending concentration may increase portfolio-level risk, particularly when banks' monitoring capacity does not expand with loan volume. This interpretation is consistent with evidence that rapid credit expansion into apparently favorable market segments can lead to a delayed deterioration in loan quality in developing economies (Akhter, 2023). The stronger relationship observed in Java may reflect its more developed rural banking sector and deeper integration with agricultural finance. Nevertheless, the present panel design cannot directly identify these loan-level mechanisms. Future research could therefore use dynamic models that jointly examine credit risk, provisioning, and capital to clarify the timing and direction of these effects (Sutanto et al., 2024).

IRBs show lower profitability and lower credit risk than RBs at typical levels of regional food security. This pattern suggests a clear risk–return trade-off. Profit-and-loss-sharing arrangements require closer monitoring and may encourage more careful borrower selection, which can reduce credit risk but also increase operating costs and lower returns (Zamore et al., 2023). Although IRBs have lower average capital adequacy ratios, they do not show higher credit risk, suggesting that their lending may be more conservative or selective. However, their lower profitability, especially in Sumatra, remains important for shareholders. This regional difference is consistent with evidence that local conditions can shape bank risk and performance even under the same national regulatory system (Barra & Ruggiero, 2022).

The confinement of significant moderation to the Java credit-risk channel, together with the region-specific pattern of institutional effects more broadly, reinforces the view that rural bank performance in Indonesia is fundamentally conditioned by regional economic and financial-market structure rather than operating uniformly at the national level. Notably, this moderation effect attenuates to marginal significance under the robustness check reported in the Result section, so the crossover point discussed below should be interpreted as suggestive rather than conclusive evidence for institutional-type differentiation in Java's credit-risk exposure. This regional heterogeneity in the determinants of bank credit risk is not unique to the Indonesian

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rural banking context. Comparable evidence from Bangladesh's commercial banking sector indicates that macroeconomic and structural conditions can shift the sign and magnitude of standard credit-risk determinants across different institutional and regulatory environments within the same country (Akhter, 2023), lending external plausibility to the geographically divergent findings reported here. The estimated crossover point in the Java non-performing loan relationship carries direct relevance for regional financial policy and institutional strategy. Because this threshold lies below the regional mean level of food security, strategies favoring the expansion of IRBs are likely to yield a comparative credit-risk advantage across many Java's districts, while RBs may retain an advantage only in the minority of districts with comparatively lower food security. In Sumatra, by contrast, the absence of a corresponding crossover within the observed data range points to a more uniform conventional-bank advantage in profitability across the region, suggesting that institutional and regulatory strategy should be differentiated between the two islands rather than treated as a single national policy question.

The results show that institutional type affects rural bank performance differently across regions. In Sumatra, the significant effects appear mainly in profitability, whereas in Java they appear mainly in credit risk. This suggests that the two regions do not follow the same pattern. One possible explanation is the difference in food security variation. Sumatra has a wider range of food security levels, making changes in profitability easier to identify. In contrast, Java has generally high and less varied food security, but more observations near the level where the credit-risk relationship between IRBs and RBs changes. These findings indicate that a single national model may not fully explain rural bank performance across Indonesia. This interpretation is consistent with evidence that local market conditions can produce different bank performance outcomes across regions under the same regulatory system (Barra & Ruggiero, 2022). Future research should examine whether these differences arise from loan portfolio composition, funding structure, or supervisory practices.

CONCLUSION

This study set out to examine how regional food security, institutional type, and their interaction jointly shape the financial performance of rural banks in Indonesia, using an unbalanced panel of 1,130 banks across Java and Sumatra between 2019 and 2024. Three principal conclusions can be drawn, each of which directly addresses one of the study's original objectives while contributing findings that extend beyond what existing literature on Indonesian rural banking had previously established.

With respect to the relationship between regional food security and bank performance, the study finds that higher regional food security is associated with elevated, rather than reduced, credit risk, an effect that is economically substantial, statistically robust, and concentrated specifically in Java. This finding runs contrary to the hypothesised direction derived from conventional financial inclusion theory and represents a genuine contribution to the literature rather than a null or ambiguous result. It suggests that food-secure districts may attract a concentration of rural bank lending that elevates portfolio-level risk over time, even where individual loan-level risk assessments remain favourable at the point of origination. This reframes regional food security not as a straightforward protective factor for lenders, but as a marker of a lending environment whose risk implications depend on how credit is allocated within it.

With respect to institutional type, the study finds that IRBs exhibit a consistent and economically meaningful lower risk, lower return profile relative to RBs when evaluated at typical levels of IKP, combining lower profitability with lower credit risk. This finding required a specific methodological correction, namely mean-centering the food security index before constructing its interaction with institutional type. In terms of the moderating role of institutional type, the study

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finds suggestive evidence that this moderation operates within the Java credit-risk channel, where the sensitivity of NPL to regional food security appears attenuated for IRBs relative to conventional rural banks at the baseline Random Effects estimates, this result weakens to marginal significance under a Correlated Random Effects robustness check (Table 6) and should accordingly be treated as a directional finding meriting further investigation with richer panel methods (e.g., Hausman-Taylor or dynamic specifications) rather than a firmly established moderation effect. This indicates that the comparative credit-risk advantage of IRBs is neither universal across Indonesia nor confined to a negligible minority of districts, but instead applies to the majority of districts in Java specifically, a geographically bounded finding that underscores the broader conclusion running through this study which are rural bank performance in Indonesia cannot be adequately understood through national level generalisations about either institutional type or food security, but must be interpreted through region-specific lenses that account for the differing structural and financial-market conditions of Java and Sumatra.

Taken together, these findings contribute to a more nuanced understanding of Indonesian rural banking than either a purely institutional or a purely regional-economic framing would provide in isolation, and they carry direct relevance for financial regulators and rural bank management in designing institutional strategy and supervisory priorities that are differentiated by region rather than applied uniformly at the national level.

Research Limitations

Several limitations should be considered when interpreting and applying these findings. First, this panel study identifies associations rather than causal effects. The Random Effects estimator was required because institutional status does not change during the sample period. However, the Hausman test rejects the assumption that the time-varying regressors are unrelated to unobserved bank characteristics in all six models. This correlation is confirmed by a Mundlak-form joint Wald test on bank-level means of the time-varying regressors in Table 6, significant across all six models ($\chi^2(6) = 16.67–61.97$, $p \leq 0.0106$), indicating that some correlation between these variables and omitted bank-specific factors indeed remains. This methodological trade-off arises when estimating a time-invariant institutional effect within a single-equation panel model. Therefore, the reported coefficients should be interpreted as robust statistical associations rather than clear causal estimates (Baltagi & Liu, 2026).

Second, the mechanism proposed to explain the counter-hypothesised food-security-credit-risk relationship, specifically the concentration of rural bank lending in seemingly favourable districts, cannot be directly tested with the bank-year panel data used in this study. Confirming or refuting this mechanism would require loan-level or sector-disaggregated lending data that identify the composition of each bank's credit portfolio by borrower sector and geography, data that lie beyond the scope of the aggregated financial statement variables available from OJK publication reports.

Third, the geographic subsamples analysed here are unequal in size and composition. The Sumatra subsample comprises 271 banks against 859 in Java, and the number of IRBs within each regional subsample is considerably smaller still, which may limit statistical power to detect institutional-type effects and moderation patterns in Sumatra relative to Java, and may partly explain why several Sumatra-specific coefficients achieve only marginal significance rather than the stronger significance levels observed in the corresponding Java and full-sample specifications. Fourth, the IKP in this study is measured annually at the district level and captures regional food security conditions rather than borrower-level or loan-level food security status. This distinction is conceptually appropriate for the study's aim of examining regional economic context as a determinant of bank performance, but it means the index cannot capture within-district

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heterogeneity in borrower food security, nor can it be interpreted as a direct proxy for individual borrower creditworthiness.

Suggestions and Directions for Future Research

Building on both the findings and the limitations identified above, several directions for future research would meaningfully extend this study. Future research will benefit from access to loan-level or sector-disaggregated lending data, which would permit a direct test of the portfolio-concentration mechanism proposed to explain the elevated credit risk observed in food-secure districts, distinguishing empirically between lending volume effects, sectoral concentration effects, and borrower-level risk effects that the current bank-year panel cannot disentangle. Relatedly, given that the estimated crossover point in the Java non-performing loan relationship implies a non-linear or threshold-dependent relationship between food security and the institutional-type effect, future work could apply threshold regression or spline-based panel methods to formally test the statistical significance of this crossover point, rather than relying on linear interaction terms and post-estimation margins as employed in the present study.

Given the smaller and less precisely estimated Sumatra-specific coefficients noted as a limitation above, future research would benefit from an expanded sample that includes rural banks operating in other major Indonesian islands, such as Kalimantan and Sulawesi, both to increase statistical power for detecting regional heterogeneity and to test whether the Java-Sumatra divergence documented here generalises to a broader set of regional financial-market conditions across the archipelago. In parallel, we implement a Correlated Random Effects (Mundlak) specification as a robustness check in Table 6. A natural further extension is a Hausman-Taylor estimator or dynamic panel methods that could more efficiently separate exogenous from endogenous time-varying regressors while retaining identification of the time-invariant institutional effect would provide a useful robustness check against the Hausman rejection documented in this study, allowing the model to remain consistent with Fixed Effects assumptions for the time-varying coefficients while retaining the ability to identify the time-invariant institutional-type effect central to this study's contribution.

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Author Contributions

CN led the research idea, conceptualized the paper, methodology, data collection, and initial draft. TI collected and cleaned the data. DK designed the interpretation for data result and decided the methodology research. AS, SCY, and SNA created the literature review and analyzed the literature result. All authors have read the article draft and agree with the idea.

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