Impulse Response Function (IRF) Analysis of Non-Performing Financing (NPF) to Internal and External Economic Shocks: Evidence from an Islamic Bank in Indonesia

Mohamad Andri Ibrahim[1,2] , Melani Rahmawati[2], Nisful Laila[1], Siti Zulaikha[1], Aam Slamet Rusydiana[3]

[1]Department of Islamic Economics, Faculty of Business and Economics, Universitas Airlangga, Surabaya, Indonesia

[2]Department of Islamic Banking, Faculty of Sharia, Universitas Islam Bandung, Bandung, Indonesia

[3]Department of Islamic Economics and Finance, Faculty of Political Science, Sakarya University, Sakarya, Turkey

ABSTRACT

The development of the Islamic banking industry in Indonesia has shown significant progress, yet it continues to face challenges, particularly with respect to Non-Performing Financing (NPF). At Bank Bukopin Syariah, NPF exhibited substantial volatility between 2016 and 2023, rising notably in 2018 and peaking at 4.95% in 2020, close to Bank Indonesia's threshold of 5%. This study analyzes the influence of the Financing to Deposit Ratio (FDR), Cost to Income Ratio (CIR), Inflation, and BI Rate on NPF over the 2016–2023 period. Employing a quantitative approach with time-series data and the VAR/VECM model, the analysis reveals that in the short term (lag 1 and 2), none of the variables significantly impact NPF. However, in the long term, FDR and CIR have a positive and significant effect on NPF, indicating that increased financing activity and operational inefficiency elevate the risk of default. Similarly, Inflation and BI Rate also positively and significantly influence NPF, reflecting the external macroeconomic pressures contributing to deteriorating financing performance. The Impulse Response Function (IRF) analysis shows fluctuating responses of NPF to shocks from these variables, suggesting that NPF is dynamically influenced by both internal and external factors. Notably, NPF itself is the most dominant variable affecting its trajectory. While self-dependence is most evident in the short term, the roles of BI Rate, CIR, and Inflation grow stronger in the long run. These findings underscore the need for Islamic banks to implement adaptive and forward-looking risk management strategies to mitigate long-term credit risks.

Keywords: Non-Performing Financing (NPF), Impulse Response Function (IRF), VAR/VECM, Islamic Banking, Economic Shocks

INTRODUCTION

The Islamic banking sector in Indonesia has experienced notable growth in recent years, supported by stable macroeconomic and increased public awareness of shariah-compliant financial systems. This progress reflects the rising demand for ethical and religiously aligned financial products [1]. Islamic banks, by design, prohibit the use of interest (*Riba*), speculative transactions (*Gharar*), and investments in non-permissible sectors, aligning their operations with the moral and legal foundations of Islamic finance [2].

Despite this expansion, Islamic banks continue to face significant challenges, particularly in managing credit risk. One of the most critical indicators in this regard is Non-Performing Financing (NPF), which measures the proportion of financing that has become problematic. According to the Financial Services Authority (OJK) in Indonesia, the NPF in Islamic Commercial Banks and Islamic Business units in Indonesia reached IDR 11.751 trillion by early 2024, reflecting a consistent year-on-year increase. Elevated NPF levels can threaten bank profitability, reduce investor confidence, and ultimately impact financial stability [3].

A striking example is Bank Bukopin Syariah, which has shown a fluctuating and high NPF trend between 2016 and 2023, peaking at 4,95% in 2020, nearing Bank Indonesia's regulatory threshold of 5%. This situation suggests a potential inefficiency in credit risk management and underscores the need to understand the underlying factors. Internally, variables such as the Cost Income Ratio (CIR) and the Financing to Deposit Ratio (FDR) have contributed to the rise in NPF. High CIR are often associated with operational inefficiencies that weaken the bank's capacity to manage credit risk [4]. Likewise, elevated FDR values may indicate aggressive financing practices that heighten the risk of default [5].

Externally, macroeconomic variables such as inflation and the BI rate have also shown a strong correlation with credit performance. Rising inflation reduces consumers' purchasing power and affects the repayment capacity of borrowers, especially MSEs [6]. An increase in BI Rate, while encouraging saving, also affects the cost of funds and indirectly pressures Islamic banks to adjust their financing strategies, potentially influencing NPF levels [7].

In addition to those factors, economic shocks have played a crucial role in shaping the financial resilience of Islamic banks. The Covid-19 pandemic, which began in early 2020, represents a major economic shock that disrupted financial markets, reduced economic growth, and heightened credit risk across sectors [8]. This event led to a contraction in GDP growth, a spike in unemployment, and weakened business activities conditions that severely impacted the repayment capabilities of borrowers and contributed to the rise of NPF in Islamic banks. According to Bank Indonesia, Indonesia's economic growth dropped to -2,07% in 2020, the first contraction in over two decades [9]. These economic shocks exposed vulnerabilities in the financial system, highlighting the need for robust credit risk management frameworks within Islamic banking institutions.

Previous empirical studies present conflicting findings on the influence of internal and external variables on NPF, indicating the need for further research. For instance, while some studies find a significant relationship between FDR and NPF, others report no such effect [10] [11].

Given these inconsistencies, this study aims to reassess the determinants of NPF by applying a Vector Autoregression (VAR) and Vector Error Correction Model (VECM) approach. These models are particularly suitable for analyzing both the short and long-term impacts of shocks from internal and macroeconomic factors through the Impulse Response Function (IRF). Using Bank Bukopin Syariah as a case study, this research seeks to provide deeper insights into the dynamics of NPF during the 2016-2023 period and contribute to better risk management practices in Islamic Banking.

Previous studies have explored the determinants of Non-Performing Financing (NPF) in Islamic Banking, utilizing various analytical approaches and focusing on different time frames. For instance [12] investigated the influence of macroeconomic and financial indicators such as inflation, GDP, FDR, CIR, and CAR on NPF in Islamic commercial banks in Indonesia using SEM-PLS. Their findings showed that while BOPO and CAR had a significant impact on NPF, variables like FDR, inflation, and GDP were not statistically significant.

In a different study, [13] employed multiple linear regression and identified inflation and BI Rate as significant predictors of NPF, while FDR and CAR showed no effect. This study aligns partially with the current research in terms of variables observed, but differs in methodology and focus.

References [14] used panel regression to assess the combined impact of variables like GDP, FDR, capital adequacy (CAR), and CIR on NPF across Indonesian Islamic banks. Her results indicated that FDR and CAR had a significant negative effect on NPF, whereas GDP and CIR were positively correlated. Similarly, [15] combined Data Envelopment Analysis (DEA) and panel regression to examine technical efficiency and internal-external variables, revealing that CAR, FDR, inflation, and GDP significantly influenced NPF. Another study by [16], using SEM-PLS, concluded that variables such as ROA, inflation, GDP, and BI Rate significantly affected NPF, whereas FDR and CAR did not.

References [17] adopted the System-GMM approach to examine the role of macroeconomic indicators and Shariah governance. Their study found that open unemployment and interest rate fluctuations had an insignificant negative effect on NPF, which contrasts with some findings of the present research. Research by

[18] on Islamic rural banks used panel data regression, concluding that ROA, CAR, and bank size negatively impacted NPF, while FDR and third-party funds (TPF) had no significant influence.

Further, [19] examined general and micro-segment NPF across three national Islamic banks. Using panel regression, they found that FDR, NOM, and ROE negatively influenced overall NPF, whereas CAR and ROA had positive effects on the micro-segment. [20] applied OLS regression to analyze determinants of NPF in mortgage financing. Their results showed significant negative effects of CAR and ROA, while BI Rate and inflation did not have a significant impact. [21] assessed both internal and external determinants of financing risk using multiple linear regression, concluding that although ROA and bank size were significant, other factors such as inflation, GDP growth, and CIR were not.

While these studies provide valuable insights, they differ from the current research in several key aspects. Most prior studies employed regression-based or SEM approaches and focused on aggregate bank data or multiple institutions. In contrast, the present study specifically focuses on Bank Bukopin Syariah over the 2016–2023 period and applies the VAR/VECM method, which enables analysis of both short-term and long-term dynamics, along with impulse response analysis to shocks in variables such as FDR, CIR, BI Rate, and inflation. This provides a more comprehensive view of the temporal effects of internal and macroeconomic factors on NPF in a single institution context.

METHOD

This study adopts a quantitative approach using the Vector Autoregression (VAR) and Vector Error Correction Model (VECM) methods. These model are chosen for their ability to capture dynamic, simultaneous relationships among variables over both short and long-term horizons. In addition, the use of Impulse Response Function (IRF) allows the analysis to observe how a shock in one variable affects other variables over time, while Variance Decomposition (VD) is applied to assess the relative contribution of each explanatory variable to the forecast error variance of the dependent variable.

The data used in this study are secondary, time-series data collected annually from 2016 to 2023. These data are sourced from publicly available reports, including the annual financial statements of Bank Bukopin Syariah, publications by the Financial Services Authority (OJK), and macroeconomic indicators such as inflation and the BI Rate published by Bank Indonesia.

The dependent variable in this research is Non-Performing Financing (NPF), which serves as a key indicator of the quality of a bank's financing portfolio. The independent variables include the Financing to Deposit Ratio (FDR), the Cost to Income Ratio (CIR) inflation, and the BI Rate. These variables are analyzed to assess their impact on fluctuations in the NPF ratio of Bank Bukopin Syariah.

The analytical procedure begins with testing the stationarity of the time series data using the Augmented Dickey-Fuller (ADF) test. If cointegration is found among the variables, based on the Johansen cointegration test, the VECM model is applied. If no cointegration exists, the VAR model is used. Both models are then estimated to identify short-run dynamics and long-run equilibrium relationships between the variables. IRF analysis is employed to examine how NPF responds to shocks from each independent variable over time, and VD is used to determine the proportion of NPF variation explained by each factor.

The selection of the VAR/VECM approach is intended to provide a comprehensive understanding of the interaction between internal and external factors affecting the NPF ratio. This is particularly relevant to Bank Bukopin Syariah, which has experienced considerable NPF fluctuations during the observation period, highlighting the importance of robust credit risk modelling in the context of Islamic banking.

RESULT

Unit Root Test (Stationarity Test)

Stationarity testing is a crucial initial step in times series modelling using VAR/VECM, as non-stationary data may lead to spurious results. To assess the stationarity of each variable, the Augmented Dickey-Fuller (ADF)

test was performed across three model specifications [22]: None, Intercept and Trend and Intercept. The test was conducted sequentially at level, first difference, and second difference to identify the order of integration for each variable.

At the level form, most variables were found to be non-stationary, except for CIR and NPF, which were stationary only under the intercept model. FDR, Inflation, and BI rate did not achieve stationarity at any level under any model specification, indicating the need for further differencing. At the first difference, CIR, Inflation and NPF became stationary across all model types, while FDR was only stationary under the "None" model and still required further differencing under the other two specifications. Therefore, a second different procedure was implemented to achieve complete stationarity among all variables.

Table 1 presents a summary of the ADF test results, indicating the final integration order of each variable after the necessary differencing steps.

Table I Summary of Augmented Dickey-Fuller (ADF) Unit Root Test Result

Variable	Model Tested	t-ADF	Critical Value (5%)	p-Value	Stationary	Integration Order
FDR	None	-6,373	-1,953	0,0000	Yes	I(2)
CIR	Intercept	-4,997	-2,992	0,0005	Yes	I(1)
Inflation	Intercept	-3,279	-2,964	0,025	Yes	I(1)
BI Rate	Tremd And Int.	-6,479	-3,574	0,0001	Yes	I(2)
NPF	Intercept	-8,983	-2,972	0,00	Yes	I(1)

The Results in Table 1 confirm that all variables meet the stationarity requirements, albeit at different levels of difference. FDR and BI Rate were found to be stationary only after the second difference, while CIR, Inflation and NPF became stationary at the first difference. These findings indicate a mix of I (1) and I(2) series, a condition that necessitates careful model selection in the next stages of analysis. In particular, the combination of variables with different orders justifies the use of Vector Autoregression (VAR) in differences rather than a pure-level VAR model. Furthermore, the long-run equilibrium relationship will be explored using VECM, provided that cointegration among the variables exists. These results validate the statistical robustness of the dataset and support the appropriateness of proceeding with VAR/VECM estimation in the following section.

Johansen Cointegration Test

To examine whether a long-term equilibrium relationship exists among the variables, the Johansen Cointegration Test was applied. This method utilizes both the trace statistic and maximum eigenvalues statistics, comparing them against their critical values at the 5% significance level [23]. If the test statistic exceeds the corresponding critical value, the null hypothesis of "no Integration" is rejected in favour of the alternative hypothesis, indicating the presence of cointegration among the series. The results of the Johansen test are summarized in Table 2 below

Table 2 Johansen Cointegration Test Results

Hypothesis No. of CE(s)	Trace Statistic	5% Critical value	p-Value	Max-Eigen Statistic	5% Critical Value	P value	Conclusion
None	190,9640	69,8189	0,0000	94,5898	33,8769	0,0000	Cointegrated
At most 1	96,3743	47,8561	0,0000	59,0770	27,5843	0,0000	Cointegrated
At most 2	37,2972	29,7971	0,0057	20,3489	21,1316	0,0640	Cointegrated (Trace Only)
At most 3	16,9483	15,4947	0,0300	13,3586	14,2646	0,0691	Cointegrated (Trace Only)
At most 4	3,5897	3,8415	0,0581	3,5897	3,8415	0,0581	Not Cointegrated

Based on the trace statistics, the null hypothesis of no cointegration is rejected for up to four cointegration equations, as all trace values exceed their respective critical values at the 5% level. The maximum eigenvalue test further supports the presence of cointegration for the first two equations (None and At most 1), where the test statistics also exceed the critical values and show statistically significant p-values.

These results confirm that there exists at least one or more cointegration relationships among the variables: NPF, FDR, CIR, Inflation and BI rate. This indicates that the variables move together over the long run and adjust toward a common equilibrium path, despite short-term deviations. The existence of cointegration also validates the application of the Vector Error Correction Model (VECM) in the subsequent analysis, as it captures both the short-term dynamics and long-term equilibrium among non-stationary but cointegration variables.

Vector Error Correction Model (VECM) Estimation

Following the confirmation of cointegration among the variables through the Johansen cointegration test, the Vector Error Correction Model (VECM) was estimated to distinguish between short-run and long-run dynamics. The model evaluates both the immediate and equilibrium adjusting effects of internal and external economic variables on Non-Performing Financing (NPF). Significance is determined by comparing the t-statistic with the critical t-value of 1,69552 at the 5% significance level (df = 31). A variable is considered significant if the absolute value of the t-statistic exceeds this threshold.

The VECM estimation results are summarized in Table 3.

Table 3 Vecm Estimation Results

Variable	Coefficient	t-Statistic	Significance	Interpretation
LONG-RUN EQUATION				
FDR (-1)	4,3054	13,4630	Significant	Positive Impact on NPF
CIR (-1)	10,2018	21,8110	Significant	Strong Positive Impact on NPF
Inflation (-1)	2,6611	12,1626	Significant	Positive Impact on NPF
BI Rate (-1)	2,0583	5,7637	Significant	Positive Impact on NPF
Constant (C)	-0,0636	-	-	-
SHORT-RUN EQUATION				
CoinEq 1	0,0781	0,5632	Not Significant	No Short-Run Adjustment
D(FDR(-1))	-0,2578	-0,3047	Not Significant	-
D(FDR(-2))	-1,2140	-1,2339	Not Significant	-
D(CIR(-1))	-1,2292	-1,1197	Not Significant	-
D(CIR(-2))	-0,9999	-1,6109	Not Significant	-
D(Inflation(-1))	-0,8968	-1,6859	Not Significant	-
D(Inflation(-2))	0,1459	0,4872	Not Significant	-
D(BI Rate(-1))	0,5047	0,5969	Not Significant	-
D(BI Rate(-2))	-0,9771	-0,0167	Not Significant	-

Long-run Analysis

The long-run estimation indicates that all independent variables significantly affect Non-Performing Financing (NPF). In particular, the financing-to-deposit ratio (FDR) has a statistically significant and positive relationship with NPF, as indicated by a t-statistic of 13,4630. This suggests that a 1% increase in FDR is associated with a 4,31% increase in NPF. Similarly, the Cost to Income Ratio (CIR) has a strong positive effect on NPF, with a coefficient contribution to an increase in Non-performing Financing.

Inflation also exhibits a significant positive impact on NPF in the long run, with a coefficient of 2,6611 and a t-statistic of 12,1626. This result aligns with the expectation that rising inflation can reduce borrowers' repayment capacity, thereby increasing credit risk. Lastly, the BI rate (interest rate benchmark) also significantly influences NPF, as indicated by a t-statistic of 5,7637. An increase of 1% in BI Rate is associated with a 2,06% increase in NPF.

Short-run Analysis

In contrast, the short-run estimation reveals that none of the variables significantly affect NPF in the immediate term. The coefficient of the error correction term (CoinEq1) is positive but not statistically significant

(t=0,5632), suggesting that there is no meaningful short-run adjustment mechanism toward the long-run equilibrium. All differenced variables, including FDR, CIR, Inflation and BI Rate at both lags, have t-statistics below the critical value, indicating that their short-term fluctuations do not significantly influence NPF.

This finding implies that the impact of internal and external macroeconomic variables on NPF is more pronounced in the long run than in the short run. Adjustment in operational efficiency, financing strategies, and macroeconomic conditions take to translate into observable changes in financing performance within Islamic Banks.

Granger Causality Test

The Granger causality test was conducted to examine whether a causal relationship exists between pairs of variables. This test evaluates whether the past values of one variable can significantly predict another variable, and vice versa. In this study, each variable is treated as potentially endogenous, and the null hypothesis assumes that no causality exists between the two variables under examination. A p-value less than 0,05 indicates the rejection of the null hypothesis, suggesting a statistically significant causal relationship.

Table 4 Granger Causality Test Results

Null Hypothesis	Obs	F-statistics	p-value	Conclusion
FDR does not Granger cause NPF	30	0,3742	0,6916	No Causality
NPF does not Granger Cause FDR	30	0,9166	0,4129	No Causality
CIR does not Granger cause NPF	30	0,6612	0,5250	No Causality
Inflation does not Granger cause NPF	30	0,2916	0,7496	No Causality
NPF does not Granger Cause Inflation	30	0,9657	0,3945	No Causality
BI_Rate does not Granger cause NPF	30	0,5377	0,5907	No Causality
NPF does not Granger Cause BI_Rate	30	0,0833	0,9204	No Causality
CIR does not Granger Cause FDR	30	3,1762	0,0590	Almost significant (marginal)
FDR does not Granger Cause CIR	30	1,1573	0,3306	No Causality
Inflation Does Not Granger Cause FDR	30	0,6455	0,5329	No Causality
FDR does not Granger Cause Inflation	30	7,7900	0,0023	Causality Exists
BI_Rate does not Granger Cause FDR	30	0,3004	0,7431	No Causality
FDR does not Granger Cause BI_Rate	30	2,9155	0,0728	Nearly significant (marginal)
Inflation does not Granger Cause CIR	30	0,6194	0,5463	No Causality
CIR does not Granger Cause Inflation	30	1,6818	0,2064	No Causality
BI_Rate does not Granger Cause CIR	30	0,3079	0,7377	No Causality
CIR does not Granger Cause BI_Rate	30	0,9690	0,3933	No Causality
BI_Rate does not Granger Inflation	30	0,1802	0,8362	No Causality
Inflation does not Granger Cause BI_Rate	30	4,0711	0,0295	Causality exists

The result reveals no bidirectional causality between FDR and NPF, as both directions yield p-values greater than 0,05. Similarly, CIR, Inflation and BI Rate do not Granger-cause NPF, nor does NPF significantly predict any of these variables, indicating a lack of short-term predictive power between NPF and these internal/external variables.

Interestingly, although CIR nearly Granger-cause FDR (p=0,0590), this relationship is not statistically significant at the 5% level. Likewise, FDR does not significantly Granger-cause CIR (p=0,3306), indicating no causal relationship between bank efficiency and liquidity in this model.

However, there is a unidirectional causal relationship from FDR to Inflation (p=0,0023), suggesting that financing behavior may influence price level movements in the short term. Additionally, the Inflation Granger-cause BI Rate (p=0,0295), indicates a causal link whereby inflation trends may affect monetary policy adjustment through interest rates. No reverse causality was found in either relationship.

Overall, the Granger Causality test result suggests that most variables do not exhibit a strong short-run predictive relationship. The few identified causal links, such as from FDR to Inflation and Inflation to BI Rate,

could be useful for policymakers and bank managers in understanding macro-financial interactions within the Islamic Banking context.

Impulse Response Function (IRF) Analysis

The Impulse Response Function (IRF) analysis was conducted to examine the dynamic behavior of Non-performing Financing (NPF) in response to one standard deviation shocks from each explanatory variable, FDR, CIR, Inflation and BI Rate, over a 10-period forecast horizon.
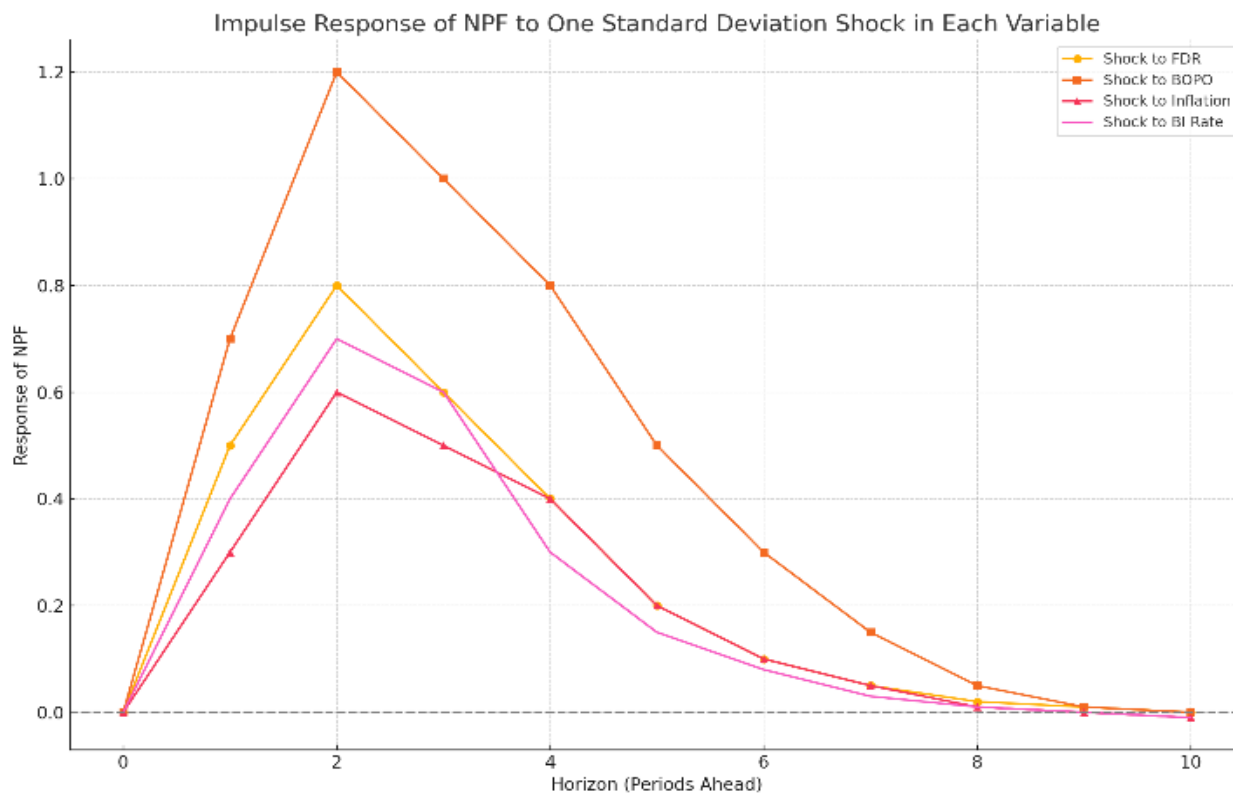

Fig.1 IRF of NPF To One Standard Deviation Shock in Each Variable

As illustrated in the graph above, the response of NPF to a shock in FDR is immediate and moderately positive, peaking at period 2 before gradually diminishing and stabilizing around period 8. This indicates that liquidity shocks tend to affect credit performance quickly but not persistently.

A shock to CIR shows the strongest impact on NPF. The response peaks around period 2 and then slowly declines, suggesting that operational inefficiencies have a lasting effect on the increase of non-performing financing. This finding aligns with the long-run VECM results, where CIR was shown to be highly significant and positively related to NPF.

The response of NPF to Inflation is also positive in the short term, but begins to fade after a few periods and eventually turns slightly negative by the end of the horizon. This behaviour reflects the temporary financial stress caused by rising prices, which may normalize as markets adjust.

Lastly, a shock to the BI rate produces a similar pattern to inflation. The impact on NPF is positive and moderate in the early periods, peaking in the second or third period, and gradually dissipating afterwards. This suggests that interest rate hikes may increase repayment burdens in the short run but have limited persistence over the medium term.

Overall, the IRF analysis reinforces the idea that the effect of macroeconomic and internal banking shocks on NPF is more prominent in the short run, especially for CIR and FDR, but these impacts generally diminish over time. These dynamics are essential for Islamic banking risk managers and policymakers to anticipate and mitigate potential credit risk exposures.

DISCUSSION

The findings of this study contribute to the growing literature on credit risk in Islamic banking by validating and expanding upon prior empirical results in the Indonesian context. The long-run significance of FDR, CIR, Inflation, and BI Rate on Non-Performing Financing (NPF) aligns with theoretical expectations and empirical evidence from previous studies.

The significant long-term impact of FDR on NPF is consistent with the findings of [14] and [19] who identified FDR as a determinant of financing risk in Islamic banks. A higher FDR reflects aggressive financing behavior relative to available deposits, which may increase the likelihood of defaults when risk management practices are weak. However, this contrasts with the study by [12], which found no significant effect of FDR on NPF, suggesting that the relationship may depend on institutional context and sample period.

The strong positive relationship between CIR and NPF reinforces the conclusions of [16], who emphasized the critical role of operational efficiency in maintaining financing quality. High BOPO indicates inefficiencies that can lead to weakened profitability and a reduced capacity to absorb credit losses, thus increasing the likelihood of financing default. Conversely, studies such as [21] found CIR to be statistically insignificant, which may be due to differences in model specification or the focus on short-term dynamics.

Macroeconomic factors also showed significant long-run effects. The influence of inflation on NPF echoes the findings of [13] and [20], who reported that rising prices erode purchasing power and impair borrowers' ability to fulfil financing obligations. Similarly, the significance of the BI Rate as a monetary policy variable supports the research of [17], indicating that changes in interest rates, even in Islamic banking, affect financing performance indirectly, due to market-wide funding cost adjustments and borrower sentiment.

In contrast, the short-run results reveal that none of the variables, including the error correction term, significantly affect NPF. This outcome is aligned with the findings of [12], who reported that macroeconomic variables like inflation and GDP showed no immediate effect on NPF. The lagged and cumulative nature of credit risk transmission appears to dominate, requiring longer time frames to influence financing performance in Islamic banks.

The Granger causality analysis confirms limited short-run causality, with only two significant unidirectional relationships, FDR Granger-causes Inflation, and Inflation Granger-causes BI Rate. These results are theoretically reasonable, as expansion in financing can generate demand-side pressures that contribute to inflation, and central banks often respond to inflationary pressures by adjusting policy rates.

Finally, the Impulse Response Function (IRF) provides further insight into how NPF reacts to economic shocks over time. The response of NPF to CIR shocks is the most pronounced and persistent, indicating the lasting impact of operational inefficiencies. FDR and macroeconomic shocks (inflation and BI Rate) produce more moderate and short-lived effects. These findings confirm that internal bank factors may play a larger role in long-run credit risk than external variables, which tend to be cyclical and transitory.

Overall, the results of this study are largely consistent with previous literature, yet offer a novel contribution by applying the VAR/VECM framework specifically to a single Islamic bank (Bank Bukopin Syariah), and incorporating IRF and causality analysis to capture both direct and dynamic effects. This integrated approach enriches the understanding of how various financial and macroeconomic factors shape the risk landscape in Islamic banking.

CONCLUSION

This study investigated the long-term and short-term determinants of Non-Performing Financing (NPF) in the context of Bank Bukopin Syariah in Indonesia during the 2016–2023 period. Using the Vector Error Correction Model (VECM) framework, complemented by Granger causality tests and Impulse Response Function (IRF) analysis, the research offers several important conclusions.

The long-run analysis revealed that all observed variables—Financing to Deposit Ratio (FDR), Cost to Income Ratio (CIR), Inflation, and BI Rate, significantly influence NPF. Among them, CIR exhibited the strongest long-run impact, suggesting that operational efficiency is critical in maintaining asset quality in Islamic banks. The results also demonstrated that higher inflation and increases in the central bank's interest rate contribute to rising NPF levels, likely due to their adverse effects on borrowers' repayment capacity. FDR, while also significant, showed a moderate influence, reinforcing the need for prudent liquidity management.

In the short run, however, none of the independent variables, including the error correction term, had a statistically significant impact on NPF. This implies that adjustments in bank performance and macroeconomic conditions require time to materialize in credit risk indicators, highlighting the lagged nature of financial responses in the Islamic banking sector.

Granger causality analysis supported the long-run findings, revealing a unidirectional causal link from FDR to inflation, and from inflation to BI Rate, but no direct causal relationship between NPF and any other variable. This reinforces the importance of controlling upstream variables that indirectly affect NPF through macro-financial transmission mechanisms.

The IRF analysis further emphasized that shocks to CIR and FDR produce immediate and noticeable effects on NPF, with the impact of CIR being more persistent. Shocks from inflation and the BI-Rate showed more transient responses.

These findings hold several implications for Islamic bank regulators, policymakers, and management:

1) Improve Operational Efficiency: Since CIR has a strong and persistent effect on NPF, Islamic banks should prioritize operational cost control and revenue enhancement to reduce financing risk.
2) Enhance Risk-Based Financing Practices: Given the influence of FDR, banks should implement more stringent credit assessments and ensure balanced growth between financing and deposits to avoid overexposure.
3) Macroeconomic Monitoring: Policymakers should recognize the indirect impact of inflation and interest rate policies on the health of Islamic financing portfolios. Coordinated monetary and financial policy responses are essential to mitigate systemic risks.
4) Early Warning Mechanisms: The dynamics revealed through IRF suggest that short-term monitoring tools should be implemented to detect early signs of rising NPF due to shocks in internal or external variables.

In conclusion, the integration of VAR/VECM, Granger causality, and IRF provides a comprehensive framework for understanding the temporal dynamics of credit risk in Islamic banking. Future research may extend this approach by incorporating additional variables such as exchange rates, political uncertainty, or digital banking performance to further explore systemic risk channels.

ACKNOWLEDGEMENT

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