

Stress test of credit risk using Monte Carlo simulation: Indonesian *sharia* rural banks

Uvy Dian Rizky^{a*}, Abdul Mongid^a

^aHayam Wuruk Perbanas University, Surabaya, Indonesia

ARTICLE INFO

Article history:

Received 17 July 2024

Revised 15 October 2024

Accepted 17 October 2024

Published 6 January 2025

Keywords:

Stress Test

Credit Risk

Montecarlo Simulation

Error Correction Model (ECM)

DOI:

10.24191/jeeir.v13i1.2135

ABSTRACT

This study examines the influence of macroeconomic shocks on credit risk within Indonesian *sharia* rural banks for a period of January 2010 to March 2020. This study employs Monte Carlo simulations and the Error Correction Model (ECM). The results indicate that GDP growth, inflation, and exchange rate are significantly influence the Non-performing financing (NPF) in the long term, while interest rate have a considerable impact on the NPF in the short term. Meanwhile, financing or credit growth has no substantial impact on the NPF in either the long term or short term. The stress test results indicate that Indonesian Islamic rural banks have a high probability of default with a forecasted NPF rate of 10.91%, a differential maximum NPF of 0.33 % at a confidence level of 95%. Therefore, it is suggested that the banks should note that the exchange rate has a strong effect on NPF, and anticipate the high probability of default with sufficient capital to cover losses.

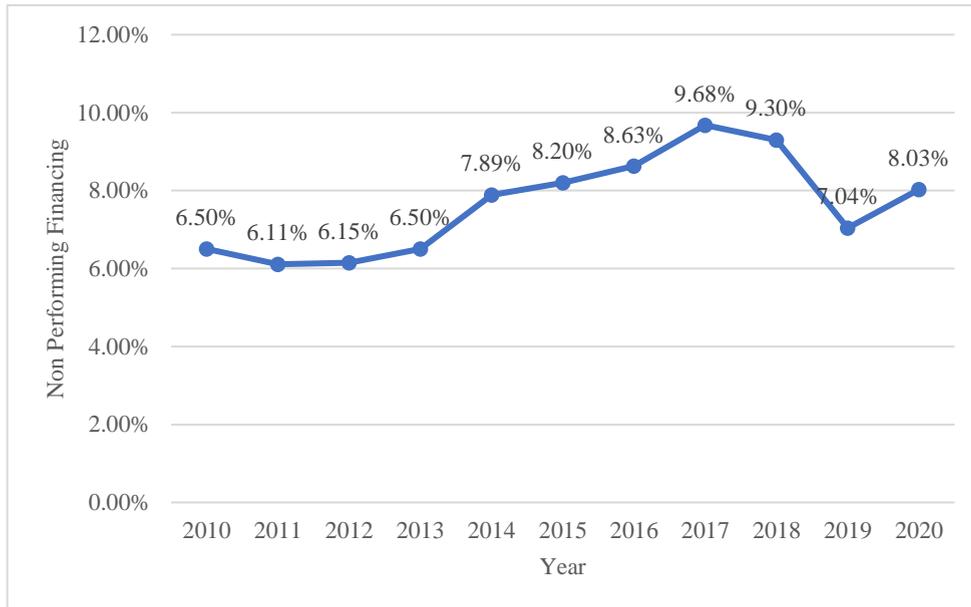
1. Introduction

The stability of the *sharia* rural bank known as Bank Pembiayaan Rakyat Syariah (BPRS) is crucial for enabling the community's economy in the real sector as a financial intermediary institution. The impediment of bank operations can hinder the efficient operation of the community's economy, particularly affecting micro, small, and medium enterprises, known as Usaha Mikro Kecil dan Menengah (UMKM), which represent the primary financing target for Islamic rural banks in Indonesia.

In Islamic banks, financing or credit refers to the provision of cash and claims based on *mudharabah*, *musyarakah* contracts, or other financing based on profit-sharing principles (Peraturan Bank Indonesia 2003). Islamic banks, primarily engaged in channeling funding are very prone to financing risks. Financing risk or credit risk, refers to the potential loss resulting from a customer's or another party's inability to fulfill their obligations to the bank. There are five levels of credit risk, including current, special mention,

* Corresponding author. E-mail address: uvydian@gmail.com

18 substandard, doubtful, and loss (SK Direktur Bank Indonesia 1998). The non-current or non-performing
 19 financing consists of substandard, doubtful, and loss categories. An increase in non-current or non-
 20 performing financing affects the value of the NPF ratio. Non-Performing Financing (NPF) is the ratio of
 21 the total non-current financing to total financing categories granted. The permissible threshold for the NPF
 22 ratio of BPRS is 7 % (Peraturan Bank Indonesia 2007).



23
 24 Figure 1. NPF of BPRS in Indonesia 2010-2020

25 The high NPF of the BPRS, with an average NPF of 8.54 % and a high NPF of 11.8 % in July 2018,
 26 signifies a substantial amount of bad financing encountered by the BPRS. The NPF can adversely affect
 27 the health of the BPRS by necessitating a larger reserve for bank losses, diminishing the impact on bank
 28 operating profit, and resulting in reduced creation of additional bank capital. This affects reduced profit
 29 sharing for the Third Party Fund (DPK) customers, prompting them to consider alternative banks or more
 30 profitable investments. Yulianto and Solikhah (2016) revealed that an increase in NPF ratio correlates with
 31 a decrease in the number of deposits. The public's inclination to deposit funds in Islamic banks will
 32 diminish due to concerns regarding the bank's ability to refund the deposited cash or provide minimal profit
 33 sharing. If mismanaged, the elevated NPF ratio can jeopardize the bank's insolvency. The determinants of
 34 NPF can be attributed to both internal and external causes. Internal factors arise from banking operational
 35 activities, including financing growth, whereas external factors stem from macroeconomics conditions,
 36 such as economic growth, inflation, interest rates, and exchange rates (Auliani & Syaikhu, 2016).

37 Prior studies do not uniformly reveal the determinants influencing financing quality, as indicated by
 38 NPF. Karmila (2013) and Saputro et al. (2019) reveal that credit growth has a positive effect on NPL,
 39 however Harahap (2017) contends that credit growth adversely affects NPL. Firdaus (2017) posits that
 40 GDP growth positively influence NPF, however Sulastris et al. (2016) and Indra (2018) indicate that GDP
 41 adversely affects NPF. Conversely, Wahyudin et al. (2020), Dewi (2020), and Romadhoni (2017) asserts
 42 that GDP has no impact on NPF. Inflation positively influences NPF, as stated by Wahyudin et al. (2020)
 43 and Indra (2018), but Romadhoni (2017), Dewi (2020), and Rindang (2019) assert that inflation has no
 44 impact on the NPF of BPRS. According to Indra (2018) and Rindang (2019), interest rates positively
 45 influence NPF, however, Putri (2016) indicated a negative effect of interest rates on NPF. Conversely,
 46 Wahyudin et al. (2020) asserted that interest rates had no impact on NPF. Romadhoni (2017) asserts that
 47 the exchanges rate positively influences NPF, however Sulastris et al. (2016) and Yolanda (2019) contend

48 that the exchange rate has no impact on NPF. Given the inconsistent findings, this study seeks to examine
 49 factors influencing NPF through the lens of credit risk stress testing at Sharia rural Banks in Indonesia,
 50 noting the absence of prior studies addressing stress test of financing or credit risk within this context.

51 2. Literature review

52 2.1 Islamic rural bank

53 An Islamic bank conducts its operations in accordance with sharia principles, and Islamic legal
 54 principles regulated in the fatwa of the Indonesian Ulema Council, which include the principles of justice
 55 and balance ('adl wa tawazun), benefit (maslahah), universalism (natural), and exclusion of gharar, maysir,
 56 usury, injustice and unlawful objects (Hasan, 2009). Islamic banks comprises of commercial banks and
 57 Islamic rural bank or called Bank Pembiayaan Rakyat Syariah (BPRS), with the primary distinction being
 58 that BPRS are prohibited from receiving deposits in the form of demand deposits and participating in
 59 payment system transactions (Undang-undang Republik Indonesia 2008).

60 2.2 Business cycle theory

61 Business cycle theory posits that economy will inevitably encounter phases of expansion and
 62 contraction, which will alternatively recur over a specific duration. Abel et al. (2008) categories the signs
 63 of business cycle as follows: Procyclical indicators are those that align with the fluctuations of the business
 64 cycle, while countercyclical indicators move inversely to the business cycle throughout both expansion and
 65 contraction. A cyclical indicator indicates a fluctuate independently of the business cycle.

66 2.3 Financing or credit risk

67 Financing refers to the provision of funds or claims based on mudharabah or musyarakah contracts, or
 68 other financing based on profit-sharing principles (Peraturan Bank Indonesia 2003). Financing can be a
 69 source of risk if the prudent principle does not accompany in its distribution. In conventional terms,
 70 financing risk or credit risk refers to potential loss incurred when a customer or another party fails to meet
 71 their obligations to the bank. NPF is the ratio of the number of non-performing financing and the total
 72 financing provided. The number of non-performing loans is the amount of financing classified as
 73 substandard, doubtful, and loss collectability.

74

$$NPF = \frac{\text{Non Performing Financing}}{\text{Total Financing}} \times 100\% \quad (1)$$

75 The safe limit for the BPRS NPF ratio is 7% (Surat Edaran Bank Indonesia 2007). The assessment of
 76 the soundness of the Islamic rural bank based on the NPF ratio (Salinan Peraturan Otoritas Jasa Keuangan
 77 Republik Indonesia 2019) includes:

78 Table 1. Level of NPF at BPRS in Indonesia

Level	Non Performing Financing (NPF)
1	$NPF \leq 7\%$
2	$7\% < NPF \leq 10\%$
3	$10\% < NPF \leq 13\%$
4	$13\% < NPF \leq 16\%$
5	$NPF > 16\%$

79 After the NPF equation estimation are obtained, scenarios based on factors such as financing or credit
 80 growth, GDP growth, interest rates, inflation rates, and exchange rates are used to conduct stress testing.

81 2.4 Financing/credit growth

82 Financing or credit growth refers to the fluctuation in the total amount of financing or credit disbursed
83 by a bank over a specific period, typically expressed as a percentage. Financing or credit growth is measured
84 by a formula as follows:
85

$$FNCG_t = \frac{Financing_t - Financing_{t-1}}{Financing_{t-1}} \times 100\% \quad (2)$$

86 The growth of financing could increase the opportunity for banks to obtain credit income, thereby
87 reducing the NPF ratio. The finding is in line with Harahap (2017), who revealed that credit growth
88 harms NPF, in contrast to Karmila (2013), Saputro et al. (2019), and Keeton (1999) in Ghosh (2015), which
89 suggests that the accelerated credit growth leads to an increased in credit losses, due to weak credit
90 standards, resulting in numerous incompetent debtors and subsequent credit issues for banks.

91 *H₁: Financing or credit growth has a significant effect on financing or credit risk (ie. NPF)*

92 2.5 Growth domestic products (GDP) growth

93 GDP is a macroeconomic term that frequently used to measure economic growth. It measures the market
94 value of all goods and services produced by a country at a given time.
95

$$GDP_t = \frac{GDP_t - GDP_{t-1}}{GDP_{t-1}} \times 100\% \quad (3)$$

96 A positive GDP growth indicates an increase in individual and company income. Consequently, the
97 ability to fulfil financial obligations (credit) potentially enhances the reduction of NPF (Ahmad & Bashir,
98 2013). Unlike the findings of Firdaus (2017) and Alfaro et al. (2004), which indicated that GDP growth,
99 indicative of economic expansion, can lead banks to have inflated expectations regarding customer payment
100 capabilities, resulting in diminished vigilance and caution in credit or financing disbursement, thereby
101 raising the risk of increased NPF.

102 *H₂: GDP growth has a significant effect on financing or credit risk (ie. NPF)*

103 2.6 Inflation

104 Inflation is a continuous increase in the price of goods, which decrease purchasing power, as actual value
105 of income diminishes under the assumption of people's income is constant (Mankiw, 2006). Inflation is
106 measured by the Consumer price index (CPI) as below:
107

$$Inflation = \frac{IHK_t - IHK_{t-1}}{IHK_{t-1}} \times 100\% \quad (4)$$

108 High inflation can hurt the decline in people's purchasing power and ability to pay debts, so it has the
109 potential to worsen the quality of bank financing (Taswan, 2006), as revealed by Indra (2018) and
110 Wahyudin et al. (2020) that inflation has a positive effect on NPF. On the other hand, Barus and Erick
111 (2016) revealed that when inflation occurs, people tend to experience financial difficulties so that bank loan
112 levels are reduced and bad loans are reduced, in line with Saputro et al. (2019) and Klein (2013), who
113 revealed that the real value of debt payments tends to decrease with higher inflation, thereby reducing NPFs.

114 *H₃: Inflation has a significant effect on financing or credit risk (ie. NPF).*

115 2.7 Interest rate

116 Interest rates are fees for services rendered by banks, to customers engaging in purchase or sale of their
117 products (Kasmir, 2011). Islamic banks benchmark their financing operations using market interest rates
118 such as LIBOR, SIBOR, or JIBOR (Rivai & Ismail, 2013). As interest rates rise, the competitiveness of

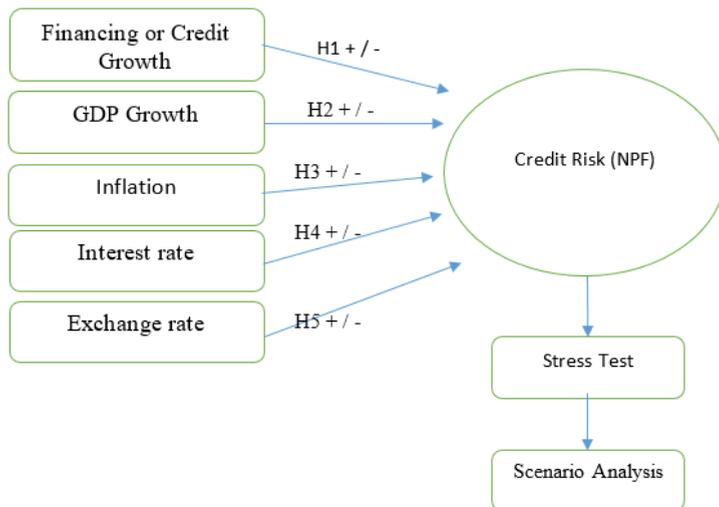
119 Islamic banks increases, with the profit/loss sharing ratio of Islamic banks being able to compete with the
 120 increasing interest rates of conventional bank loans. Some features cause people to choose to borrow or
 121 finance at Islamic banks whose cost of funds is considered lower (Kasmir, 2011), thus causing financing at
 122 Islamic banks to be higher and affecting the larger NPF ratio. This finding is in line with the studies of
 123 Indra (2018) and Nugrohowati and Bimo (2019), which demonstrate that interest rates have a positive effect
 124 on NPF. In contrast, Putri (2016) shown that interest rates adversely affect NPF, since rising interest rates
 125 lead to a reluctance among individual to borrow funds from banks, thereby reducing NPF due to low
 126 demand.

127 *H₄: Interest rate has a significant effect on financing or credit risk (ie. NPF)*

128 2.8 Exchange rate

129 The exchange rate represents the value of one currency in another country's currency (Sukirno, 2002).
 130 The nominal exchange rate is the relative price of the currencies of two countries. The real exchange rate
 131 is the relative price of goods between two countries. A country's exchange rate closely correlates with its
 132 exports. If the real exchange rate is low, domestic goods will be cheaper than foreign goods, increasing
 133 exports (Mankiw, 2006). When the currency depreciates (weakens), the success of entrepreneurs tends to
 134 be hampered due to increased production costs, especially those related to imported goods. The increase in
 135 production costs affects decreasing the income of entrepreneurs and decreasing the ability to pay debts so
 136 that it has the potential to increase the NPF, as revealed by Indra (2018) that the depreciation of the exchange
 137 rate contributed to the increase in NPF. On the other hand, an increase in the exchange rate has an impact
 138 on benefiting export entrepreneurs (exporters) because the price of domestic goods increases, so that
 139 businesses earn more income and the ability to pay debts increases, resulting in a decrease in bank NPF, as
 140 Widyarningsih (2021) states that the exchange rate harms NPL.

141 *H₅: Exchange rate has a significant effect on financing or credit risk (i.e. NPF)*



142

143

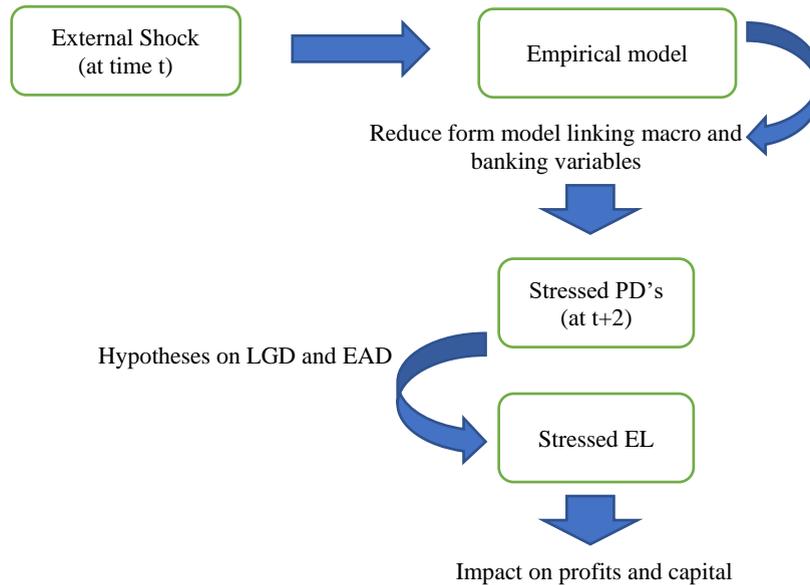
Figure 2. Conceptual framework

144

2.9 Stress test

145 The stress test is a method to assess the level of resilience and soundness of banks when faced with crisis
 146 conditions that originate from extreme shocks, either externally or internally. A stress test helps the
 147 authority and management to develop knowledge in the risk assessment process and improve understanding
 148 and perception of risks (Basel Committee on Banking Supervision, 2009). We simplify the test using

149 financing risk only. The ratio of NPF serves as a measure of this risk, and it also indicate the probability of
 150 default (Quagliariello, 2009) reveals that external shocks originating from macroeconomics can affect
 151 giving stress to the probability of default (PD) and expected loss (EL) with hypotheses on loss given default
 152 (LGD) and exposure at default (EAD), which have an impact on a bank's profit and capital.



153

154

Figure 3. Bank stress test

155 The probability of default (PD) is the probability that the debtor will default on his obligations to the
 156 creditor. The probability of default is measured using the ratio of NPF, adopting the default risk model from
 157 Ong (1999) which assumes that default risk is a company's uncertainty in terms of its ability to fulfil all
 158 obligations to debtors and obligators. Expected Loss (EL) is the amount of loss that is expected as a result
 159 of default. A bank may face an estimated amount of loss when a default occurs, known as Exposure at
 160 Default (EAD). After accounting for the collateral the debtor provides as a substitute for the debtor's
 161 obligations, Loss Given Default (LGD) represents the portion of bank losses that the bank cannot recover
 162 due to a default (Hibbeln, 2010).

163 2.10 2.10 Monte carlo simulation

164 The Monte carlo simulation is a quantitative risk assessment technique utilised by organizations in the
 165 risk management process, particularly during risk analysis and evaluation. It involves random variables and
 166 employs probability distribution derived from historical data and theoretical probability distributions. In a
 167 Monte Carlo simulation, values of parameters are drawn randomly from the input probability distribution.
 168 Each set of samples is called an iteration, and the outcomes derived from those samples are recorded. A
 169 Monte Carlo simulation does this process hundreds or thousands of times, yielding a distribution of
 170 potential outcomes. The Monte Carlo simulation offer a more comprehensive view of what might happen
 171 and their probabilities.

172 3. Method

173 The study population comprises Islamic banks in Indonesia registered with the OJK, as summarized in
 174 the consolidated data of Islamic banks in Indonesia, including a sample of Islamic rural banks, known as
 175 Bank Pembiayaan Rakyat Syariah (BPRS), operating from January 2010 to March 2020. The data used are
 176 monthly time series data on financing growth (FNCG), inflation (INFL), interest rates (JIBOR), exchange
 177 rates (LKURS) and Non-Performing Financing (NPF). Data is sourced from data documentation officially
 178 released by the websites of Bank Indonesia (BI) and the Otoritas Jasa Keuangan (OJK). The tests used in
 179 this study include descriptive analysis, Error Correction Model (ECM) regression and Stress test using
 180 Monte carlo simulation

181 3.1 Error Correction Model (ECM)

182 Error Correction Model (ECM) is a regression technique for correcting short-term discrepancies towards
 183 long-term equilibrium, with aimed at elucidating the impact of financing growth, GDP growth, inflation,
 184 interest rates and exchange rates on NPF of BPRS in Indonesia. The stages and criteria for implementing
 185 the ECM technique, including the stationarity test, degree of integration test and cointegration test were
 186 carried out. The stationary distribution of the data indicates a tendency for the data distribution to approach
 187 the average value, resulting in a constant variance of the data. It is crucial to conduct a stationary test to
 188 prevent lancing regression, which can lead to unreliable interpretation results. The Phillips-Perron test
 189 (PPTest) is a standard procedure for the stationarity test. This study employs the Phillips-Perron test (PP
 190 test) at a significance level of 5%. The criteria states that if the probability value is less than the critical
 191 value of 5%, the data is considered stationary; if the probability value exceeds the critical value of 5%, the
 192 data is not considered stationary. The degree of integration test is a continuation of the unit root test and is
 193 only needed if all the data is not stationary at degree zero or 1 (0). We use the degree of integration test to
 194 determine the extent to which the data will be stationary. This test is also carried out with a PP test with a
 195 significance level of 5% until the resulting data is stationary. Cointegration is a long-term relationship
 196 between variables which although individually are not stationary, but the linear combination between these
 197 variables can be stationary. The cointegration test used is the Johansen Cointegration test. If the trace
 198 statistic value is greater than the critical value and the probability value is less than the critical value 0.05,
 199 it can be concluded that there is a cointegration relationship between variables.

200 The model estimation of this study as follows:

201

$$NPF_t = \alpha + \beta_1 FNCG_t + \beta_2 GDP_t + \beta_3 INFL_t + \beta_4 JIBOR_t + \beta_5 LKURS_t + \varepsilon_t \quad (5)$$

202 Description :

- 203 • NPF = Non Performing Financing
- 204 • FNCG = Financing growth
- 205 • GDP = GDP growth
- 206 • INFL = inflation
- 207 • JIBOR = interest rate
- 208 • LKURS = exchange rate
- 209 • ECT = Error Correction Term
- 210 • D = Difference
- 211 • α = Constanta
- 212 • $\beta_1, 2, 3 \dots$ dst. = coefficient
- 213 • ε = Error term

214 ECM estimates are valid if the cointegrated variables are supported by significant ECT coefficient values
 215 (ECT coefficient <1) and negative. If the ECT coefficient is positive, then the direction of the variables

216 used will be further away from the long-term equilibrium, which means that the ECM model cannot be
 217 used (Rahutami, 2011).

218 3.2 Stress test using Monte carlo simulation

219 Stress tests with Montecarlo simulation were used to predict the value of NPF at Islamic rural banks
 220 (BPRS) in Indonesia. There are several stages as follows:

- 221 1. Determine the best equation model. This simulation uses previously tested equation 5.
- 222 2. Determine the coefficients, variable values, standard errors and data distribution assumptions to be
 223 used in the simulation. In this simulation, the data distribution is assumed to be normal.
- 224 3. Incorporate into the monte carlo simulation. The simulation in this study was carried out to predict
 225 the value of NPF based on the intended equation model formula by using Crystal Ball software by
 226 Oracle.
- 227 4. Set the number of experiments. The simulation in this study used 500,000 trials with a 95% confidence
 228 level
- 229 5. Carry out simulations and generate simulation results

230 Table 2. Assumptions of simulation

Long term				
Variable	coefficient	Data		Distribution
		Mean	Std.Error	
C	-55.56			
FNCG	-0.02	1.57	1.35	
GDP	0.28	4.65	1.91	
INFL	-0.12	4.66	1.66	Normal
JIBOR	-0.11	5.2	0.88	
LKURS	6.83	9.37	0.19	
Short term				
Variable	coefficient	Data		Distribution
		Mean	Std.Error	
C	-0.010396			
D(FNCG)	0.02	0.02	1.63501	
D(GDP)	0.06	-0.02	1.08393	
D(INFL)	-0.05	-0.01	0.56718	Normal
D(JIBOR)	-0.23	-0.02	0.39531	
D(LKURS)	3.68	0	0.01886	
ECT(-1)	-0.16	-8.41E-15	0.79143	

231 4. Result and discussion

232 The study focuses on Islamic Rural Banks (BPRS) in Indonesia, with the dependent variable being
 233 financing quality, represented by NPF. The independent variable include financing growth and

234 macroeconomic factors, proxied by GDP growth, inflation, interest rates and the Rupiah exchange rate
 235 against US Dollar for the period January 2010 to March 2020.

236 Table 3. Descriptive analysis

	FNCG	GDP	INFL	JIBOR	LKURS	NPF
Mean	1.57	4.65	4.66	5.20	9.37	8.55
Med	1.60	5.05	4.13	5.40	9.47	8.27
Max.	5.06	5.59	8.36	7.59	9.66	11.80
Min.	-3.80	-5.33	2.53	3.78	9.05	6.11

237 The data presented in Table 3 indicates that the mean value of each variable exceed the standard
 238 deviation. This indicates that throughout the study period, all variables adhere to acceptable standards, at
 239 the standard deviation is less than the mean value. A lower the standard deviation, indicates that the data
 240 points are more closely clustered around the mean, resulting in reduced variability. The highest financing
 241 growth recorded was 5,063720 in May 2011, whereas the lowest financing growth observed was -3.795081
 242 in December 2019. The highest economic growth was 5.588000 in May 2010, while the lowest economic
 243 growth was -5.325000 in December 2019. The highest inflation rate was 8.363000 in November 2014,
 244 while the lowest inflation rate was 2.530000 in February 2019. The highest interest rate was 7.591670 in
 245 December 2015, while the lowest interest rate was 3.776600 in April 2012. The highest LKURS was
 246 9.663452 in March 2020, while the lowest LKURS was 9.051227 in July 2011. The highest NPF was
 247 11.80000 in July 2018, while the lowest NPF was 6.110000 in December 2011.

248 Table 4 indicates that all variables are stationary at the first difference, suggesting that the variables have
 249 constant variance and do not change at this level of differencing.

250 Table 4. Stationary test

Variable	Philips Peron (PP)			
	Level		1st Difference	
	Probability	Noted	Probability	Noted
FNCG	0.0000	Stationary	0.0001	Stationary
GDP	0.0254	Stationary	0.0000	Stationary
INFL	0.2798	Non Stationary	0.0000	Stationary
JIBOR	0.1155	Non Stationary	0.0000	Stationary
LKURS	0.9255	Non Stationary	0.0000	Stationary
NPF	0.4966	Non Stationary	0.0000	Stationary

262 Table 5. Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.407060	146.6865	95.75366	0.0000
At most 1 *	0.345393	84.48964	69.81889	0.0022
At most 2	0.139121	34.06687	47.85613	0.4982
At most 3	0.083196	16.24045	29.79707	0.6953
At most 4	0.043836	5.903885	15.49471	0.7069
At most 5	0.004775	0.569587	3.841466	0.4504
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.407060	62.19685	40.07757	0.0000
At most 1 *	0.345393	50.42277	33.87687	0.0002
At most 2	0.139121	17.82641	27.58434	0.5096
At most 3	0.083196	10.33657	21.13162	0.7125
At most 4	0.043836	5.334298	14.26460	0.6992
At most 5	0.004775	0.569587	3.841466	0.4504

263 Table 5 indicates the trace value and maximum value. The eigen statistic at None ($r=0$) and at most 1
 264 ($r=1$) exceeds the critical value at the 5% significance level, with a probability of less than 0.05. This
 265 indicates a cointegration among the variables, with two cointegrating equations present in the model,
 266 allowing for the application of Error correction model (ECM) analysis in the study.

267 Table 6. Long term estimation output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-55.55856	4.346280	-12.78301	0.0000
FNCG	-0.015960	0.059826	-0.266767	0.7901
GDP	0.280198	0.041033	6.828565	0.0000
INFL	-0.123909	0.052620	-2.354795	0.0202
JIBOR	-0.114005	0.091592	-1.244700	0.2157
LKURS	6.831408	0.449821	15.18693	0.0000

268

269 Table 7. Short term estimation output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.010396	0.041598	-0.249918	0.8031
D(FNCG)	0.017885	0.026250	0.681350	0.4970
D(GDP)	0.057435	0.039308	1.461168	0.1467
D(INFL)	-0.049110	0.072288	-0.679367	0.4983
D(JIBOR)	-0.234221	0.103761	-2.257316	0.0259
D(LKURS)	3.681570	2.198616	1.674494	0.0968
ECT(-1)	-0.164319	0.053896	-3.048847	0.0029

270 The estimation output in Table 6 and 7 indicates that the Error Correction Term (ECT) value is -
 271 0.164319. This suggests that the speed of error correction for each variable the short term to return to long-
 272 term equilibrium is - 0.16%. The ECT coefficient value is negative and, in absolute terms, less than 1
 273 (qualifying $0 < \text{ECT} < 1$). The t statistic value is -3.048847], which exceed the t value of 1.65734, and a
 274 probability value of $0.0029 <$, which is less than 0.05. Therefore, the ECM model is significant and valid.

275 The finding that the financing growth variable (FNCG) has no significant influence on the financing
 276 quality variable (NPF) is contrary to the hypothesis that financing growth has a significant effect on
 277 financing quality. The rising increase of financing (credit) at Islamic Rural Banks (BPRS) in Indonesia does
 278 not significantly impact the poor quality of financing (NPF) in either the long term or short term. This is
 279 generally due to the loose credit system which is not matched by strict and selective credit supervision,
 280 resulting in a high NPF value which is not even comparable to the increase in financing (credit) growth
 281 which tends to be slow. These findings are in line with Curak et al. (2013), who found that there was no
 282 significant relationship between credit growth and NPF. Over the long term, credit growth has an inverse
 283 relationship to the quality of financing (NPF), meaning that when the bank's credit growth declines, the
 284 NPF will increase because the slowdown in BPRS credit growth is not matched by qualified control quality
 285 so that the NPL ratio increases. Meanwhile, in the short term, credit growth has a positive relationship to
 286 the quality of financing (NPF), meaning that when financing growth increases, the NPF increases. This is
 287 because an increase in credit caused by public consumption, an increase in people's income, or for the
 288 productive sector in developing micro-enterprises that are the object of a BPRS poses the risk of an increase
 289 in the NPF level, as revealed by Karmila (2013) and Saputro et al. (2019), which state that credit growth
 290 has a positive effect against NPF.

291 The result that in the long-term equation, GDP growth has a significant effect on financing quality (NPF)
 292 is in line with the hypothesis. In line with Firdaus (2017) and Alfaro et al. (2004), which state that GDP
 293 growth has a positive effect on NPF. This is because GDP growth, which also shows economic growth, can
 294 provide high expectations for banks in assessing their ability to pay customers so that banks are less careful
 295 in distributing financing so that it has the potential to increase NPF. GDP growth has a positive effect on
 296 financing quality, as is the procyclical indicator in the business cycle theory, which states that the indicator
 297 moves in line with the movement of the business cycle, while the NPF moves up in line with GDP growth,
 298 which also indicates a cyclical increase of business. The short-term findings indicate that the GDP growth
 299 variable has no significant effect on the financing quality variable. This is in line with Wahyudin et al.
 300 (2020), Dewi (2020), and Romadhoni (2017) who also revealed that GDP growth had no significant effect
 301 on financing quality. This is because not all customers have the ability or good faith to expanding their
 302 debts to banks despite GDP growth, which indicates improvement in the community's economy, so that the
 303 NPF value continues to rise even though it is not significant because the value is small or insignificant.

304 The long-term equation demonstrates that inflation significantly influences the quality of finance,
 305 corroborating the theory. Inflation adversely impacts the quality of financing, indicating that an increase in
 306 inflation results in a fall in the NPF. This is due to the activities of Islamic People's Financing Banks that

307 that provide funding in the real sector. Inflation, characterized by a rise in market prices, benefits
308 entrepreneurs by increasing their income, thereby facilitating debt repayment to banks and diminishing
309 NPF. This aligns with the findings of Poetry and Sanrego (2014), which indicated that inflation adversely
310 affects NPF. In the short term, inflation has no significant effect on the financing quality variable (NPF).
311 Continuous demand leading to inflation compels entrepreneurs to adjust their production capacity,
312 including capital, raw materials, technology, and labor. Consequently, it takes time later for entrepreneurs
313 to enhance income and pay debts to banks, which subsequently affects the reduction of bank NPF.
314 Quagliariello (2009) indicates that external shocks from the macroeconomy can impose pressure on the
315 probability of default on the t+2. The financial status of entrepreneurs is still undergoing adjustment, hence
316 in the near term, inflation does not necessarily decrease the NPF, consistent with the findings of Romadhoni
317 (2017), Dewi (2020), and Rindang (2019), which assert that inflation does not impact the NPF of BPRS.

318 The short-term results indicate that interest rates (JIBOR) significantly impact on financing quality,
319 supporting the hypothesis and aligning with Putri (2016), who demonstrated that interest rates have a
320 negative effect on NPF. In the short term, the interest rate (JIBOR) has a negative effect on the quality of
321 financing (NPF), meaning that when JIBOR increases, the NPF decreases. The return mechanism in Islamic
322 banking is based on a *ju'alah* contract or aligned with the benefits accrued (Fatwa Dewan Syariah Nasional
323 MUI 2007), ensuring that when the debtor achieves business success, rising interest rates do not impede
324 the debtor's ability to meet obligations, consequently reducing the NPF. In the long term, the JIBOR interest
325 rate has no significant effect on the financing quality variable (NPF). Islamic banks utilize alternative
326 financial instruments, such as Interbank *Mudharabah* Investment Certificate instruments or *Mudharabah*
327 Investment Certificate (IMA) to determine profit-sharing levels and margins in financing contracts
328 (Muhammad, 2002). The yields from these instruments is calculated based on a mutually agreed ratio.
329 Although JIBOR serves as short-term money market interest rate (overnight tenor) and generally acts as a
330 benchmark in determining the equivalent profit sharing in Islamic banks sharia, its impact on NPF is
331 minimal. This finding aligns with Wahyudin et al. (2020), which indicates that interest rates do affect NPF.

332 The long term outcomes indicates that the exchange rate (LKURS) has a significant effect on the quality
333 of financing (NPF). The finding is in line with Romadhoni (2017), which asserts that the exchange rate
334 (LKURS) has a positive effect on the NPF. Over the long term, the exchange rate (LKURS) has a positive
335 effect on financing quality (NPF), indicating that when the exchange rate (LKURS) increases or
336 depreciates, the NPF increases. The depreciation of the currency has an impact on hampering business
337 success by escalating production costs, particularly for importers and the diminishing entrepreneurs'
338 revenues. Consequently, entrepreneurs encounter challenges in debts repayment, which may lead to an
339 escalation in NPF. This aligns with Indra (2018), which states that exchange rate depreciation relates to an
340 increase in NPF. In the short term, the exchange rate (LKURS) exerts no significant influence on the
341 financing quality variable (NPF), as fluctuations in the rupiah exchange rate are relatively transient and do
342 not impede customers' ability to fulfil their financing obligations as stipulated in the contract (Wijoyo,
343 2016). Fluctuations in the rupiah exchange rate influence the timing of customer engagement in *murabahah*
344 finance, namely during the initiation of the transaction. The price of the purchased goods is established
345 according to market costs, the installments payments were agreed upon without accounting for future
346 fluctuations in the rupiah exchange rate. Consequently, in the short term, the exchange rate variations do
347 not necessarily elevate the NPF. This aligns with the findings of Sulastris et al. (2016) and Yolanda (2019),
348 which indicated that the exchange rate does not influence the NPF of BPRS.

349 Table 8. Sensitivity test

Long term equation									
F-stat	Prob. F(2,15)	Obs* R-sq	Prob. Chi-Sq	Note	F-stat	Prob. F(1,120)	Obs*R-sq	Prob. Chi-Square(2)	Note
90.4361 ₄	0.0000	75.19	0.0000	Autocorrelation	81.32	0.0000	49.28	0.0000	Heteroskedasticity
F-Stat	p-value								
6.659	0.0000								
Short term equation									
F-stat	Prob. F(2,113)	Obs* R-sq	Prob. Chi-Sq	Note	F-stat	Prob. F(1,119)	Obs*R-s	Prob. Chi-Sq	Note
0.03720 ₅	0.9635	0.080	0.9607	No Autocorrelation	1,839088	0.1776	1,841537	0.1748	No Heteroskedasticity
F-stat	P-value								
3.885	0.0001								

350 Tables 9 and 10 indicate that the long-term equation model exhibits issues with autocorrelation and
 351 heteroskedasticity. However, the short term equation models demonstrate no issue of autocorrelation and
 352 heteroskedasticity, with a probability chi-square value greater than 0.05.

353 4.1 Stress test

354 This study employed a stress test utilising a Monte carlo simulation comprising 500,000 trials, facilitated
 355 by Crystal ball software from Oracle. The variables considered in this analysis include financing growth
 356 (FNCG), GDP growth (GDP), inflation (INFL), interest rate (JIBOR) and exchange rate (LKURS), with
 357 the assumption that the follow a normal distribution.

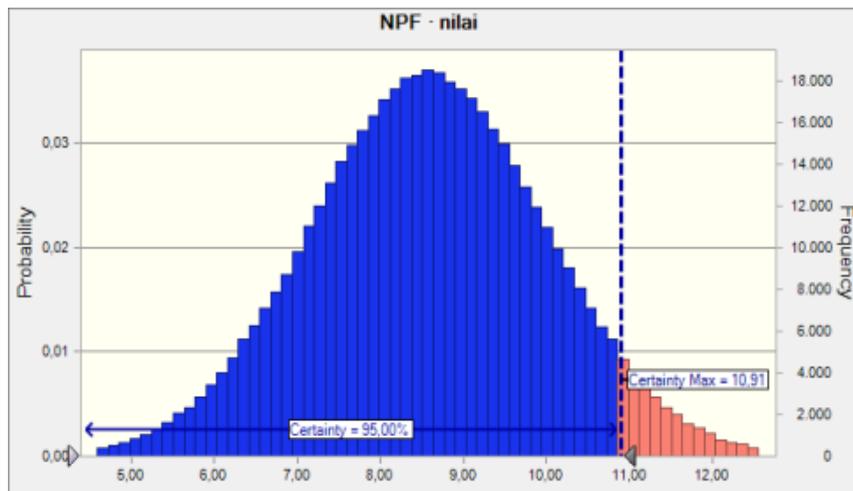


Figure 4. Forecast NPF

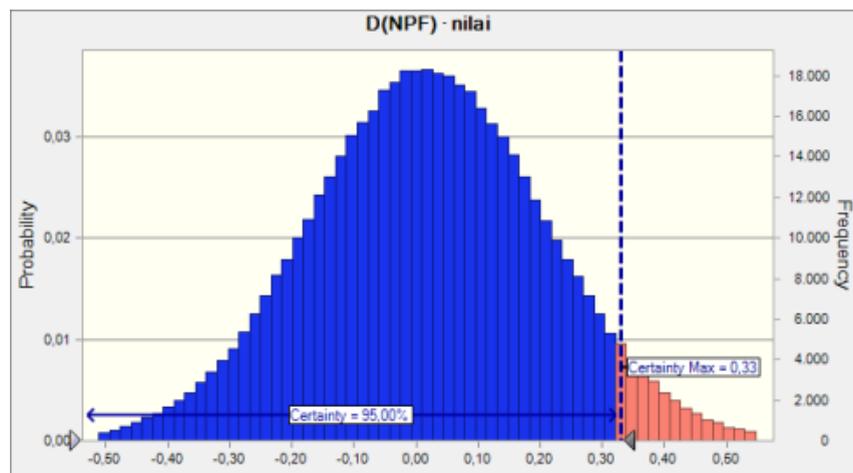


Figure 5. Forecast D(NPF)

358
359

360
361

362 Figure 4 dan Figure 5 indicate that, over the long term, the forecast maximum NPF is 10.91%, with a
 363 confidence level of 95%. The short term forecast indicates that the maximum D(NPF) is 0.33%, with a
 364 certainty level is 95%. The data indicates that Islamic Rural Banks (BPRS) in Indonesia exhibit a default
 365 probability, as evidenced by the NPF value exceeding 7%, categorizing them at level 3 in terms of the
 366 bank's health rating according to NPF (Salinan Peraturan Otoritas Jasa Keuangan Republik Indonesia
 367 2019). The high probability of default can influence the anticipated losses that impact the bank's
 368 profitability and capital reserves. The outcome will lead to an increased reserve for bank losses, resulting
 369 in a diminished effect on bank operating profit, while the formation of additional bank capital will be low.
 370 An increase in expected losses (EL) correlate with a higher the potential loss or credit risk encountered by
 371 banks. Consequently, it is essential for Islamic rural banks (BPRS) to exercise caution, remain vigilant, and
 372 proactively anticipate the high probability of default by maintaining sufficient capital reserves to mitigate
 373 potential losses. The role of a bank supervisor requires banks to hold more capital reserves (Bernanke,
 374 2013), and Beltratti and Stulz (2011) affirm that capital is a critical factor influencing a bank's performance.

375
376
377
378
379
380
381
382
383
384
385
386
387
388

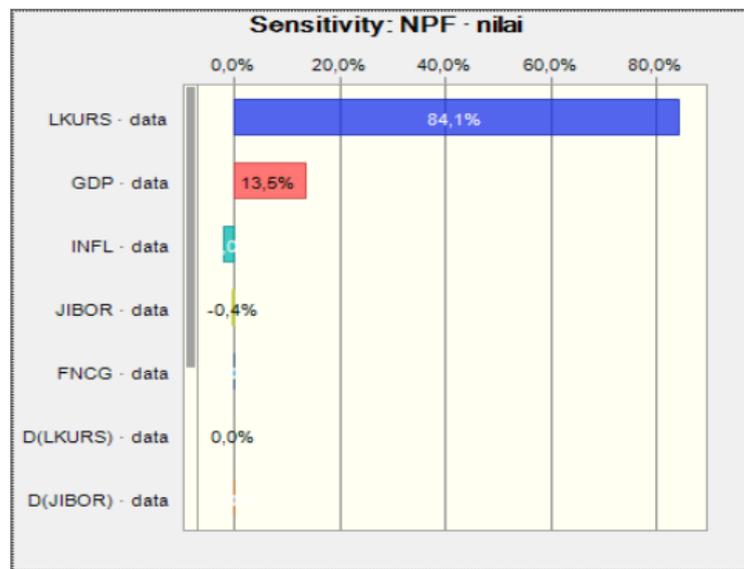


Figure 6. Sensitivity

389 Figure 6. indicates that the high level of NPF is influenced by the exchange rate, GDP growth, inflation
390 and interest rate. The strong influence of the exchange rate on NPF is due to the depreciation of the rupiah
391 against the US dollar from 2010 to 020. This depreciation adversely affected entrepreneurs' debt repayment
392 capabilities, consequently influencing NPF levels. The depreciation of the exchange rate can be attributed
393 to several factors, including the ongoing current account deficit since 2012, the withdrawal of
394 predominantly foreign portfolio investments from Indonesia, state budget politics concerning debt, the
395 strengthening of the US economy, and global economic slowdown (Adam, 2015).

396 The evidence supports the notion that the exchange rate contributed to the 2008 global crisis. The
397 stagnation of interbank loan flows and hampered international trade transactions were the primary factors
398 contributing to this situation. The 1998 financial crisis was initiated by external shocks, characterized by a
399 significant depreciation in the exchange rate. This event contributed to instability within the Indonesian
400 banking sector and resulted in a multi-dimensional crisis. It is worth noting that controlling the probability
401 of default requires careful consideration of various influencing factors, with particular emphasis on the
402 exchange rate, which significantly impacts NPF. It is crucial regulators and the government to manage
403 macroeconomic factors, particularly the exchange rate, to foster a favourable environment for the stability
404 of banks, especially Islamic Rural Bank (BPRS) in Indonesia.

405 5. Conclusion

406 The study concluded that the long-term increase of gross domestic product (GDP), inflation, and
407 currency rates significantly influences the NPF. Conversely, the interest rate significantly influences the
408 NPF in the short run. The augmentation of financing has no significant effect on the NPF budget, both in
409 the short term and the long term. The forecasted maximum NPF is 10.91%, the differential maximum NPF
410 is 0.33% at the confidence level of 95%. The results of the stress test reveal that the Islamic Rural Bank
411 (BPRS) in Indonesia has a substantial probability of defaulting on its obligations. This signifies that the
412 bank must focus more on the determinants influencing NPF, especially the currency rate, which exerts
413 considerable influence, and strive to anticipate the elevated likelihood of failure while ensuring adequate
414 capital reserves to sufficiently mitigate losses.

415 Acknowledgements

416 This study has many limitations including variables, theories, data, analytical methods, and simple stress
417 tests that has not yet measured the resilience of bank capital. Suggestions, criticisms and constructive input
418 are needed for further improvement.

419 Conflict of interest statement

420 The authors agree that this research was conducted in the absence of any self-benefits, commercial or
421 financial conflicts and declare the absence of conflicting interests with the funders.

422 References

- 423 Abel, A. B., Bernanke, B. S., & Croushore, D. (2008). *Macroeconomics* (6th ed.). Addison Wesley.
- 424 Adam, L. (2015). Mengurai penyebab dan solusi pelemahan nilai tukar rupiah. *Jurnal Ekonomi dan*
425 *Kebijakan Publik*, 7(15), 13-16.
- 426 Ahmad, F., & Bashir, T. (2013). Explanatory power of macroeconomic variables as determinants of non-
427 performing loans: Evidence from Pakistan. *World Applied Science Journal* 22(2): 243-255.
- 428 Alfaro, R., Franken, H., Garcia, C., & Jara, A. (2004). *The bank lending channel in Chile*. Banking
429 Market Structure and Monetary Policy.
- 430 Auliani, M. M., & Syaichu, M. (2016). Analisis pengaruh faktor internal dan faktor eksternal terhadap
431 tingkat pembiayaan bermasalah pada bank umum syariah di Indonesia periode tahun 2010-2014.
432 *Diponegoro Journal of Management*, 5(3), 559-572.
433 <https://ejournal3.undip.ac.id/index.php/djom/article/view/14644>
- 434 Barus, A. C., & Erick. 2016. Analisis faktor-faktor yang mempengaruhi non performing loan pada bank
435 umum di Indonesia. *Jurnal Wira Ekonomi Mikroskil*, 5(1), 113-122.
436 <https://doi.org/10.55601/jwem.v6i2.325>
- 437 Basel Committee on Banking Supervision. (2009). *Principles for sound stress testing practices and*
438 *supervision*. Bank for International Settlements.
- 439 Beltratti, A., & Stulz, R. M. (2011). *The credit crisis around the globe: why did some banks perform*
440 *better?* Fisher College of Business Working Paper No. 2010-03-005
- 441 Bernanke, B. S. (2013). *Stress testing banks: What have we learned?* Financial Markets Conference
442 Speech. Federal Reserve Bank of Atlanta.
- 443 Curak, M., Pepur, S., & Poposki, K. (2013). Determinants of non-performing loans -evidence from
444 Southeastern European banking systems. *Banks and Bank Systems*, 8(1). 45-53.
- 445 Dewi, I. P. (2020). Pengaruh inflasi, kurs, dan harga minyak dunia terhadap indeks harga saham
446 gabungan di bursa efek Indonesia. *Jurnal Ilmu Manajemen*, 17(1), 10-19.
- 447 Fatwa Dewan Syariah Nasional MUI 2007 No: 64/DSN-MUI/XII/2007
- 448 Firdaus, N. N. 2017. *Analisis determinan non performing loan pada bank umum konvensional di*
449 *Indonesia* [Master's thesis, Universitas Negeri Yogyakarta]. Eprints UNY.
450 https://eprints.uny.ac.id/52223/1/NoviaNurulFirdaus_13808141036.pdf
- 451 Ghosh, A. (2015). Banking-industry specific and regional economic determinants of non performing
452 loans: Evidence from US states. *Journal of Financial Stability*, 20, 93– 104.
- 453 Harahap, M. A. (2016). *Faktor-faktor yang mempengaruhi non performing financing pada bank syariah*

- 454 [Master's thesis, Universitas Islam Negeri Sumatera Utara]. UIN Sumatera Utara Repository.
455 <http://repository.uinsu.ac.id/1247/1/Tesis%20Muhammad%20Arfan%20Harahap%20docx.pdf>
- 456 Hibbeln, M. (2010). *Risk management in credit portfolios, concentration risk and basel II*. Physica-
457 Verlag.
- 458 Indra. (2018). A macro stress test model of credit risk: An empirical studies of conventional and Islamic
459 banking in Indonesia. *Jurnal Ekonomi & Kebijakan Publik*, 9(2). 113-129.
460 <https://jurnal.dpr.go.id/index.php/ekp/article/view/1063/654?csrt=12585961355698327835>
- 461 Karmila. (2013). *Bank loans*. PT Intan Sejati Klaten.
- 462 Kasmir. (2011). *Manajemen perbankan*. PT Raja Grafindo Persada.
- 463 Keeton, W. R. (1999). *Does faster loan growth lead to higher loan losses?* Economic Review, Second
464 Quarter. Federal Reserve Bank of Kansas City.
- 465 Klein, N. (2013). *Non-Performing Loans in CESEE: Determinants and impact on macroeconomic*
466 *performance*. IMF Working Paper No 13/72. International Monetary Fund.
467 <https://doi.org/10.5089/9781484318522.001>
- 468 Mankiw, N. G. (2006). *Pengantar ekonomi makro* (3rd ed.). Salemba Empat Jakarta.
- 469 Muhammad. (2002). *Sistem dan operasional bank syariah*. UII Press.
- 470 Nugrohawati, R. N. I., & Bimo, S. (2019). Analisis pengaruh faktor internal bank dan eksternal terhadap
471 non-performing financing (NPF) pada bank perkreditan rakyat syariah di Indonesia. *Jurnal Ekonomi*
472 *& Keuangan Islam*, 5(1), 42-49.
- 473 Ong, M. K. (1999). *Internal credit risk models: Capital allocation and performance measurement*. Risk
474 Books.
- 475 Peraturan Bank Indonesia 2003 No.5/7/PBI/2003
- 476 Peraturan Bank Indonesia 2007 No.9/29/PBI/DPbs/2007
- 477 Poetry, Z. D., & Sanrego, Y. D. (2014). Pengaruh variabel makro dan mikro terhadap NPL perbankan
478 konvensional dan NPF perbankan syariah. *Tazkia Islamic Finance and Business Review*, 6(2), 79-
479 104. <https://doi.org/10.30993/tifbr.v6i2.53>
- 480 Putri, R. N. S. (2016). Perilaku suku bunga perbankan di Indonesia. *Jurnal Pendidikan Ekonomi Dan*
481 *Bisnis*, 4(2), 109-135.
- 482 Quagliariello, M. (2009). *Stress testing the banking system: Methodologies and applications*. Cambridge
483 University Press.
- 484 Rahutami, A. I. (2011). *Model linier dinamik*. Universitas Katolik Soegijapranata.
- 485 Rindang. (2019). Analysis of the influence of bank internal and external factors on non-performing
486 financing (NPF) in Islamic rural banks in Indonesia. *Journal of Islamic Economics & Finance*, 5(1),
487 42-49
- 488 Rivai, V., & Ismail, R. (2013). *Islamic risk management for Islamic bank*. PT Gramedia Pustaka Utama.
- 489 Romadhoni, N. (2017). *Analisis kinerja keuangan PT. BRI Syariah dengan menggunakan pendekatan*
490 *rasio risk profile, good corporate governance, earnings, and capital tahun 2015-2017* [Master's
491 thesis, Institut Agama Islam negeri Purwokerto]. UNI Saizu. <https://repository.uinsaizu.ac.id/7436/>

- 492 Salinan Peraturan Otoritas Jasa Keuangan Republik Indonesia 2019 No.40/POJK.03/2019
- 493 Saputro, A. R., Sarumpaet, S., & Prasetyo, T. J. (2019). Analisa pengaruh pertumbuhan kredit, jenis
494 kredit, tingkat bunga pinjaman bank dan inflasi terhadap kredit bermasalah. *Ekspansi: Jurnal*
495 *Ekonomi, Keuangan, Perbankan dan Akuntansi*, 11(5), 1-11.
- 496 SK Direktur Bank Indonesia 1998 No.30/267/KEP/DIR
- 497 Sukirno, S. (2002). *Makro ekonomi modern*. P.T.Rajawali Grafindo Persada.
- 498 Sulastri, E., Hariadi, S., & Ariani, M. (2016). Analisis faktor atas non-performing financing BPR Syariah
499 di Indonesia periode 2012–2014. *Jurnal Ekonomi dan Bisnis*, 20(2), 59–68.
- 500 Surat Edaran Bank Indonesia 2007 No 9/29/DPbS
- 501 Taswan. (2006). *Manajemen perbankan*. Upp Stim Ykpn Yogyakarta.
- 502 Undang-undang Republik Indonesia 2008
- 503 Wahyudin, M. W., Novianty, I., & Burhany, D. I. (2020). The effect of economic condition and banking
504 policy on non-performing financing and profitability: Evidence from Islamic rural banks in
505 Indonesia. In *ISSAT: International Seminar of Science and Applied Technology. Advances in*
506 *Engineering Research*, 198 (pp.545-551). Atlantis Press. <http://dx.doi.org/10.2991/aer.k.201221.090>
- 507 Widyarningsih, A. (2021) *Analisis faktor makro ekonomi yang mempengaruhi non performing loan pada*
508 *perusahaan perbankan yang terdaftar di BEI* [Thesis, Universitas Muhammadiyah Surakarta].
509 Eprints UMS. <https://eprints.ums.ac.id/89472/1/NASKAH%20PUBLIKASI.pdf>
- 510 Wijoyo , N. A. (2016). *Menakar kinerja perusahaan pembiayaan*. Penerbit Universitas Indonesia.
- 511 Yolanda, S. (2019). Pengaruh faktor internal dan eksternal terhadap pembiayaan bermasalah pada Bank
512 Umum Syariah (BUS) dan Bank Pembiayaan Rakyat Syariah (BPRS). *Jurnal Kajian Ekonomi dan*
513 *Pembangunan*, 1(3), 834-844.
- 514 Yulianto, A., & Solikhah, B. (2016). The internal factors of Indonesian sharian banking to predict the
515 mudharabah deposits. *Review of Integrative Business & Economic Research* 5(1), 210–218.

516 About the Authors

517 Uvy Dian Rizky, S.Sos. M.M. (ORCID : <https://orcid.org/0009-0004-5726-4995>) is an alumnus of Masters
518 in Management at Hayam Wuruk Perbanas University, Surabaya. Interest in Islamic banking and financial
519 business research. Once taught as an extraordinary lecturer at STIE IBMT Surabaya in strategic
520 management, micro and macro economics courses. Currently she is focusing on studying in preparation for
521 pursuing a PhD scholarship in management. Her email address is uvyidian@gmail.com.

522 Prof. Drs. Ec. Abdul Mongid, MA., Ph.D. (ORCID : <https://orcid.org/0000-0001-5778-9194>) is currently a
523 faculty member at the Universitas Hayam Wuruk Perbanas, Surabaya. His current research interests include
524 governance, financial system stability, risk management especially in Islamic banking. Currently he is a
525 Director Executive II of the Islamic Economic Development of East Java, Governor / State organization
526 level. He is a member of the Central Board of the Indonesia Economic Association (ISEI), Islamic
527 Economics Scientist Association (IAEI) and the Risk Association (BSMR-GARP). His email address is
528 amongid@gmail.com.



© 2025 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).