

ANALYSIS OF BANK HEALTH STABILITY USING THE LOTKA-VOLTERRA COMPETITION MODEL APPROACH

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Abstract

The purpose of this study is to conduct a mathematical analysis to determine the stability of bank health through profitability and liquidity variables. Profitability is measured by return on assets (ROA), and liquidity is measured by the loan-to-deposit ratio (LDR). In addition, this study also forecasts the ROA and LDR values for the next few years. This study adopts the Lotka-Volterra (LV) competition model approach. The data used are ROA and LDR values from the annual report of PT Bank Rakyat Indonesia (BRI) Tbk for the period 2007-2023. The results of the study show that BRI bank is in a healthy condition in the period 2012-2023. On the other hand, the stability analysis shows that BRI bank's health is stable. The forecasting results of the ROA and LDR values are stagnant. However, the ROA and LDR values are still healthy because they remain above the minimum threshold.

Keywords: BRI; forecasting; liquidity; LV model; profitability; stability of bank health

INTRODUCTION

The history of banking in Indonesia cannot be separated from the Dutch East Indies colonial era. At that time, De Javasche Bank (DJB) was established in Batavia on January 24, 1828, and then followed by other banks. In Indonesia, banking practices have spread to remote villages. Currently, the type of banking financial institutions in Indonesia are Commercial Banks, Rural Credit Banks (BPR), Islamic Commercial Banks, and also Islamic BPRs (BPRS) (OJK, 2019). In Indonesia, banks are basically grouped into Commercial Banks and Rural Credit Banks (BPR), while Bank Indonesia (BI) functions as the central bank. However, in line with changes in the financial system, especially those related to banking institutions as a result of the issuance of laws in the field of banking finance, banks in Indonesia can be distinguished based on: (1) function; (2) ownership; (3) interest rate system; (4) activities in the foreign exchange sector; and (5) type of office (Hasan, 2014).

The banking sector plays a vital role in economic growth and development activities in Indonesia. Through the distribution of credit that has a positive and transformative impact, as well as the digitalization of products and services, banks provide extensive benefits to the community (KemsetnegRI, 2024). This is in line with several studies which state that the stability and growth of the banking sector determines the long-term projections of companies and the economy (Ali et al., 2022; Belkhir et al., 2022).

Every bank indeed continues to innovate in order to survive in the competition and to gain maximum profit. Banks expect profits like other companies, but banks are required to be careful, for example, in loan management. Riskier but profitable loans can lead to a decline in asset quality. This can affect the long-term survival of banks (Banerjee & Velamuri, 2015). In addition, every bank undoubtedly aims to generate large profits. Profitability is a ratio used to measure a bank's ability to earn profits or the difference between the bank's operating costs and income (Bassey & Moses, 2015). The instrument used to measure bank profitability is the return on assets (ROA). In general, the ROA value can be seen from the bank's annual report, for example the annual report of BRI bank (BRI, 2024).

Bank profitability is influenced by several factors, one of which is liquidity (Koroleva et al., 2021). Bank liquidity refers to the bank's ability to ensure the availability of funds to meet financial commitments or maturing obligations at a fair price at all times (Olagunju et al., 2011). Insufficient liquidity can damage the company's goodwill, lower its credit rating and even lead to a forced sale of its assets. On the other hand, excess liquidity refers to the accumulation of idle money that does not generate income (Gill, 2022) and also invites various problems (Acharya & Naqvi, 2012; Ahmad et al., 2022). Furthermore, the instrument used to measure bank liquidity is the loan-to-deposit ratio (LDR). In general, the LDR value can be seen from the bank's annual report, for example the annual report of BRI bank (BRI, 2024).

The relationship between liquidity and profitability has been widely studied by other researchers. A research found that higher liquidity is often detrimental to banks, which implies that higher liquidity can reduce profitability (Vu, 2024). In addition, if liquidity increases, profitability decreases, and vice versa (Javid, et al., 2024). Furthermore, studies related to the relationship between profitability and liquidity have also been conducted by (Paul et al., 2021; Thinh et al., 2022). The results of the study from (Paul et al., 2021) stated that, in general, liquidity has a significant effect on profitability in the commercial banking sector of Bangladesh, while the results of the study from (Thinh et al., 2022) found that liquidity has a positive relationship with bank profitability which includes return on assets, return on equity and net interest margin.

According to the trade-off theory, higher liquidity can reduce the bank's risk and hence, the premium is required to compensate investors for the costs of bankruptcy. The survival of a bank's deposits depends heavily on how liquid it is, since a lack of liquidity is a sign of trouble ahead. This can undoubtedly erode public confidence in the banking system and lead to withdrawals from deposits (Olagunju et al., 2011).

Although research on the relationship between profitability (measured by ROA) and liquidity (measured by LDR) in the banking sector has been widely conducted (Javid, et al., 2024; Paul et al., 2021; Thinh et al., 2022; Vu, 2024), the analysis of the stability of both is still under investigated. Therefore, the novelty of this study includes the dynamics of stability between ROA and LDR. In the process of determining this stability, we also involve the bank's internal competition factor in the analysis process.

Based on the explanation above, the objectives of this study are: (1) to determine the stability of bank health through ROA variables and LDR variables; and (2) to forecast ROA and LDR values for the next few years. The method employed in this study is the Lotka-Volterra (LV) competition model approach (Hastings, 2013). The LV model basically aims to analyze the dynamics of competition that occurs among competing populations. Based on the number of variables analyzed, the LV model adopted in this study consists of two variables and six model parameters. To obtain the six parameter values, we complete the parameter estimation process based on data using the Log Integral method (Kloppers & Greeff, 2013). The data of this study are data taken from the annual report of Bank Rakyat Indonesia (BRI) for the period 2007-2023 (BRI, 2024). The annual report is in the form of profitability and liquidity values. Profitability is measured by return on assets (ROA), and liquidity is measured by loan-to-deposit ratio (LDR).

There are four main contributions made by this study. First, by applying the mathematical model approach of competition, this study provides a new perspective in viewing the dynamics of

stability between ROA and LDR in the banking sector. In addition, this study provides information related to the type of competition between ROA and LDR in the banking sector. Based on its role, competition is divided into six types: mutualism, predator-prey, commensalism, amensalism, pure competition and neutralism (Mougi, 2016). Third, this study also presents the results of forecasting the ROA and LDR values of BRI Bank for the next few years. Finally, it offers a policy analysis that can be taken to maintain a balance between ROA and LDR values.

The rest of this study is structured as follows. The second section provides a more in-depth literature review, while the third section presents the data and methodology. In this section, we briefly describe the historical data and explain the stages of the methodology used. The fourth section presents the results and discussion, focusing on estimating ROA and LDR values using the LV competition model approach. The last section is the conclusion and suggestion.

METHODS

The data of this study are taken from the annual report of PT Bank Rakyat Indonesia (BRI) Tbk for the period 2007-2023 (BRI, 2024). The annual report is in the form of profitability and liquidity data. Profitability is measured by return on assets (ROA) and liquidity is measured by the loan to deposit ratio (LDR).

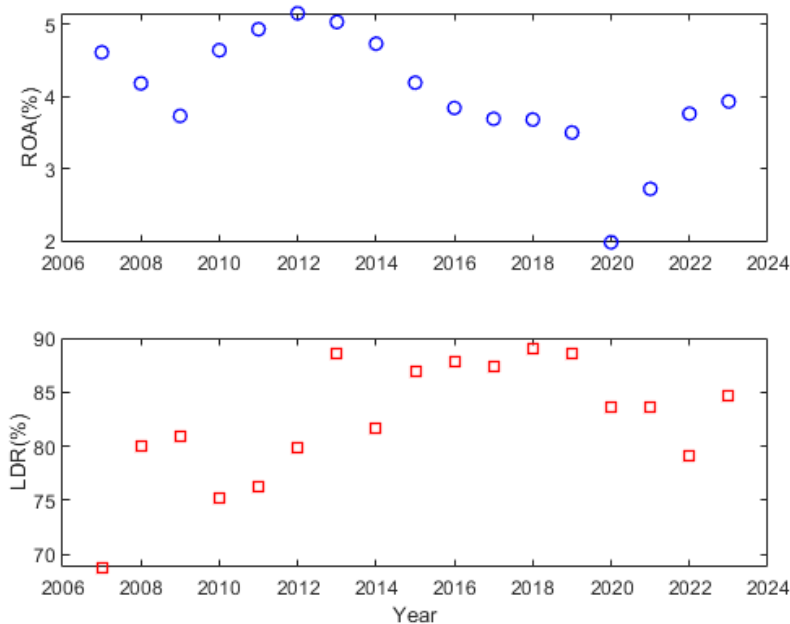


Figure 1. ROA and LDR Values of BRI Bank for the Period 2007-2023

Based on Figure 1, the ROA and LDR values of BRI Bank fluctuated throughout the 2007-2023 period. The highest ROA value was achieved by BRI Bank in 2012 at 5.15 percent, while the lowest one was achieved in 2020 at 1.98 percent. On the other hand, the highest LDR value was achieved by BRI Bank in 2018 at 88.96 percent, while the lowest value was achieved in 2007 at 68.8 percent.

In general, several important phenomena can be summarized from the data above: (1) if the LDR value increases, the ROA value decreases, as exemplified by the ROA and LDR values of 2007-2008 period; (2) if the LDR value decreases, the ROA value increases, as exemplified by the ROA and LDR values of 2014-2016 period; (3) if the LDR value increases, then the ROA value also increases, as instanced by the ROA and LDR values of the 2022-2023 period; and (4) if the LDR value decreases, then the ROA value also decreases, as exemplified by the ROA and LDR values of 2013-2014 period. Therefore, these four phenomena can be explained by the Lotka-Volterra (LV) competition model (Hastings, 2013; Jamal et al., 2024).

This study uses a mathematical approach by adopting the Lotka-Volterra (LV) competition model (Hastings, 2013; Kloppers & Greeff, 2013). This model is a system of first-order differential equations involving several time-dependent variables. The LV competition model approach basically aims to analyze the dynamics of competition that occurs among competing populations. Based on the number of variables analyzed in this study, the LV competition model formed consists of two variables and contains six model parameters. In this study, BRI bank's ROA and LDR are sequentially assumed to be variables x and y . There are three basic assumptions used to form the LV competition model: (1) the growth rate of ROA and LDR grows exponentially; (2) the growth rate of ROA and LDR depends on time t ; and (3) the existence of intra-competition and inter-competition. Based on these three assumptions, the LV competition model can be written as follows:

$$\frac{dx}{dt} = a_0x + a_1x^2 + a_2xy, \quad \frac{dy}{dt} = b_0y + b_1y^2 + b_2xy, \quad \dots\dots\dots(1)$$

where variable $x, y \geq 0$ and parameters $a_0, a_1, a_2, b_0, b_1, b_2 \in \mathbb{R}$. Parameters a_0 and b_0 are the intrinsic growth rate of ROA and the intrinsic growth rate of LDR, respectively. Parameters a_1 and b_1 are the intra-competition coefficient of ROA and the intra-competition coefficient of LDR, respectively. Parameters a_2 and b_2 are the inter-competition coefficient of ROA against LDR and the inter-competition coefficient of LDR against ROA, respectively. (Hastings, 2013).

The differential equation system (1) contains six parameters, namely a_0, a_1, a_2, b_0, b_1 and b_2 . To obtain these six parameter values, we complete the parameter estimation process based on data using the Log Integral method (Kloppers & Greeff, 2013). After estimating the parameters, the values of the six parameters were substituted into the model (1). Furthermore, we calculated the equilibrium point and tried to determine the stability properties of the two variables (Ang et al., 2019; Jamal et al., 2024; Jamal & Suparno, 2022; Mohammed et al., 2021). In this study, the process of parameter estimation, forecasting and numerical simulation used the Matlab application.

After performing the above analysis, we evaluated the accuracy of the generated LV model. The accuracy of this model was evaluated using the Mean Absolute Percentage Error (MAPE). The size of the MAPE error can be calculated using the following formula:

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{h_i - p_i}{h_i} \right| \times 100\%, \quad i = 1 \dots n, \quad \dots\dots\dots(2)$$

where h_i and p_i are historical data and estimated data, respectively, and n is the number of research data. The criteria for MAPE accuracy can be found in (Castle et al., 2023). If the MAPE accuracy value produced by model (1) provides a highly accurate or good value, then we continued the process to the ROA and LDR value forecasting stage for the next few years.

RESULTS

To obtain parameter values in model (1) based on empirical data, we applied the Log Integral method (Kloppers & Greeff, 2013). The calculation results can be seen in the Table 1.

Table 1. Parameter Values

Variable	Parameter values (percent/year)		
ROA	$a_0 = 1.4464$	$a_1 = -0.0407$	$a_2 = -0.0156$
LDR	$b_0 = 0.4421$	$b_1 = -0.0027$	$b_2 = 0.0238$

Based on the parameter estimation results shown in Table 1, model (1) can be written as

$$\frac{dx}{dt} = 1.4464x - 0.0407x^2 - 0.0156xy, \quad \frac{dy}{dt} = 0.4421y - 0.0027x10^{-9}y^2 + 0.0238xy. \quad \dots\dots(3)$$

From model (3) it can be seen that the intrinsic growth rates a_0 and b_0 are each positive. The intra-competition coefficients of ROA and LDR are each negative. In addition, the interaction coefficient a_2 is negative and the interaction coefficient b_2 is positive. Therefore, the type of competition between ROA and LDR is the predator-prey type, where ROA acts as prey and LDR acts as predator.

The estimation of ROA and LDR values based on empirical data was obtained by performing numerical calculations using the Matlab application. The numerical calculation process was completed by writing model (3) into the Matlab script, then performing numerical analysis using the ode45 tool. The results of the numerical calculations can be seen in the Figure 2.

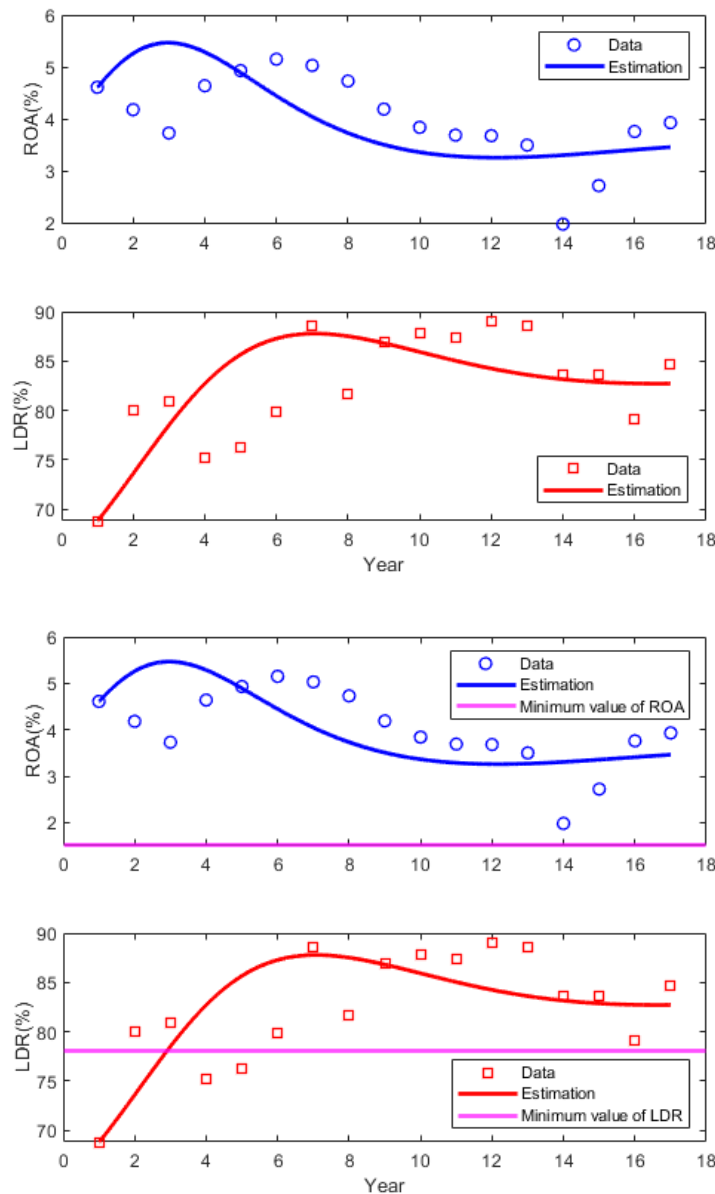


Figure 2. (a) The Results of the ROA and LDR Estimation for the Period 2007-2023; and (b) The Minimum Threshold for ROA and LDR Values

Figure 2.a is the estimated trajectory produced by the LV model. It is clearly seen that the trajectory of model (3) follows the empirical data distribution pattern, while Figure 2.b is a graph of the minimum threshold for ROA and LDR values based on Bank Indonesia (BI) regulations. The minimum threshold value for ROA is 1.5 percent/year, and for LDR is 78 percent/year (BI, 2024).

Furthermore, to determine the level of model accuracy, the errors produced by model (3) are important to calculate. One of the formulas used to measure the level of accuracy of a model is the MAPE formula. The MAPE values of BRI bank's ROA and LDR are presented in the Table 2.

Table 2. MAPE Values and Model Accuracy

No.	Year	ROA Data (%)	LDR Data (%)	Estimated ROA (%)	Estimated LDR (%)	(ROA) $\sum_{i=1}^n \left \frac{h_i - p_i}{h_i} \right \times 100\%$	(LDR) $\sum_{i=1}^n \left \frac{h_i - p_i}{h_i} \right \times 100\%$
1	2007	4.61	68.8	4.61	68.8	0.000	0.000
2	2008	4.18	79.93	5.254	73.519	25.694	8.021
3	2009	3.73	80.88	5.466	78.484	46.542	2.962
4	2010	4.64	75.17	5.286	82.689	13.922	10.003
5	2011	4.93	76.2	4.891	85.651	0.791	12.403
6	2012	5.15	79.85	4.445	87.271	13.689	9.294
7	2013	5.03	88.54	4.046	87.773	19.563	0.866
8	2014	4.73	81.66	3.731	87.506	21.121	7.159
9	2015	4.19	86.88	3.506	86.801	16.325	0.091
10	2016	3.84	87.77	3.363	85.917	12.422	2.111
11	2017	3.69	87.44	3.285	85.027	10.976	2.760
12	2018	3.68	88.96	3.258	84.237	11.467	5.309
13	2019	3.5	88.64	3.269	83.603	6.600	5.683
14	2020	1.98	83.66	3.305	83.145	66.919	0.616
15	2021	2.72	83.67	3.354	82.859	23.309	0.969
16	2022	3.76	79.17	3.408	82.723	9.362	4.488
17	2023	3.93	84.73	3.460	82.709	11.959	2.385
Total (%)						310.660	75.119
MAPE (%)						18.274	4.419
Model accuracy (%)						81.726	95.581

Table 2 shows that the MAPE value for ROA is 18.274 percent (less than 20 percent), and the accuracy value of model (3) for ROA reaches 81.724 percent. In addition, the MAPE value for LDR is 4.429 percent (less than 10 percent) and the accuracy value of model (3) for LDR reaches 95.581 percent. Based on the MAPE accuracy criteria, the accuracy level of the model (3) in estimating the ROA value is good, and the accuracy level of the model (3) in estimating the LDR value is very accurate. Thus, the proposed LV model is an accurate model to describe the dynamics of interaction between ROA and LDR.

Next, we analyzed equilibrium points generated by model (3) and its stability properties. Based on the equilibrium point analysis (Jamal et al., 2024; Novoa-Muñoz et al., 2021; Windarto & Eridani, 2020), the model (3) has four equilibrium points with positive values, with one equilibrium point that does not contain zero. The equilibrium points were obtained by making model (3) equal to zero ($dx/dt = dy/dt = 0$). By performing algebraic manipulation techniques, we obtained the four equilibrium points. Each equilibrium point obtained was then determined for its stability properties by taking several initial values around the equilibrium point, and evaluated based on time t (Hastings, 2013; Jamal et al., 2024). The four equilibrium points and their stability properties are presented in the Table 3.

Table 3. Equilibrium Points of Model (3) and Its Stability

No.	Equilibrium point	Bank health	Stability
1	$E_0(0, 0)$	Unhealthy	Unstable
2	$E_1(35.4680, 0)$	Unhealthy	Unstable
3	$E_2(0, 52.4560)$	Unhealthy	Unstable
4	$E_3(3.5247, 83.4323)$	Healthy	Stable

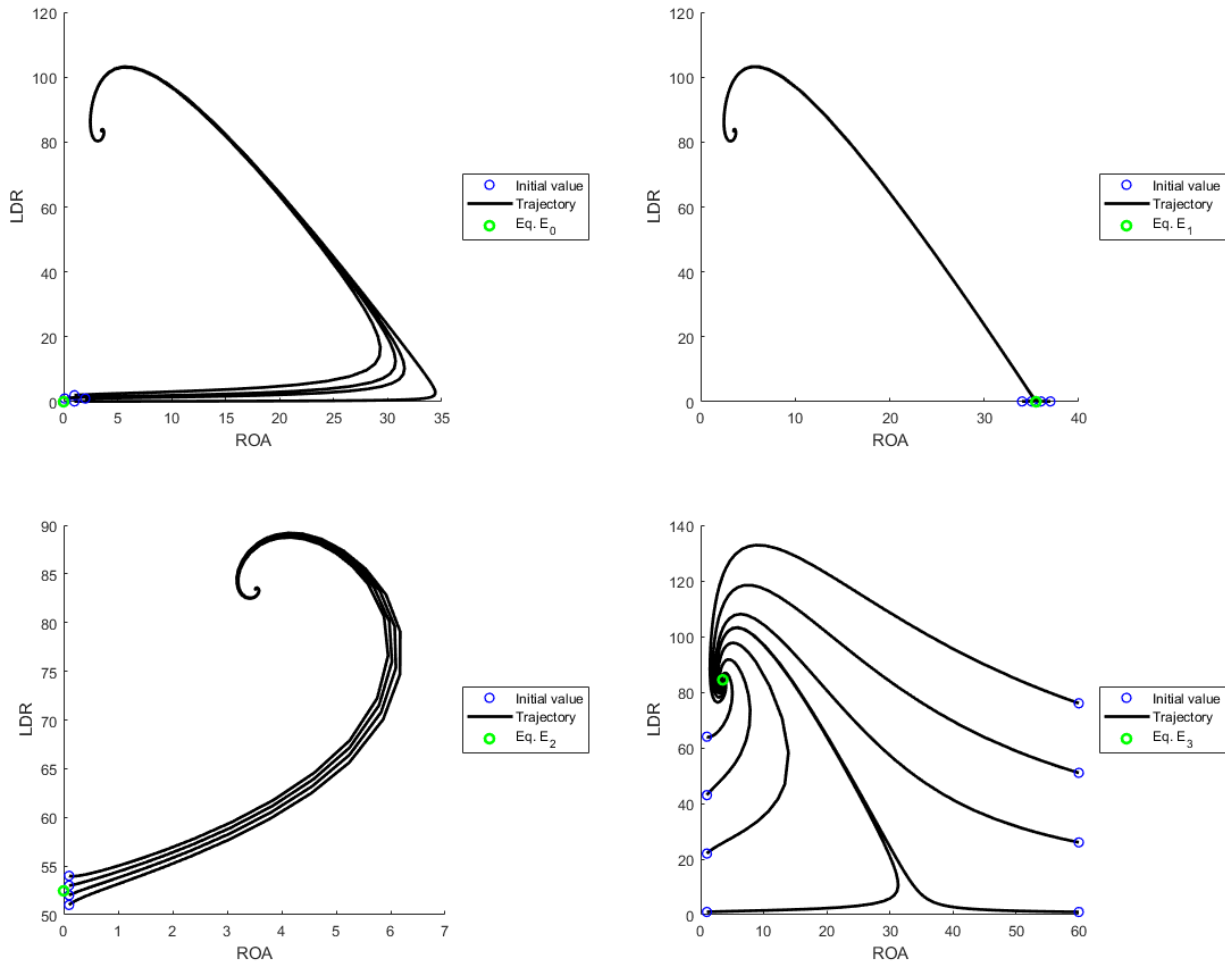


Figure 3. Phase Portrait of the Stability of the Four Equilibrium Points of Model (3) with Several Initial Values

Based on Figure 3, the phase portraits of the equilibrium points E_0 , E_1 and E_2 are each unstable because for each initial value taken around each equilibrium point, it moves away from its equilibrium point. However, a different phenomenon is shown by the equilibrium point E_3 . This equilibrium point is stable, because for each initial value taken around the equilibrium point, it always converges to its equilibrium point. Because the equilibrium points E_0 , E_1 and E_2 indicate that the bank is in an unhealthy state, the following discussion will only focus on the non-zero equilibrium point E_3 .

We have determined the model's accuracy using the MAPE formula measure. The calculation results show that model (3) has a good level of accuracy for ROA and is very accurate for LDR. Therefore, it can be used in forecasting the ROA and LDR values of BRI bank for the next few years. The results of forecasting the ROA and LDR values can be seen in the Table 4 and Figure 4.

Table 4. Results of Forecasting ROA and LDR Values for the Period 2024-2030

No.	Year	ROA (%)	LDR (%)
1	2024	3.503	82.781
2	2025	3.536	82.906
3	2026	3.559	83.055
4	2027	3.569	83.202
5	2028	3.571	83.331
6	2029	3.567	83.432
7	2030	3.559	83.501

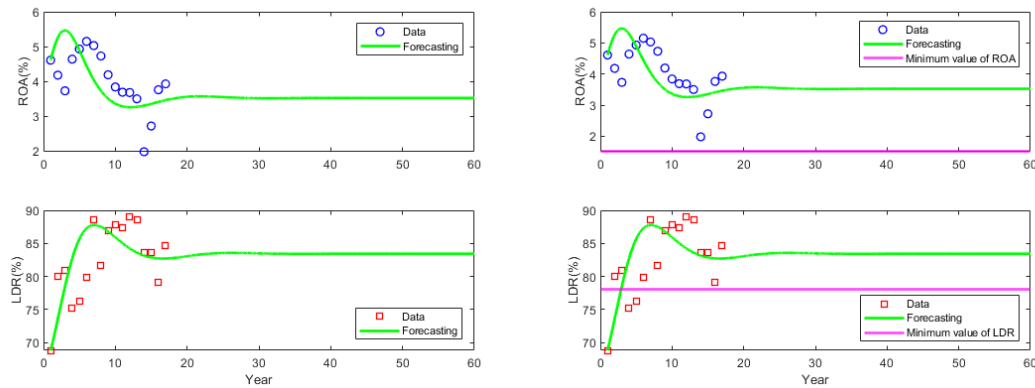


Figure 4. (a) Trajectory Results of Forecasting ROA and LDR Values for the Next Several Years; and (b) Minimum Threshold for ROA and LDR Values

Based on Table 4, it is clear that the ROA value for the period 2024-2030 does not exceed 4 percent and the LDR value for the same period does not reach 84 percent. In addition, based on Figure 4.a, both ROA and LDR values have been stagnant for a fairly long period. However, BRI bank's ROA and LDR values are still above the minimum threshold set by Bank Indonesia (BI) (Figure 4.b).

From the analysis of the competition type between ROA and LDR of BRI bank, it was obtained that the competition type between the two is the predator-prey type, with the predator being LDR and the prey being ROA. Based on the nature of this competition type, every increase in the LDR value always reduces the ROA value. Therefore, to increase the ROA value, BRI bank must reduce the intrinsic growth rate of LDR. Based on this fact, model (3) above can be modified by substituting a new parameter (β) which is of a nature to reduce the LDR value in the system. The new model can be written as follows:

$$\frac{dx}{dt} = 1.4464x - 0.0407x^2 - 0.0156xy, \quad \frac{dy}{dt} = (0.4421 - \beta)y - 0.0027x10^{-9}y^2 + 0.0238xy, \quad \dots\dots\dots(4)$$

where parameter β is the decrease in the intrinsic growth rate of LDR.

Non-zero equilibrium point $E_{\beta} (E_{\beta_{ROA}}, E_{\beta_{LDR}})$ of model (4) is written as follows.

$$\begin{aligned} E_{\beta_{ROA}} &= 32.36\beta + 3.5246, \\ E_{\beta_{LDR}} &= -84.5309\beta + 83.4323. \end{aligned} \quad \dots\dots\dots(5)$$

By varying the parameter value β in equation (5), we obtained the ROA and LDR values for the next few years. Changes in the parameter values β , ROA and LDR can be seen in the Table 5 and Figure 5.

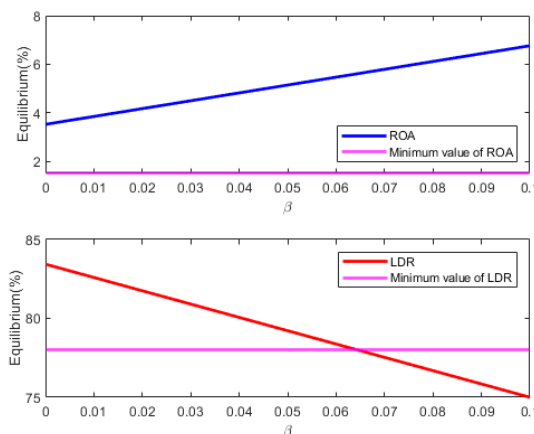


Figure 5. Graph of Changes in ROA and LDR Values due to the Influence of Parameter β

Table 5 clearly shows that the ROA and LDR values are influenced by parameter β . While the ROA value has consistently increased, the LDR value has consistently decreased. In addition, the ROA value is always above the minimum ROA value threshold, while the LDR value continues to drop until its value is smaller than the minimum LDR value threshold (see Figure 5). By using the minimum LDR value threshold set by Bank Indonesia (BI), the tolerable value of parameter β is $0 \leq \beta \leq 0.06$, with the smallest LDR value of 78.3605 percent.

DISCUSSION

Based on the analysis results, the intrinsic growth rates of ROA and LDR are each positive, with the intrinsic growth rate of ROA being greater than that of LDR (see Table 1). This is indeed a great finding for BRI bank. The high intrinsic growth rate causes the estimated ROA value to always be above 1.5 percent each year during the 2007-2023 period. In addition, the intrinsic growth rate of LDR also causes the estimated LDR value to be more than 78 percent each year during the 2012-2023 period (see Figure 2). In general, both of these results exceed the minimum threshold specified in Bank Indonesia (BI) regulations. The minimum threshold value for ROA is 1.5 percent per year, and for LDR it is 78 percent per year (BI, 2024). These results are in line with the annual report released by BRI bank (BRI, 2024). The annual report states that both ROA and LDR values are in normal conditions.

The intra-competition coefficients of ROA and LDR are each negative, with the intra-competition coefficient of ROA being smaller than that of LDR (see Table 1). Since both coefficients are negative, the intra-competition that occurs in BRI bank always reduces the ROA and LDR values. However, the reduction in ROA value is always greater than the reduction in LDR value. Furthermore, the inter-competition coefficients of ROA and LDR have different signs. The inter-competition coefficient of ROA against LDR is negative, while that of LDR against ROA is positive. Therefore, the type of competition that occurs between the two is the predator-prey type. This type of competition states that every increase in the value of the intra-competition coefficient of LDR causes a decrease in the ROA value, and vice versa. These results are in line with research conducted by (Jamal et al., 2024) for PT. Indofood, which found that the type of competition between profitability (ROA) and liquidity (LDR) of the period 2011-2022 is the predator-prey type. In addition, these results are also in line with other studies conducted by (Paul et al., 2021). The results of the study by (Paul et al., 2021) stated that, in general, liquidity has a significant effect on profitability in the commercial banking sector of Bangladesh.

The minimum threshold in Bank Indonesia (BI) regulations for ROA is 1.5 percent per year, and for LDR is 78 percent per year (BI, 2024). Based on the study results above, the ROA value for the 2007-2023 period was always above the minimum threshold, except the one in 2010-2011 period (see Figure 2). In general, from 2012 to 2023, both the ROA value and the LDR value of BRI bank always exceeded the minimum threshold. Therefore, in the 2012-2023 period, BRI bank was in a healthy condition. These results are in line with research conducted by (Wiyati et al., 2023). They analyzed the health of BRI bank using a descriptive method with a quantitative approach, and found that in the 2017-2021 period, the bank received a composite rating of 1, which means that its condition is generally very healthy.

It is known that BRI Bank is in a healthy condition, so the question that arises then is whether BRI Bank is stable or not. To answer this question, stability analysis is important to perform. Stability analysis shows that the non-zero equilibrium point E_3 in model (3) indicates that the equilibrium point is stable (see Figure 3.d). Thus, BRI Bank is in a healthy and stable condition. This result is in line with research conducted by (Santoso et al., 2023). Their study analyzed the effect of concentration levels on the stability of Indonesian general-Islamic banks for 2011-2020. The main result they found was that in a more concentrated environment, banks tend to be more stable.

Furthermore, the analysis of the model accuracy using the MAPE formula shows that model (3) has a good level of accuracy. Therefore, the model can be used in forecasting. The forecasting

results show that the ROA and LDR values for the 2024-2030 period are stagnant (see Table 4). If the analysis period is extended, both values will continue to show the same stagnant pattern. However, the ROA and LDR values are still healthy, because they remain above the minimum threshold (see Figure 4).

The type of competition that occurs between ROA and LDR of BRI bank for the period 2007-2023 is the predator-prey type, and the stability of both is good (stable). In addition, the forecast results for a fairly long period also show a stable pattern. Thus, for the next few years, the ROA and LDR values will not increase or stagnate. Therefore, BRI bank must take a step to overcome this situation. Given the predator-prey type of competition, where LDR always reduces the ROA value, one policy that can be taken by BRI bank is to reduce the intrinsic growth rate of LDR.

The results of the equilibrium analysis show that the equilibrium for ROA is inversely proportional to the equilibrium for LDR (see equation (5)). By reducing the intrinsic growth rate of LDR, the ROA value increases. However, it should be noted that the reduction in the LDR value must not be less than its minimum threshold so that the reduction in the intrinsic growth rate of LDR must be in the tolerance interval $0 \leq \beta \leq 0.06$, with the smallest LDR value of 78.361 percent (see Table 5). Because there is a tolerance interval for the LDR value, the increase in the ROA value must have a maximum value. The maximum value is 5.466 percent (see Figure 5). If the reduction in the intrinsic growth rate of LDR is more than the permitted tolerance interval, then BRI bank is in an unhealthy condition.

CONCLUSIONS

Profitability and liquidity are two important factors that must be studied and considered by the management of every organization, especially the banking sector. Both can be used to see the level of bank health. In this study, profitability is measured by return on assets (ROA), and liquidity is measured by the loan-to-deposit ratio (LDR). This study has conducted an analysis to determine the stability of bank health through the ROA and LDR variables and also forecasted the ROA and LDR values for the next few years. This study adopts the Lotka-Volterra competition model approach. The data used are the ROA and LDR values taken from the annual report of PT Bank Rakyat Indonesia (BRI) Tbk for the period 2007-2023. The results of the analysis show that in general, BRI bank is in a healthy condition in the period 2012-2023. This is evidenced by the ROA and LDR values which consistently exceed the minimum threshold set in Bank Indonesia (BI) regulations. Furthermore, the type of competition that occurs between the ROA and LDR variables is the predator-prey type, with ROA acting as the prey and LDR acting as the predator. This means that if the LDR value increases, the ROA value decreases, and vice versa. On the other hand, it is found that the BRI bank's health is stable. Furthermore, the forecasting results show that the ROA and LDR values for the 2024-2030 period are stagnant. However, the ROA and LDR values are considered healthy because they remain above the minimum threshold.

The study's findings suggest that BRI's stable ROA and LDR make it a low-risk investment, though investor should monitor loan growth to avoid profitability decline. Forecast indicate stagnation in both indicators, emphasizing the importance of realistic expectations for future returns. For regulators, the results highlight the need to supervise lending practices and conduct stress tests to ensure ongoing bank stability. The predator-prey relationship between ROA and LDR also suggest that imbalances in liquidity and profitability could risks if not managed properly.

The limitation of this study is that the model used includes only two dependent variables, namely ROA and LDR. For more comprehensive research, researchers can add one or more new variables to the system, so that the competition model formed becomes more complex (three-dimensional or more). The addition of these new variables can provide more accurate and precise estimation results since they are closer to reality.

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