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Competition Dynamics of Market Share for Assets in the Banking Industry Using the Lotka-Volterra Model Approach

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Abstract

Research Originality: Competition in the banking sector is unavoidable. Such competition is present among state-owned banks in Indonesia. In contrast to the previous studies that did not include the competition type and its stability, this study includes the competition type and its stability in the estimation.

Research Objectives: This study aims to discover the competition type and its stability, and to forecast the market share among the four state-owned banks.

Research Methods: Using market share data of assets published annually by each of the banks from 2010 to 2023, the study employs the Lotka-Volterra model approach to analyze the competition type and its stability that occur among the four state-owned banks.

Empirical Results: The study discovers that the competition types of the four state-owned banks vary. There have been three competition types among the four state-owned banks: mutualism, predator-prey and pure competition. Besides, the stability property of the four state-owned banks tended to be unstable. As a result, the total market share gains for the four state-owned banks declined sequentially.

Implications: This research holds significance for four state-owned banks in Indonesia as it provides valuable insights into considering the three competition types (mutualism, pure competition and predator-prey) as the primary key to achieving a significant market share value.

Keywords:

asset; competition type; Lotka-Volterra model; market share; stability

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INTRODUCTION

A bank is a financial institution and intermediary that accepts deposits, provides loans, and actively participates in stock market derivatives as a liaison between customers (individuals or companies) who lack capital and customers (individuals or companies) who have excessive capital. Financial institutions are considered the key component in economic development and growth. Therefore, measuring the strength and potential of the macroeconomy as a whole requires a sustainable banking industry (Talpur, 2023).

The earliest manifestation of the "banking phenomenon" is Monte dei Paschi di Siena, headquartered in Siena, Italy, operating since 1472, followed by Berenberg Bank of Hamburg in 1590, Germany, and Sveriges Riskbank of Sweden in 1668, Sweden. Banks play an essential role in developing the economy by injecting funds into the financial sector, mobilizing funds from surplus units to deficit units, and providing various innovative services (Uddin et al., 2022).

The banking system offers a complex array of products and services, directly or indirectly connecting with almost every economic sector (Citterio, 2024; Hurd, 2018). However, it is also crucial to examine the efficiency of banks, as they directly affect the stability of the banking sector and the effectiveness of the country's economic policies. The banking sector's stability plays a crucial role in fostering economic growth and enhancing the overall health of the financial system in all countries (Athari, 2022; Balcilar et al., 2018; Stewart et al., 2021).

Efficient financial systems are essential for the economic growth and development desired by countries worldwide (Bekele & Degu, 2023; Diallo, 2018). Furthermore, an efficient financial system is less susceptible to financial crises and contributes to financial and economic stability (Yuan et al., 2022). Over the past few decades, there has been steady growth in research related to coopetition strategies (Czakon & Czernek, 2016; Felzensztein et al., 2018; Meena et al., 2023). Coopetition refers to the interaction between cooperation and competition, wherein organizations collaborate with their industry competitors to achieve mutually beneficial outcomes, such as acquiring new assets and enhancing customer satisfaction (Bengtsson & Raza-Ullah, 2016; Pattinson et al., 2018). Industrial market conditions can strongly influence bank efficiency, especially market competition (Cheng et al., 2022).

Fundamentally, the primary motivation for banking competition is attributed to the booster of economic growth via the channel of lower prices (Huynh, 2023). The traditional view is that increased banking competition is associated with a drop in lending rates, an essential driver of increased business investment and improved economic growth (Abuselidze, 2021). Banking competition can offer welfare gains by wiping out monopoly rents and reducing cost inefficiencies, leading to better access to financial services and improved financial stability (Claessens & Leaven, 2005). However, despite its numerous benefits, one has been concerned about the negative aspects of high competition in the banking sector (Huynh, 2023). The most considerable concern is based on the competition fragility view (Ekananda, 2023), implying that greater competition may damage bank

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prudence through reduced profits, thereby raising risk-taking incentives of incumbent banks and posing a threat to the safety and soundness of the banking system. Also, increased competition may discourage banks from investing in lending relationships and negatively influence enterprises' access to finance (Sääskilahti, 2016).

In the banking industry, differentiation from competitors hinges on providing top-notch service. Technological advancements enable businesses to offer superior services that meet clients' needs and expectations (Ejigu, 2016). Competition dynamics, particularly among companies, are currently very tight, but most companies offer products or services almost the same as their competitors. To differentiate themselves from competitors, companies need to offer excellent services. It is known that higher service quality leads to more satisfied customers, and higher customer satisfaction leads to customer loyalty. Providing quality and taking the market, as well as offering more services, will make customers satisfied and loyal, and in return, the company will earn more profits (Ozatac et al., 2016).

The increasingly intense competition in the Indonesian banking sector began with the transparency of Indonesian banking, issuing a policy package on June 1, 1983 (Pakjun83), aiming for banking modernization. This regulation was followed by the October policy package (Pakto88) on October 27, 1988, which eased the licensing for establishing new banks, including opening branch offices. At that time, with only IDR 10 billion, an investor could already establish a new bank (Daruri & Edward, 2004), which led to a significant increase in banks. Thus, the increase in the number of banks will certainly result in competition dynamics in the banking sector.

The mathematical modeling approach, particularly the competition model among species, has been extensively used in economics. Based on its role, competition is divided into six types: mutualism, predator-prey, commensalism, amensalism, pure competition, and neutralism (Mougi, 2016). One is applying the competition model to see the company's market share dynamics. Undeniably, external and exogenous factors (technological innovation and regulation) greatly affect the market's functioning and push companies to change their competitive strategies. This condition is because competitive interactions among companies change over time in response to technological innovations and regulations (Cerqueti et al., 2015; Marasco et al., 2016b).

Several studies have explored competition among banks in Indonesia, such as those conducted by Widyastuti and Armanto (2013) and Qori'ah (2016). In their studies, Widyastuti and Armanto (2013) examined the level of competition in the banking industry before and after the introduction of the Indonesian Banking Architecture (API). Using panel data, they found a decrease in banking competition after the introduction of API and a tendency toward large monopolies or collusive oligopolies. Similarly, (Qori'ah, 2016) examined the concentration and competitive behavior of conventional commercial banks in the national banking industry. Her analysis revealed less competitive bank behavior due to high industry concentration. While Widyastuti and Armanto (2013) utilized the Panzar Rosse (PR) model, Qori'ah (2016) employed a panel data regression model. However, neither study determined the specific competition

types and their stabilities among competing banks. Therefore, this study aims to fill this gap by analyzing the competition types and their stabilities among the competing banks.

Competition in the banking sector is also often supposed to benefit bank clients because it increases the available choices and contributes to the lowering of the borrowing rates and the raising of the deposit rates (Ferreira, 2023). Two main competing hypotheses are identified. The competition-fragility hypothesis views competition as reducing stability because it encourages banks to increase risk and operate with low capital buffers, highlighting the potential trade-off between competition and stability (Anhert & Martinez-Miera, 2021; Horvath et al., 2016) The competition-stability hypothesis views financial consolidation as improving stability, namely through higher capital buffers and a greater degree of diversification (Goetz, 2018; Schaeck & Cihák, 2014). Based on some studies above, it is important to recognize the competition type and stability among banks. Hence, the novelty of this research includes the competition type and stability among the four state-owned banks in Indonesia.

In this study, we apply the Lotka-Volterra model approach (Lotka, 1925; Volterra, 1926) to determine the competition type and its stability that occur among state-owned banks (BRI, BNI, Mandiri, and BTN) based on market share data for assets owned by each bank. In addition, we also forecast the market share for assets in the next few years. This forecast is intended to see the dynamics of future competition among the four banks. We use market share data for annual assets published by each bank from 2010-2023 (BNI, 2024; BRI, 2024; BTN, 2024; Mandiri, 2024). Our model assumes that each bank can change its competitive behavior based on time. This model allows us to know the level of asset growth and the interaction coefficient at the four banks, which depends on time. It is hoped that the results of this research can provide important information about the competition type and stability in the banking sectors as a basis for consideration, support, and contribution of thought to decision-makers in business to increase income and carry out business development.

METHODS

The types of banks in Indonesia are Commercial Banks, Rural Banks, and Sharia Banks. One business entity that plays an important role in Indonesia is State-Owned Enterprises. The State-Owned Enterprises Industry Cluster consists of Tourism and Support Services, Telecommunications and Media Cluster, Energy, Oil, and Gas Cluster, Health Cluster, Manufacturing Cluster, Food and Fertilizer Cluster, Plantation and Forestry Cluster, Mineral and Coal Cluster, Insurance and Pension Fund Services, Financial Services, Infrastructure Services and Logistics Services (BUMN, 2023). Financial Services consists of Bank Rakyat Indonesia (BRI), Bank Negara Indonesia (BNI), Bank Mandiri (Mandiri), and Bank Tabungan Negara (BTN). The data we use in this study is market share data for assets published annually by each bank. There are fourteen pieces of data, and those are from 2010 to 2023.

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In Figure 1, it can be seen that the market share gain from the four banks has fluctuated from 2010-2023. BTN's market share has always been under BRI, BNI and Mandiri. The lowest market share for assets was obtained by BTN of 0.023 in 2010, while the highest market share gain for BRI was 0.178 in 2022. In Figure 2, it appears that the total market share for the assets of the state-owned banks with 0.504 gain occurred in 2022. On the other hand, the highest market share gain was for assets not owned by BRI, BNI, Mandiri, and BTN (for example, other banks, insurance companies, pawn shops, and others) was 0.621 in 2013. In addition, the total market share gain for BRI, BNI, Mandiri, and BTN assets has increased from 2013 to 2020. On the contrary, the market share gain for assets outside of BRI, BNI, Mandiri, and BTN tended to decrease over the same period.

Figure 1. The Assets Market Share of the Four State-Owned Banks

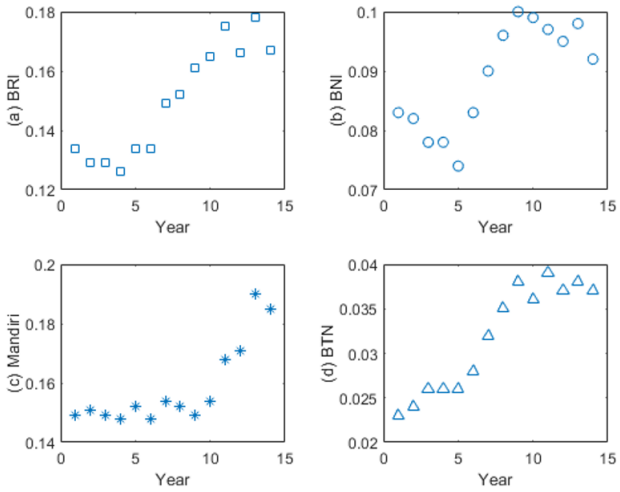
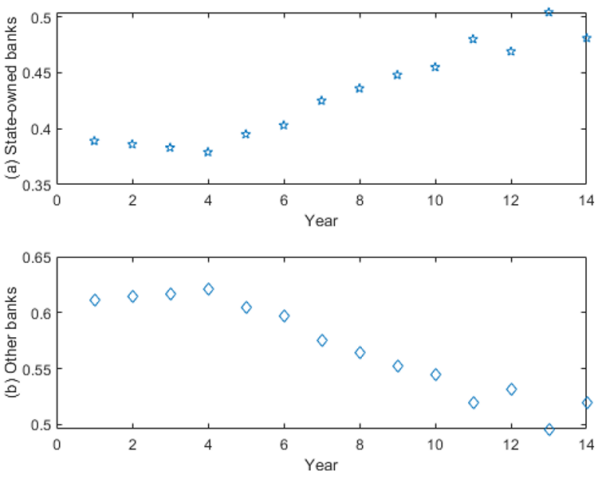


Figure 2. The Total Market Share for Assets of the State-Owned Banks and the Market Share Outside the State-Owned Banks



This study used a mathematical approach by adopting the Lotka-Volterra (LV) model (Marasco et al., 2016a). This model generally describes the dynamics of interaction between species in a population. The LV model in question is as follows.

$$\dot{x}_i(t) = x_i(t)\left[g_i(t) - \sum_{j=1}^{N} g_j(t)x_j(t)\right], \quad i = 1,2,3,\dots,N, \tag{1}$$

where $g_i(t)$ that is a function that can be integrated over the interval $0 \le t \le \infty$, and N is the number of competing species.

If Model (1) is applied to the market share for a bank's asset ($x_i(t)$ denotes market share), two cases arise. In this research, we only use the first case.

If $\sum_{i=0}^{N} x_i(t) = 1$, Model (1) supplies market share for all assets and $x_0(t) = 1 - \sum_{j=1}^{N} x_j(t)$. According to the research results, the solution of Model (1) is as follows (Nevo & Rossi, 2008).

$$x_i(t) = \frac{\exp(f_i(t))}{1 + \sum_{j=1}^{N} \exp(f_j(t))}, \quad i = 1,2,3,\dots,N, \tag{2}$$

where $f_i(t)$ is the utility function that consumers choose the i bank, $g_i(t) = \dot{f}_i(t) = \frac{df_i}{dt}$, and $x_i(t_0) = \frac{\exp(f_i(t_0))}{1+\sum_{j=1}^{N} \exp(f_j(t_0))}$.

By using Equation (2), we can evaluate the utility function $f_i(t)$ based on available market share data. In fact, like the classical logarithmic model, we can easily find the discrete value solution of the utility function as follows:

$$f_i(t) = \ln x_i(t) - \ln x_0(t), \quad i = 1,2,3,\dots,N. \tag{3}$$

Furthermore, by using the curve fitting, which is available in Matlab software, we can find a function that is close to the utility function $f_i(t)$,i=1,2,3,...,N. The approximation result function obtained depends on time t. After the utility function is approximated, the approximation result is substituted into Equation (2). Thus, up to this point, we have found the function $g_i(t)$, which is the value of the parameter in Model (1) and we have also found the estimation result of market share. Through the calculation result of function $g_i(t)$, we can determine the competition type that occurred among banks. The function $g_i(t)$ is no other than a function that can be zero, positive or negative (Marasco et al., 2016a).

To evaluate the accuracy of the market share value estimated by the LV model, we use Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE to compare historical data with estimated data. The MSE and MAPE error sizes can be calculated as follows:

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{N}(h_i - p_i)^2, \qquad \text{MAPE} = \frac{1}{n}\sum_{i=1}^{N}\left|\frac{h_i - p_i}{h_i}\right| 100\%,$$

where h_i and p_i sequentially are historical data and estimation result data. The final stage of this study is to forecast market share by extending the time t.

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RESULTS AND DISCUSSION

Result

Based on the annual market share data for assets from BRI, BNI, Mandiri and BTN that we have collected, the total market share for the assets of the four banks from 2010-2023 is less than one (see Figure 2). This means that there is a market share for the assets of banks or other companies, symbolised by $x_0(t)$, which is involved in the dynamics of competition. In other words, the discussion in this study accommodates the existence of other market shares for assets.

Since the market share data for the observed assets were taken from four state-owned banks, the discussion in this study involves a system of four-dimensional differential equations. The system is as follows:

$$\begin{aligned}
\dot{x}_1(t) &= g_1(t)x_1(t) - g_1(t)x_1^2(t) - g_2(t)x_1(t)x_2(t) - g_3(t)x_1(t)x_3(t) - g_4(t)x_1(t)x_4(t)\\
\dot{x}_2(t) &= g_2(t)x_2(t) - g_2(t)x_2^2(t) - g_1(t)x_1(t)x_2(t) - g_3(t)x_2(t)x_3(t) - g_4(t)x_2(t)x_4(t)\\
\dot{x}_3(t) &= g_3(t)x_3(t) - g_3(t)x_3^2(t) - g_1(t)x_1(t)x_3(t) - g_2(t)x_2(t)x_3(t) - g_4(t)x_3(t)x_4(t)\\
\dot{x}_4(t) &= g_4(t)x_4(t) - g_4(t)x_4^2(t) - g_1(t)x_1(t)x_4(t) - g_2(t)x_2(t)x_4(t) - g_3(t)x_3(t)x_4(t),
\end{aligned} \tag{4}$$

where $x_1(t)$, $x_2(t)$, $x_3(t)$ and $x_4(t)$ consecutively are market share for BRI assets, market share for BNI assets, market share for Mandiri assets and market share for BTN assets. The term $x_1(t)x_2(t)$, $x_1(t)x_3(t)$, $x_1(t)x_4(t)$, $x_2(t)x_3(t)$, $x_2(t)x_4(t)$ and $x_3(t)x_4(t)$ consecutively is the competition term between BRI and BNI, the competition term between BRI and Mandiri, the competition term between BRI and BTN, the competition term between BNI and Mandiri, the competition term between BNI and BTN and the competition term between Mandiri and BTN.

Model (4) represents the growth rate of four banks over time t. The operator $\dot{x}_1(t)$ is the growth of market share for BRI, $\dot{x}_1(t)$ is the growth of market share for BNI, $x_3(t)$ is the growth of market share for Mandiri, and $\dot{x}_1(t)$ is the growth of market share for $g_i(t)$ BTN. On the other hand, Model (4) also includes function $g_i(t)$, i =1,2,3,4. Function g_i (t) is called the parameter. So, there are four parameter functions in Model (4). Every parameter function determines the behaviour and stability of the Model (4). Every change of parameter values (from positive to negative or vice versa, or zero) will change the competition type and stability of the Model (4). Function $g_i(t)$ as the parameter depends on time t.

To get the best estimation of market share for assets, we need to find the solution of Model (4). Mathematically, the analytical solution of Model (4) is

$$x_i(t) = \frac{\exp(f_i(t))}{1 + \sum_{j=1}^{4} \exp\left(f_j(t)\right)}, \quad i = 1,2,3,4, \tag{5}$$

where $f_i(t)$ is the utility function that consumers determine the choice of the i bank, $x_i(t_0) = \frac{\exp(f_i(t_0))}{1+\sum_{j=1}^{4} \exp(f_j(t_0))}$, and $x_0(t) = 1 - \sum_{j=1}^{4} x_j(t)$.

In this section, we will show the utility functions of BRI, BNI, and Mandiri using curve fitting with Matlab software. In economics, the utility function measures consumer welfare or satisfaction. As it is known in Equation (5), the market share value for bank $x_i(t)$ assets depend on the fit utility function $f_i(t)$, i = 1,2,3,4. Therefore, in estimating the market share value for an asset, we must first find its utility function. According to the data, we can find the function $f_i(t) = \ln x_i(t) - \ln x_0(t)$ for each bank. The utility function is polynomial functions of degree three, with an accurate fit test. The utility functions of each bank are as follows.

$$f_1(t) = -0.00091t^3 + 0.0208t^2 - 0.088t - 1.457, \quad f_3(t) = -0.00011t^3 + 0.00588t^2 - 0.0325t - 1.37$$
$$f_2(t) = -0.00128t^3 + 0.0289t^2 - 0.142t - 1.873, \quad f_4(t) = -0.001001t^3 + 0.0205t^2 - 0.0486t - 3.23,$$

where $f_1(t)$, $f_2(t)$, $f_3(t)$ and $f_4(t)$ consecutively is the utility function for BRI, the utility function for BNI, the utility function for Mandiri and the utility function for BTN.

Theoretically, the competition type of BRI, BNI, Mandiri and BTN can be observed through the (negative, zero, or positive) signs in each parameter value ($g_i(t)$, i=1,2,3,4) in Model (4) (Marasco et al., 2016a). It is found that the utility function is a polynomial function of degrees three. Therefore, we can calculate $g_i(t)$ easily. The function $g_i(t)$ is the first derivative from the utility function $f_i(t)$ toward time t. Hence, we obtain the function $g_i(t)$ as follows:

$$g_1(t) = -0.002739t^2 + 0.041728t - 0.08862, \quad g_3(t) = -0.0003357t^2 + 0.011772t - 0.0325{,}8$$
$$g_2(t) = -0.003867t^2 + 0.05788t - 0.1424, \quad g_4(t) = -0.003003t^2 + 0.04104t - 0.04868,$$

where $g_1(t)$, $g_2(t)$, $g_3(t)$ and $g_4(t)$ consecutively are parameter value for BRI, parameter value for BNI, parameter value for Mandiri and parameter value for BTN.

Since the derivative of the polynomial function is also a polynomial function, the function $g_i(t)$ can be integrated at the interval $0 \le t \le \infty$. Table 1 shows the parameter value of $g_i(t)$ toward time t from each bank from 2010-2023.

Table 1. The parameter value of $g_i(t)$ from each bank

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14
g_1	-0.05	-0.016	0.012	0.035	0.052	0.063	0.070	0.070	0.066	0.055	0.040	0.019	-0.008	-0.040
g_2	-0.09	-0.045	-0.007	0.024	0.048	0.064	0.073	0.075	0.070	0.058	0.038	0.011	-0.023	-0.064
g_3	-0.02	-0.011	-0.001	0.008	0.017	0.025	0.032	0.039	0.045	0.050	0.055	0.059	0.062	0.065
g_4	-0.01	0.021	0.047	0.067	0.081	0.089	0.091	0.087	0.077	0.061	0.039	0.011	-0.023	-0.063

Based on the sign of the parameter value in Table 1, we can determine the competition type of each bank by looking at the sign of each parameter value. The competition types of the four banks are explain in Table 2. Generally speaking, from 2010-2023, the competition types of the four banks vary from year to year. There have been three competition types among the four state-owned banks: mutualism, predator-prey and pure competition.

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Market share is the percentage of sales of a product in units, dollars or measures generated by the company on all product sales. Based on this definition, market share is directly affected by the utility function of a product, or mathematically we can say that market share can be measured through the utility function.

Table 2. Competition types

Year	BRI & BNI	BRI & Mandiri	BRI & BTN	BNI & Mandiri	BNI & BTN	Mandiri & BTN
2010	Mutualism	Mutualism	Mutualism	Mutualism	Mutualism	Mutualism
2011	Mutualism	Mutualism	Prey-predator	Mutualism	Prey-predator	Prey-predator
2012	Predator-prey	Predator-prey	Pure competition	Mutualism	Prey-predator	Pure competition
2013-2021	Pure competition	Pure competition	Pure competition	Pure competition	Pure competition	Pure competition
2022-2023	Mutualism	Prey-predator	Mutualism	Prey-predator	Mutualism	Predator-prey

To obtain the estimated value of the market share for those four banks, we can directly substitute the utility function $f_1(t)$, $f_2(t)$, $f_3(t)$ and $f_4(t)$ into Equation (5). Therefore, we obtain the results of the estimated market share for assets from BRI, BNI, Mandiri and BTN, which are presented in Table 3, Figure 3, and Figure 4.

Table 3. Estimated market share for assets from each bank

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Time (t)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
X_1	0.133	0.130	0.130	0.132	0.136	0.142	0.148	0.155	0.161	0.167	0.171	0.173	0.172	0.168
X_2	0.084	0.079	0.078	0.078	0.080	0.084	0.088	0.092	0.096	0.099	0.101	0.100	0.097	0.091
X_3	0.151	0.150	0.149	0.149	0.149	0.150	0.151	0.152	0.155	0.159	0.164	0.171	0.180	0.192
X_4	0.023	0.024	0.025	0.026	0.028	0.030	0.032	0.034	0.036	0.037	0.038	0.039	0.038	0.037
Total	0.390	0.383	0.382	0.386	0.394	0.405	0.418	0.433	0.448	0.462	0.474	0.483	0.488	0.488

Figure 3. Historical Data and Estimated Market Share for the 2010-2023 period

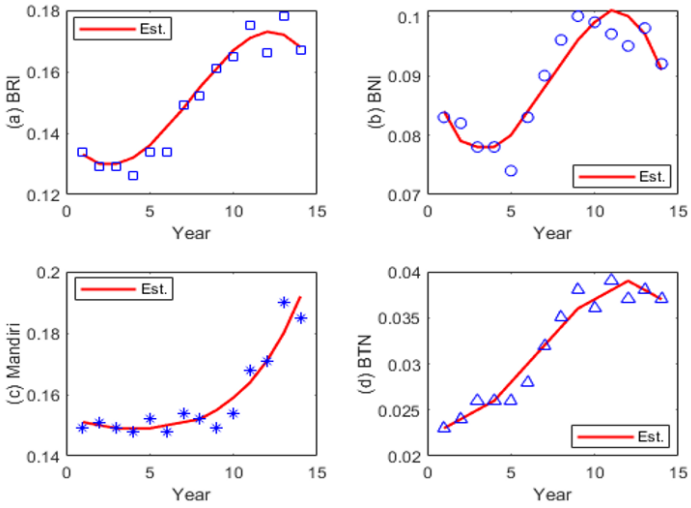
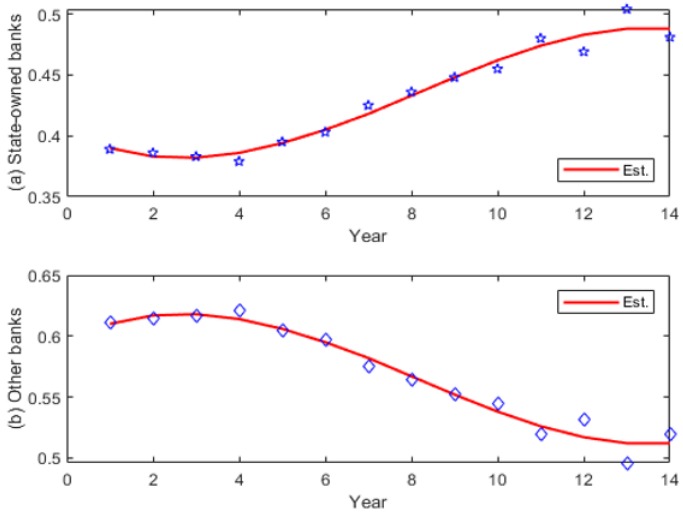


Figure 4. Historical Data of the Total Market Share for Assets

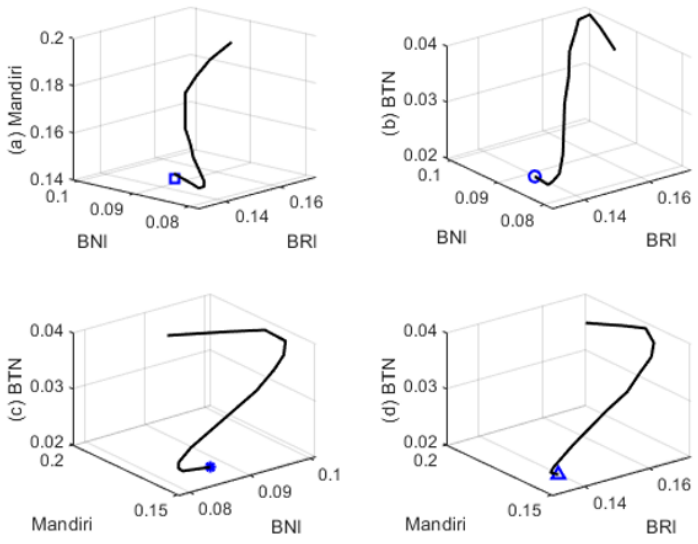


In this section, we will conduct an analysis to analyze the stability of the competition model that occurs among the four banks. Stability analysis is important, because by knowing the stability properties of the model, we can determine the behavioral tendencies of each bank resulted by the competition. Next, we present the stability properties of the model for the 2010–2023 period. The results of the competition analysis are presented in Table 4 and Figure 4.

Table 4. The Stability of the Four State-owned Banks

Period	BRI, BNI & Mandiri	BRI, BNI & BTN	BNI, Mandiri & BTN	BRI, Mandiri & BTN
2010-2023	Unstable	Unstable	Unstable	Unstable

Figure 5. The Stability of Market Share for BRI, BNI, Mandiri and BTN Assets



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To evaluate the estimation result of the four banks' market share values, we present the estimation result of the Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE). The MSE and MAPE error measures for the 2010-2023 period are showing in Table 5. Based on the MSE and MAPE results, the resulting model has very high accuracy. Therefore, this model can be used to analyze the competition dynamics that occur in the four banks. Apart from that, this model can also be used to predict the competition type that may occur between the four banks in the next few years.

Table 5. MSE and MAPE values of each bank

Bank	MSE	MAPE (%)
BRI	0.000013890463739776	1.924
BNI	0.000008885906335308	2.636
Mandiri	0.000018321384683592	1.908
BTN	0.000001658459607784	3.478
Total market share	0.000051787709303120	1.198

Table 6. The Forecasting of Competition Type for the 2024-2028 period

Year	BRI & BNI	BRI & Mandiri	BRI & BTN	BNI & Mandiri	BNI & BTN	Mandiri & BTN
2024	Mutualism	Prey-predator	Mutualism	Prey-predator	Mutualism	Predator-prey
2025	Mutualism	Prey-predator	Mutualism	Prey-predator	Mutualism	Predator-prey
2026	Mutualism	Prey-predator	Mutualism	Prey-predator	Mutualism	Predator-prey
2027	Mutualism	Prey-predator	Mutualism	Prey-predator	Mutualism	Predator-prey
2028	Mutualism	Prey-predator	Mutualism	Prey-predator	Mutualism	Predator-prey

This section will forecast the market share for BRI, BNI, Mandiri and BTN assets. This forecast assumes that the four state-owned banks will not change their strategy, either in adopting new technology or updating internal policies. They will compete for consumers over the next few years. Based on these assumptions, using Model (5), we obtain the competition type and the result of market share forecasting for the assets of the four banks for the 2024-2028 period shows in Table 6, Table 7, Figure 6 and Figure 7.

Table 7. The forecasting of Market Share for Assets from Each Bank

Year	Time (t)	X_1	X_2	X_3	X_4	Total
2024	15	0.160	0.082	0.207	0.034	0.483
2025	16	0.147	0.070	0.226	0.030	0.473
2026	17	0.130	0.056	0.249	0.026	0.461
2027	18	0.110	0.042	0.274	0.021	0.446
2028	19	0.087	0.029	0.301	0.015	0.433

Figure 6. The Forecasting of Market Share for Assets for the 2024-2028 Period

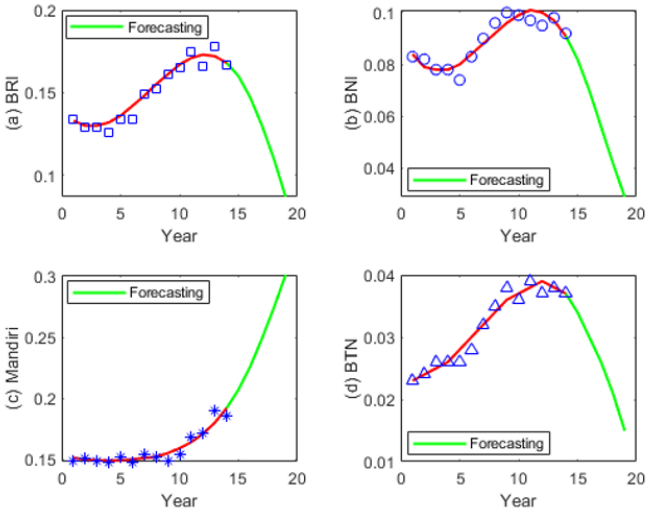
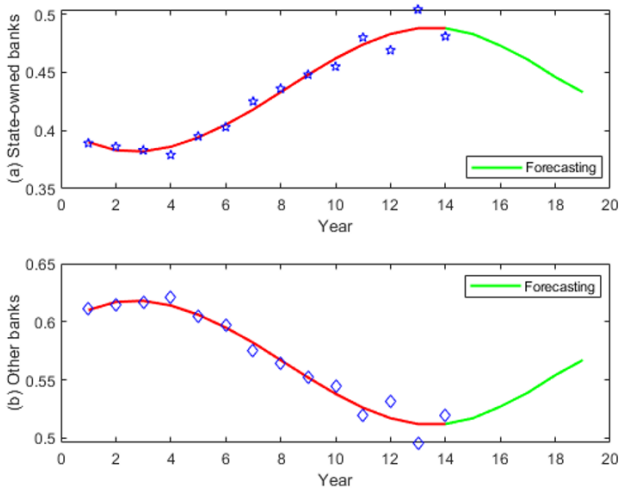


Figure 7. The Forecasting of the Total Market Share for Assets of the State-Owned Banks and the Market Share Outside the State-Owned Banks for the 2024-2028 period



DISCUSSION

Theoretically, market share is measured through a time-dependent utility function. In economics, the utility function measures consumer welfare or satisfaction. So, market share can change if the utility function changes occasionally. According to the annual market share data for assets published by BRI, BNI, Mandiri, and BTN, we can calculate their utility function. The four utility functions are four polynomial functions of degree 3. Through the utility functions of these four banks, we can quickly determine the parameters of each equation in Model (5) by differentiating every utility function toward time. Every parameter function determines the competition type and stability of the four state-owned banks.

The competition type of the four banks varies yearly from 2010-2023. Based on Table 2, the competition type of the four banks was mutualism in 2010, in which the

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market share for assets of the four banks benefited each other. In the 2022-2023 period, the competition type of BRI & BNI, BRI & BTN, and BNI & BTN also changed to mutualism, in which the market share for assets of the three banks benefited each other. These results align with previous studies (Goetz, 2018; Schaeck & Cihák, 2014). The research conducted by Goetz (2018) suggested that fewer barriers to entry significantly contribute to bank stability because more competition boosts bank profits and reduces individual bank shares of non-performing loans. Another study examined the effect of market competition on bank stability in the belief that competition incentivizes banks to enhance cost efficiency, increasing reallocation from unsuccessful (inefficient) banks to successful banks (Schaeck & Cihák, 2014). So, this competition type is identified as the competition-stability hypothesis.

In 2011, the competition type of BRI & BTN, BNI & BTN, and Mandiri & BTN changed to prey-predator, in which BTN (predator) benefit through the increased market share gains, while BRI, BNI, and Mandiri (prey) did not get any benefit. In 2012, the competition type of BRI & BNI and BRI & Mandiri also changed to predator-prey, in which BRI (predator) got a benefit through the increased market share gains, while BNI and Mandiri (prey) did not get any benefit. In addition, in the 2022-2023, all competition types changed. The competition type of BRI & BNI, BRI & BTN, and BNI & BTN changed to mutualism. In contrast, the competition type of BRI & Mandiri, BNI & Mandiri, and Mandiri & BTN changed to prey-predator, in which BRI, BNI, and BTN behaved as prey. In contrast, Mandiri behaved as a predator and benefited from increased market share gains. This information shows that the level of competition among the four banks was high and had a good impact on the four banks (Wibowo & Wibowo, 2019).

In 2012, the competition type of BRI & BTN and Mandiri & BTN changed to pure competition, in which the three banks competed quite fiercely with each other. When observed from the market share values, the decline in Mandiri's market share (0.149) (see Table 3). Besides, from 2013 to 2021, the four banks had the same competition type (see Table 2). It was pure competition, in which the four banks competed quite fiercely. When observed from the market share values, the market share of BRI, Mandiri, and BTN tended to increase. The market share of BNI only tended to increase in 2013-2020, while it tended to decrease in 2021 (see Table 3).

These results align with previous studies(Anhert & Martinez-Miera, 2021; Ferreira, 2023). The research conducted by Anhert and Martinez-Miera (2021) found that increased bank competition or transparency contributes to increasing deposit rates, costly withdrawals, and, thus, bank fragility. Another study concluded that higher banking market competition does not increase banking stability (Ferreira, 2023). So, the pure competition type is identified as the competition-fragility hypothesis.

Generally speaking, from 2010 to 2023, there were three types of competition among the four state-owned banks: mutualism, predator-prey, and pure competition. Based on the estimation, the three competition types increased the total market share of the four banks (see Figure 4). In addition, there were two scenarios that we could

take to obtain the total maximum market share gain: (1) The suitable competition type of the four state-owned banks must be pure competition. This competition type lasted for nine years and continued to provide an increased total market share, and (2) the suitable competition type of the four state-owned banks must be a mix of mutualism and predator-prey. Especially for Scenario 2, mutualism is the suitable competition type for BRI, BNI, and BTN. However, BRI, BNI, Mandiri, and BTN are predator-prey, with Mandiri as the predator, while BRI, BNI, and BTN are the prey (see Tables 2 and 3). The two scenarios support previous research by Yin (2021). Policymakers understand the value of bank competition and then try to establish policies that stimulate competition, such as banking deregulation.

After estimating the market share, we can determine the stability of the competition model. The stability analysis is important because by knowing the stability property of the model, we can determine the behavioral tendencies of each bank resulting from the competition. Based on the estimation, the stability property of the four state-owned banks tended to be unstable (see Table 4 and Figure 5). This instability was caused by the competition type varying in 2010-2023. This finding aligns with previous research conducted by Ekananda (2023). The research found that banking transactions and activities affect a country's financial stability. The impact of banking competition on financial stability can change at certain regime levels. Nonlinear impact occurs according to the regime.

One of the indicators that a model can be used as a reference for predicting the dynamics of competition in the future is the model's accuracy. A tiny error usually proves this (Marasco et al., 2016a). Of the two ways (MSE and MAPE) to measure the magnitude of the error produced by the Lotka-Volterra model, all have tiny errors (see Table 5). Thus, the model we use is a very reliable basis for forecasting. Market share forecasting for the assets of the four state-owned banks is carried out for 2024-2028. Based on the competition types (see Table 6), mutualism was the competition type of BRI & BNI, BRI & BTN, and BNI & BTN in the 2024-2028 period. The competition type of BRI & Mandiri and BNI & Mandiri is the same as that of Mandiri & BTN, which is predator-prey, with BRI, BNI, and BTN as the prey and Mandiri as the predator.

Only Bank of Mandiri market share gains are predicted to increase in 2024-2028 (see Figure 6 and Table 7). On the other hand, although Mandiri gained market share during this period, the total market share gains for the four state-owned banks declined sequentially. Consequently, the total market share outside the state-owned banks increased significantly (see Figure 7). Based on the literature, this decline in market share gain can be overcome by adopting the latest technology and new policies within state-owned banks that support the increase of market share gains. This needs to be done because there are quite several private banks, insurance companies, pawn shops, and so on that move as competitors in the same field. Since they compete with state-owned banks to get potential markets, these competitors will adopt new technologies and policies that will enable them to dominate the market.

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CONCLUSION

Determining competition type and forecasting market share values for the assets of the four state-owned banks has been conducted using the Lotka-Volterra (LV) model approach with very accurate estimation results. The competition type of the four banks from 2010-2023 varies greatly. There have been three competition types among the four state-owned banks: mutualism, predator-prey, and pure competition. The stability property of the four state-owned banks tended to be unstable. This instability was caused by the competition type varying in 2010-2023. Besides, the forecasting of market share for the assets of the four state-owned banks is conducted for the 2024-2028 period. By looking at the gains of market share for assets since 2023, only Mandiri's gains will increase in 2024-2028. On the other hand, although Mandiri gained market share during this period, the total market share gains for the four state-owned banks declined sequentially.

Building on the forecasting results, this study proposes a significant opportunity for the Indonesian government to influence the market dynamics. By considering policies that can alter the competition types for the four banks (pure competition or a mix of mutualism and predator-prey), the government can potentially enhance the market share values. Therefore, the key policy recommendation from this research is to maintain the market share of bank Mandiri, while strategically increasing the market share of BRI, BNI and BTN.

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