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Analysis of the dynamics of interaction between profitability and liquidity using a predator-prey model approach

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Abstract
Profitability and liquidity are among the critical issues that must be studied and considered by the management of every organisation as their foremost task. This research aims to analyse the bidirectional dynamics of profitability ratios and liquidity ratios over time. This research also aims to present forecasted values of profitability and liquidity for the next five years. The data used in this study are obtained from the food industry company's annual reports for the period 2011-2022. This research adopts a predator-prey model containing a pair of non-linear differential equations to describe the interaction between two species. The results show that the predator-prey model can explain the bidirectional dynamics of profitability ratios and liquidity ratios with high accuracy. Besides, this study indicates that the type of relationship between profitability and liquidity is predator-prey. The forecasting results show that for 2023-2027, both profitability and liquidity tend to decrease. Based on the data, the company's profitability and liquidity dynamics periodically fluctuate over time. This fluctuation indicates a positive sign for company's profitability and liquidity are in good condition. In the future, company has to take preventive measures to continue stabilising its profitability and liquidity.

Keywords:
dynamics; forecasting; liquidity; predator-prey; profitability.

JEL Code: G30, C60, C62

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Introduction

The non-oil and gas processing industry sector in Indonesia plays a crucial role in the national economy. The non-oil and gas processing industry still consistently provides a dominant contribution to the achievement of national export value. In 2023, manufacturing sector exports contributed 72.24 per cent of the total national export value of USD 258.82 billion (Kemenperin, 2024). One type of non-oil and gas processing industry is the food and beverage industry. The food and beverage industry is one of the key sectors supporting manufacturing growth and the national economy (Kemenperin, 2017). In 2022, the growth rate of the Gross Domestic Product (GDP) for the food and beverage industry reached 4.90 per cent, marking a higher GDP growth compared to 2021, which stood at 2.54 per cent (BPS, 2023). The demand for the food and beverage sector will continue to persist, given that consumption is essential for human survival. Consequently, the food and beverage industry needs to perpetually innovate to fulfil societal needs (Tseng et al., 2020).

One of the methods to ensure company's sustained longevity is by evaluating organisation's financial stability. Organisation's financial stability can be determined by considering company's profitability and liquidity level. In the business world, investors always pay attention to a company's ability to generate, maintain, and increase profits. Company profits are reviewed using profitability ratios. However, apart from that, investors also pay attention to the company's financial stability which is evaluated using liquidity ratios. Therefore, both profitability and liquidity are very important to achieve financial performances, and cannot be separated. The relationship between liquidity and profitability has become a crucial issue among any organisation. Maximising profit can be gained through managing current assets and current liabilities in such a way. Nevertheless, if liquidity increases, profitability decreases, and if profitability increases, liquidity decreases (Hossain & Alam, 2019). Thus, profitability and liquidity are two important topics that the management of every organisation must study and think about.

Many studies have been conducted on the relationship between profitability and liquidity. For example, Paul et al. (2021) stated that, simultaneously, liquidity has a significant effect on profitability in the commercial banking sector in Bangladesh, while Thinh et al. (2022) argue that liquidity has a positive relationship with bank profitability which includes return on assets, return on equity, and net interest margin. In addition, other research found that there is a relationship between liquidity and profitability. The cash conversion cycle has a strong negative relationship with all profitability ratios (NPM, ROA, and ROE). Liquidity ratios (CR and QR) are

positively related to all profitability ratios in the cement industry (Hossain & Alam, 2019). Based on the results of prior research, this research involves an analysis of the bidirectional relationship between profitability and liquidity which is evaluated based on time, which become the novelty of the research.

Liquidity plays an important role in the equity market. The significance of liquidity in the equity market is underscored by extensive research coverage within the field of financial economics (Pan, 2023). The financial stability of a company can be evaluated using liquidity ratios. The liquidity ratio is a metric that provides an overview of a company's ability to meet its short-term debt obligations within a year. The short-term and daily business operations require a company's ability to generate sufficient cash to settle its maturing obligations. In this context, it is necessary to assess the company's competency in converting adequate non-cash assets into the required cash to fulfil obligations promptly (Ježovita, 2015; Brigham & Houston, 2020).

The company's ability to maintain its capacity to meet short-term debt obligations is crucial for all users of financial statements. If the company fails to sustain its ability to meet long-term debt obligations, it will undoubtedly fail to satisfy shareholders (Al-Qadi & Khanji, 2018). The short-term financial policies of a company are focused on two main objectives. The primary goal of short-term financial management for any company is to maximise the excess revenue over costs. Ideally, the ability to generate profits, which is profitability, should be accompanied by the capability to ensure short-term liquidity. On the one hand, it relates to pricing policies and margins that can be realised at the appropriate level of working capital components (inventory, receivables, and cash) (Brealey et al., 2016; Jaworski & Czerwonka, 2021). Liquidity is important for the short term; the more liquid a company is, the lower the risk of being unable to meet its short-term obligations (Hossain & Alam, 2019). The measure used for liquidity in this study is the current ratio (CR), which is the ratio of current assets to current liabilities. A high current ratio provides a good guarantee for short-term creditors, meaning the company has the ability to meet its short-term financial obligations at any time. However, a high current ratio will negatively impact the ability to generate profits, as some working capital remains idle or experiences unemployment (Martono & Harjito, 2014). Only an optimal level of liquidity can benefit the profitability of the company (Al-Qadi & Khanji, 2018).

Investors always pay attention to the company's ability to generate, maintain, and increase profits. Generally, a company's profit is assessed using profitability ratios. Profitability ratios are a group of ratios that indicate the influence of a combination of liquidity, asset management, and debt on operational results (Brigham & Houston, 2020). The measure used for profitability in this study is a return on assets (ROA), which is the ratio of net income to total assets.

The correlation between liquidity and profitability has emerged as a crucial concern across organisations. It revolves around the strategic management of current assets and liabilities to optimise profit margins. The interplay between liquidity and profitability is inherently interconnected. An increase in liquidity often corresponds to a decrease in profitability and conversely (Hossain & Alam, 2019). Liquidity and profitability are related to each other, so increasing profitability will tend to reduce the company's liquidity, and too much attention to liquidity tends to affect profitability. Although every company tries to maximise profitability by maintaining liquidity, increasing profits at the expense of liquidity can cause serious problems for the company, and these problems can also lead to financial bankruptcy (Gill, 2022). Hence, a financial manager will endeavour to balance the company's liquidity and profitability.

Research on the influence of profitability and liquidity on various variables has been extensively conducted in various cases (Husain, 2021; Jamal et al., 2022; Reschiwati et al., 2020; Righi & Vieira, 2014) . Furthermore, research related to the relationship between profitability and liquidity has also been quite extensively conducted (Hossain & Alam, 2019; Jaworski & Czerwonka, 2021; Paul et al., 2021). Lim & Rokhim (2021) stated that overall, liquidity, sustainable growth rate, firm size, and market power had a positive impact on profitability, while Thinh et al. (2022) show that liquidity has a positive relationship with bank profitability, which includes return on assets, return on equity, and net interest margin. Net interest margin includes the liquidity ratio of debt to deposits and short-term debt. Short-term debt has the opposite effect with liquidity ratio of debt to deposits.

On the other hand, Jaworski & Czerwonka (2021) stated that it is not possible to identify a common effect that describes the relationship between company profitability and financial liquidity measured by the current liquidity ratio. Based on the several recent studies above, this study highlights three main significances: (1) liquidity has a significant effect on profitability; (2) liquidity can have a positive or negative relationship to profitability; (3) it is impossible to identify general effects that describe the relationship between profitability and liquidity. However, neither study determined the bidirectional dynamics of profitability ratios and liquidity ratios. Therefore, this study aims to fill this gap by analysing the bidirectional dynamics of profitability ratios and liquidity ratios over time.

The objective of this research is to examine the bidirectional dynamics between profitability ratios and liquidity ratios over time. Additionally, this study also aims to present forecasted values of profitability and liquidity for the next five years. These annual reports contain profitability ratios and liquidity ratios. Profitability ratios are measured using return on assets (ROA), while liquidity ratios are measured using the current ratio (CR).

Unlike other studies, this research attempts to offer a new approach (a mathematical modelling approach) to examine the bidirectional dynamics of profitability ratios and liquidity ratios over time. The mathematical approach referred to is the predator-prey model approach (Brauer & Castillo-Chavez, 2012; Lotka, 1910). This model is one derivative from the Lotka-Volterra model using a system of differential equations. By adopting this model, profitability ratios can be assumed as prey and liquidity ratios act as predators. The predator-prey model has been widely used in various fields (Hung et al., 2017; Wu et al., 2021). Data processing and numerical simulations in this study are conducted using the Matlab application. The results of this research can contribute to provide information as a basis for consideration, support, and contribution to decision-makers in business in order to increase income and carry out business development.

The rest of this paper is organised as follow. The second section explores more on literature review, while in the third section, data and the methodology are presented. In this section, the rationale behind the predator-prey model approach is explained. Furthermore, this section describes source and short description of data. In the fourth section, results and discussion are presented. In this part, the estimation results using the predator-prey model is shown and followed by forecasting results. Finally, the last section concludes.

Literature review

Bidirectional dynamics of profitability ratios and liquidity ratios

Generally, one of the accepted main indicators of company performance is profitability (Spitsin et al., 2020). Profitability is an instrument for assessing a company's ability to gain profits (Petchsakulwong & Jansakul, 2018). Maximising profits and adding company value are the main goal of a company (Nguyen & Nguyen, 2024). Improving operational performance and maintaining company sustainability are the foundations for establishing long-term business strategies (Do et al., 2021). The income and costs shown in the income statement refer to profitability, while the cash inflow & cash outflow shown in the cash flow statement refer to the company's liquidity (Das et al., 2015). Liquidity is a company's capacity to liquidate short-term debt that matures (within one year) (Siegel & Shim, 2000). Holding back liquidity in the short term can reduce profitability, but can ultimately increase profitability in the medium and long term. Increasing liquidity is fundamental in increasing stakeholder trust and reducing the risk of bankruptcy (Nanda & Panda, 2018).

Profitability and liquidity are among the critical issues that must be studied and considered by the management of every organisation as their foremost task (Goldmann, 2017). Studies on liquidity are crucial for internal and external analyses as it is closely related to day-to-day business operations (Al-Homaidi et al., 2020). Every manager needs to consider liquidity and

profitability as primary components in all financial decision-making (Chaudhary & Raja, 2021).

The relationship between company's liquidity and financial profitability is based on working capital decisions. Strategies minimising the risk of liquidity loss involve implementing flexible short-term financial policies (Jaworski & Czerwonka, 2021). The more flexible policies a company adopts by enhancing its liquidity, the higher the costs limiting its profitability (Gill, 2022).

One concept regarding the relationship between liquidity and profitability is based on efforts to explain the occurrence of influence in both positive and negative directions. The relationship between profitability and liquidity is nonlinear and can be represented by the Gentry curve, which resembles an inverted U shape. One determinant of a company's direction and strength is the level of financial liquidity. Companies characterised by low liquidity primarily invest retained earnings in improving their payment ability. Therefore, with increased profitability, liquidity also increases (positive direction). Further investment in liquidity results in high maintenance and financing costs. Therefore, increased liquidity leads to a decrease in profitability (negative direction) (Jaworski & Czerwonka, 2021).

The mathematical modelling approach, particularly the predator-prey model, has been widely used across various fields, particularly in economics. Starting from the pioneering of Lotka (1925) with the Lotka-Volterra (LV) model, it has been extensively utilised in ecology and biology to model population dynamics where one species competes with another for survival. In its development, the predator-prey model can also be applied in economics to examine market dynamics (Hung et al., 2017; Jamal & Suparno, 2022; Miranda & Lima, 2013).

Hung et al. (2017) proposed a forecasting framework (an enhanced application of the Lotka-Volterra model). The sales data of each retail format is considered as a compound data, which is decomposed into three individual components: aggregate, competition, and seasonal components. In the proposed method, the competition component is forecasted by the Lotka-Volterra model. The other two components are forecasted by some other time series methods. Then all three components are finally combined into one. Empirical study indicated that the proposed method substantially outperforms the traditional approach in terms of forecasting errors. This method reveals that the two competing species form a predator–prey relationship. The proposed method claims that the predator is the convenience-oriented one, and is more convincing because convenience-oriented benefits shall be preferred.

However, technological substitution can be aptly understood as an evolutionary economics process encompassing the hierarchically related concepts of change, order, direction, progress, and perfectibility, in accordance

with the ideology of evolutionism. Variation and selection, as the operative Darwinian principles, together with development, a third component essentially provided by knowledge and innovation, seem to be the underlying motors for the evolution of a technological substitution process. Under this framework, the process of analog-for-digital imaging technological substitution becomes a disruptive evolution. On the other hand, for the mobile communication process, the evolution seems to be better accounted for as a pure variation-selection-development process (a sequence of logistic phases) where innovation, through successive new models, controlled the best-fit contender's survival (Miranda & Lima, 2013).

Previous research tried to analyse the relationship between agricultural production and agricultural community income using predator-prey model approach. Based on the market price (high and low market price), they found that six phenomena may occur. (1) High market price: first, if the crop yield is abundant, the farmers' income is increasing rapidly; second, if the crop fields are low due to bad weather such as drought and floods, the farmers' income tends to stable; third, if the crop yield is abundant, the farmers' income is increasing rapidly; and fourth, if the crop fields are low, the farmers' income will also decrease. (2) Low market price: first, if the crop yield is abundant, the farmers' income tends to stable; and second, if the crop yield is low, the farmers' income will also decrease significantly (Jamal & Suparno, 2022).

Research method

Predator-prey model approach

This research adopts a predator-prey mathematical model that contains a pair of non-linear differential equations commonly used to describe the interaction between two species. The first species is called the prey, and the second one is called the predator (Brauer & Castillo-Chavez, 2012; Lotka, 1910). In this case, the prey variable is profitability, while the predator variable is liquidity.

By adopting this model, a predator-prey model that describes the interaction dynamics between profitability and liquidity is obtained in model (1) and (2), where variables $x \geq 0$ and $y \geq 0$ are the profitability and liquidity of the company, respectively. The operators $\frac{dx}{dt}$ and $\frac{dx}{dt}$ represent the growth rate of both variables over time t. The parameters $a > 0$, $b > 0$, $c > 0$ respectively represent the growth rate of profitability, the effect of liquidity on the growth rate of profitability, the decline rate of liquidity, and the effect of profitability on the growth rate of liquidity. The interaction of these two variables reduces the value of profitability. In addition, model (1) and (2) have two equilibrium points: $E_0(x^*, y^*) = (0,0)$ and $E_1(x^*, y^*) = (c/d, a/b)$.

$$\frac{dx}{dt} = ax - bxy \quad (1)$$

$$\frac{dy}{dt} = dxy - cy \quad (2)$$

In model (1) and (2), it is clear that the predator-prey model contains four parameters, i.e., a, b, c, and d. To obtain those four parameter values, this research performed a parameter estimation process based on the data by applying the log integral method (Kloppers & Greeff, 2013). Additionally, based on the obtained parameter estimation results, this research to determine the two variables' stability properties by applying a mathematical approach (Ang et al., 2019; Jamal & Suparno, 2022; Mohammed et al., 2021). In this research, the parameter estimation and numerical simulation used the Matlab application.

To gain the best estimation of profitability and liquidity, this research transformed model (1) and (2) into a system of difference equations (Leslie, 1958). Thus, this research obtained a new model as shown in model (3) and (4) where $a = \ln \alpha$, $b = \frac{\beta \ln \alpha}{\alpha - 1}$, $c = \ln \rho$, and $d = \frac{\delta \ln \rho}{\rho - 1}$.

$$x(t+1) = \frac{\alpha x(t)}{1+\beta y(t)}, \; t = 1,2, \dots, n-1 \quad (3)$$

$$y(t+1) = \frac{\rho y(t)}{1+\delta x(t)}, \; t = 1,2, \dots, n-1 \quad (4)$$

After conducting the analysis, this research evaluated the accuracy of the resulted model (3) and (4). This accuracy evaluation was measured using the Mean Absolute Percentage Error (MAPE). The MAPE error measure is calculated as shown in formula (5) with h_i and p_i are historical data and estimated data respectively. The criteria for MAPE accuracy can be found in (Marasco et al., 2016; Wang & Wang, 2016).

$$\text{MAPE} = y \frac{1}{n} \sum_{i=1}^{n} \left| \frac{h_i - p_i}{h_i} \right| x100\%, \; i = 1 \dots n. \quad (5)$$

Data description

This research includes annual report from the biggest food industry company in Indonesia, i.e., PT. Indofood Sukses Makmur Tbk for the period 2011-2022 which can be accessed by the public via the Indonesian Stock Exchange website (Indonesian Stock Exchange, 2011; INDF, 2023a). PT. Indofood Sukses Makmur Tbk. is a total food solutions company with operational activities covering all stages of food production processes, from raw material processing to the production of final products available in the market. PT. Indofood Sukses Makmur Tbk is a well-established and leading company in all of its business categories. In conducting its operational

activities, the company benefits from economies of scale and the robustness of its business model, consisting of four strategic business groups that complement each other as follows: Consumer Branded Products (CBP), Bogasari flour mills, agribusiness, and distribution (INDF, 2023b).

These annual reports used in this study comprised profitability ratios and liquidity ratios. Profitability was assessed using the return on assets (ROA) metric, whereas liquidity was evaluated using the current ratio (CR) (Martono & Harjito, 2014). For subsequent analyses, the profitability and liquidity ratios of PT. Indofood Sukses Makmur Tbk. are referred to simply as the company's profitability and liquidity.

Results

Parameter estimation and model stability

Based on the data (see Appendix 1 and 2), the company's profitability and liquidity data from 2011 to 2022 seem to fluctuate. The highest profitability was gained by the company in 2011 at 9.7 per cent, while its lowest ratio was in 2015 at 4.2 per cent. On the other hand, the highest liquidity was achieved in 2012 at 205 per cent, while the lowest ratio was at 107 per cent in 2018 (INDF, 2023a).

In model (1) and (2), it is clear that the predator-prey model contains four parameters, i.e., a, b, c, and d. To obtain those four parameter values, this research performed a parameter estimation process based on the historical data by applying the log integral method (Kloppers & Greeff, 2013). By applying this method, this research obtained the parameter values of a = 0.5789, b = 0.0041, c = 0.1097, and d = 0.0165. Subsequently, the values of these four parameters are substituted into model (1) and (2) generating a predator-prey model that illustrates the interaction between profitability and liquidity as shown in model (6) and (7).

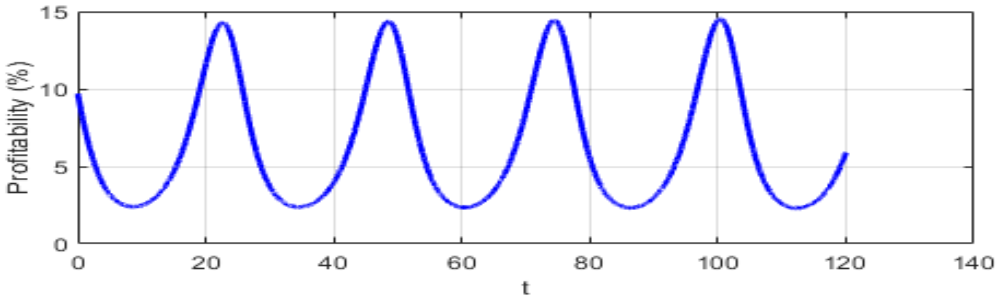
$$\frac{dx}{dt} = 0.5789x - 0.0041xy \quad (6)$$

$$\frac{dy}{dt} = 0.0165xy - 0.1097y \quad (7)$$

The equilibrium points of model (6) and (7) is obtained by solving the system $\frac{dx}{dt} = \frac{dy}{dt} = 0$. Model (6) and (7) have two equilibrium points, which are E_0 (x, y) = (0,0) and E_1 (x, y) = (6.648, 141.195). The stability property of the equilibrium point E_0 is a saddle, and the non-zero equilibrium point E_1 is a centre (closed curve) in a counterclockwise direction. As the equilibrium point, E_0 has no economic meaning. In the following discussion, this research focus on the equilibrium point E_1. The equilibrium point is $E_1(x^*, y^*) = (c/d, a/b)$. Based on this equilibrium point, if the reduction of liquidity rate (c) is greater than the effect of profitability on the growth rate of liquidity (d), then the

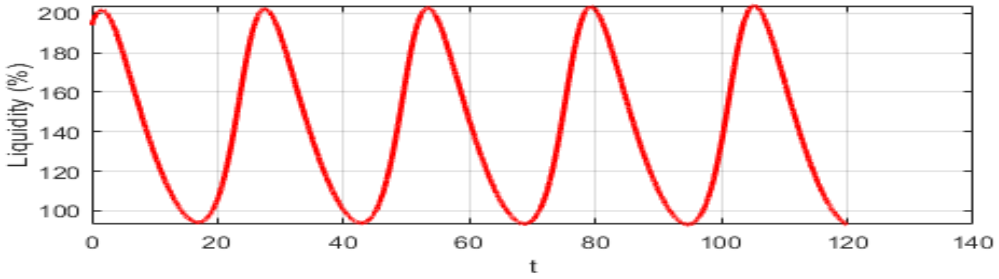
company's profitability has a great opportunity to grow. On the contrary, if the level of liquidity reduction (c) is smaller than the effect of profitability on the growth rate of liquidity (d), then the company's profitability only has a small opportunity to grow and may even reach zero. Furthermore, dynamics of profitability change, liquidity change, and phase between profitability and liquidity with initial values $(x_0, y_0) = (9.7, 194)$ are presented in Figure 1, 2, and 3.

Figure 1.
Dynamics of profitability change



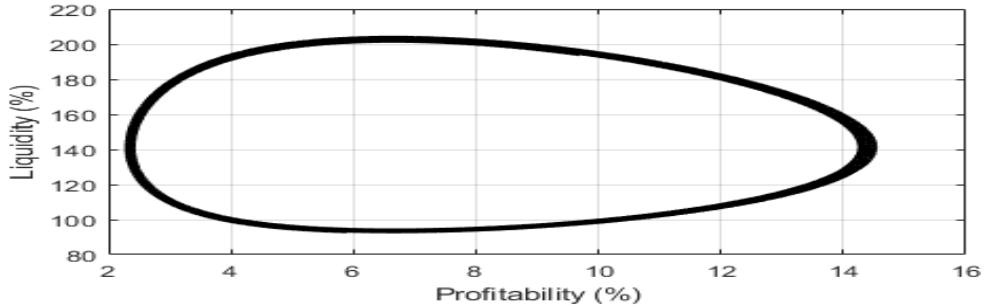
Source: Authors' work (2024)

Figure 2.
Liquidity change



Source: Authors' work (2024)

Figure 3.
Phase between profitability and liquidity with initial values



Source: Authors' work (2024)

Estimation results of profitability and liquidity

To determine the results of profitability and liquidity estimation based on model (6) and (7), this research transformed model (6) and (7) to a system of

difference equations (Leslie, 1958) with $\alpha = 1.7841$, $\beta = 0.00555$, $\rho = 0.8961$, and $\delta = -0.0156$. Thus, this research obtained a new model as shown in (8) and (9). By substituting the profitability and liquidity data into model (8) and (9), this research obtained the profitability and liquidity estimation results which is available in Table 1 and Appendix 5 and 6. In Table 1, the estimation results of the company's highest and lowest profitabilities are 9.7 percent and 3.852 percent respectively, while their highest and lowest liquidity are 211.838 percent and 125.796 percent respectively.

$$x(t+1) = \frac{1.7841x(t)}{1+0.00555y(t)}, t = 1,2,\dots,n-11 \quad (8)$$

$$y(t+1) = \frac{0.8961y(t)}{1-0.0156x(t)}, t = 1,2,\dots 11 \quad (9)$$

Table 1.
Data of profitability and liquidity vs. results of profitability and liquidity estimation

Year	Profitability data (%)	Estimated profitability (%)	Liquidity data (%)	Estimated liquidity (%)
2011	9.7	9.7	194	194
2012	8.5	7.108	205	211.8
2013	5.0	4.639	167	162.3
2014	6.4	5.708	181	180.2
2015	4.2	3.852	171	163.9
2016	6.1	5.933	151	149.5
2017	6.0	5.818	152	150.2
2018	5.4	6.057	107	104.7
2019	6.16	6.397	127	125.7
2020	6.8	6.906	137	137.3
2021	6.6	6.767	134	133.8
2022	5.1	4.574	179	174.2

Source: Authors' work (2024)

Model accuracy

This research tested the accuracy of Model (4) based on the Mean Absolute Percentage Error (MAPE) value of each variable (Marasco et al., 2016; Wang & Wang, 2016). The criteria for the accuracy value and the MAPE calculation results are presented in Table 2.

Table 2.
The level of estimation accuracy by MAPE

MAPE (%)	Accuracy level
< 10	very accurate
10 – 20	good
20 – 50	normal
> 50	inaccurate

Source: Authors' work (2024)

In Table 3, it can be seen that MAPE generates a profitability value of 6.656 per cent and a liquidity value of 1.565 per cent. It shows that the MAPE value for liquidity is smaller than that of profitability. However, based on Table 2, both MAPE values are less than 10. Therefore, model (3) has a very high level of accuracy.

Table 3.
MAPE values for profitability and liquidity

	Profitability (%)	Liquidity (%)
MAPE (%)	6.656	1.565

Source: Authors' work (2024)

Profitability and liquidity forecasting

MAPE calculation value also shows that model (3) has a very high level of accuracy, allowing the model to be used to forecast future profitability and liquidity. The forecast results for the next five years are presented in the following Appendix 3, 4, and 7.

Discussion

The aforementioned predator-prey model demonstrates the existence of a non-zero equilibrium point. According to this point, if the reduction of the liquidity rate exceeds the impact of profitability on the liquidity growth rate, the company's profitability stands a substantial chance of expanding. This expansion is contingent upon the company's liquidity levels. Conversely, if the reduction in liquidity is less significant than the influence of profitability on the liquidity growth rate, in that case, the company's profitability has limited growth potential and may decline to zero.

On the other hand, the liquidity of the company will rise given the effect of liquidity on profitability is smaller than the growth rate of profitability. In other words, the amount of liquidity is determined by the growth of the company's profitability. However, an overly high liquidity will negatively affect the company's ability to earn profit, because some of the working capital does not circulate or is immobile. We have already perceived that there is no specific standard to determine the best current ratio (CR). However, as a precautionary principle, a CR of around 200 percent is considered good (Martono & Harjito, 2014).

The result shows that the company's liquidity level is still deemed good to sustain the company. In addition, the dynamics of the company's profitability over time fluctuate periodically for a relatively long time (see Figure 1). Similar dynamics can also be found in the liquidity of the company (see Figure 2). Furthermore, the figure of the interaction dynamics phase between profitability and liquidity in the long term forms a closed curve (see Figure 3). This indicates a positive signal for the company that its profitability and liquidity are in a good condition and can last for a long time.

To sum up, the predator-prey model demonstrates that the correlation between profitability and liquidity is negative. This means that the company's liquidity always reduces the amount of its profitability. This result is in line with Chaudhary & Raja (2021) and Hossain & Alam (2019). Hossain & Alam (2019) found that there is a relationship between liquidity and profitability. The cash conversion cycle has a strong negative correlation with all profitability ratios (NPM, ROA, and ROE), while the research result of Chaudhary & Raja, (2021) show that the profitability indicators are inversely correlated to the liquidity indicators.

In addition, the predator-prey model approach can be utilised to comprehend the interaction dynamics between profitability and liquidity. This is evident from the fact that the dynamics of the estimated profitability and liquidity results can follow the fluctuations in the historical data of PT. Indofood Sukses Makmur Tbk for the period of 2011-2022 (see Appendix 5 and 6) with a very high accuracy (see Table 3).

The results of profitability and liquidity forecasting show that for the period 2023-2027, profitability tends to decline. This results in the decline of liquidity value (see Appendix 3 and 4). In addition, the profitability experienced the largest decline in 2024 and 2026 (see Appendix 7). The decrease in liquidity is primarily attributed to the company's heavy reliance on the profits generated from its core business activities to meet its financial obligations and maintain sufficient cash flow.

Considering the forecasting results obtained, the value of profitability and liquidity which tends to decrease indicates that PT. Indofood Sukses Makmur Tbk must establish a policy to overcome this situation in the future. Such measure is urgently needed to counteract the predation activities of liquidity on profitability and to ensure that profitability can grow healthily. If the company cannot establish the right policy, then the profitability acquisition will not counterbalance the company's liquidity in the future. This situation will eventually lead the company to a considerable loss.

Conclusion, limitation, and future research

This research examines the interaction dynamics between profitability and liquidity by utilising the predator-prey model approach. This model contains two variables, namely predator and prey variables. The model indicates that the relationship between profitability and liquidity is negative. This means that liquidity always reduces the amount of profitability of the company. The equilibrium analysis demonstrates that the growth of the company's profitability depends entirely on the company's level of liquidity, while the amount of liquidity is determined by the growth of the company's profitability. An overly high liquidity will negatively affect the company's ability to earn profits. Results shows that the dynamics of the company's

profitability over time periodically fluctuate for a long time. Similar dynamics is also found in the company's liquidity. This indicates a positive signal for PT. Indofood Sukses Makmur Tbk that its profitability and liquidity are in a good condition. On the other hand, the results of profitability and liquidity forecast show that for the period of 2023-2027, both profitability and liquidity tend to fall. Therefore, this is an important signal for the company to take preventive measures so that it can continue to stabilise its profitability and liquidity in the future.

Forthcoming studies can incorporate other assumptions, such as the existence of competition between variables, so the model formed can be more comprehensive and complex. By adding assumptions, the model created can become a competition model that illustrates the actual reality. This research can provide information as a basis for consideration, support, and thought contribution to business decision-makers, thereby increasing income and carrying out business development.

Author contribution

Sri Wahyuni Jamal and Suparno: Writing—Original Draft and Writing—Review, Methodology, and Editing. **Fenty Fauziah, Umi Kartini Rashid and Azhar Latief**: Investigation, Validation, Data Curation, and Visualisation.

Declaration of interest

The authors declare no conflict of interest. All authors have agreed to the published version of the manuscript.

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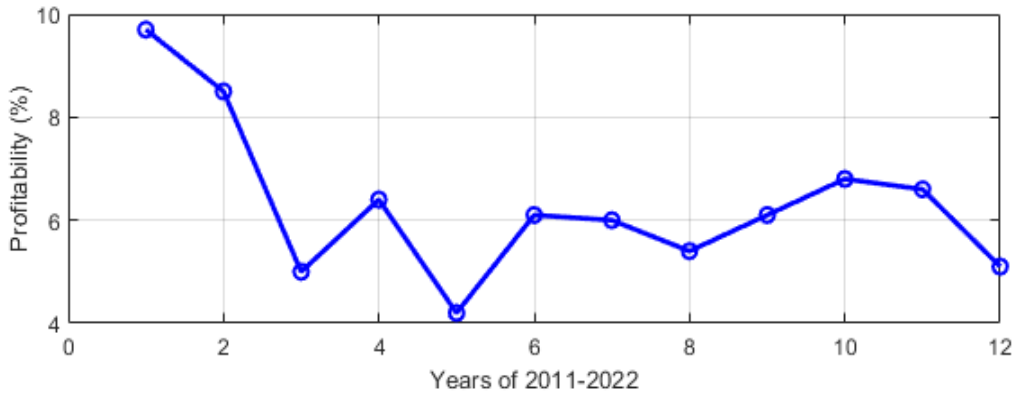
Appendix 1.

Historical data on profitability of PT Indofood Sukses Makmur Tbk (2011-2022)



Source: (INDF, 2023a)

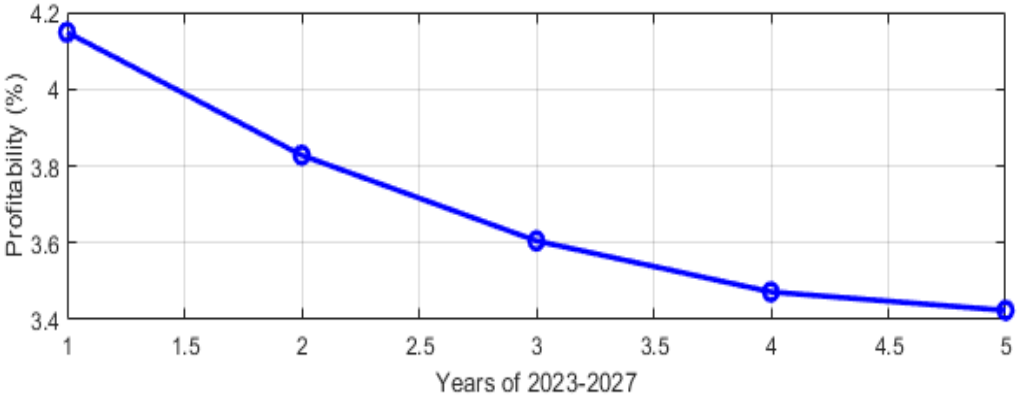
Appendix 2.

Historical data on liquidity of PT Indofood Sukses Makmur Tbk (2011-2022)

Source: (INDF, 2023a)

Appendix 3.

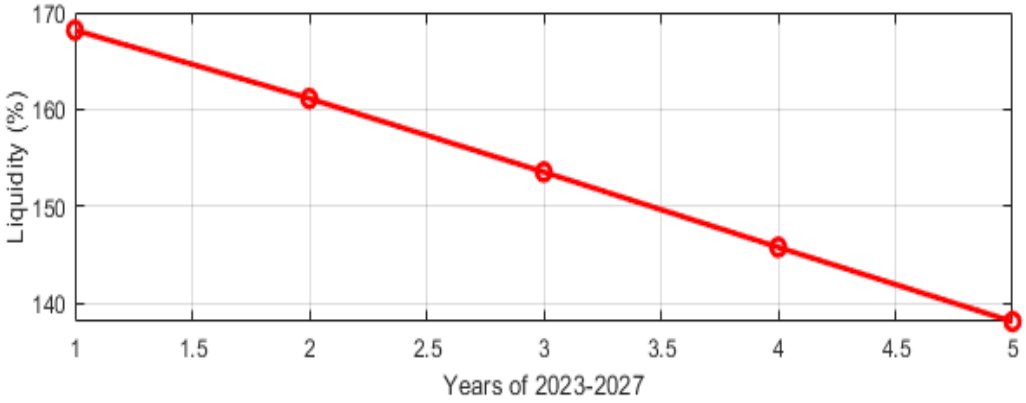
Results of profitability values forecast (2023-2027)



Source: Authors' work (2024)

Appendix 4.

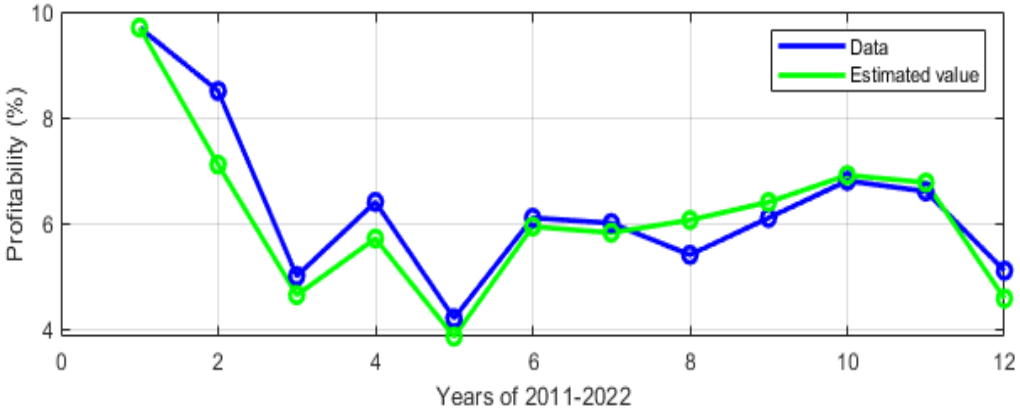
Results of profitability values forecast (2023-2027)



Source: Authors' work (2024)

Appendix 5.

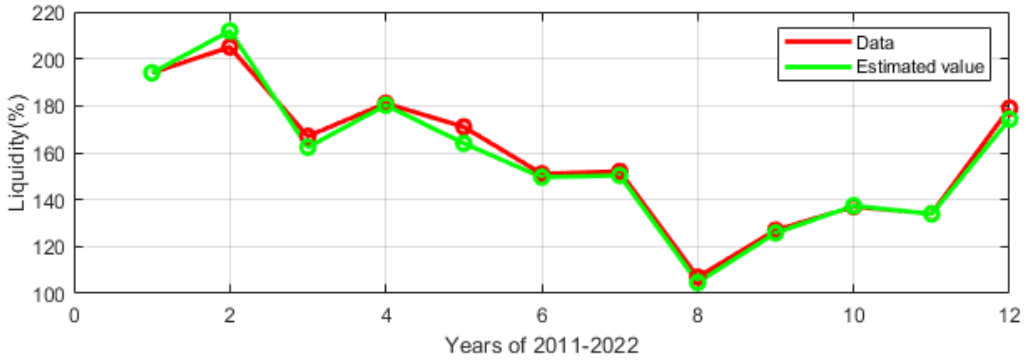
Results of liquidity values forecast (2023-2027)



Source: Authors' work (2024)

Appendix 6.

Historical data vs. estimated profitability result



Source: Authors' work (2024)

Appendix 7

Results of profitability and liquidity forecast

Year	Profitability (%)	Liquidity (%)
2023	4.148	168.184
2024	3.828	161.136
2025	3.605	153.564
2026	3.472	145.808
2027	3.424	138.142

Source: Authors' work (2024)