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Effect of Financial Factor and Accounting Anomaly on Financial Fraud Detection in Mining Sector Companies Listed on the Indonesia Stock Exchange 2021 – 2023

Maraditta Puteri Noor, Martdian Ratna Sari*

Sekolah Tinggi Manajemen PPM,
Jl. Menteng Raya No.9, Kb. Sirih, Menteng, Central Jakarta 10340, Indonesia
martdianratnasari@gmail.com

**Corresponding Author*

Abstract— Fraud is a significant problem in the financial sector, particularly in the Asia-Pacific region. This research focuses on the mining companies listed on the Indonesia Stock Exchange (IDX) from 2021 to 2023. The objective is to identify specific financial factors and accounting anomalies that effectively detect financial fraud within this industry. This research used a comprehensive approach that begins with descriptive statistics to provide an overview of the key variables under study, a classical assumption test to evaluate the feasibility and reliability of the sample data, and panel data linear regression to identify relationships between financial indicators and fraud detection. Results show that Return on Assets and Ownership structure have a positive impact on fraud detection. Conversely, a Change in Inventory has a negative impact on fraud detection. However, the debt-equity ratio, receivable-to-sales ratio, and Earning Growth did not significantly influence financial fraud detection in the studied companies. The analysis suggests that while some financial metrics are potent indicators of fraud, others may not be as effective in the mining industry context. This discrepancy underscores the importance of tailoring fraud detection mechanisms to the specific characteristics of the industry being analyzed. This study underscores the need to consider industry-specific financial indicators in fraud detection efforts and the need to maintain performance stability and transparency to reduce the likelihood of financial fraud. Companies in the mining sector can utilize these insights to enhance their internal controls and fraud detection mechanisms, thereby mitigating the risk of financial statement fraud.

Keywords— *Accounting Anomaly, Financial Factors, Financial Fraud Detection, Indonesia Stock Exchange, Mining Industry*

I. INTRODUCTION

Fraud in the financial sector is one of the main problems in Indonesia. According to the ACFE Report To The Nations in 2024 [1], there are three categories of fraud, namely, corruption, misappropriation of assets, and financial statement fraud, with the largest median loss in financial statement fraud of \$766,000 even though the percentage of cases is the smallest compared to other types of fraud. In 2024 Indonesia ranked 3rd as the country with the largest number of fraud (fraud/corruption) in Asia-Pacific. Given these conditions, it is important for all stakeholders to realize that the crime of financial statement fraud is very detrimental to many parties and realize the increase in this crime in Indonesia.

Fraud can occur in various industries, including the mining industry. This industry is the largest victim organization globally in 2024 from fraud, with a median value of the largest loss of \$550,000 with a total of 24 cases. This shows that this industry is very vulnerable to fraud compared to other industries, especially in large companies that have many stakeholders. In early 2024, a case emerged that shocked Indonesia in this industry, namely, a case of alleged corruption in the management of tin mining in the IUP of PT Timah Tbk from 2015-2022. This case is considered to have cost the state IDR 271 trillion [2]. This value comes from various types of losses that must be borne, namely environmental and economic losses, as well as recovery costs. This makes the tin corruption case the biggest corruption scandal that has ever occurred in Indonesia.

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The quality of financial information is a vital point that can be influenced by practices, for example, earning management, creative accounting, and fraud. Both earning management and financial statement fraud fall under the category of manipulation of earnings. However, earnings management may not contravene general accounting principles, while accounting fraud clearly violates principles and is a criminal offense. There is no universally recognized set of financial metrics for quantifying the likelihood of fraudulent financial reporting or identifying signs of creative accounting, which can influence bankruptcy prediction models reliant on traditional financial ratios [3]. Given the context of financial fraud in the mining industry, this research seeks to establish the link between specific accounting anomalies and financial factors that may serve as early indicators of fraudulent activities. In this study, we focus on several key variables: Return on Assets (ROA), Debt to Equity Ratio (DER), Change in Inventory, Receivable to Sales Ratio, and Earnings Growth as accounting anomalies, alongside Ownership structure as a financial factor.

20 Return on Assets (ROA), which measures the company's effectiveness, uses its assets to generate profits. Typically, the higher the ROA value, the more efficient the company is at generating profits. However, in companies that engage in accounting manipulations, the profit used to calculate ROA may be inflated through various means, such as manipulating inventory levels and increasing receivables from sales, which can artificially boost the company's profit growth. DER provides insights into the company's financial leverage, which may be manipulated to present a more favorable financial position. Change in Inventory can indicate discrepancies in stock management that are often linked to fraudulent reporting, while the receivable-to-sales ratio and Earnings Growth reflect potential earnings manipulation through aggressive revenue recognition practices. Financial factors such as ownership also play an important role, as companies with certain ownership structures may be more susceptible to accounting manipulation to meet the expectations of owners or major shareholders, examining more deeply the specific financial aspects.

23 This study focuses on analyzing financial factors that can be used in detecting fraud in mining sector companies listed on the Indonesia Stock Exchange for the period 2021-2023. This research will identify specific financial indicators that have not been widely discussed in the previous literature, especially in the context of the mining industry relevant to the conditions of the industry. Thus, this research is aim of expanding insights into fraud detection through financial analysis that is more focused. Therefore, this study wants to answer whether there are financial factors or simple accounting anomalies that can be used to detect fraud early.

31 Agency theory explains the formation of a relationship between shareholders and management due to the need for financial information for management welfare and shareholder decision-making [4]. Two primary assumptions that construct agency theory [5]: (1) information asymmetry exists between principals and agents, and (2) principals and agents have different points of view and interests. In this case, both principals and agents share certain risks. The principal takes on a certain level of risk as a result of hiring the agent to carry out the task and expects the best form of return by the agent. Agents, on the other hand, have better information about the company's operations and have an interest in earning a high rate of return for themselves. However, unethical managers can take advantage of this condition to manipulate financial statements due to this information asymmetry to make operational performance results look better than they actually are so that they can get high bonuses. As a result of this, both the principal and the company are at risk of financial loss.

2 According to agency theory, principals and management really expect positive performance in the company, one of which is profitability. Principals expect to get returns in the form of dividends, while agents expect bonuses for their performance. A high ROA indicates management's efficiency in using the company's assets to generate profits. However, unethical agents may manipulate this figure to show better performance than in reality in order to meet the expectations of the principal and get personal incentives. Previous research shows that ROA has a positive impact on financial fraud [6], where high ROA is one of the reasons for generating profits so as to maximize shareholder profits. Something similar was tested in research by [7] and [8], which proxies ROA to measure the pressure factor in fraud, showing ROA has a positive effect on financial fraud. Management will feel pressured to meet the company's financial targets, hoping that if these

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targets are achieved, they will get bonuses and high income. This can be achieved with optimal performance. However, this optimal performance can be obtained through opportunistic actions, such as committing fraudulent actions. Based on this description, the proposed hypothesis is:

H₁: ROA has a positive effect on Financial Fraud Detection.

According to agency theory, principals can create pressure for agents to make the company perform well and maximize good returns to principals, not to other parties such as creditors, banks, and others. A high DER can signal that the company has a high financial risk to the principal, which can trigger the agent to commit financial fraud in an attempt to appease the principal or investor regarding the company's financial health. The existence of information asymmetry between the two parties can make agents likely to hide the true level of debt or manipulate reports to demonstrate a more stable condition in order to maintain the trust of the principal. Research by [6] shows DER has a positive impact on financial statement manipulation practices. Dependence on debt increases the risk of financial statement fraud and has a negative impact on company profits and dividends. In line with this, research by [9] and [10] shows that companies with high DER are more likely to commit financial statement fraud because they are in a financial distress situation, which forces them to display better financial performance than they actually are. Based on this description, the proposed hypothesis is:

H₂: DER has a positive effect on Financial Fraud Detection.

According to agency theory, the ownership gap between the principal as the owner of the shares and the agent as management who can own minimal shares can lead to differences in goals. This is because principals are more focused on the returns they get from shares while agents focus on their performance bonuses. The ownership structure of the company can also create the potential for financial fraud. Agents with low share ownership may be less motivated to act in the long-term interests of the company and more likely to manipulate financial statements for short-term gain. In line with this issue, research conducted by [6] and [11] shows that ownership proxied to measure personal financial needs has a positive and significant effect on financial fraud; higher share ownership by a company's insiders or management will increase the risk of fraudulent financial statements. Previous research by [12] states that high institutional share ownership increases pressure on companies, which can encourage companies to create or manipulate financial reports, so institutional share ownership positively affects financial statement fraud. Based on this description, the proposed hypothesis is:

H₃: Ownership has a positive effect on Financial Fraud Detection.

According to agency theory, information asymmetry could make agents change the company's internal information to satisfy the principal; in this case, one is the inventory value change. Significant changes in inventory can be a sign of financial fraud, especially if there is a large difference between reported and actual inventory levels. Agents may use this tactic to adjust financial statements to make them look more favorable if inventory decreases. Research by [6] shows that changes or increases in inventory have a positive effect at the 0.1 level on financial statement manipulation. Increasing inventory can be done through double recording, capitalizing costs that should not be capitalized, or not reducing the cost of obsolete inventory, causing potential fraud. Based on this description, the proposed hypothesis is:

H₄: Change in Inventory has a positive effect on Financial Fraud Detection.

According to agency theory, agents who execute work for the company, of course, control the policies on the company's sales and receivables. This will cause information asymmetry in the principal. The receivable-to-sales ratio can measure the company's effectiveness in collecting receivables from sales, which, if this ratio is high, can indicate problems in the collection. Unethical agents may extend the collection period or overstate sales revenue to improve financial reports and make it seem as if the company is performing well so that agents get incentives as a result of this good performance. Research conducted by [6][11][13], shows that an increase in the ratio of receivables to sales, proxied as the nature of industry, has a positive impact on financial fraud. This can be shown by low cash turnover, which drives companies to manipulate

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financial statements by unlawfully estimating bad debts. Based on this explanation, the proposed hypothesis is:

H₅: Receivable to Sales Ratio has a positive effect on Financial Fraud Detection.

According to agency theory, management as an agent can use information asymmetry to subtly increase the company's profits. They do this to maintain principal satisfaction and increase agent compensation. Consistent earnings growth is a sign of a company's financial health, but it is also susceptible to financial manipulation. This is because earnings growth does not necessarily reflect the company's actual operations but is the result of agent manipulation to achieve personal gain. Research by [6] shows that earnings growth has a positive impact on financial fraud, which is due to companies often finding ways within accounting regulations to show better financial performance. Based on this description, the proposed hypothesis is:

H₆: Earning Growth has a positive effect on Financial Fraud Detection.

II. RESEARCH METHODS

This research is quantitative, and data is collected from a case or phenomenon. This research is statistical in nature, and data collection for analysis is mostly in the form of numbers (numeric). The goal of quantitative research is to create and utilize mathematical models, theories, or hypotheses related to the subject matter. The data used in this study are secondary data from the financial statements and annual reports of the mining sector industry for three years (2021 - 2023) listed on the Indonesia Stock Exchange. The data is sourced from the official IDX website (www.idx.co.id) and the official companies' websites. The population of this study are companies listed in the mining sector of the Indonesia Stock Exchange. The sample was taken using a purposive sampling technique based on several criteria in **Table 1**.

Table 1. Population and Sample Criteria

| Criteria | Total |
|--|-------|
| Companies listed in Mining Sector IDX | 62 |
| The company has not published Financial Reports/Annual Reports for five consecutive years. | (27) |
| Companies included in the IDX Special Monitoring Board | (1) |
| Total companies sampled | 23 |
| Total data observed (3 years) | 102 |
| Outlier Data | 32 |
| Total Sample | 70 |

Source: Authors' work (2024)

The data was gathered using the documentation method, which involved collecting and summarizing research-related data from the source mentioned before. This study also uses the financial ratio analysis method to measure several ratios used in this study. The following is measurement methods variables used in this study:

$$ROA = \frac{\text{Earning After Tax (EAT)}}{\text{Total Assets}} \quad (1)$$

$$DER = \frac{\text{Total Debt}}{\text{Shareholder Equity}} \quad (2)$$

$$OSHIP = \frac{\text{Total Shares Owned by Insiders}}{\text{Total of Ordinary Shares in Circulation}} \quad (3)$$

$$CI = \frac{\text{Inventories}_t}{\text{Sales}_t} - \frac{\text{Inventories}_{t-1}}{\text{Sales}_{t-1}} \quad (4)$$

$$RS = \frac{\text{Receivables}}{\text{Sales}} \quad (5)$$

$$EG = \frac{\text{Operating Profit}_t - \text{Operating Profit}_{t-1}}{\text{Operating Profit}_{t-1}} \quad (6)$$

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$$Mscore (FFD) = 4.84 + 0.92 DSRI + 0.528 GMI + 0.40 AQI + 0.892 SGI + 0.115 DEPI - 0.172 SGAI + 4.679 TATA - 0.327 LVGI \tag{7}$$

With:

- DSRI = Days Sales in Receivables Index*
- GMI = Gross Margin Index*
- AQI = Asset Quality Index*
- SGI = Sales Growth Index*
- DEPI = Depreciation Index*
- SGAI = Sales, General, and Administrative Expenses Index*
- TATA = Total Accruals to Total Assets*
- LVGI = Leverage Index*

M-score, which measures financial statement fraud with eight variables, can be useful for detecting financial statement fraud before company bankruptcy or liquidation [14][15][16]. Several studies use the Altman Z-Score measurement to detect financial statement fraud, but some research results indicate that this measurement cannot detect fraud as effectively as the M-Score model and is more effective in measuring bankruptcy [17]. Therefore, in detecting financial statements, the measurement used is the M-Score model.

Descriptive statistics provide an overview of the variables in the study and present them in the form of mean and standard deviation. Descriptive statistics can be used to classify, summarize, and present data descriptively or explanatory. To prove that the sample data and variables used in this study are feasible to use, it is essential to test the classical assumptions, including the normality test, multicollinearity, autocorrelation, and heteroscedasticity. The panel data linear regression method is a regression model that combines cross-section data and time series data, measuring the same cross-sectional unit at different points in time. The regression equation in this research is as follows:

$$FFD = \alpha + \beta1. ROA + \beta2. DER + \beta3. OSHIP + \beta4. CI + \beta5. RS + \beta6. EG + \epsilon \tag{8}$$

III. RESULT AND DISCUSSION

Table 2 displays the descriptive statistics of the variables utilized in the study. For variable FFD (Financial Fraud Detection), the average value recorded is -1.7517819, and the standard deviation is 1.11146328, with a sample size of 70. This shows that variable FFD has a value spread around the average -1.7517819 with significant variation. ROA descriptive results indicate that the average Return on Assets is 0.1597115 with fairly low variation among the sample. DER has an average of 0.5733901, and a standard deviation of 0.65785703, indicating it is considerable among the sample. OSHIP indicates that the ownership among the sample is relatively small with significant variation. CI has a mean of -0.0019845 and a standard deviation of 0.0484223, which means the ratio of receivables to sales has a value very close to zero and low variation. RS has a mean of 0.1126765 and a standard deviation of 0.06496768 means it has relatively little variation. EG has a mean of 0.5042171 and a standard deviation of 1.32168730. It means that there is a large variation in ownership among the sample. In conclusion, this descriptive data shows that there is significant variation among these variables, especially in the variables DER and EG. The rest of the variables show lesser variation among the sample under study.

Table 2. Descriptive Statistical Analysis Results

| Variable | Mean | Std. Deviation | N |
|----------|------------|----------------|----|
| FFD | -1.7517819 | 1.11146328 | 70 |
| ROA | 0.1597115 | 0.17521418 | 70 |
| DER | 0.5733901 | 0.65785703 | 70 |
| OSHIP | 0.0740950 | 0.19331604 | 70 |
| CI | -0.0019845 | 0.04842233 | 70 |
| RS | 0.1126765 | 0.06496768 | 70 |
| EG | 0.5042171 | 1.32168730 | 70 |

Source: Authors' work (2024)

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For the assumption classic test, this research used normality test, multicollinearity test, autocorrelation, and heteroscedasticity. The analysis reveals that the linear regression model in use is normally distributed, supported by a One Sample Kolmogorov-Smirnov Test showing a significance level of 0.200 which is greater than 0.05. Multicollinearity, assessed through the Glejser test shows all Variance Inflation Factor (VIF) values between 0.10 and 10, suggesting no issues between independent and dependent variables. Autocorrelation, examined using the Durbin-Watson (DW) test reveals a value of 1.633, indicating positive autocorrelation, though its relevance in cross-section or panel data is questioned [18]. Heteroskedasticity, evaluated via the Glejser test, indicates no significant issues, with all significance levels for independent variables ROA to EG exceeding 0.05. Thus, the regression model appears suitable for further research purposes.

The coefficient of determination (R²) test in **Table 3** shows that the Adjusted R Square value of the regression equation is 0.280. This value indicates that all independent variables in the study contributed 28 percent to financial statement fraud, while the remaining 72 percent came from other variables not tested in this study.

Table 3. Coefficient Determination Test Result

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------|----------|-------------------|----------------------------|
| 1 | 0.585 | 0.343 | 0.280 | 0.94312509 |

Source: Authors' work (2024)

Table 4 shows that the calculated F value is greater than the F table, namely $5.472 > 2.246$. This means that there is a significant influence between ROA, DER, Ownership, Change in Inventory, Receivable to Sales Ratio, and Earning Growth together on the detection of financial fraud. Hypothesis testing focuses on accounting anomalies consisting of ROA, DER, Change in Inventory, Receivable to Sales Ratio, and Earning Growth, as well as financial factors, namely, Ownership.

Table 4. ANOVA Table

| | Sum of Squares | df | Mean Square | F | Sig. |
|------------|----------------|----|-------------|-------|--------|
| Regression | 29.202 | 6 | 4.867 | 5.472 | <0,001 |
| Residual | 56.038 | 63 | 0.889 | | |
| Total | 85.239 | 69 | | | |

Source: Authors' work (2024)

Based on **Table 5**, the t-test shows that ROA and Ownership have a positive effect on the detection of financial fraud. This is shown by the significance value is less than 0.05. The results of this study support hypotheses 1 and 3. In addition, a Change in Inventory has a negative effect on the detection of financial fraud. Thus, the results of the study reject hypothesis 4. Meanwhile, DER, Receivable to Sales Ratio, and Earning Growth have significance values greater than 0.05. Thus, the results of the study reject hypotheses 2, 5, and 6. This shows that DER, receivable-to-sales ratio and Earning Growth have no effect on the detection of financial fraud.

Table 5. Multiple Linear Regression Analysis Results

| Variable | Unstandardized | Std. Error | Standardized | t | Sig. |
|------------|----------------|------------|--------------|--------|-------|
| | Coefficients | | Coefficients | | |
| | B | | Beta | | |
| (Constant) | -2.601 | 0.290 | | -8.963 | 0.000 |
| ROA | 2.763 | 0.769 | 0.436 | 3.594 | 0.001 |
| DER | 0.214 | 0.191 | 0.127 | 1.123 | 0.266 |
| OSHIP | 1.527 | 0.628 | 0.266 | 2.430 | 0.018 |
| CI | -7.436 | 2.419 | -0.324 | -3.074 | 0.003 |
| RS | 1.560 | 1.966 | 0.091 | 0.794 | 0.430 |
| EG | -0.038 | 0.094 | -0.045 | -0.405 | 0.686 |

Source: Authors' work (2024)

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Referring to the **Table 5**, the coefficient of ROA in this study shows a value of 2.763 with a significance value of 0.001. This means that ROA has a positive effect on financial fraud detection. The findings of this study indicate that high ROA indicates financial fraud. Management tends to pursue a certain level of profitability so that it can be moved to manipulate financial statements. This is in line with agency theory. Unethical agents may manipulate this figure to show better performance than in reality, to fulfill the principal's expectation and obtain personal incentives. In addition, when viewed in the interpretation of the M-Score calculation, many companies that have high ROA fall into the "likely profit manipulation" category or the M-Score value > 1.78. So, the research hypothesis that ROA has a positive effect on financial fraud detection is accepted. This result is supported by previous studies, namely [6][7][8][19].

Furthermore, accounting anomalies related to DER with a coefficient value of 0.214 and a significance value of 0.266 indicate that DER has no effect on financial fraud detection. Higher DER in the sense of high financial risk does not trigger financial statement fraud. Financial risks that arise from external parties to the company (creditors, banks, and others) cause the company to be increasingly monitored because external parties will expect debt repayment and interest from the funding that has been given to the company. Therefore, the research hypothesis that assumes DER has a positive effect on financial fraud detection is not accepted. This is inconsistent with agency theory, which suggests that high DER can trigger agents to commit financial fraud to appease principals or investors about the company's financial health. This result is supported by previous studies [11].

The coefficient value of inventory changes (Change in Inventory) is -7.436 with a significance value of 0.003, which indicates that inventory changes have a negative effect on financial statement fraud. This means that the greater the change in inventory, the lower the financial statement fraud. Companies that have high inventory changes must record and manage inventory more transparently and regularly, thereby reducing opportunities to hide or manipulate financial data. In addition, the data taken from this sample is in 2021 - 2023, when inventory in the mining industry has just passed the pandemic period and is aggressively returning to mining operational activities, so the value of inventory tends to increase every year. Therefore, the research hypothesis that assumes Change in Inventory has a positive effect on financial fraud detection is not accepted.

The receivable-to-sales ratio shows a coefficient value of 1.560 with a significance value of 0.430. It can be translated that the ratio of receivables to sales has no effect on financial statement fraud. The total receivable ratio is the ratio used by the company to assess how fast or slow the collection of receivables is during the current period. The faster the turnover of accounts receivable, the better the company's financial condition. The amount of receivables held by the company does not affect the available cash for operational activities, meaning this ratio has no impact on motivating managers to engage in fraudulent financial reporting. This is not in line with agency theory, where if this ratio is higher, it can indicate problems in collection, which can be made possible by unethical agents extending the collection period or overstating sales revenue to improve financial statements. Then, the nature of industry variables cannot be used to detect fraudulent financial statements. Therefore, the research hypothesis that assumes the receivable-to-sales ratio has a positive effect on financial fraud detection is not accepted. The same results of this study are shown by [20][21].

In line with the receivable-to-sales ratio variable, earnings growth has also been proven to have no effect on financial statement fraud in this study. Earning Growth, with a coefficient value of -0.038 and a significance value of 0.686, means that earnings growth has no effect on detecting fraudulent financial statements. According to [11], when companies experience an increase in revenue, management is prouder to show the results of their actual performance without any manipulation of their financial statements. In addition, this account may not be used to manipulate financial statements because it is the result of previous account calculations. Management may manipulate accounts that are directly related to their control, such as sales growth or expense minimization. This contradicts the agency theory, where agents can use information asymmetry to make it appear as if the profits generated by the company are increasing subtly. They do this

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to maintain principal or investor satisfaction and increase agent compensation. Therefore, the hypothesis that Earning Growth affects financial fraud detection is not accepted.

1 The financial factors are shown by the hypothesis testing of organizational ownership (Ownership). The results before show that ownership has a positive influence on financial fraud detection. This can be shown by the coefficient value of 1.527 and the significance value of 0.018. It means that the amount of share ownership owned by management affects the potential for financial fraud. The more common shares management has in his or her company, the higher the possibility of financial fraud. These results are in accordance with agency theory, which states that agents with low share ownership may be less motivated to act in the long-term interests of the company and more likely to manipulate financial statements for short-term gain. Meanwhile, high institutional share ownership increases pressure on the company, which can encourage management to commit fraud. This is supported by previous research [6][11][12].

Based on the test results and analysis of research data, practical information was obtained to contribute to detecting fraud earlier with simpler calculations or ratios. An in-depth understanding of accounting anomalies and financial factors that affect financial fraud detection, such as the positive influence of ROA and share ownership, as well as the negative influence of inventory changes, allows companies to improve their supervision and risk management systems. By knowing that receivables-to-sales ratio and profit growth have no effect on fraud, companies can focus on more relevant indicators. This not only improves management transparency and accountability but also strengthens stakeholders' confidence in the company's financial health, thereby supporting better investment decisions and more effective risk management.

IV. CONCLUSION

This study examines ASEAN experts' research patterns in open innovation publications from 2009 to June 2024. Over the past 15 years, ASEAN researchers have focused on open innovation, leading to a substantial boost in publishing productivity starting in 2018. Among the seven ASEAN countries involved in research on OI, Indonesia has the highest publishing productivity, with 95 author participation; Malaysia and Thailand follow closely behind. Singapore is the first country in the ASEAN region to conduct research on OI. Malaysia, Thailand, Indonesia, and the Philippines follow. Vietnam and Brunei Darussalam are recent additions to the OI theme, representing ASEAN countries.

The Journal of Open Innovation: Technology, Market, and Complexity is the most influential in its field, surpassing all other journals in terms of effectiveness. It is worth noting that this journal only started publishing articles on Open Innovation in 2019. In that order, the subsequent journals are the European Journal of Innovation Management and Technovation.

Vanhaverbeke W holds the distinction of being the most prolific author in terms of publications and citations in the field of IO. Authors Priyono A, Redi A.A.N.P, Young MN, and Surya B, while not being part of the top 10 ASEAN authors in terms of publications on OI, have a significant impact with their citations in the top 10. Furthermore, all of them have contributed to the publication of works on the subject of OI starting in 2020.

ASEAN scholars used co-occurrence keywords to explore prominent themes in OI research. During each period, scholars in the ASEAN region concentrate on various subjects. Research areas such as open innovation ecosystems and open innovation techniques have garnered significant interest in recent times. The Open Innovation (OI) research topics are not widely distributed throughout the ASEAN region. Specifically, Open Innovation in Small and Medium Enterprises (SMEs) is closely linked to Thailand, while Open Innovation collaboration is associated with Vietnam. Indonesian scholars focus on the topic of the Open Innovation Ecosystem, and Malaysian scholars concentrate on the topic of open innovation strategy.

29 According to trend analysis of research themes using co-word analysis, the current focus of interest is on Innovation in Small and Medium Enterprises (SMEs) and the concept of collaboration for Open Innovation. This also implies that scholars will continue to focus on this research topic in the upcoming

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period. More precisely, it refers to the open innovation model, the internal and external resources that facilitate open innovation, and the effectiveness of Open innovation.

This study also has some limitations. First, the author has only collected and analyzed English documents. This may lead to the omission of research that is not presented in English. Second, while the Scopus database ensures research quality, it may not index the quality of other ASEAN scholars' studies on open innovation. Future studies should also supplement other reliable international databases, such as PubMed or Web of Science (WoS), to comprehensively understand the research topic. Finally, since the scope of this research focuses on the ASEAN region, we recommend that scholars continue to analyze and compare across different regions of the world.

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