Ekonomi Bisnis
Volume 31, Nomor 2, July 2026 (107-123)
ISSN 0853-7283 (Print), 2528-0503 (Online)
Available online at: http://journal2.um.ac.id/index.php/ekobis

The moderating role of total asset turnover in the effect of cash holdings on investment efficiency: Empirical evidence from listed energy sector companies

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Article Info

Article History:
Submitted: 6 May 2026
Revised: 10 June 2026
Accepted: 19 June 2026

Keywords:
cash holdings, investment efficiency, total asset turnover

Abstract

This study analyzes the effects of liquidity (cash holdings) and asset utilization efficiency (TATO) on investment efficiency. Additionally, this study examines the interaction between liquidity and TATO among companies in Indonesia's energy sector during 2018–2024. The results indicate that both liquidity and TATO have significant positive effects on investment efficiency. Furthermore, the interaction between liquidity and TATO with respect to investment efficiency yields a significant negative effect. This suggests that when a company holds high liquidity reserves, it actually weakens investment efficiency. The study also included a COVID-19 dummy variable; the results remained consistent, showing that the interaction between liquidity and TATO was significantly negative. Overall, the findings indicate that liquidity and TATO have a direct positive effect on investment efficiency. However, the interaction coefficient between liquidity and TATO is negative, meaning that TATO acts as a moderating variable that weakens the relationship between liquidity and investment efficiency. This finding suggests that high liquidity does not automatically improve investment efficiency, as its effectiveness depends on a company's ability to allocate cash and utilize assets productively.

Peran moderasi total asset turnover dalam pengaruh cash holdings terhadap efisiensi investasi: bukti empiris dari perusahaan sektor energi yang terdaftar di Bursa Efek Indonesia periode 2018 – 2024

Abstrak

Penelitian ini menganalisis pengaruh Likuiditas (*Cash Holdings*) dan Efisiensi penggunaan aset (TATO) terhadap efisiensi investasi. Selain itu, penelitian ini menguji peran interaksi antara likuiditas dan TATO pada perusahaan di sektor energi di Indonesia periode tahun 2018 – 2024. Sektor energi dipilih karena memiliki karakteristik padat modal, membutuhkan investasi jangka panjang, serta menghadapi risiko ketidakpastian harga, permintaan, dan regulasi. Hasil penelitian menunjukkan bahwa likuiditas dan TATO masing – masing memiliki nilai positif signifikan terhadap efisiensi investasi. Lebih lanjut, hubungan antara likuiditas dan TATO terhadap efisiensi investasi menghasilkan pengaruh negatif yang signifikan. Hal ini menjelaskan bahwa ketika sebuah perusahaan memiliki cadangan likuiditas yang tinggi, justru memperlemah terhadap efisiensi investasi. Penelitian juga memasukkan variabel *dummy* COVID-19, hasilnya menunjukkan tetap konsisten bahwa interaksi antara likuiditas dengan TATO bersifat negatif secara signifikan. Secara keseluruhan, penelitian ini menjelaskan bahwa likuiditas dan TATO berpengaruh positif terhadap efisiensi investasi, namun interaksi keduanya memperlemah pengaruh terhadap efisiensi investasi.

How to Cite: Rozali, R.H.B., & Lubis, A.W. (2026). The moderating role of total asset turnover in the effect of cash holdings on investment efficiency: Empirical evidence from listed energy sector companies. *Ekonomi Bisnis*, *31*. (2.), 107-123

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ISSN
0853-7283 (print) 2528-0503 (online)

INTRODUCTION

The energy sector plays a strategic role in supporting national economic activity, as it serves as the main pillar for industry, transportation, households, and infrastructure development. In Indonesia, this sector encompasses various business activities such as mining, oil, natural gas, coal, and alternative energy. The key characteristics of the energy sector include high capital requirements, substantial fixed assets, and long-term investment projects. This sector plays a vital role in Indonesia's economic structure. The mining and quarrying sector contributed approximately 7.71% of the national Gross Domestic Product (GDP) in the first half of 2025 (BPS, 2025). During this period, Indonesia's national GDP rose to Rp. 5,947 trillion, representing a 5.12% *year-on-year* increase. The rising GDP growth in the energy sector led to investment realization in the mining, oil and gas, and electricity sectors reaching US$ 13.9 billion in the first half of 2025 (ESDM, 2025). This figure represents an increase compared to the first half of 2024, which reached only US$ 11.2 billion.

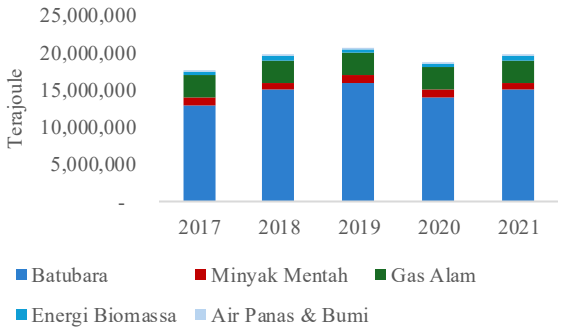
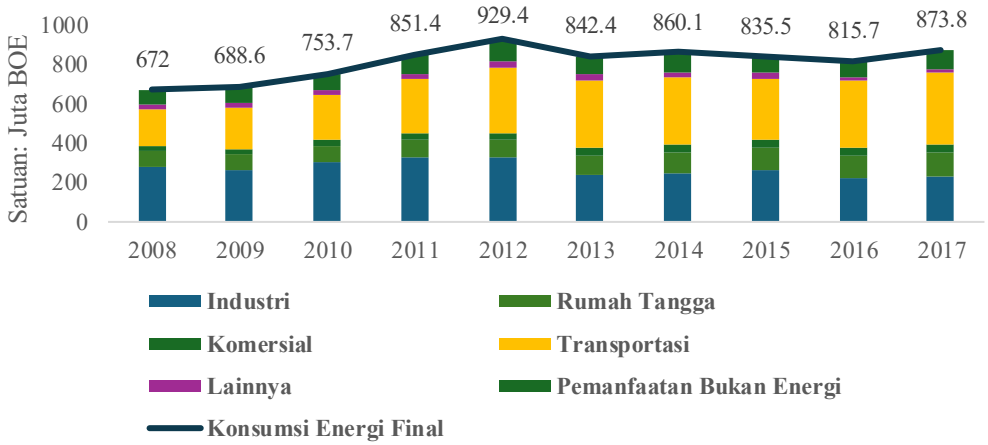


Figure1 . Primary Energy Production

Source: Indonesian Energy Publication (2021)

Furthermore, data on national energy demand by sector from 2008 to 2017 shows that Indonesia's energy consumption has generally followed an upward trend, peaking in 2012. The industrial and transportation sectors are the largest contributors to national energy consumption . This increase in energy demand indicates the growing economic activity of the population.



Sektor	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Industri	276.1	260.3	305.7	330.2	325.4	237.8	244.6	264.4	222	231.9
Rumah Tangga	84.5	80.8	81.6	85.4	92.5	99.7	106.4	110.5	115	120
Komersial	26.8	28.2	29.6	32.8	35.8	37.9	38.9	41.1	40.2	42.1
Transportasi	185.7	210	230.3	277.5	329.5	341.4	342.8	309.3	340	361.7
Lainnya	25.1	25.3	22.3	27.2	33.7	31.1	28.7	32.8	20.4	20.1
Pemanfaatan Bukan Energi	73.8	84.1	84.1	98.3	112.6	94.5	98.7	77.4	79	97.3
Konsumsi Energi Final	**672**	**688.6**	**753.7**	**851.4**	**929.4**	**842.4**	**860.1**	**835.5**	**816**	**873.8**

Figure 2 . Energy Demand in Indonesia by Sector

Source: Energy and Economic Statistics of Indonesia (2017)

These conditions make investment decisions by companies in the energy sector a critical aspect, as errors in capital allocation can lead to inefficiencies, whether in the form *of overinvestment* or *underinvestment*. The energy sector is also characterized by high risk, such as market demand uncertainty, price fluctuations, and political risks, which can potentially increase a company's capital costs.

Investment efficiency is a critical issue because increased investment in assets does not always lead to higher revenue or improved corporate productivity. Energy sector companies are heavily influenced by macro- and microeconomic factors. Asset utilization efficiency in this sector is highly dependent on the volatility of global commodity prices—such as crude oil, natural gas, and coal—so that when prices plummet, corporate revenue declines as well, making the asset utilization efficiency ratio appear inefficient even though production capacity remains stable. On the other hand, the capital-intensive nature of the energy sector leads many companies to carry high levels of debt to finance expansion costs, which can potentially squeeze net profits and further worsen asset utilization efficiency. Significant initial investments are required for the purchase and construction of fixed assets such as production facilities, networks, and technology. This industry requires large-scale investments that are generally long-term in nature. Comparisons of the TATO ratio across industries are used because of differences in *capital intensity* levels. The following table shows TATO ratios used to determine *the capital intensity* of various industries

Table 1 . Capital Intensity by Industry (Tractian, 2026)

Industry	Range	*Capital Intensity*
Energy, Oil, & Gas	0.4 – 1.2	Very High
Manufacturing Plants	0.8–2.5	High
Food and Beverages	2.0–4.0	Medium
Retail	4.0 – 8.0	Low to Medium
Technology	5.0 – 15.0	Low

In addition, global market dynamics and investor sentiment toward the energy sector also influence asset valuations. Companies may possess substantial assets but may not necessarily be able to manage them optimally to generate sales. In the context of the energy sector, this situation is particularly relevant because energy companies require significant investment to finance productive assets such as production facilities, heavy equipment, mining infrastructure, technology, and distribution networks. Therefore, investment efficiency is determined not only by the amount of available funds but also by the company's ability to manage and utilize its assets productively.

One factor that influences investment efficiency is a company's liquidity. The energy sector is a capital-intensive sector that is highly sensitive to fluctuations in commodity prices, macroeconomic conditions, and global dynamics such as the COVID-19 pandemic and geopolitical tensions, all of which affect the revenue and investment needs of energy companies. This phenomenon makes the availability of cash a crucial factor; when sufficient, it provides companies with the flexibility to finance operations and investment opportunities without relying on external funding. However, excessively high liquidity can pose risks such as *idle cash* or encourage management to allocate funds to less productive projects. Thus, *cash holdings* can support investment efficiency but may also lead to inefficiencies if not managed properly, resulting in unprofitable investment opportunities. Excess

cash can serve as *a buffer* to determine whether company managers need to increase their investments or not. Liquidity in this study is proxied by *cash holdings*, defined as the ratio of cash and cash equivalents to total assets.

In addition to liquidity, the efficiency of asset utilization is also a key factor in investment efficiency. One indicator used is *Total Asset Turnover* (TATO), which serves as a proxy for a company's ability to utilize its assets to generate sales. In the asset-intensive energy sector, TATO is a relevant indicator because the size of a company's assets does not necessarily reflect the effectiveness of their use. A low TATO value may indicate that assets are not being used optimally, meaning that the investments made have not yet fully yielded commensurate economic benefits.

Several previous studies have examined the relationship between liquidity or *cash holdings* and investment efficiency, but most have focused on companies in general; consequently, these findings do not adequately reflect the unique characteristics of the energy sector—which is capital-intensive, has substantial assets, and is sensitive to commodity price fluctuations and changes in energy policy (Alkhouri, 2019; Wang *et al.,* 2020). Indonesia's energy sector faces commodity price volatility and the need for substantial investment in the clean energy transition during the 2018–2024 period. Energy companies require large-scale, long-term investments that are highly exposed to fluctuations in commodity prices and the global economy (Apergis & Payne, 2014). This affects asset utilization efficiency; when prices plummet, company revenue declines as well, making the asset utilization efficiency ratio appear inefficient even though production capacity remains stable. On the other hand, the capital-intensive nature of the energy sector means many companies carry high levels of debt to fund expansion costs, which can potentially squeeze net profits and further worsen asset utilization efficiency. Furthermore, global market dynamics and investor sentiment toward the energy sector also influence asset valuation. This leads many companies to hold large amounts of cash but not always be able to convert it into productive investments, thereby posing a unique challenge to investment efficiency in the energy sector (Zhang & Li, 2021; Nguyen *et al.*, 2022). Furthermore, the literature remains limited in examining the impact of total asset turnover (TATO) as a moderating variable in the relationship between liquidity and investment efficiency. TATO reflects a company's operational ability to maximize its assets to generate *returns*, which is particularly important in the context of corporate assets in the energy sector (Chen *et al.*, 2011). Although some previous studies have used TATO as a moderating variable in various corporate financial relationships (Salehi *et al.*, 2022; Sunaryo *et al.*, 2022; Ridwan & Alghifari, 2024), research examining TATO's role in moderating the effect of *cash holdings* on investment efficiency remains very limited. The use of TATO as a moderator implies that the level of asset management efficiency can either strengthen or weaken the impact of liquidity on investment efficiency. Furthermore, this study focuses on the energy sector, which is capital-intensive and requires substantial long-term investments. According to Memon et al. (2019), the importance of moderation is emphasized to explain the inconsistencies in empirical results from previous studies. Thus, this study is expected to provide further insights into investment efficiency. The findings of this study are expected to provide an academic contribution to the development of investment theory in capital-intensive sectors and practical implications for corporate management, investors, and regulators in making more efficient cash allocation and investment decisions amid the dynamics of the global energy market.

Research Hypotheses

This study examines whether a company's liquidity, as measured by *cash holdings*, has an impact on its

investment efficiency. *Cash holdings* refer to the ratio of cash and cash equivalents to a company's total assets. Liquidity is a key factor in supporting a company's investments. Companies with adequate liquidity have greater financial flexibility to fund profitable projects, thereby reducing the risk *of underinvestment* (Gao et al., 2025). Sufficient cash availability can increase a company's opportunities for profitable investments, thereby enhancing investment efficiency. According to agency theory, managers may hold large amounts of cash for personal gain or liquidity security, thereby risking overinvestment (Jensen & Meckling, 1976). This can create agency problems, leading managers to make inefficient investments. However, when cash is used optimally, its availability enables the company to fund profitable projects, thereby reducing the risk *of underinvestment*. In the capital-intensive energy sector, adequate liquidity is crucial for supporting investments in large assets; therefore, this study hypothesizes that liquidity has a significant positive effect on investment efficiency. The first hypothesis of this study is:
H1: Liquidity has a significant positive effect on investment efficiency

TATO measures how efficiently a company utilizes its assets to generate revenue. In the context of this study, the higher the TATO, the more efficiently the company manages its assets. TATO reflects the extent to which a company utilizes its assets to generate sales. Research by Patin et al. (2020) found that TATO has a positive effect on company performance. Conversely, when TATO is low, companies tend to be less capable of optimizing the use of their assets. This situation occurs even when a company has high liquidity, meaning that available cash is not utilized productively (Ditmar & Smith, 2007), thereby reducing efficiency. This can enhance investment efficiency because companies can maximize the use of existing assets to achieve better investment returns. This hypothesis will test the extent of TATO's influence on a company's investment efficiency. The second hypothesis in this study is:
H2: Asset Utilization Efficiency has a significant positive effect on investment efficiency

In the context of a moderating role, TATO has the potential to strengthen or weaken the relationship between liquidity and investment efficiency. If a company has a high TATO—where assets are used productively—this can strengthen *cash holdings* and redirect them toward more productive activities. This is further supported by the finding that the higher the TATO ratio, the more efficient the company is in conducting its operations (Patin et al., 2020), and vice versa. However, the opposite may also occur: if a company has a high TATO, it may weaken the influence of *cash holdings*, meaning there is *idle cash* that leads to *overinvestment*. This aligns with agency theory, which emphasizes the risk of conflicts of interest between managers and shareholders (Jensen & Meckling, 1976). Previous research has highlighted the importance of moderating variables in explaining inconsistencies in financial relationships within capital-intensive firms (Baron & Kenny, 1986; Memon *et al.*, 2019; Farhan *et al.*, 2023). Thus, the hypothesis is that asset utilization efficiency can moderate the direction and strength of liquidity's effect on investment efficiency, particularly in energy sector firms facing market volatility and significant investment needs. The third hypothesis in this study is:
H3: Asset Utilization Efficiency weakens the relationship between liquidity and investment efficiency in energy sector firms in Indonesia

Research Objectives

This study aims to analyze the effect of liquidity on investment efficiency in energy sector companies in Indonesia. Additionally, this study examines the effect of asset utilization efficiency on investment efficiency and analyzes the role of asset utilization efficiency as a moderating variable in the

relationship between liquidity and investment efficiency. This study is important because the energy sector is capital- -intensive and highly sensitive to fluctuations in commodity prices, macroeconomic conditions, and national and global energy policies. Energy companies must be able to balance available cash with substantial investment needs to avoid over- or underinvestment. Thus, by analyzing the role of asset utilization efficiency as a moderator, this study examines whether companies capable of optimally utilizing their assets can convert their cash into more efficient investments—or whether the opposite occurs. Consequently, this study not only assesses the direct effects of liquidity and asset efficiency but also provides additional analysis regarding energy companies' operational readiness to maximize the use of resources and assets, while examining whether a company's ability to utilize its assets can strengthen or weaken the impact of liquidity on investment efficiency.

LITERATURE REVIEW

Agency Theory

Agency theory explains the relationship between company owners and managers, which has the potential to give rise to conflicts of interest because managers do not always make decisions that are fully aligned with the interests of shareholders (Jensen & Meckling, 1976; Rashid, 2016). In the context of investment efficiency, this conflict can arise when a company has high liquidity, giving managers greater discretion in the use of internal funds. According to Jensen (1986), the availability of large cash flows can increase the potential for agency problems because funds are allocated to less productive projects, leading to *overinvestment*. Furthermore, overly optimistic managers tend to be more sensitive to the availability of funds and may make inefficient decisions (Heaton, 2005; Huang et al., 2011; Osaba et al., 2018; Lin et al., 2005). Conversely, funding constraints can lead to underinvestment, which occurs when a company misses out on more profitable projects (Campbell et al., 2011; Huang, 2020). Information distortions in financial reporting can also lead to biased growth expectations and drive suboptimal investment decisions (McNichlos & Subben, 2008). Thus, agency theory serves as the foundation for explaining that liquidity can support investment efficiency but can also lead to inefficiencies if not managed productively.

Investment Efficiency

Investment efficiency describes a company's ability to allocate funds to value-added projects and avoid suboptimal investment decisions, whether in the form of overinvestment or underinvestment. Distortions in investment decisions can lead to moral hazard and adverse selection between shareholders and managers (Avery et al., 1998; Huang, 2020). Investment efficiency is also influenced by internal and external factors such as the quality of financial statements, financing structure, corporate governance, and financial market conditions (Huang *et al*., 2022; Naeem & Li, 2019).

Liquidity

Liquidity reflects a company's ability to provide internal funds to support its operational and investment activities, thereby ensuring sufficient flexibility to capitalize on investment opportunities without the need for external financing (Ardianto & Sulaiman, 2024; Gao *et al.,* 2025). Furthermore, strong liquidity serves as a positive signal to the market, as it indicates the company's financial stability and enhances investor confidence (Salehi *et al*., 2022). However, excessively high liquidity does not always have a positive impact, as it may reflect the presence of *idle cash* that is not allocated productively. This situation has the potential to create agency problems and encourage *overinvestment* in projects that provide little added value, thereby reducing efficiency (Biddle *et al*., 2009; Dittmar & Mahrt-Smith, 2007; Sheu & Lee,

2012). Therefore, liquidity must be managed optimally to support investment efficiency, financial stability, and the company's long-term profitability.

Moderation of Asset Utilization Efficiency

Asset utilization efficiency is proxied by *Total Asset Turnover* (TATO), which reflects a company's ability to utilize its assets. A high TATO indicates that assets are managed productively, thereby supporting more efficient investment decision-making (Delen *et al.,* 2013; Patin *et al*., 2020; Nguyen & Nguyen, 2020). In this study, TATO is used not only as an independent variable' t but also as a moderating variable that can strengthen or weaken the relationship between liquidity and investment efficiency. This occurs when high liquidity does not necessarily improve investment efficiency if assets are not utilized optimally. Conversely, a low TATO may indicate suboptimal asset utilization, potentially leading to *idle cash* and reducing investment efficiency (Ditmar & Smith, 2007).

METHOD

Data and Sample

This study examines companies listed on the Indonesia Stock Exchange during the 2018–2024 period using data from the companies' annual financial reports. To ensure data quality, this study applied specific criteria. Companies lacking complete investment efficiency data were excluded from the sample. The selection process resulted in a final sample of 70 Oil, Gas, and Energy companies, yielding 490 data observations. The following are the energy subsectors in Indonesia.

Table2 . Energy Industry Sub-Sectors (IDX Classification, 2025)

Energy Sub-Sectors	Sub-Industry
A1. Oil, Gas, and Energy	• Oil & Gas Production & Refining • Oil & Gas Storage & Distribution • Coal Production • Coal Distribution • Oil & Gas Drilling Services • Equipment
A2. Alternative Energy	• Alternative Energy Equipment (Renewable energy generators, solar panels, wind turbines, etc.) • Alternative Fuels (*Biofuels*, plant-based fuels, etc.)

To minimize the influence of *outliers* and extreme values, all continuous variables in the dataset were winsorized—that is, extreme values at the 1st and 99th percentiles were adjusted—with the exception of the *dummy* variable. This method aims to reduce potential data distortion caused by values that are too high or too low. The *dummy* variable used here is *COVID-19* for the 2020–2021 period. This study employs *random-effects* regression as the data analysis technique. However, to simultaneously address and correct for heteroscedasticity and autocorrelation*, clustered standard errors* were used *-regression* with the code *`vce(cluster_firmid)`*, ensuring that the resulting *standard errors* are robust to statistical tests, thereby allowing the use of *random-effects* estimates. The model was estimated using STATA 17.0 software.

Operational Variables

This study uses a proxy for investment efficiency as the dependent variable, which assesses how companies make investment decisions to achieve a balanced approach without leaning toward either excessive or insufficient investment (Ardianto & Sulaiman, 2024). Following previous research on investment efficiency by Biddle *et al.* (2009), this study measures abnormal investment as the difference between a firm's actual investment level and the expected investment level from a theoretical perspective. This model stems from the concept described by Modigliani & Miller (1958), such as several commonly used indicators, namely the sales growth ratio (*SG*) (Barro, 1990; Servaes, 1994; Coles *et al*., 2006). However, previous empirical studies have shown that the basic

equation of Modigliani & Miller (1958) is overly simplistic because, in practice, firms face constraints in obtaining external financing. To account for this, this study uses several other variables to measure investment efficiency, namely *Operating Cash Flow* (OCF), *Leverage* (LEV), and firm size measured by the natural logarithm of revenue (*LOGSALE*) (Hubbard, 1998; Richardson, 2006). Investment efficiency is measured using a modified model developed by Huang (2020), with the residual obtained from the following equation:

$$\text{INVEST (CAPEX, R\&D)}_{i,t} = \beta_0 + \beta_1 \text{SG}_{i,t-1} + \beta_2 \text{OCF}_{i,t} + \beta_3 \text{LEV}_{i,t-1} + \beta_4 \text{LOGSALE}_{i,t-1} + \varepsilon_{i,t}$$

The residual values obtained are converted to absolute values and then multiplied by -1 to ensure that the dependent variable reflects the firm's investment efficiency in a negative direction (EI). This adjustment is necessary to align the variable's values with the concept of investment efficiency, where a higher investment efficiency value indicates a greater level of investment efficiency. The investment efficiency (EI) variable is derived using the company's characteristics from the previous period (t-1). The use of a lagged " " variable at this stage aims to capture current-period investment decisions influenced by the company's prior conditions.

Econometric Model

The analytical model in this study includes descriptive statistics, Pearson's correlation, and panel data regression. The main analysis employs a *random-effects* model with *cluster-robust standard errors* to correct for potential heteroscedasticity and autocorrelation within firms, thereby enhancing the validity of the estimation results. Additionally, this study performs Winsorization to reduce outlier values. The regression model used, based on the model developed by Ardianto & Sulaiman (2020), is as follows:

$$\textit{(i)}EI_{i,t} = \beta_0 + \beta_1 CASH\ HOLDINGS_{i,t} + \beta_2 TATO_{i,t} + \beta_3 FIRMSIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 ROE_{i,t} + \beta_6 PPE_{i,t} + \varepsilon_{i,t}$$

$$\textit{(ii)}EI_{i,t} = \beta_0 + \beta_1 CASH\ HOLDINGS_{i,t} + \beta_2 TATO_{i,t} + \beta_3\ CASH\ HOLDINGS\ x\ TATO_{i,t} + \beta_4 FIRMSIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 ROE_{i,t} + \beta_7 PPE_{i,t} + \varepsilon_{i,t}$$

$$\textit{(iii)}EI_{i,t} = \beta_0 + \beta_1 CASH\ HOLDINGS_{i,t} + \beta_2 TATO_{i,t} + \beta_3\ CASH\ HOLDINGS\ x\ TATO_{i,t} + \beta_4 FIRMSIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 ROE_{i,t} + \beta_7 PPE_{i,t} + COVID-19_{i,t} + \varepsilon_{i,t}$$

Where *EI* is the dependent variable derived from the residual values converted to absolute values and then multiplied by -1, reflecting the company's investment efficiency in a negative direction (*EI*). The definitions and other operational variables are as follows:

Table 3. Operational Variables

Variable	Definition	Reference Journal	Source
EI	Residual values, which are absolute values multiplied by -1.	Huang, 2020	Annual Report
CASH HOLDINGS	Cash and Cash Equivalents divided by Total Assets	Ardianto & Sulaiman, 2024	Annual Report
TATO	Total Sales Ratio divided by Total Assets	Do *et al.,* 2020; Liu & Han, 2013	Annual Report
FIRMSIZE	Natural Log of Total Assets	Huang, 2020	Annual Report
LEV	Total Liabilities divided by Total Assets	Thi Thuy, 2023; Huang, 2020; Richardson, 2006	Annual Report
ROE	Profit Before Tax divided by Total Equity	Parzonko et al., 2023; Rosario & Mavuri, 2026	Annual Report
PPE	Property, Plant, and Equipment divided by Total Assets	Ardianto & Sulaiman, 2024;	Annual Report

RESEARCH RESULTS

Descriptive Statistics

The values of the investment efficiency (*EI*) variable after Winsorization range from -5.981 to -0.028. This range reflects a fairly wide variation in investment efficiency levels across companies. Some companies have values close to zero, indicating a fairly high level of investment efficiency, while low values such as -7.582 indicate low investment efficiency. Furthermore, the main independent variable—*Cash Holdings*, which measures the proportion of cash and cash equivalents to total assets—had an average value of 12.50% after Winsorization. A similar pattern was found in a study of companies in the United Kingdom, where the average cash holdings ranged from 9.9% to 98.8% (Ardianto & Sulaiman, 2024). The variable used for moderation is TATO, which measures the proportion of total revenue to total assets; it has an average value of 67.40% with a minimum range of 0.2%–27.7%, while after winosorization, the average is 65.50% with a minimum range of 0.01%–22.24%. In addition, the control variables include *Firm Size, LEV, ROE,* and *PPE*. *Firm Size* has a mean of 15.57 with a moderate standard deviation of 1.843. *Firm Size* is expected to account for differences in asset size across observations. Other control variables, such as *LEV, ROE*, and *PPE,* have low standard deviations, indicating that these variables were relatively stable throughout the study period. This suggests that changes in these variables between periods were not significant, resulting in smaller fluctuations compared to *the Firm Size* variable.

Table 4 . Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
EI	-1.323	1,196	-5,981	-0.028
CASH HOLDINGS	0.125	0.121	0.001	0.583
TATO	0.655	0.472	0.001	2.248
FIRMSIZE	15,513	1,871	9,654	19,679
LEV	0.466	0.224	0.020	0.980
PPE	0.456	0.231	0.004	0.901
ROE	0.117	0.409	-2.067	1.470
COV	0.285	0.452	0	1

Multicollinearity Test

The researchers found that investment efficiency (*EI*) has a significant relationship with independent variables, including *Cash Holdings* and TATO. The independent variables *Cash Holdings* and TATO are positively correlated with investment efficiency at the 10% significance level. This is also consistent with the study by Ardianto & Sulaiman (2024), in which, based on the Pearson test, *Cash Holdings* was positively correlated with investment efficiency at the 10% significance level. Other control variables, such as Firm Size and ROE, also showed a positive correlation with investment efficiency at the 10% significance level. Other control variables, such as LEV, PPE, and the *COVID-19* dummy variable, did not show a significant correlation with investment efficiency.

Table 5 . Pearson Correlation

	1	2	3	4	5	6	7
EI	1,000						
CASH HOLDINGS	0.144*	1,000					
TATO	0.169*	0.246*	1.000				
FIRMSIZE	0.233*	0.196*	0.066	0.151*	1.000		
LEV	0.054	-0.246*	-0.122*	-0.213*	0.216*	1.000	
PPE	-0.050	-0.380*	-0.406*	-0.408*	-0.195*	0.127*	1.000
ROE	0.136*	0.197*	0.365*	0.360*	0.236*	-0.081*	-0.155*
COV	-0.017	0.017	-0.064	-0.040	0.023	0.040	-0.012

Next, a multicollinearity test was conducted to ensure that the panel regression model did not exhibit high correlation among variables; the test used *the Variance Inflation Factor* (VIF), which yielded an average value of 2.41. This is also explained by Brooks (2019). The VIF values for each variable were below 5, which is generally used as a safe threshold, and it can be concluded that the regression model in this study did not suffer from multicollinearity.

Endogeneity Test Analysis

To ensure that the estimation results obtained were not distorted by endogeneity issues, this study conducted an endogeneity test using the *Durbin-Wu-Hausman* (DWH) test. This test is used to evaluate whether variables suspected of being endogenous are correlated with *the error term* in the regression model (Wooldridge, 2010). The test results show that the probability value for the *Durbin Score Test* is 0.0247 and for the *Wu-Hausmann Test* is 0.0261, both of which are smaller than the 5% significance level. These results indicate that the tested variables are exogenous. Therefore, to obtain more consistent estimation results and reduce bias caused by endogeneity, this study employs *the Generalized Method of Moments* (GMM) as a *robustness* test, which is considered capable of addressing potential endogeneity by utilizing instrumental variables derived from *the lags* of the variables within the model (Arellano & Bond, 1991).

DISCUSSION

Main Results of the *Random Effects Model*

The results of the panel data regression with moderation between *Cash Holdings* and TATO (3 and 4) indicate a significant positive relationship between *Cash Holdings* and TATO and investment efficiency, with coefficient values of 1.921 at the 10% significance level and 0.842 at the 1% significance level, respectively. This finding is consistent with the study by Sheu & Lee (2012), which found that the availability of cash and cash equivalents yields positive coefficients associated with increased investment. Research by Alawneh (2022) also explains that *Asset Turnover* has a

significant positive coefficient on firm performance. Subsequently, the researcher tested the moderating effect through the interaction between *Cash Holdings* and TATO, yielding a significant negative interaction coefficient of -2.570 at the 5% significance level. The researchers also created a COVID-19 dummy variable, and the results remained consistent with the main regression: the interaction between *Cash Holdings* s and TATO was significant and negative at -2.447 (significant at the 5% level). However, the COVID-19 variable did not have a significant effect on investment efficiency.

Table 6 . Main Results

Variables	***(1)*** ***EI (Baseline)***		***(2)*** ***EI (Baseline)***		***(3)*** ***EI (Moderation)***		***(4)*** ***EI (Moderation)***	
	Coef	*Std. Err*	*Coeff.*	*Std. Err*	*Coef*	*Std. Err*	*Coef*	*Std. Err*
CASH HOLDINGS	0.113	0.621	0.209	0.601	1.921*	0.993	1.884*	0.955
TATO			0.470***	0.170	0.856***	0.267	0.842***	0.258
CASH HOLDINGS × TATO					-2.570**	1.041	-2.447**	0.936
COVID-19							0.020	0.101
FIRMSIZE	0.125***	0.047	0.131***	0.044	0.127***	0.043	0.128***	0.041
LEV	0.088	0.376	0.078	0.368	0.113	0.356	0.110	0.353
ROE	0.206	0.171	0.072	0.183	0.114	0.183	0.115	0.185
PPE	0.369	0.614	0.704	0.601	0.784	0.571	0.784	0.568
Obs	420		420		420		420	
R-squared	0.083		0.130		0.153		0.155	

Endogeneity Concerns

Generalized Method of Moments

Due to the presence of endogeneity issues in the previously run regression model, an alternative approach—*the Generalized Method of Moments* (GMM)—was employed. This test was conducted to obtain more valid estimation results, reduce bias caused by endogeneity, and address this issue through the use of *lagged variables* in the model (Arrelano & Bond, 1991). This method is effective for reducing bias, addressing issues with relevant variables in the model, and handling heteroscedasticity (Nasri et al., 2025). This indicates that robust testing using GMM can also address the endogeneity of all variables, thereby producing more consistent and efficient estimates. The estimation results show that *Cash Holdings* has a coefficient of 2.383 at the 5% significance level, while TATO has a coefficient of 0.678 at the 5% significance level; both coefficients are positive. However, the moderation effect between *Cash Holdings* and TATO has a coefficient of 3.226 with a negative direction (5% significance). Several control variables have a 5% significance level, namely *Firm Size* and PPE. The GMM estimation results remain consistent with the main regression both before and after winsorization.

Table 7 . Generalized Method of Moments

Variables	***Generalized Method of Moments EI***	
	Coef	*Std. Err*
CASH HOLDINGS	2,383**	1,113
TATO	0.678**	0.292
CASH HOLDINGS × TATO	-3.226**	1.082
FIRMSIZE	0.093**	0.041
LEV	0.127	0.246
ROE	0.202	0.156
PPE	0.900**	0.352
Obs	420	
R-squared	0.164	

Based on the results of the GMM diagnostic tests, the research model can be assessed as meeting the estimation criteria. The results of the Arrelano–Bond test show an AR(2) value of 0.388. In GMM estimation, a value greater than 0.05 indicates that there is no second-order autocorrelation in the model (Arrelano and Bond, 1991). Additionally, the Sargan test shows a probability of 0.086, and the Hansen test shows a value of 0.671, both of which are greater than 0.05. This indicates that the instruments are valid and uncorrelated with *the error term* (Roodman, 2009). Therefore, based on these results, no endogeneity issues were found that would compromise the model's validity, as the GMM results meet the validity and consistency criteria, align with the main regression results, and the model exhibits no second-order autocorrelation.

Table 8 . GMM Diagnostic Tests

Diagnostic Tests	Statistic Value	P-Value	Conclusion
Arrelano-Bond AR(2)	Z = 0.86	0.388 > 0.05	There is no second-order correlation
Sargan Test	Z = 6.59	0.086 > 0.05	Instrument validity at the 5% significance level
Hansen Test	Z = 1.55	0.671 > 0.05	The instrument is valid and uncorrelated with the *error term*

Robustness Check

Robust Least Squares

The test was conducted by re-estimating the effect of *cash holdings* on investment efficiency, with TATO as a moderating variable, using the *Robust Least Squares* data analysis method. The *Least Squares* method is applied to various regression problems and typically yields better results when there are issues with normal distribution (Chu et al., 2025). This also provides consistent results, where the *Robust Least Squares* test—after winstorizing *cash holdings*—yields a positive coefficient significant at the 1% level (*Coef:* 3.515), TATO has a positive coefficient significant at the 1% level (*Coef:* 1.067), and the moderation effect has a negative coefficient significant at the 1% level (*Coef:* -3.182). These estimation results are consistent with previous findings using panel data regression. Thus, the model used is robust to various variations, enabling it to produce relevant and consistent findings under various conditions. Therefore, the research model in this study can be deemed valid and reliable.

Table 9 . *Robust Least Squares*

Variable	***Robust Least Squares (EI)***	
	Coeff.	*Std. Err*
CASH HOLDINGS	3.515***	0.864
TATO	1,067***	0.221
CASH HOLDINGS × TATO	-3.182***	0.912
COVID-19	0.016	0.119
FIRMSIZE	0.135***	0.031
LEV	0.291	0.265
ROE	0.030	0.195
PPE	1.141***	0.375
Obs	420	
R-squared	0.164	

CONCLUSION

This study aims to analyze the moderating effect of asset utilization efficiency (TATO) on liquidity (Cash Holdings) regarding investment efficiency in energy sector companies in Indonesia during the period from 2018 to 2024. Based on the estimation results and robustness checks conducted, several key conclusions were drawn. First, the results indicate that the Cash Holdings variable has a significant positive effect on investment efficiency. This indicates that companies with high cash availability tend to have better efficiency because it provides flexibility for the company to finance productive assets or investment projects. This was also found in the study by Sheu & Lee (2012), which showed that cash and cash equivalents yield a positive coefficient with increased investment. This is further supported by the finding that companies with ample cash reserves are encouraged to invest in " " assets (Ardianto & Sulaiman, 2024). Thus, substantial cash reserves can reduce a company's reliance on external financing and enhance its ability to make more efficient investment decisions.

Second, the study also found that the asset utilization efficiency variable (TATO) has a significant positive relationship with investment efficiency. This indicates that companies that are already able to utilize their assets efficiently to generate revenue will also achieve higher investment efficiency, thereby enabling them to allocate resources to generate even greater revenue. This is also supported by the study by Patin et al. (2020), which shows that when a company has high asset efficiency, it tends to be able to utilize its resources and assets to improve company performance. Additionally, Alawneh's (2022) study explains that Asset Turnover has a significant positive coefficient on company performance. Thus, a company's asset efficiency can enhance its investment efficiency. Third, the results indicate that the interaction between Cash Holdings and TATO has a significant negative effect on investment efficiency. This suggests that TATO acts as a moderating variable that weakens the influence of Cash Holdings on investment efficiency. Thus, for companies that already exhibit high asset utilization efficiency, an increase in Cash Holdings does not improve investment efficiency. This suggests that when a company is already capable of managing its assets efficiently, additional liquidity leads to less productive use of funds or overinvestment. This is further supported by the finding that companies with higher Cash Holdings face an increased risk of overinvestment (Bhuiyan & Hooks, 2019).

Overall, the results of this study indicate that for companies that already manage their assets and resources efficiently, an increase in cash holdings actually exposes the company to the risk of overinvestment. Thus, the findings of this study can serve as a reference for both stakeholders and shareholders in formulating policies related to investment efficiency.

RESEARCH LIMITATIONS

A limitation of this study is that not all components of the financial ratios used are directly available in the companies' annual financial statements. Some variables had to be calculated manually based on data available in the companies' annual financial statements. This

situation has the potential to lead to differences in interpretation regarding the classification of certain accounts, especially if the presentation formats of financial statements across companies are not entirely uniform. Therefore, this study sought to minimize potential errors by using consistent operational definitions for all research variables.

This study also measures investment efficiency using a residual approach, which assumes that the investment value predicted by the model reflects the firm's optimal investment level, while the residual is considered a deviation from that optimal condition. However, this measure is a direct approach and depends on the model specifications used. Thus, the residuals obtained may not fully reflect the actual level of investment efficiency. Furthermore, this study uses a model estimated at the aggregate level across the entire sample of energy sector firms. This approach assumes relatively uniform investment characteristics across firms, even though each energy subsector may have different investment patterns and capital requirements. Future research could consider using alternative models that are more comprehensive in explaining investment efficiency, even within the same industry.

RECOMMENDATIONS

Given the study's limitations, a recommendation for future research is to use more complete and standardized data to avoid manual calculations and minimize potential biases resulting from differences in reporting formats across companies. Furthermore, alternative proxies could be considered to measure the research constructs more comprehensively; for example, other liquidity ratios such as *the Cash Conversion Cycle* could be used to capture the quality of liquidity usage. The use of asset utilization efficiency ratios can be expanded to include measures of asset productivity or operational effectiveness. Corporate governance variables can be incorporated as control variables to more accurately capture agency conflicts and assess whether cash and asset management can be optimized. Furthermore, future research may consider using other alternative models to provide a more comprehensive explanation of investment efficiency, even within the same industry. Consequently, future research will be able to produce findings that are more accurate and applicable to the energy sector.

ACKNOWLEDGMENTS

I realize that, without the help and guidance of various parties throughout the preparation of this thesis, it would have been very difficult for me to complete it. Therefore, I would like to express my gratitude to:

(1) Arief Wibisono Lubis, Ph.D., my thesis advisor, who devoted his time, energy, and expertise to guiding me in the preparation of this thesis;

(2) My parents and family, who have provided both material and moral support; and

(3) All those who have greatly assisted me in completing this thesis

In closing, I pray that God Almighty will reward all those who have helped me. May this thesis contribute to the advancement of knowledge.

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