JEMA: Jurnal Ilmiah Bidang Akuntansi dan Manajemen, 20(2) 2023, 177-199
http://dx.doi.org/10.31106/jema.v20i2.19508, ISSN (Online) 2597-4017

Assessing the investment viability of Indonesia's upstream electric vehicle (EV) sector stocks amidst the COVID-19 pandemic

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ABSTRACT

Amidst the global push for sustainability, the burgeoning electric vehicle (EV) industry has driven increased demand for batteries, placing the Indonesian nickel ore sector in a pivotal position due to its vast reserves. This study thoroughly examines the investment landscape of this sector, utilizing advanced portfolio optimization techniques to analyze four major nickel ore mine firms in Indonesia. Through Monte Carlo simulations, the study evaluates the optimal portfolios of risky assets, comparing their performance before and during the COVID-19 pandemic. Findings reveal a significant shift in portfolio composition during the Pandemic, reflecting investors' response to global disruptions by diversifying their holdings. Notably, the Sharpe Ratio, a risk-adjusted return measure, demonstrates an impressive increase in return relative to risk during the Pandemic, emphasizing the sector's resilience and attractiveness for investment, especially in times of economic uncertainty like the COVID-19 pandemic. The transformation in portfolio weights and the corresponding increase in risk-adjusted returns highlight the sector's potential as a lucrative investment avenue, especially during periods of global economic uncertainty like the COVID-19 pandemic.

Keywords: Electric Vehicle Industry; Nickel Ore Sector; Capital Investment Viability; Portfolio Optimization; COVID-19

JEL Code:
G11, G32, L62

DOI:
10.31106/jema.v20i2.19508

Article History:
Received 2023-07-13
Reviewed 2023-08-08
Revised 2023-09-12
Accepted 2023-10-23

Licensed:
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How to Cite:

Patria, H., Rahim, D. A., Hermawan, H., & Prasetyo, H. B. (2023). Assessing the investment viability of Indonesia's upstream electric vehicle (EV) sector stocks amidst the COVID-19 pandemic. *JEMA: Jurnal Ilmiah Bidang Akuntansi dan Manajemen, 20*(2), 177-199. doi: 10.31106/jema.v20i2.19508

Introduction

Nickel ore exploration in Indonesia commenced in 1901 when a Dutch mineralogist discovered deposits in the Verbeek Mountains of Sulawesi. Subsequent discoveries occurred in what is now Kolaka Regency in 1909. Further prospecting by a Canadian geologist from Inco and exploration efforts by a Dutch mining company in 1934 led to initial production between 1936 and 1941. Operations expanded during the Japanese occupation of the Dutch East Indies. After Indonesia gained independence, the American Freeport Sulphur Company's attempt to establish operations failed due to security concerns. Local company NV Perto took over operations until it was eventually acquired by the Indonesian government. Following this takeover, the government restructured the company into PN Pertambangan Nickel Indonesia in 1961. Later, it merged with Aneka Tambang, which began exporting nickel ore to Japan by 1969. The International Nickel Company also initiated metallurgical operations in the 1970s, culminating in commercial nickel production starting in 1978. (Irwandy, 2018). Despite the passage of over four decades since the initial prospecting and exploration efforts in Indonesia's nickel ore reserves, the nation's significance as a nickel production magnet has only grown stronger, particularly in light of the burgeoning electric vehicle (EV) industry. Signifying this heightened importance, Indonesia is expected to contribute to approximately half the global nickel production growth anticipated between 2021 and 2025 (Huber, 2021).

Indonesia, recognized as a prominent hub for nickel ore production with abundant reserves and a strategic role in the global nickel supply chain, took a significant step by enforcing a nickel export ban, which came into effect in January 2020 as Regulation of the Minister of Energy and Mineral Resources 11/2019 and amendment to Law Number 3 of 2020, to process the ore domestically and thereby add value to its nickel production. Following the implementation of nickel export restrictions, the European Union (EU) complained with the World Trade Organization (WTO) to safeguard its export operations. The EU contended that Indonesia's policy of banning nickel exports could potentially disrupt the global stainless-steel industry, given the crucial role of nickel ore in both stainless steel and battery production. This action by the EU resulted in several notable consequences. Firstly, it prompted the EU to initiate proceedings before the WTO's Dispute Settlement Body (DSB), with a primary request for Indonesia to resume nickel exports. Secondly, Indonesia responded by considering an increase in the tax ratio applicable to nickel exports. Thirdly, in response to these developments, various new policies were introduced, particularly concerning investments in smelting and downstream industries, details of which

will be elaborated upon in the subsequent discussion (Meirizal et al., 2023). The significance of raw materials (nickel ore) in the global supply chain cannot be understated, as they exert a profound influence on the sustainability of global products. These materials serve as the foundation of economic activities, exerting an impact on economic growth, innovations, and overall competitiveness (Bleischwitz & Perincek, 2017).

The ban on nickel ore exports, however, has yielded positive outcomes for Indonesia's collaboration with China, primarily evident in increased Chinese investments within Indonesia, particularly in the metal processing sector, and the establishment of smelters aimed at processing existing nickel ore into ferronickel or nickel pig iron. Furthermore, effective management of derivative products like stainless steel has significantly contributed to the export value of Indonesian products (Cristina, 2022). While this partnership may appear to disproportionately benefit China's national interests, Indonesia can leverage these opportunities to develop smelter infrastructure in various locations. This exemplifies a evolving diplomatic approach, highlighting Indonesia's strategic use of diplomacy to secure protection, attain objectives, and serve national interests (Meirizal et al., 2023). The reinforcement of cooperation between Indonesia and China through smelter construction underscores how Indonesia's diplomatic efforts can be bolstered by support from China's assistance.

The Indonesian government dreams of becoming the biggest player in the EV industry. This aligns with nickel ore reserves in Indonesia, which has 5.24 billion tons of wet metric tons, or 27% of the world's contributor producers (Sembiring, 2021; Ridwan, 2022). The development of the battery industry will also increase the attractiveness of Indonesia as an investment destination country for derivative industries that use batteries, such as investment in electric motors, electric buses, and electric cars. Despite Indonesia's earnest efforts to maintain its national interests, the year 2020 brought significant challenges as the nation grappled with the volatile fluctuations in nickel ore prices amid the global COVID-19 pandemic. In March 2020, the outbreak of COVID-19 and the broad measures required to prevent its spread resulted in a decline in world nickel prices due to reduced demand. Nickel prices had plunged into negative territory in March 2020. Following a decline to $11,142 per ton, the price of nickel gradually rebounded the next month, reaching a peak of $19,722 per ton (Sandria, 2021). Subsequently, in April 2020, a regulation imposing a minimum nickel price was introduced, taking effect on May 13, 2020. This regulatory measure was initiated at the behest of the Indonesian Nickel Miners Association (APNI) to safeguard the interests of small-scale miners. As of January 21, 2022, Nickel's price reached its highest since February

7, 2012, at USD 24,028/ton due to reduced world nickel supplies (Andriato, 2022). World nickel prices are also increasing due to the Russia-Ukraine war on February 24, 2022, in which Russia is a producer that contributes 10% of the world's nickel (Pickrell, 2022). It is not surprising that this has an impact on nickel prices as well. Nickel prices experienced the highest jump on Tuesday, March 8, 2022. Nickel prices published by the London Metal Exchange (LME) experienced sharp gains, reaching US$101,350 per dry metric ton or around 110.80 percent compared to the previous trade (Muddasir, 2022; Asmarini, 2022).

The study on electric vehicles (EVs) has garnered significant attention, driven not only by the industry's steadfast commitment to sustainability and addressing environmental challenges but also by the surge in demand for key raw materials like nickel ore. With nickel being a critical component in EV batteries, the EV industry's rapid expansion has further intensified the focus on securing a sustainable and responsible supply chain for nickel ore. As EV manufacturers increasingly prioritize eco-friendly practices and technologies, their commitment to sustainability and responsibility in addressing green issues has become a central focus, reflecting a growing trend towards environmentally conscious and responsible business practices to pursue a greener future. Studies from Flammer (2015) and Albuquerque et al. (2020) found that sustainability plays a pivotal role in building brand equity and fostering brand loyalty for responsible businesses. This, in turn, translates into increased profitability and reduced vulnerability to systematic risks and economic downturns.

Also, responsible businesses often excel due to their high-quality management, as Siddiq and Javed (2014) indicated. These businesses tend to attract ethical managers with commendable values in their business conduct, employee treatment, and societal interactions. Becchetti et al. (2015), Nakai et al. (2016), and Chiappini and Vento (2018) have discovered that responsible businesses can draw in steadfast investors. These investors, driven by nonfinancial considerations such as environmental, social, and governance (ESG) concerns, exhibit unwavering support for responsible companies, even during turbulent crisis periods when the broader investor community tends to divest their holdings.

A significant gap exists in the research landscape regarding the comparative performance of responsible investments versus conventional investments during economic downturns, with findings yielding mixed results. While some studies suggest that responsible investments exhibit superior performance (Tripathi & Bhandari, 2016; Risalvato et al., 2019; Arefeen & Shimada, 2020), others present opposing or inconclusive outcomes (Leite & Cortez, 2015; Morales et al., 2019; Lean & Pizzutilo, 2020). Moreover, a growing body of academic research has explored the repercussions of the COVID-19 pandemic on financial markets, as

evidenced by studies conducted by Folger-Laronde et al. (2020), Heyden and Heyden (2020), and Sakurai and Kurosaki (2020).

Despite there being a growing body of academic research investigating the effects of the COVID-19 pandemic on financial markets, knowledge pertaining to the performance of investment decisions influencing the portfolio of upstream sector EV (Nickel Ore Mine) stocks during this crisis in Indonesia, a key player in the global nickel industry, remains undeveloped. To address this gap, our study aims to conduct a comprehensive analysis, evaluating the performance of such investment decisions within the context of the COVID-19 pandemic. Also, the study offers a unique perspective compared to previous studies on predictive analytics in finance While previous works focused on prediction models and data analytics (Patria & Adrison, 2015; Patria, 2021; Patria, 2022), our primary focus is to assess and provides a practical application of these models in assessing the viability of investments in the EV sector amid the economic challenges posed by the Pandemic. Through empirical investigation, we endeavor to provide valuable insights into the relative performance of these investments, contributing to a deeper understanding of responsible investing within the realm of global crises.

Literature Review

Nickel Benchmark

Four years after the establishment of the coal benchmark price, the Indonesian government expanded its regulatory framework by introducing a formula for determining the monthly benchmark price for both base and precious metals. This regulatory step was formalized through Directorate General of Mineral and Coal (DGMC) Regulation No. 630.K/32/DJB/2015, issued on April 27, 2015, which specifically outlines the Formula for Determining Metal Minerals Benchmark Price (DGMC 630/2015). Notably, DGMC 630/2015 unequivocally states that this benchmark price formula is universally applicable, encompassing all mining companies operating within Indonesia, including those holding a Mining Business License and those with a Contract of Work (Kontrak Karya), covering both domestic sales and mineral exports. DGMC 630/2015 encompasses a comprehensive range of twelve mineral types, including nickel, cobalt, lead, zinc, bauxite, iron, silver, gold, tin, copper, manganese, and chromium. However, due to the variations in mineral types and grades, the benchmark price is calculated based on the average mineral prices from the 20th day of the second month before a specific benchmark price period up to the 19th day of the preceding month, as published in the relevant price reference. Four distinct price references

are used in DGMC 630/2015: the London Metal Exchange (LME) for nickel, cobalt, lead, zinc, bauxite, and copper; the London Bullion Market Association (LBMA) for gold and silver; Asian Metal (AM) for iron, manganese, and chromium; and the Indonesia Commodity & Derivatives Exchange (ICDX) for tin. In this study, we utilize data from the Mineral Ore Benchmark Price (HPM) - Reference Mineral and Coal Price Table in ICDX and LME, aligning with Indonesian nickel regulations.

Stock Share & Prices

Shares are evidence of a person's or entity's involvement or ownership in a corporation or limited liability business. A certificate stating that the bearer of a share is an investor in the corporation that issued the securities is known as a stock. The percentage of ownership is determined by the amount of money invested in the business (Loderer & Martin, 1997). The determination of stock prices on the stock market, on the other hand, is impacted by market players who are involved in the demand and supply of stock market shares. Stock price fluctuations are a typical occurrence. Stock prices can rise or fall due to a variety of basic variables. These factors are divided into two categories: internal factors and external ones. Internal factors are those that exist within the organization. Furthermore, external influences are caused by events outside of the firm. As a result, if the external factors are compared to the company's internal factors in terms of which elements can be managed or not, the external factors are more difficult to control. Corporate action, prospects of company performance in the future, exchange rate fluctuations, and fundamental conditions of macroeconomics are the main external factors influencing the stock (Utami & Nugroho, 2017). In the Indonesia Commodity & Derivatives Exchange (ICDX), the Nickel sector is classified under ICDX.

Monte Carlo Simulation and Sharpe Ratio Value

Modern portfolio descriptions rely on fundamental statistical measures such as expected return, asset or portfolio standard deviation, and return correlations. In general, risk can be mitigated by diversifying single assets into a portfolio, especially when returns exhibit less than perfect positive correlation. Portfolio management embraces the concept of risk reduction through the inclusion of various securities (Markowitz, 1952), recognizing the potential for enhancing risk-adjusted returns by constructing portfolios that balance the trade-off between risk and return.

Monte Carlo simulation, a mathematical method, assesses potential outcomes of uncertain events by leveraging mathematical relationships between outputs and inputs, along with the

probability distributions associated with these inputs (Robert & Casella, 2004; Truong, 2021). According to Rubinstein and Kroese (2004), Monte Carlo simulation stands as a powerful tool for scrutinizing uncertainty, allowing us to discern how alterations in distribution or errors impact the sensitivity, performance, or reliability of the modeled system. What sets Monte Carlo simulation apart is its status as a real-world sampling method, requiring the model to select an input distribution that best mirrors the available data. By employing Monte Carlo simulation, not only can one identify the least variance portfolio, thus achieving a well-diversified portfolio with the lowest attainable risk given the expected return rate, but it also allows for a thorough assessment of portfolio performance. This is particularly relevant when measuring the effectiveness of portfolios in terms of risk-adjusted returns, as exemplified by the Sharpe Ratio, which sheds light on the trade-off between risk and return, ultimately aiding in making informed investment decisions. The Sharpe Ratio, developed by William Sharpe, serves as a valuable metric for quantifying the trade-off between risk and return, thereby supporting informed investment decision-making. With the highest Sharpe ratio indicating superior performance, it becomes a crucial tool for investors and decision-makers striving to optimize portfolios amidst the intricate landscape of financial uncertainties. The portfolio with the highest Sharpe ratio value, signifying the best-predicted return per unit of risk, is referred to as a Tangency optimization portfolio (Cheong et al., 2017; Qudratullah, 2021; Ulfa et al., 2022; Syarif et al., 2022).

Methods

In terms of data collection, daily price data for the top four major players in Indonesia's EV upstream sector (ANTM, HRUM, INCO, NICL) was gathered from Yahoo Finance using the 'yfinance' library in Python. This study relies on secondary data obtained from Yahoo Finance, covering the period from 2017 to 2022. The study's population comprises Indonesian companies operating in the nickel ore mining sector listed on the Indonesian Stock Exchange (IDX). Based on the total population listed in the IDX sector mineral, 4 (four) companies were found to meet the criteria. Table 1 demonstrates the names of enterprises selected with detailed information about company name, stock share, and code, including date of listing in IDX. Furthermore, to explore the optimal portfolio dynamics before and during the COVID-19 pandemic, the research period is divided into two distinct sub-periods: the first spans from March 15, 2019, to March 15, 2020 (pre-pandemic), and the second extends from March 16, 2020, to April 12, 2022 (pandemic era). Worth noting is that NICL (PAM Mineral), a newly established enterprise during the Pandemic in July 2021, had

no available stock data before the COVID-19 pandemic and was not included in the Monte Carlo simulation.

In this study, daily price data for each company was obtained from Yahoo Finance using the 'yfinance' library in Python programming code, divided into two distinct periods. Figure 1 illustrates these periods in relation to Nickel price (USD/T), with a dashed line indicating the division between them. The left side of the graph represents the period before the Pandemic, denoted as Period 1, spanning from March 15, 2019, to March 15, 2020. During this time, the nickel price fluctuated between a minimum of 11,142 USD/T and a maximum of 18,102 USD/T. On the right side of the graph lies Period 2, spanning from March 16, 2020, to April 12, 2022, coinciding with the official declaration of COVID-19 transmission in Indonesia. This period witnessed a significant drop in nickel prices, attributed to the rise in COVID-19 cases, followed by a gradual recovery with a peak price of 48,226 USD/T. Notably, Period 2 also encompassed the Russia-Ukraine War, which commenced on February 24, 2022.

In order to examine the optimal portfolio model, we calculate daily returns for upstream EV battery sector stocks, particularly those related to nickel ore, using the provided equation (1).

$$r_{it} = \frac{p_{it} - p_{it-1}}{p_{it-1}} \quad (1)$$

In this analysis, we focus on the daily returns of EV stocks, denoted as $_i$, where P_{it} represents the price of EV stock $_i$ at time $_t$, and P_{it-1} represents the price of the same stock at time $_{t-1}$. Subsequently, we calculate the expected return, denoted as $E(r_p)$, and the standard deviation, represented as σp, for the portfolio of stocks. These calculations are based on equations (2) and (3). To determine the portfolio weight of each stock, Wi, we utilize the bordered covariance matrix, following the methodology outlined by Bodie et al. (2014). The Monte-Carlo simulation is then employed to identify the efficient set of portfolios, commonly referred to as the Efficient Frontier of risky assets. As per Modern Portfolio Theory (MPT), the Efficient Frontier comprises the optimal portfolios along the risk-return spectrum. Hence, the portfolio combinations within the Efficient Frontier provide the highest return for a given level of risk and the lowest risk for a given level of return, offering valuable insights for portfolio optimization and risk management.

$$E(r_p) = \sum_{i=1}^{n} W_{i=1} r_{it} \quad (2)$$

$$\sigma_p = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} W_i W_j Cov(r_i r_j)} \quad (3)$$

Result and Discussion

The Prices of the Upstream Sector of EV (Nickel Ore Mine) Stocks

Analyzing the stock price trends of the four major players in Indonesia's Upstream Sector of EV (Nickel Ore Mine) from 2017 to 2021, we observe that HRUM consistently had significantly higher prices compared to other Nickel Ore Mine companies. However, a common trend among all key players in Indonesia's upstream EV sector was the price drop on the day of the WHO COVID-19 pandemic announcement (March 11, 2020). This observation aligns with the idea that financial markets tend to move in tandem during crises, as supported by prior research (Goodell & Goutte, 2021; Yunus, 2023; Chang et al., 2023).

Remarkably, in contrast to the backdrop of the ongoing COVID-19 pandemic since its WHO announcement, all key players in Indonesia's upstream EV sector have experienced significant price surges. Notably, HRUM, ANTM, and INCO have displayed remarkably strong stock performance during the pandemic when compared to the pre-pandemic period. This intriguing resilience in stock performance during a period of global uncertainty highlights the investment attractiveness of upstream EV stocks, possibly attributed to various contributing factors. This suggests that the sector remains appealing to investors seeking opportunities even in challenging economic environments, further solidifying its allure in the investment landscape.

Upstream Sector of Electric Vehicle (Nickel Ore Mine) Stocks – Before COVID-19 Pandemic

We proceed to explore the optimal portfolio allocation for the four key players in the upstream sector of EV stocks by seeking the portfolio with the highest Sharpe ratio, indicating the portfolio's ability to yield the highest excess return relative to its risk (standard deviation). Utilizing Monte Carlo simulation through Python programming, we uncover that HRUM commands the highest optimal portfolio weight at 95.01%, followed by ANTM at 2.66%, INCO at 2.32%, while NICL holds no weight as it has not been established yet (see to Table 2 and Table 3 for details). In Figure 4, we present the efficient Frontier of the upstream EV stock sector before the pandemic, while Figure 5 illustrates the plot showcasing the maximum Sharpe ratio and minimum variance portfolio. The optimal portfolio within the upstream EV stock sector exhibits an expected return of -16.63% and an expected standard deviation of 27.38%. Notably, the Sharpe ratio of -0.6072 reveals that the excess return of the stock portfolio amounts to -60.72% concerning the portfolio risk level.

Table 1. List of Upstream Sector of EV (Nickel) Companies (Selected Stocks)

Name	Code	Date of Listing	Stock Share (Unit)
Aneka Tambang	ANTM	27-Nov-97	24.030.764.725
Vale Indonesia	INCO	16-May-90	9.936.338.720
Harum Energy	HRUM	06-Oct-10	2.703.620.000
PAM Mineral	NICL	09-Jul-21	9.662.504.494

Figure 1. Nickel Price (USD/T)

Figure 2. Prices of EV Selected Stocks in Indonesia from 2017-2022

Note: The dashed line marks the onset of the WHO-declared COVID-19 pandemic on March 15, 2020.

Figure 3. Prices of EV Selected Stocks in Indonesia from 2019-2022

Note: The dashed line signifies the commencement of the Russian invasion of Ukraine on February 24, 2022.

Table 2. Descriptive Statistics of 4 Market Caps of Upstream Sector of EV Battery Stocks – Before the COVID-19 Pandemic

	ANTM	HRM	INCO	NICL
Mean	844.74	1329.27	3194.82	-
Std. Deviation	127.84	73.30	366.25	-
Min	484.21	1136.33	1912.10	-
Max	1156.19	1577.96	3933.18	-
Count	256	256	256	-

Table 3. Optimal Portfolio Weight of 4 Market Caps of Upstream Sector of EV Stocks – Before the COVID-19 Pandemic

Code	Weight - Before Pandemic (%)	Portfolio Performance	Values (%)
ANTM	2.66	Sharpe-Ratio	-60.72
HRM	95.01	Expected Returns	-16.63
INCO	2.32	Expected Std. Deviation	27.38
NICL	95.01		

Upstream Sector of Electric Vehicle (Nickel Ore Mine) Stocks – During COVID-19 Pandemic

Throughout the COVID-19 pandemic, there were substantial price fluctuations among the top four market cap companies in the upstream sector of EV stocks. HRUM exhibited the

highest average price at 5,168 US Dollars (USD), while NICL had the lowest at 96 USD (refer to Table 4). HRUM also recorded the highest maximum price for upstream EV (Nickel Ore Mine) stocks at 13,750 USD, in contrast to NICL, which had the lowest maximum price at 318 USD per stock. Notably, HRUM had the highest volatility stock during the pandemic, with a value of 3,458 USD, while NICL had the lowest volatility at 48 USD (see Table 4). Consequently, the overall standard deviation of the upstream sector of EV stocks during the pandemic significantly exceeded that of the pre-pandemic period.

In Figure 6, we can observe the efficient Frontier of the upstream sector of EV stocks during the COVID-19 pandemic, while Figure 7 provides a visualization of the maximum Sharpe ratio and minimum variance portfolio. The maximum Sharpe ratio, representing the optimal portfolio, stands out as a noteworthy feature, alongside the minimum variance portfolio, which embodies the lowest-risk stock portfolio. It's worth emphasizing that the optimal portfolio for Nickel Ore stocks during this challenging period exhibits an anticipated return of 119.26%, coupled with an expected standard deviation of 48.31%. This intriguing combination reflects the resilience and potential of the stock portfolio. The Sharpe ratio (Table 5) further underscores this by registering at 2.4687, indicating that the stock portfolio's excess return surpasses the portfolio risk level by a substantial margin, as elaborated.

Upstream Sector of EV Stocks Portfolio Performance Evaluation – Full (Before and During the COVID-19 Pandemic)

The data presented in Table 6 provides insights into the performance of the upstream sector of EV stocks portfolio over the entire research period. From March 2019 to April 2022, the optimal upstream sector of EV (Nickel) stocks portfolio exhibits a noteworthy expected return of 96.69%, accompanied by an expected standard deviation of 40.29%. In aggregate, the optimal portfolio of the upstream sector of EV (Nickel) stocks demonstrates an excess return that surpasses its standard deviation by 239.97%. This outcome suggests that, throughout the entire research duration spanning from March 2019 to April 2022, the upstream sector of EV (Nickel) stocks presents attractive investment opportunities.

Table 6 offers valuable insights into the dynamics of optimal portfolio weights during the COVID-19 pandemic. Notably, HRUM stock maintains its position as the highest-weighted stock in the optimal portfolio, both before and during the pandemic. Interestingly, the weights of ANTM and INCO stocks experience significant shifts from being the second and third highest weights before the pandemic to the third and second highest weights during the pandemic, respectively. This underscores HRUM's consistent ability to provide an optimal

risk-return trade-off throughout the research period. However, the variations in optimal portfolio weights highlight the time-varying nature of the risk-return trade-off among stocks. ANTM and INCO stocks, for instance, experienced a significant shift in their portfolio weights, moving from the second and third highest weights before the pandemic to the third and second highest, respectively, during the pandemic. As such, investors should continually adjust their portfolio weights to optimize outcomes (Anggraeni et al., 2022; Mariana & Patria, 2022). Figures 4 and 6 depict how the expected return and Sharpe ratio of the upstream sector of EV stocks portfolio were lower before the pandemic, indicating that nickel investment was less attractive due to a lower Sharpe ratio and expected return. The increasing investment in this sector holds promise for low-carbon energy development, particularly in the context of electric vehicles and their components (upstream sector - nickel ore), potentially catalyzing a bandwagon effect among other investors. In the long term, this trend could accelerate the adoption of low-carbon practices, contributing to a more sustainable economy (Mariana & Patria, 2021).

Table 4. Descriptive Statistics of 4 Market Caps of Upstream Sector of EV Battery Stocks – During COVID-19 Pandemic

	ANTM	**HRM**	**INCO**	**NICL**
Mean	1789.80	5168.82	4483.63	96.04
Std. Deviation	820.04	3458.99	1115.22	48.823
Min	343.89	1071.81	1426.65	62
Max	3166.98	13750	7575	318
Count	505	505	505	189

Table 5. Optimal Portfolio Weight of 4 Market Caps of Upstream Sector of EV Stocks – During COVID-19 Pandemic

Code	**Weight - During Pandemic (%)**	**Portfolio Performance**	**Values (%)**
ANTM	17.60	Sharpe-Ratio	246.87
HRM	58.64	Expected Returns	119.26
INCO	23.76	Expected Std. Deviation	48.31
NICL	0.64		

Figure 4. Efficient Frontier of Upstream Sector of EV Stocks – Before the COVID-19 Pandemic

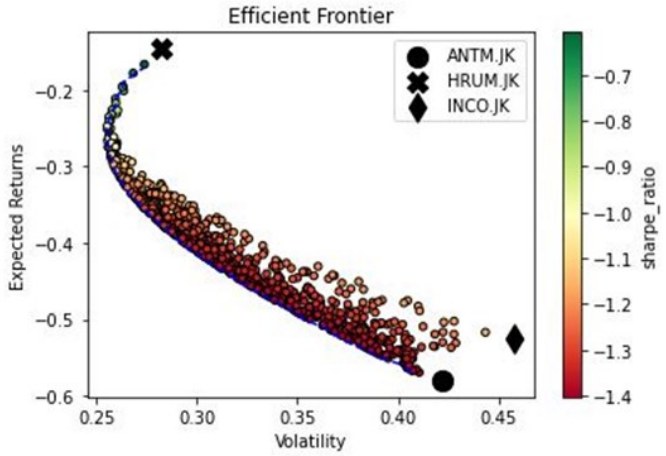

Figure 5. The Maximum Sharpe Ratio and Minimum Variance Portfolio Dynamics Before the COVID-19 pandemic

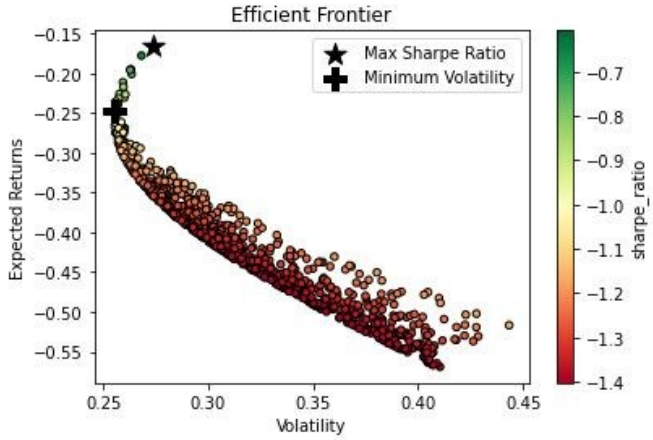

Figure 6. Efficient Frontier of Upstream Sector of EV Stocks – During the COVID-19 Pandemic

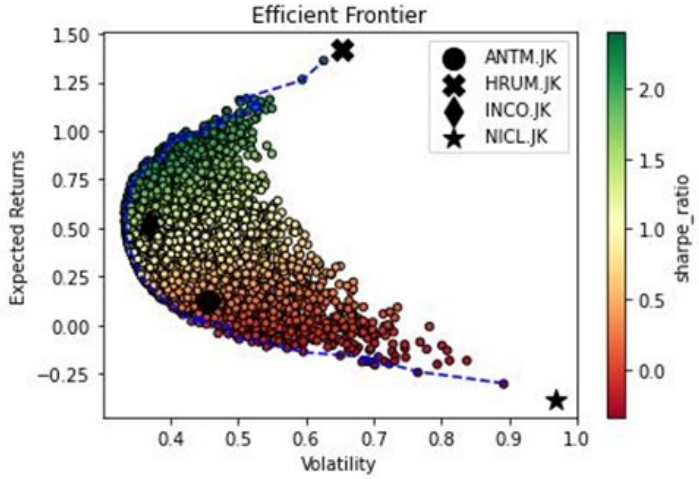

Figure 7. The Maximum Sharpe Ratio and Minimum Variance Portfolio Dynamics During the COVID-19 pandemic

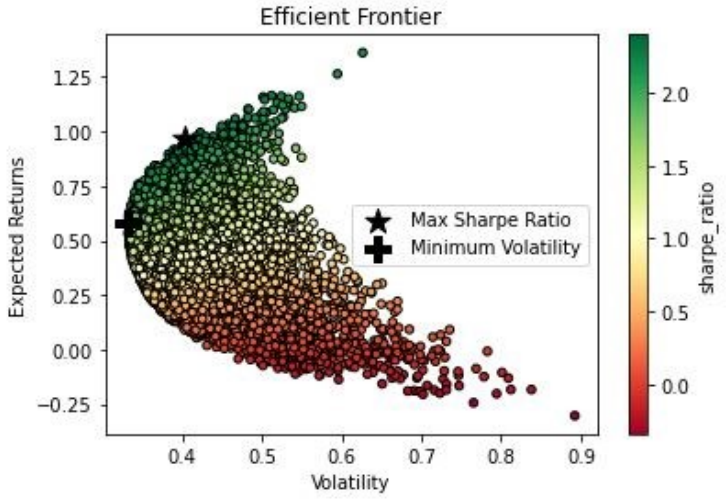

Table 6. Optimal Portfolio Weights and Performances – Full Period

Code	Weight - Full Period (%)	Portfolio Performance	Values (%)
ANTM	0.08	Sharpe-Ratio	239.97
HRM	50.49	Expected Returns	96.69
INCO	48.79	Expected Std. Deviation	40.29
NICL	0.64		

Overall Analysis

This study provides a comprehensive view of the investment landscape in Indonesia's upstream electric vehicle (EV) sector before or during the COVID-19 pandemic, especially in the context of the global push for sustainability. This study aligns with the findings of Mariana and Patria (2021), who observed similar resilience in the broader ASEAN EV market. Both studies highlight the sector's adaptability and attractiveness to investors, emphasizing the notable performance of key players like HRUM, ANTM, and INCO during the Pandemic. This resilience is indicative of the sector's ability to adapt and remain appealing to investors, especially in times of economic uncertainty. The increase in the Sharpe Ratio during the Pandemic signifies a higher risk-adjusted return, which is crucial for investors during volatile periods. This finding echoes the emphasis on risk management in portfolio optimization studies such as those by Cheong et al. (2017), Qudratullah (2021), and Ulfa et al. (2022). These studies, focusing on different sectors, highlight the importance of balancing risk and return, especially in times of market instability. The enhanced

performance of the EV sector, as seen in the increased Sharpe Ratio, suggests strong investment potential, even in challenging economic landscapes.

The impact of global events, such as the COVID-19 pandemic and the Russia-Ukraine war, on nickel prices and the EV sector is critical to this study. This impact resonates with findings in other sectors, as explored by Folger-Laronde et al. (2020), Heyden and Heyden (2020), Sakurai and Kurosaki (2020), Shehzad et al. (2020), Agustin (2021), Syarif et al. (2022) and Truong (2021). Collectively, these studies illustrate how external shocks can lead to significant market fluctuations, necessitating dynamic portfolio strategies. The EV sector's response, particularly in the context of nickel ore prices and supply chain dynamics, highlights the interconnectedness of global events and sector-specific investment opportunities. The findings of the study point to the long-term prospects of the EV sector, particularly in the context of low carbon energy development. This forward-looking perspective is shared by Kapustin and Grushevenko (2020), Wen et al. (2021), and Li et al. (2022), who recognize the potential of the EV sector to contribute to a sustainable economy. The emphasis on sustainability aligns with the broader trend towards environmentally conscious investments, a factor increasingly considered by investors worldwide.

Conclusion and Suggestion

In the wake of the WHO’s official declaration of the COVID-19 pandemic on March 11, 2020, this study rigorously evaluates the investment prospects of the upstream electric vehicle (EV) stock sector in Indonesia. Employing Monte Carlo simulations to construct efficient frontiers, our analysis demonstrates the enhanced performance of a portfolio comprising four nickel enterprises integral to the upstream EV sector during the pandemic period. A confluence of factors has underpinned the appreciable increase in nickel stock prices within the Indonesian market. Notably, pivotal government policies such as prohibiting unprocessed nickel ore exports and the presidential inauguration of an EV battery manufacturing facility have played instrumental roles. Additionally, the geopolitical ramifications of the Russia-Ukraine conflict have exerted a considerable influence, given Russia’s substantial contribution of 10% to global nickel production. Our empirical investigation reveals that, throughout the research period, HRUM consistently commanded the largest portfolio weight among the upstream EV (Nickel) stocks.

Contrary to prevailing market trends, the empirical evidence indicates that the upstream EV stock sector exhibited resilience to market downturns during the Pandemic, with performance seemingly more tethered to government investment policies than to broader

market fluctuations. This is further substantiated by the observed lower standard deviation of the upstream EV battery stock portfolio during the pandemic, suggesting that nickel ore stocks could potentially constitute a robust investment choice. However, investors must engage in continuous portfolio monitoring and adjustment in acknowledgment of the time-variant nature of risk and return trade-offs.

Acknowledgment

The authors wish to express their profound gratitude to Institut Teknologi Sepuluh Nopember (ITS), Indonesia, and the University of Strathclyde UK for providing unwavering support in terms of resources and a conducive forum for the execution of this study. Our sincere thanks also extend to PT. Strategi Transforma Infiniti (Patria & Co.) for their invaluable assistance and comprehensive coding support, which were pivotal in facilitating the computational finance aspects of our research. Their combined contributions have been instrumental in the realization of this work, and for that, we are deeply appreciative.

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Heri Hermawan, Heru Budi Prasetyo, graduate students at the Magister Technology Management (MMT) program at Sepuluh Nopember Institute of Technology (ITS) in Surabaya, Indonesia, have made significant contributions in the field of data collection and processing. Both of them have also garnered valuable experience working in the energy industry, which has further enriched their academic pursuits and practical understanding of the sector. Their combined expertise in technology management, coupled with real-world industry experience, positions them uniquely to contribute to the evolving landscape of data analytics and machine learning in the energy sector. Contribution: Collected the data and Contributed data or analysis tools.