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Project Final Report

Portfolio Optimisation for Mining and Metal Commodities in Australian Market

Cem Alpaslan

Supervised by

Professor Benchawan Wiwatanapataphee

Master of Science in Industrial Engineering

Faculty of Science and Engineering | School of Electrical Engineering, Computing and Mathematical Sciences

Declaration

The work presented in this report is my own work and all references are duly acknowledged.

This work has not been submitted, in whole or in part, in respect of any academic award at Curtin University or elsewhere.

Cem Alpaslan

22.05.2025

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I believe this project has improved my knowledge and understanding of traditional portfolio optimisation techniques and provided me with practical experience. I express my gratitude to my professors, and to Curtin University for providing this opportunity as a core elective unit.

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Abstract

Portfolio Optimisation is a mathematical concept that has been studied over the years to find optimal financial asset combinations. Modern Portfolio Theory has always been an inspiration optimisation model for investors and academicians all over the world. The theory has been developed and published by Harry Markowitz and shaped the investment strategy of the world`s financial markets. Furthermore, advanced portfolio optimisation models and techniques have been developed to extend the scope and compensate for the limitations of the Modern Portfolio Theory. This paper has focused on developing and testing the mathematical models of the Modern Portfolio Theory for the selected financial assets. Moreover, Mean Variance optimisation has been compared with Risk-Parity, Black-Litterman, and Conditional Value at Risk (CVaR) Models. Lasty, detailed analysis of the portfolios obtained from the optimisation techniques has been presented to the investors to provide investment strategies for their future financial needs.

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Table of Contents

1. Introduction

1.1 Problem Description and Background

The main concern of the investors nowadays is to find to best financial asset allocation to maximize their return. The profile and the purpose of the investors are various. There are academic investors who are research oriented and trying to develop advanced models to contribute to the industry, there are individual investors who are trying to maximize their income, there are consulting companies and investment banks which are providing financial services to their customers and trying to provide investment opportunities to their clients. Regardless of the profile and the characteristics, the main purpose of the investment mentality is to achieve financial targets and financial independence.

Over the years academicians and professionals have focused on various portfolio optimisation models to find the most efficient and productive investment strategies. Various portfolio optimisation algorithms have been developed to determine the optimal financial asset combinations. Moreover, the global financial crisis and economic recession throughout history have triggered professionals to push their limits to achieve advanced and innovative approaches. Financial and economic challenges throughout history have enhanced the knowledge of finance professionals and provided sophisticated studies for industry and to academia.

Collin (2024) indicates that portfolio optimisation is a study of obtaining the best possible combination of the various financial assets with a purpose of maximizing the return of the investor at a certain level of risk. Furthermore, the primary target of determining the efficient portfolio is to evaluate the risk profile of the investor and the relationship between the selected assets to provide well-diversified investment strategies (Collin 2024). Over the years various theories and algorithms which are concentrating on the tradeoff between risk and return have been developed, but the Modern Portfolio Theory was the study that has shaped the investment mentality of the world of economics. Modern Portfolio Theory is a traditional portfolio optimisation approach which is presented by an American Economist called Harry Markowitz in 1952 and received a Nobel Prize in 1990 (Investopedia Team 2023). Markowitz has developed an approach based on considering the risk and return features collectively to understand their impact on portfolios overall performance (Investopedia Team 2023). Furthermore, the theory has evaluated the correlation of the financial assets and proposed a sloping curve which focuses on capturing the optimal portfolios with the given level of risk to the investors (Investopedia Team 2023). This curve is presented as the efficient frontier to the finance industry and has helped the investors to manage their investment decisions (Investopedia Team 2023).

Mining industry and its operations is one of the dominant and essential fields in Australia and contributes significantly to the Australian economy. Minetek (2024) indicates that 13.7% of the Gross Domestic Product of Australia has been provided by the mining operations. Furthermore, the power of the mining field has minimized the harmful effects of the global financial crisis and reduced the impacts of the coronavirus pandemic as much as possible in Australia (Minetek 2024). In addition, mining industry is one of the leading export sources in Australia economy and provides employment opportunities to 250,000 people (Minetek 2024). The dominance of the mining industry in Australia is an undeniable fact. Considering the size and the impact of the mining operations, proposing a portfolio selection approach consists of mining and metal commodities to the financial investors in the Australian Market is the main purpose of this study.

1.2 Scope of the Project

The main purpose of this project is to provide optimal investment strategies for the investors for the selected metal and mining stocks. The selected stocks are BHP.AX, EVN.AX, FMG.AX, GOLD.AX, IGO.AX, LTR.AX, NST.AX, PLS.AX, RIO.AX, SFR.AX, SVL.AX. These stocks were chosen to evaluate because these financial assets are the dominant metal and mining commodities in the Australian Financial Market. Furthermore, the selected stocks include the leading corporations. Most of the companies are conducting the operations of extraction and processing of metal and mining commodities such as iron ore, gold, silver, lithium, copper, nickel and aluminum.

One of the main concentrations of the project is to evaluate the historical performances of the selected financial assets after the coronavirus pandemic. The selected time horizon for this study is between 2021 and 2025. This way, the impact of the pandemic process was minimized and the performances of the selected financial assets after the coronavirus have been evaluated.

This study has used the Modern Portfolio Theory as the main mathematical framework to build an effective portfolio selection algorithm for the selected mining and metal commodities in the Australian Market. Moreover, Markowitz Portfolio Optimisation Model has been used as the main mathematical formulation and Maximum Sharpe Ratio Portfolio (Tangency Portfolio) and Minimum Variance Portfolio has been provided as the main investment strategies to the investors. Furthermore, due to the time limitation of the project, development of the Particle Swarm Optimisation algorithm and Machine Learning techniques were abandoned and Risk-Parity Model, Black-Litterman Model and Conditional Value at Risk (CvaR) were developed to provide productive comparisons to the investors who have different investment strategies. Furthermore, short selling has been prohibited in every optimisation model.

Lastly, the developed python code has not been provided in the appendix section but it can be shared with the professionals and academicians who are interested in it.

1.3 Objectives, Significances and Contributions of the Project

The main target of the project is to provide optimal investment strategy opportunities to investors who are interested in the selected metal and mining financial commodities in the Australian Market. Various portfolio optimisation algorithms have been developed and compared with each other to present various investment selection strategies to the investors who have different risk profiles and investment views. This study has been sought:

- Developing a portfolio optimisation algorithm for the selected financial assets by using the Modern Portfolio Theory as the main framework and employing Markowitz Portfolio Optimisation Model as the mathematical formulation with providing Maximum Sharpe Ratio Portfolio (Tangency Portfolio) and Minimum Variance Portfolio techniques.
- Designing and implementing the Risk-Parity Portfolio Optimisation Model for the selected financial assets to provide more balanced portfolio selection opportunities for the investors.
- Designing and implementing the Black-Litterman Optimisation Model for the selected financial assets to consider the investor views.
- Designing and implementing the Conditional Value at Risk (CvaR) Optimisation Model for the selected financial assets to capture the tail risk of the established portfolio.
- Make a performance comparison between portfolio optimisation algorithms and analyzing the results.
- Provide practical investment strategies for the investors who are interested in the selected financial assets.

It is expected that the project will be significant both academically and practically. The portfolio optimisation algorithms have been developed in a theoretical approach and productive investment strategies for the selected assets have been obtained by applying the developed algorithms via Python as a programming language. Academic and practical contributions have been provided. Moreover, it is believed that the project will contribute to the financial engineering field by providing various portfolio optimisation models and will provide beneficial investment recommendations to investors who are interested in those financial assets and who have different investment purposes.

1.4 Literature Review

Australian Market has always been an attractive location for the financial investors. Academicians and professionals have been developed and still developing portfolio optimisation models and testing those models on the financial assets in the Australian Market. Various portfolio optimisation algorithms concentrated on different time horizons have been developed and provided to the investors as investment suggestions. Cui and Cheng (2022) indicate that economic fluctuations have a huge impact on the performance of the financial markets. In their study they have focused on testing a trading algorithm which has been developed by their Professor`s and generated from the Modern Portfolio Theory Model (Cui and Cheng 2022). Furthermore, the main purpose of this study is to evaluate the performance of the trading algorithm throughout a time horizon which includes the economic fluctuations such as 2008 crisis and coronavirus pandemic (Cui and Cheng 2022). Moreover, the study has shown that the developed trading algorithm has provided efficient trading performances throughout the time horizon for the selected financial assets (Cui and Cheng 2022). This research is one of a significant example of the applications of Modern Portfolio Theory in the Australian Market. Lastly, various research and academic studies have been conducted under the scope of the Modern Portfolio Theory and tested in the Australian Market as well.

2. Methodology

2.1 Steps Followed

The research has consisted of three main stages which are historical data collection, portfolio optimisation algorithms development and analysis and comparison of the results. Data visualization and portfolio optimisation models have been presented by using Python as programming language.

Data Collection:

- Historical data of the selected financial assets which are BHP.AX, EVN.AX, FMG.AX, GOLD.AX, IGO.AX, LTR.AX, NST.AX, PLS.AX, RIO.AX, SFR.AX, SVL.AX have been gathered from Yahoo Finance.
- The volume, prices and return of each financial asset throughout the selected time frame have been analyzed and visualized.
- Data accuracy concern has been avoided by utilizing Yahoo Finance.

Model Development:

- Modern Portfolio Theory has been used as the main mathematical framework.
- Markowitz Portfolio Optimisation Model (Mean-Variance Portfolio Optimisation) has been used as the main mathematical model and efficient frontier, maximum sharpe ratio portfolio and minimum variance portfolio have been calculated.
- The optimized portfolio has been presented and tested with the performance of the ASX200 index.
- Risk Parity, Black-Litterman and Conditional Value at Risk (CVaR) portfolio optimisation models have been developed.

Analysis and Comparison of the Results:

- Outcomes of the developed portfolio models have been analyzed and compared with each other.
- Investment suggestions for investors who have different financial characteristics have been proposed.

2.2 Mean-Variance Optimisation

Markowitz (1952) highlights that the focus of the Modern Portfolio Theory is analyzing the future performances of the financial assets because it has a huge impact on investors portfolio construction strategies. Moreover, the study has been proposed by Markowitz, shaped the investment knowledge and strategies of the industry because the relationship between risk and return has never been included in the portfolio selection algorithms (Lagowski 2022). Markowitz (1952) analyzed the risk-return tradeoff by using the mean as calculation metric for the return and standard deviation as the calculation metric of the risk and developed a portfolio selection theory which maximizes the expected return of the investors at a certain level of volatility.

Chen (2021) highlights that mean-variance analysis (Markowitz Portfolio Theory) is the mathematical formulation of the Modern Portfolio theory which has developed by American Economist Harry Markowitz in 1952. Emanuelsson and Marling (2012) indicate that mean-variance analysis is the mathematical model of the Modern Portfolio Theory with a goal of minimizing the overall risk of the portfolio under certain constraints. Furthermore, this study has strengthened mean-variance optimisation by including the efficient frontier visualization, maximum sharpe ratio portfolio (tangency portfolio) and minimum variance portfolio. Ganti (2024) suggests that efficient frontier is the visual representation curve of the potential portfolios on the coordinate plane. In addition, efficient frontier provides investment recommendations to the investors who have different risk-return purposes. Moreover, Tamplin (2024) points out that maximum sharpe ratio portfolio is the optimal portfolio combination which provides highest risk-adjusted anticipated return at determined level of risk. Tamplin (2024) argues that minimum variance portfolio is the optimal investment strategy for the investors who are risk-averse because it is the safest financial asset cluster.

Expected Portfolio Return:

$$E[R_p] = \sum_{i=1}^{N} w_i r_i = \sum_{i=1}^{N} w_i \mu_i$$

Where $E[R_p]$ is the expected return of the portfolio, w_i is the weight of each financial asset in the portfolio, μ_i or r_i is the expected return of each asset in the portfolio.

Variance of the Portfolio:

$$\sigma_p^2 = w^T \Sigma w$$

Where σ_p^2 is the variance of the portfolio, $w^T$is the transpose of the weight vector, Σ is the covariance matrix of the financial asset returns.

Standard Deviation (Volatility) of the Portfolio:

$$\sigma_p = \sqrt{w^T \Sigma w}$$

Where σ_p is the standard deviation (volatility) of the portfolio $w^T$is the transpose of the weight vector, Σ is the covariance matrix of the financial asset returns.

Sharpe Ratio (Risk-Adjusted Return):

$$S = \frac{R_p - r_f}{\sigma_p}$$

Where S is the sharpe ratio, R_p is the return of the portfolio, r_f is the risk-free rate which is determined as 3% in this project (interest rate of the Reserve Bank of Australia), σ_p is the standard deviation (volatility) of the portfolio.

Maximum Sharpe Ratio Portfolio (Tangency Portfolio):

$$\max_w \left(\frac{w^T \mu - r_f}{\sqrt{w^T \Sigma w}} \right)$$

The goal of Maximum Sharpe Ratio Portfolio is to maximize the risk adjusted return (which is expected return – risk-free rate) divided by the volatility of the portfolio.

Minimum Volatility Portfolio:

$$\min_w \sqrt{w^T \Sigma w}$$

$$\text{subject to} \sum_{i=1}^{N} w_i = 1$$

The goal of the Minimum Volatility Portfolio is to minimize the standard deviation (volatility) with respect to the constraint which ensures that summation of the weight of each financial asset equals 1 (fully invested).

Mean-Variance Optimisation Model:

$$\begin{aligned} \min_w \quad & \sqrt{w^T \Sigma w} \\ \text{subject to} \quad & w^T \mu = R_t \\ & \sum_{i=1}^{N} w_i = 1 \end{aligned}$$

The main purpose of the mean-variance optimisation mathematical model is to minimize the total risk of the potential portfolio with respect to certain constraints. The first constraint ensures that the anticipated return of the portfolio will be equal to the target return, and the second constraint ensures that total weights of the selected financial assets should be equal to 1 (fully invested).

2.3 Risk-Parity Model

Chen (2021) points out that the Risk-Parity optimisation technique is often used to adjust the mean-variance optimisation portfolio for risk-averse investors. Qian (2011) conducted a Risk-Parity analysis study which is based on evaluating the portfolio performances with different weight scenarios. He reached the conclusion that avoiding single asset concentration and building well-diversified portfolio with equal risk parameters have enhanced the gain of the investors (Qian 2011).

Risk-Parity Model:

$$\min_w \sum_{i=1}^{N} (RC_i - \overline{RC})^2$$

$$\text{subject to} \quad \sum_{i=1}^{N} w_i = 1$$

Where RC_i is the risk contribution of each financial asset and $\overline{RC}$ is the mean risk contribution. The main target of the Risk-Parity mathematical formulation is to ensure that each financial asset provides the same risk contribution and the constraint satisfies that summation of the weight of each financial asset equals 1 (fully invested).

2.4 Black-Litterman Model

Bessler, Opfer and Wolff (2017) indicate that the main advantage of the Black-Litterman model is to provide an investment algorithm by involving investor`s views. Moreover, the main benefit of the Black-Litterman approach is to upgrade the outcome of the Markowitz Portfolio Model by setting the Markowitz Portfolio as the reference asset allocation and gives the opportunity to the investors to provide their return estimates, their confidence levels and their opinions (Bessler, Opfer and Wolff 2017).

Black-Litterman Model:

$$\pi = \delta \cdot \Sigma \cdot w_{\mathrm{m}}$$

Where π is the vector of implied equilibrium return, δ is the risk aversion coefficient of the investor, Σ is the covariance matrix and w_{m} is the vector of market weights (Bessler, Opfer and Wolff 2017).

$$\mu_{\mathrm{BL}} = ((\tau\Sigma)^{-1} + \mathrm{P}^{\mathrm{T}}\Omega^{-1}\mathrm{P})^{-1}((\tau\Sigma)^{-1}\pi + P^{T}\Omega^{-1}Q)$$

Where μ_{BL} is the posterior expected returns, τ is a measurement factor for the reliability, P is the binary matrix representing investor views, Q is a vector of expected returns established by investor opinions and Ω is a matrix presents the uncertainty of the investor opinions (Bessler, Opfer and Wolff 2017).

$$\max_{w}\left(\frac{w^{T}\mu_{BL} - r_f}{\sqrt{w^{T}\Sigma w}}\right)$$

$$\text{subject to} \sum_{i=1}^{N} w_i = 1$$

The main purpose of the mathematical model of the Black-Litterman Model is to maximize the risk adjusted return by using the expected returns gained from investor views. The constraint ensures that summation of the weight of each financial asset equals 1 (fully invested).

2.5 Conditional Value at Risk (CVaR) Model:

Chen (2024) highlights that Conditional Value at Risk strategy is the extended version of the Value at Risk strategy which focuses on capturing the tail risk by computing the average values that are below the VaR threshold. Moreover, Sarykalin, Serraino and Uryasev (2014) argue that CVaR evaluates and measures the losses which are exceeding the cut-off point of VaR. Furthermore, accurate estimation of the tail losses is a very significant part for presenting efficient portfolio and investment strategies for the investors (Sarykalin, Serraino and Uryasev 2014).

Conditional Value at Risk (CVaR) Model:

$$\min_{w,\mathrm{VaR},z}\left(\mathrm{VaR} + \frac{1}{(1-\alpha)\cdot n}\sum_{i=1}^{n} z_i\right)$$

$$\text{subject to} \quad \sum_{i=1}^{m} w_i = 1$$

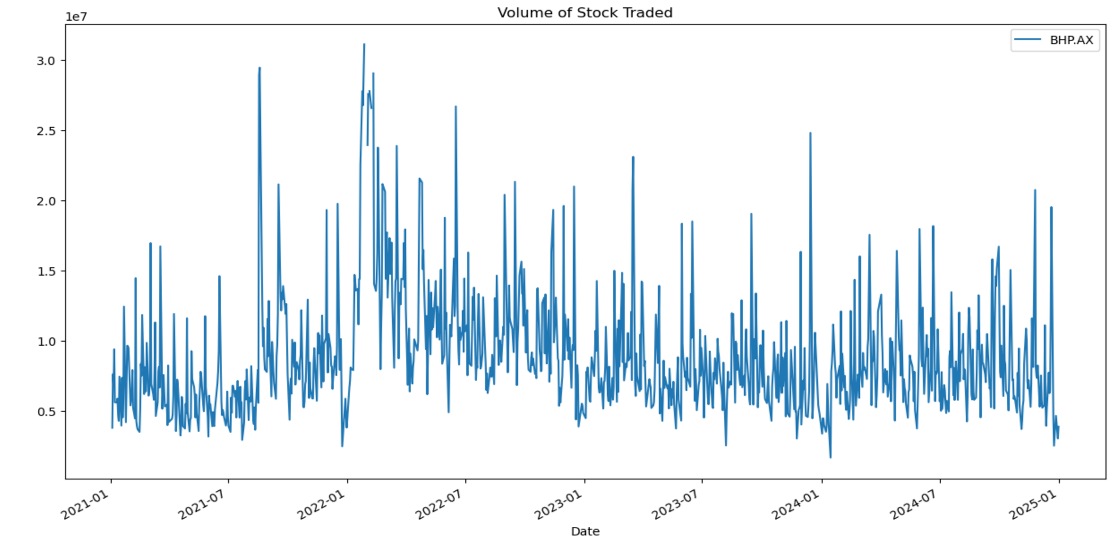
$$w_i \geq 0 \quad \forall i \in \{1,2,\dots,n\}$$

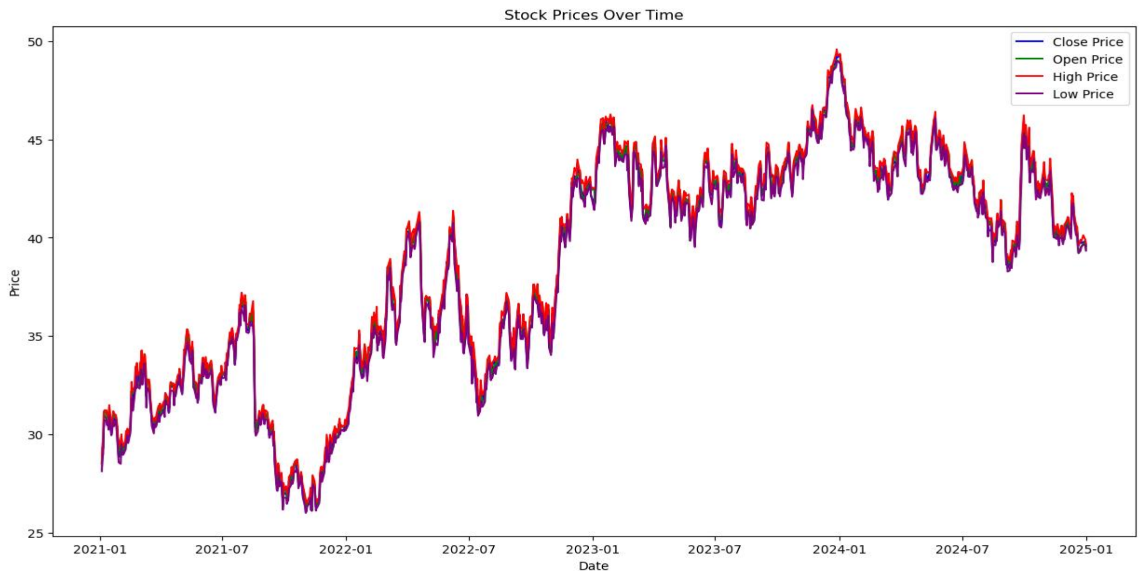
$$z_i \geq -r_i^T w - \text{VaR} \quad \forall i \in \{1,2,\dots,n\}$$

The objective function of the CVaR Model aims to minimize the Value at Risk and the expected tail losses. First constraint of the mathematical model ensures that summation of the weight of each financial asset equals 1 (fully invested). Furthermore, the second constraint prohibits the short-selling opportunity. The last constraint satisfies capturing the tail losses.

3. Results

3.1 Theoretical / Numerical Results and Analysis





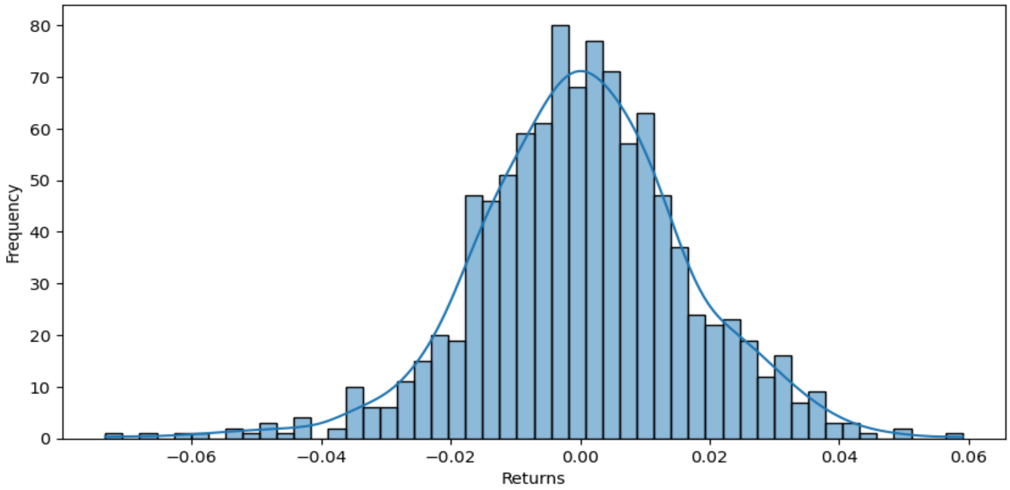


Figure 1. BHP.AX information about its volume, prices and returns

Firstly, for each financial asset the volume of the stocks traded between 2021 and 2025 has been calculated and visualized by a time series graph. Moreover, prices for each financial asset throughout the selected time horizon have been visualized by a line graph. Lastly, returns for each financial asset have been calculated and presented with a histogram throughout the time horizon. Figure 1 presents the information about the BHP.AX stock. The volume, prices and returns of the remaining ten financial assets have been provided in the appendix section of the report.

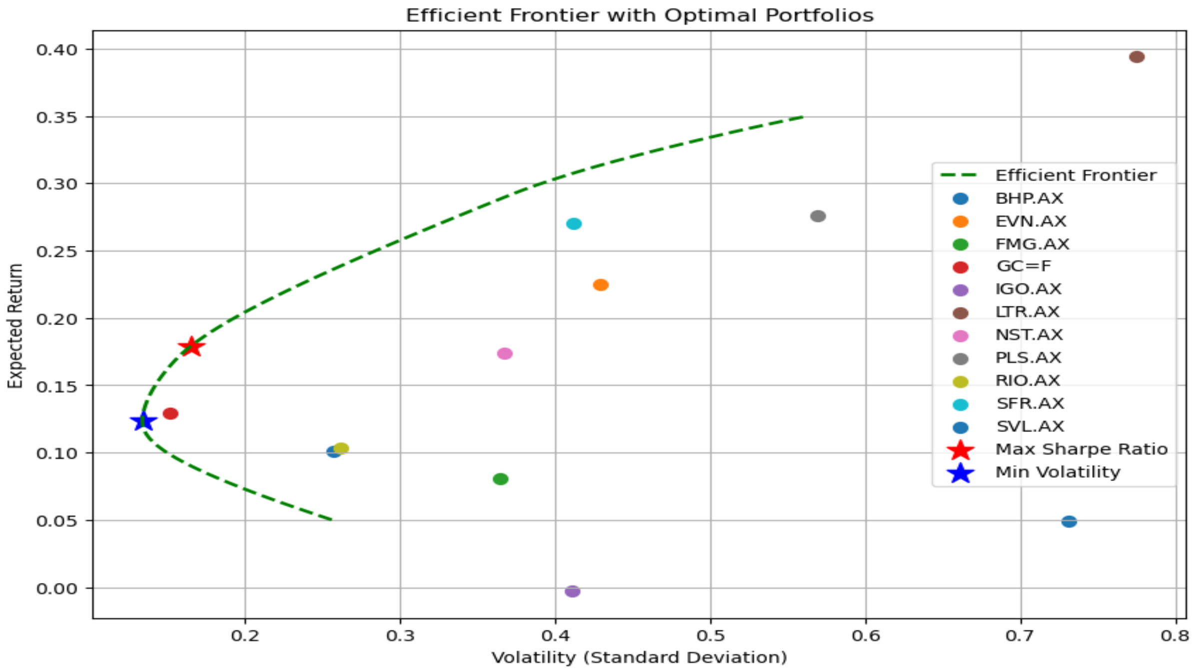


Figure 2. Mean-Variance Optimisation Result and Efficient Frontier Visualization

Maximum Sharpe Ratio Portfolio	
Assets	**Weights**
BHP.AX	0.0
EVN.AX	0.0778
FMG.AX	0.0
GC = F	0.6791
IGO.AX	0.0
LTR.AX	0.0628
NST.AX	0.0
PLS.AX	0.0345
RIO.AX	0.0
SFR.AX	0.1458
SVL.AX	0.0
Expected Annual Return	17.90%
Annual Volatility	16.50%
Sharpe Ratio	0.90

Table 1. Maximum Sharpe Ratio Portfolio Results

Minimum Volatility Portfolio	
Assets	**Weights**
BHP.AX	0.1421
EVN.AX	0.0

FMG.AX	0.0
GC = F	0.7314
IGO.AX	0.0035
LTR.AX	0.0
NST.AX	0.0251
PLS.AX	0.0
RIO.AX	0.0978
SFR.AX	0.0
SVL.AX	0.0
Expected Annual Return	12.34%
Annual Volatility	13.38%
Sharpe Ratio	0.70

Table 2. Minimum Volatility Portfolio Results

Figure 2, Table 1 and Table 2 present the visualization and results of the mean-variance (Markowitz) Portfolio optimisation model. Figure 2 shows the efficient frontier curve and the locations of the Maximum Sharpe Ratio Portfolio and Minimum Volatility Portfolio. According to Figure 2, BHP.AX has low return high volatility. A possible reason for this relationship is a tight time window. EVN.AX is a good option for risk seeking investors because it provides high return but high risk. FMG.AX is not an efficient option because it provides low returns at a moderate risk level. GC = F is a well-balanced opportunity. IGO.AX is an option that should not be considered. LTR.AX is the best investment strategy for risk-seeking investors because it is the most aggressive asset. Furthermore, NST.AX, PLS.AX, RIO.AX, SFR.AX and SVL.AX provide different expected return rates at various risk levels. Those financial assets can provide different investment opportunities for the investors who have different investment targets.

According to Table 1 and Table 2 the established Maximum Sharpe Ratio Portfolio, which is the optimal investment strategy in terms of risk and return tradeoff, has a 17.90% expected return at a moderate volatility (16.50%). On the other hand, Minimum Volatility Portfolio, which is the safest investment strategy, provides 12.34% expected return to the risk-averse investors.

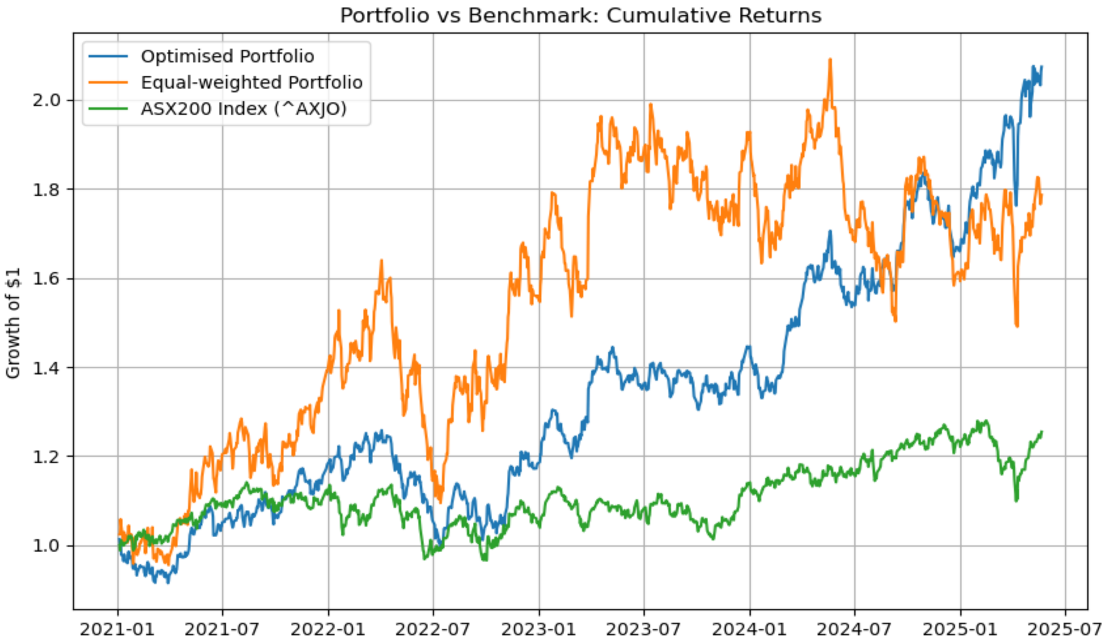


Figure 3. Cumulative Returns and Performance Comparison of Three Strategies

Portfolio	**Annual Return**	**Annual Volatility**	**Sharpe Ratio**
Optimized	0.184599	0.165600	0.933573
Equal-Weighted	0.172302	0.270028	0.526991
ASX200	0.061801	0.131408	0.241999

Table 3. Annual Return, Annual Volatility, Sharpe Ratio of the Compared Strategies

Figure 3 and Table 3 provides back test comparison between three investment strategies throughout the time horizon of 2021 and 2025. Optimized portfolio has been established by mean-variance method and compared with equal weighted portfolio and ASX 200 index (Top 200 performing companies in the Australian Market). As shown in Figure 3 equal weighted portfolio was the top-performing strategy until 2025. Since 2025 the optimized portfolio started maintaining the most efficient performance among the strategies. ASX 200 is the stable and safest investment strategy but compared to the other two strategies it has the lowest expected return rate and growth potential. As shown in Table 3, Optimized Portfolio has the highest sharpe ratio (93.3%), which reflects that in terms of risk-adjusted return it is the most productive investment strategy.

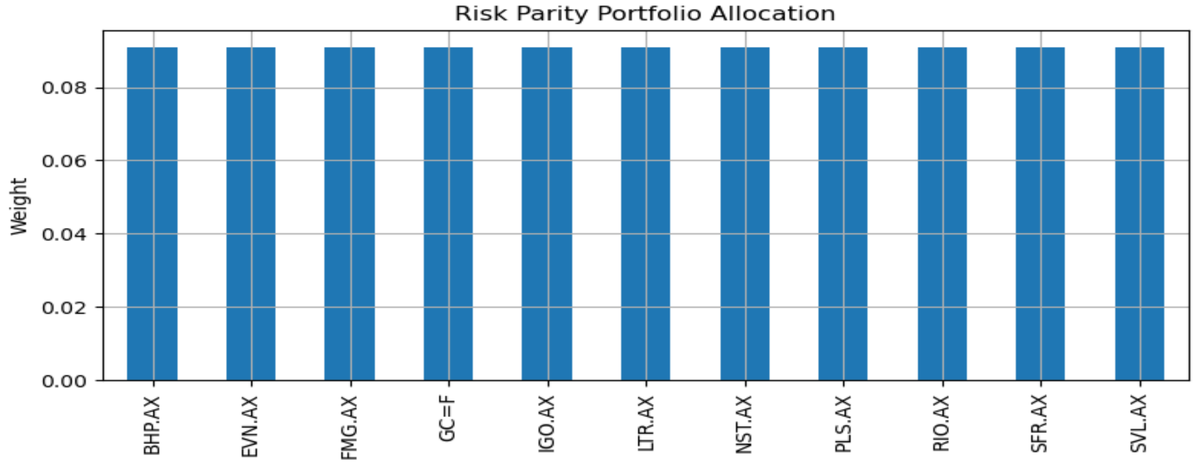


Figure 4. Risk Parity Portfolio Allocation

Assets	Weights
BHP.AX	0.0909
EVN.AX	0.0909
FMG.AX	0.0909
GC=F	0.0909
IGO.AX	0.0909
LTR.AX	0.0909
NST.AX	0.0909
PLS.AX	0.0909
RIO.AX	0.0909
SFR.AX	0.0909
SVL.AX	0.0909

Table 4. Portfolio Weights

Assets	Risk
BHP.AX	0.0010
EVN.AX	0.0013
FMG.AX	0.0013
GC=F	0.0002
IGO.AX	0.0017
LTR.AX	0.0028
NST.AX	0.0011
PLS.AX	0.0022
RIO.AX	0.0010
SVL.AX	0.0023
Total Volatility	1.66%

Table 5. Risk Contributions

Figure 4, Table 4 and Table 5 present the outcomes of the Risk-Parity Optimisation Model. The chart and statistics show that Risk-Parity technique has distributed equal weights (9.09%) to each financial asset. Although the security weights were equally distributed, the risk contributions of the financial assets were assigned differently from each other. Lastly, as presented in Table 5, the total volatility of the Risk-Parity portfolio is 1.66% which indicates that this model has provided a low-risk profile investment strategy. This is a very common feature for portfolios designed with Risk-Parity methods.

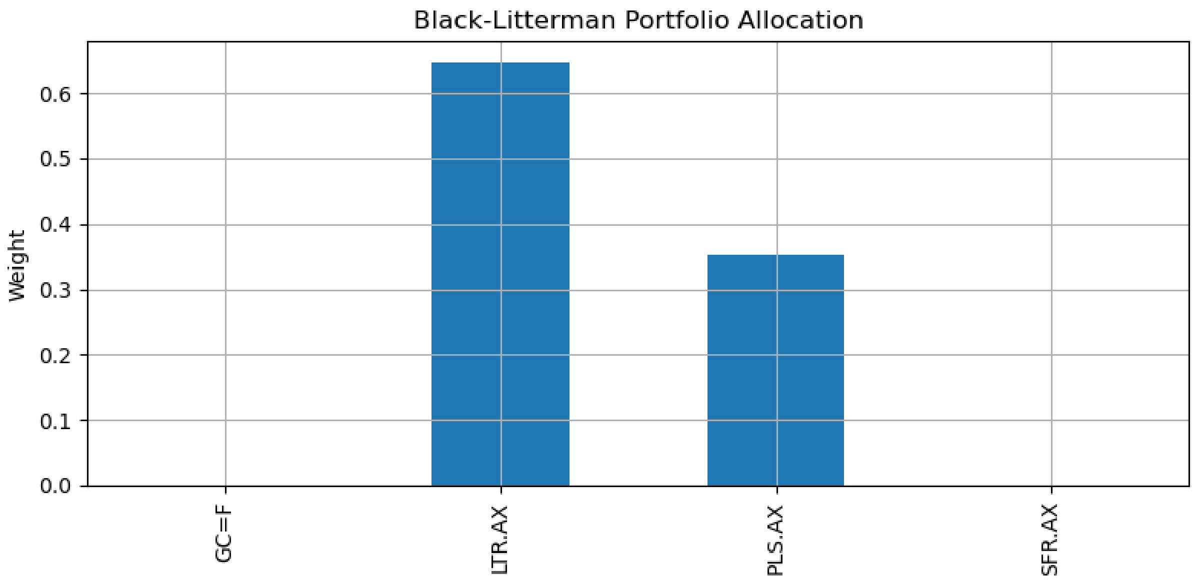


Figure 5. Black-Litterman Portfolio Allocation

Black-Litterman Portfolio Weights	
GC=F	0.0000
LTR.AX	0.6468
PLS.AX	0.3532
SFR.AX	0.0000

Table 6. Black-Litterman Portfolio Weights

Figure 5 and Table 6 illustrate the Black-Litterman Portfolio Model results. The Black-Litterman Portfolio technique combines the market equilibrium returns with investor views. In this study 4 financial assets which are GC=F, LTR.AX, PLS.AX and SFR.AX have been selected from the Maximum Sharpe Ratio Portfolio (Tangency Portfolio). Those 4 securities have had the highest weights in the Maximum Sharpe Ratio Portfolio; therefore, the Black-Litterman model has been used to analyze and provide investment strategies for the investors who are interested in those financial securities. Furthermore, Black-Litterman technique has been utilized to provide an investment strategy for risk-seeking investors. From the mean-variance portfolio optimisation result it has been obtained that LTR.AX dominates GC = F in terms of expected return by 26% and has higher risk as expected. The Black-Litterman model has been focused on the relationship between these two selected financial assets and has added the investor views to the analysis.

As presented in Table 6 Black-Litterman strategy has been focused on LTR.AX and PLS.AX. GC = F and SFR.AX are not included in the portfolio. This clustering shows that investor opinion dominates the market-implied equilibrium returns. Moreover, one of the main reasons for avoiding GC = F and SFR.AX in the portfolio allocation is posterior returns of GC = F and SFR.AX might be too low.

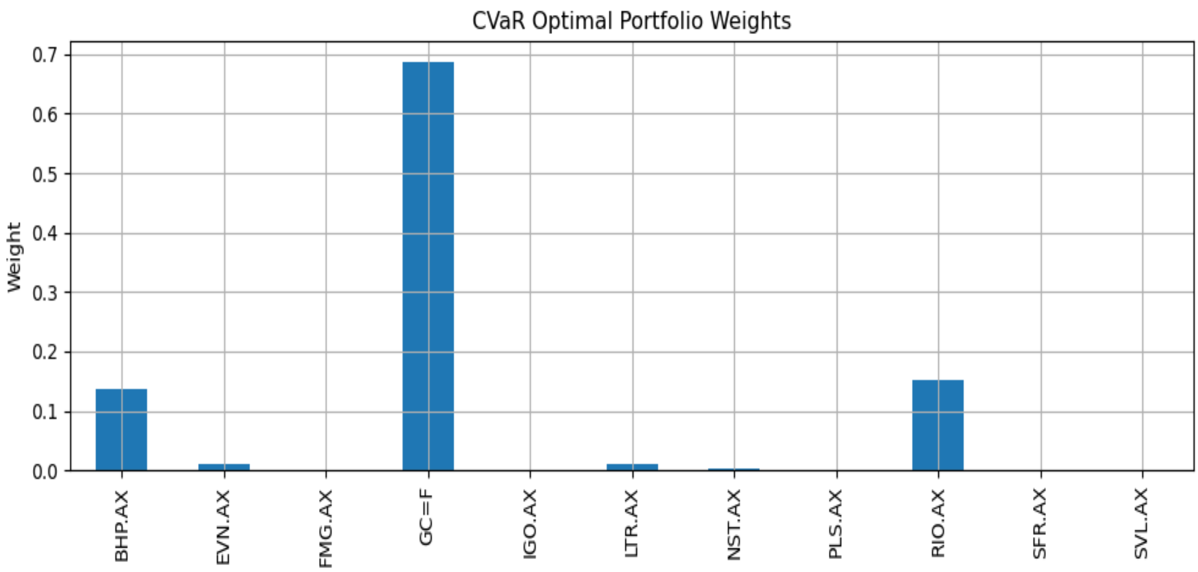


Figure 6. Conditional Value at Risk (CVaR) Portfolio Weights

CVaR Portfolio Weights	
BHP.AX	0.1374
EVN.AX	0.0098
FMG.AX	0.0000
GC=F	0.6870
IGO.AX	0.0000
LTR.AX	0.0095
NST.AX	0.0040
PLS.AX	0.0000
RIO.AX	0.1523
SFR.AX	0.0000
SVL.AX	0.0000

Table7. CVaR Portfolio Weights

Figure 6 and Table 7 present the CVaR Portfolio results. As shown in Table 7 the weights of the financial assets in the established portfolio by CVaR technique are not equal and some securities have not been selected in the portfolio. GC=F dominates the portfolio. One of the possible reasons for this concentration is gold might have a negative correlation with the other financial assets. Moreover, the main purpose of the CVaR approach is to evaluate and capture tail risk. Furthermore, the objective function of the CVaR mathematical formulation tries to minimize the VaR and expected tail losses; therefore, the financial assets which are not included in the CVaR portfolio might have high tail losses.

4. Conclusion and Future Work

4.1 Significance of Findings

The project has presented portfolio optimisation algorithms and investment strategies for the investors who have different risk approaches. Modern Portfolio Theory and its mathematical formulation has been proposed to the investors as the main model. In addition, other portfolio optimisation techniques such as Risk-Parity Method, Black-Litterman Model and CVaR strategy have been developed and introduced to the investors to provide productive comparisons. Furthermore, the selected financial assets have consisted of the metal and mining commodities in the Australian Market; therefore, this project might become a significant source for professionals who are interested in Australian Market and those securities.

4.2 Recommendations and Future Work

The study has focused on the top -performing metal and mining commodities in the Australian Market, but portfolio selection strategies have been developed by using the popular and efficient portfolio optimisation models. For the investors who are interested in different financial assets can use this study as the main source and implement the necessary adjustments to develop their portfolio optimisation strategies.

In this project, the Black-Litterman model has been evaluated from a single investor perspective. For further developments the model can be tested from various investor views as well. Moreover, a meta-heuristic algorithm such as Particle Swarm Optimisation can be developed and tested with these financial securities. With this approach the obtained portfolio optimisation solutions can be compared with the performance of a meta-heuristic technique. To enhance the scope of the project and to provide beneficial suggestions for the investors, machine-learning models can be developed to predict the future performance of the financial assets. Lastly, developing a trading algorithm can be considered to provide better outcomes for the investors.

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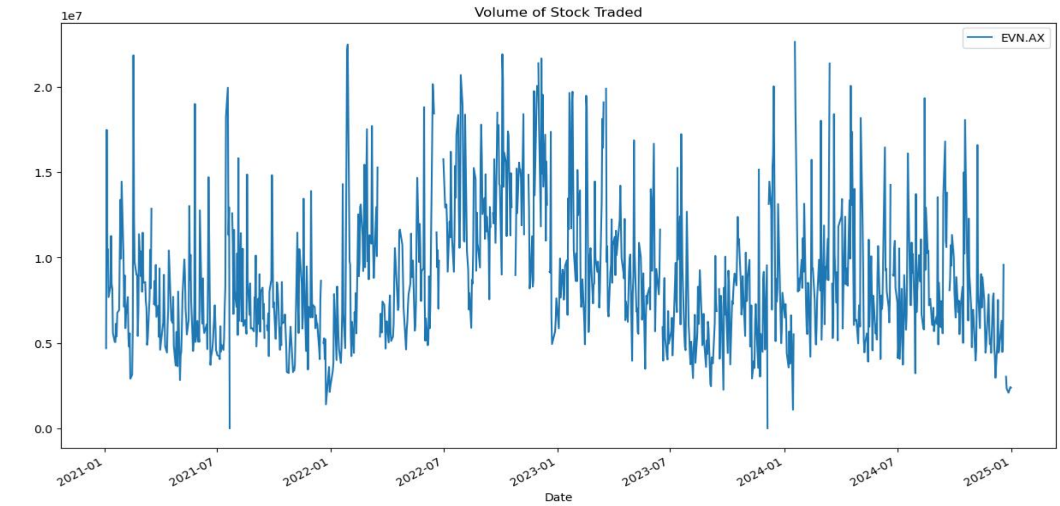
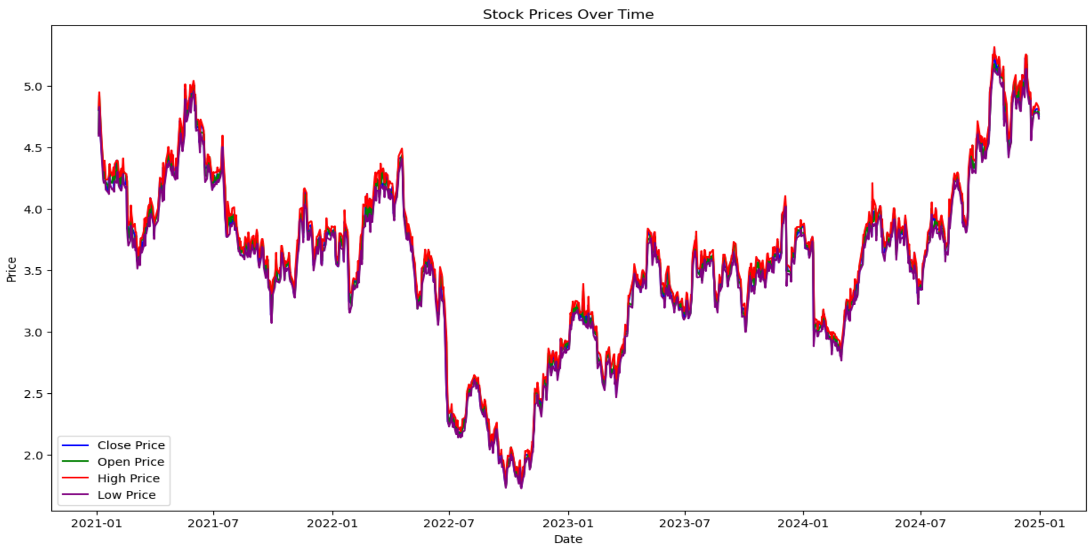
6. Appendix





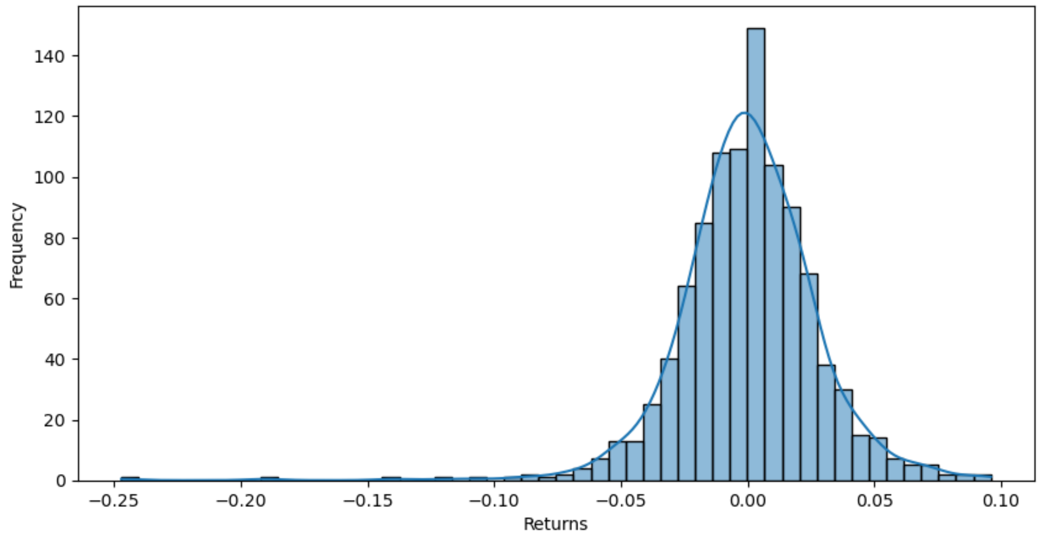
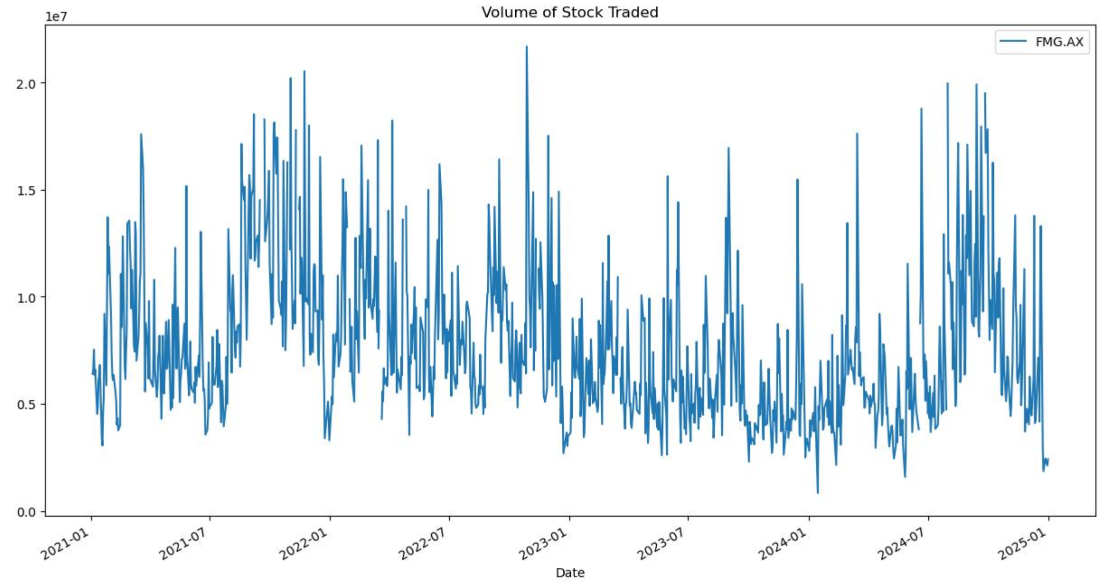
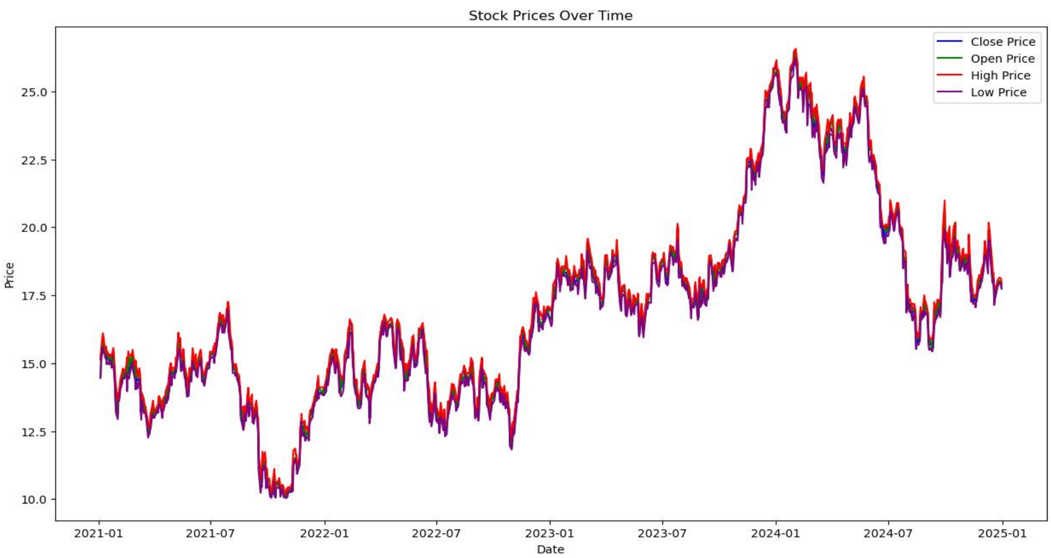


Figure 7. EVN.AX information about its volume, prices and returns





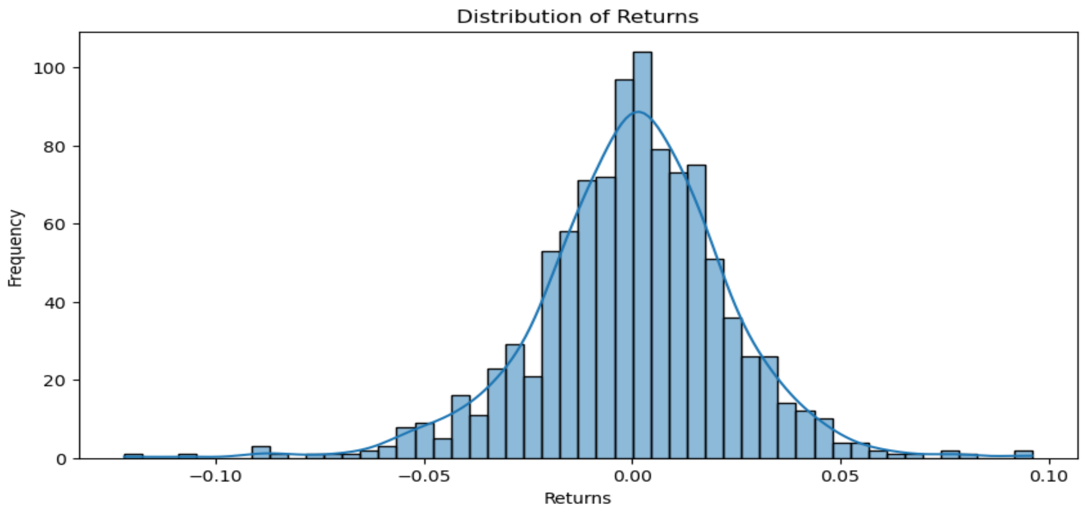
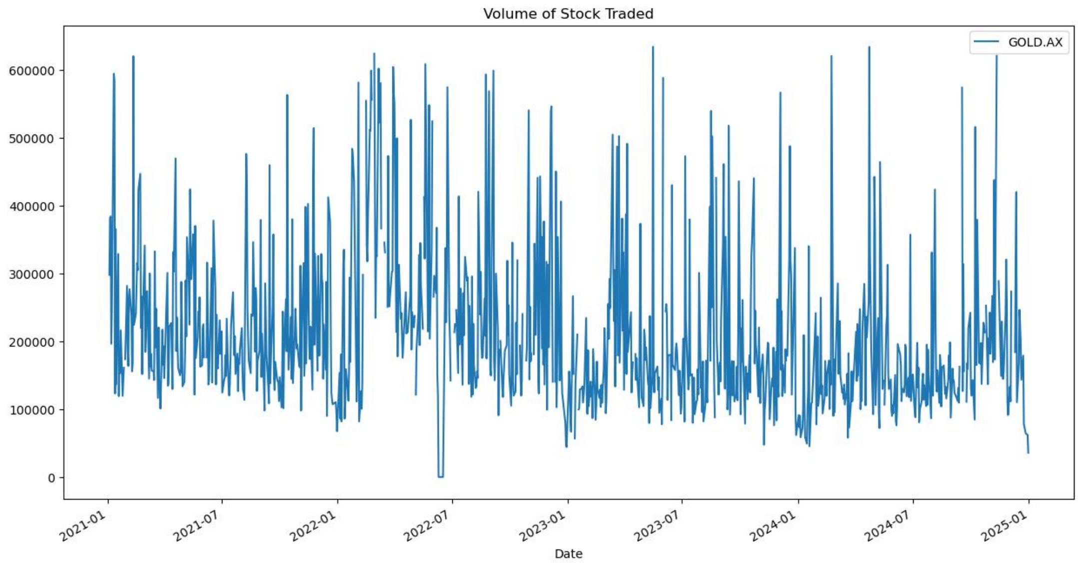
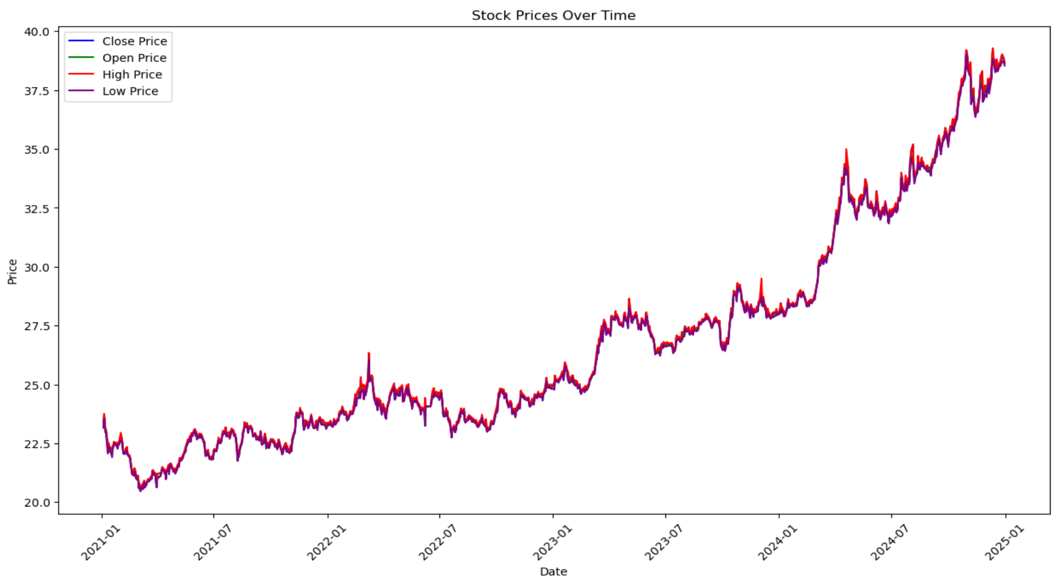
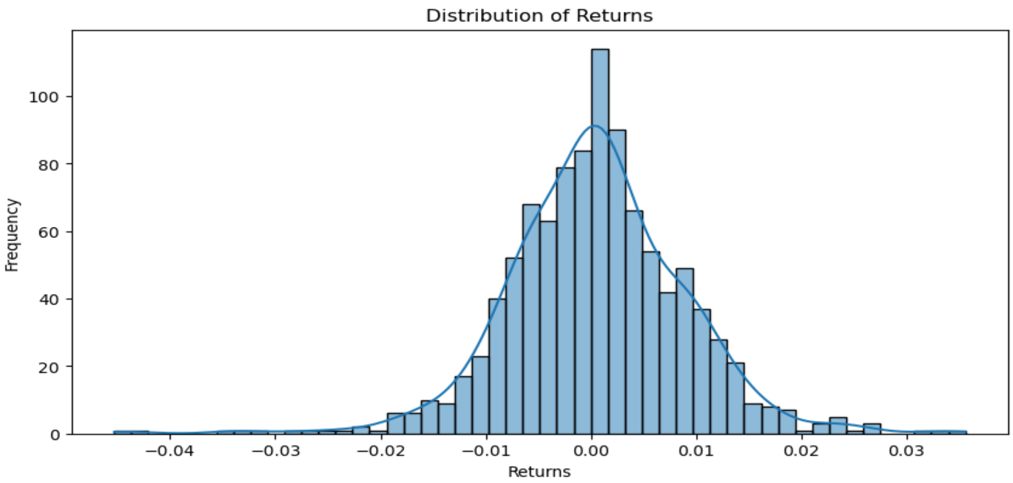


Figure 8. FMG.AX information about its volume, prices and returns







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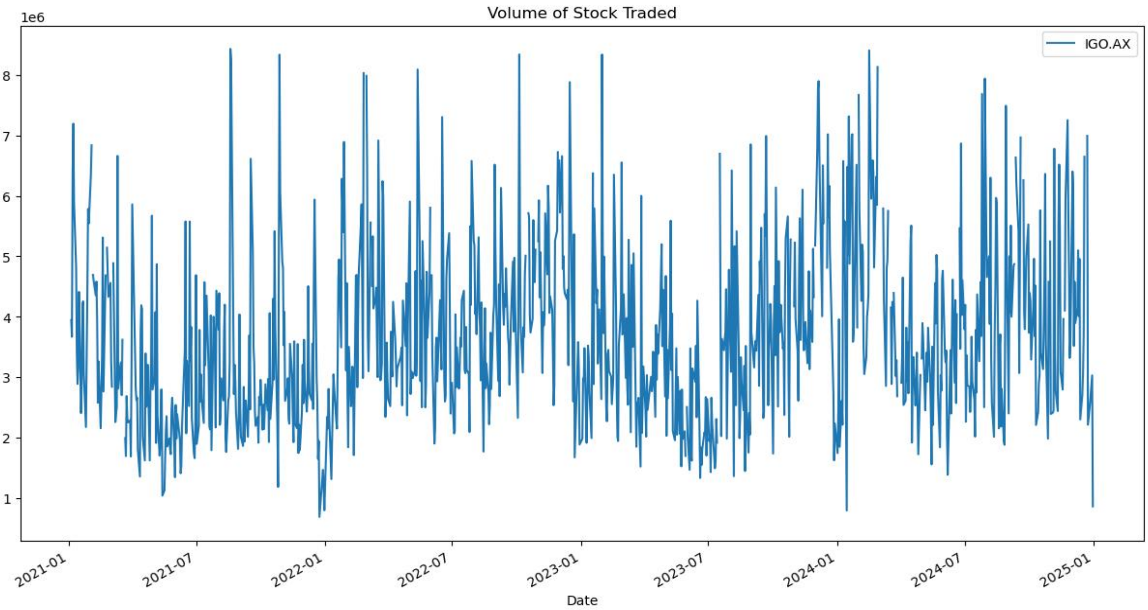
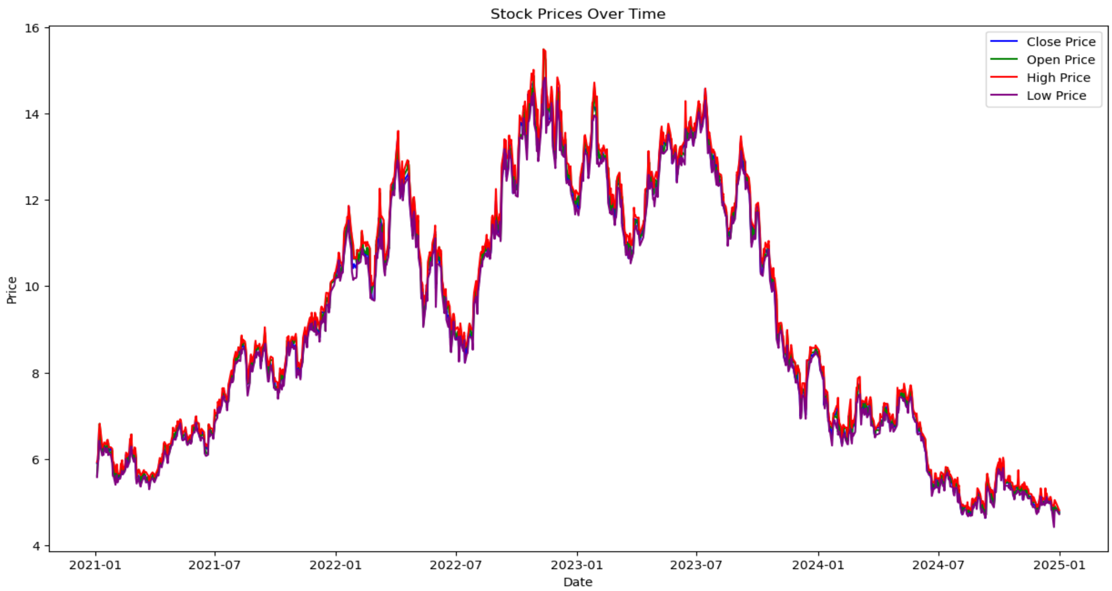




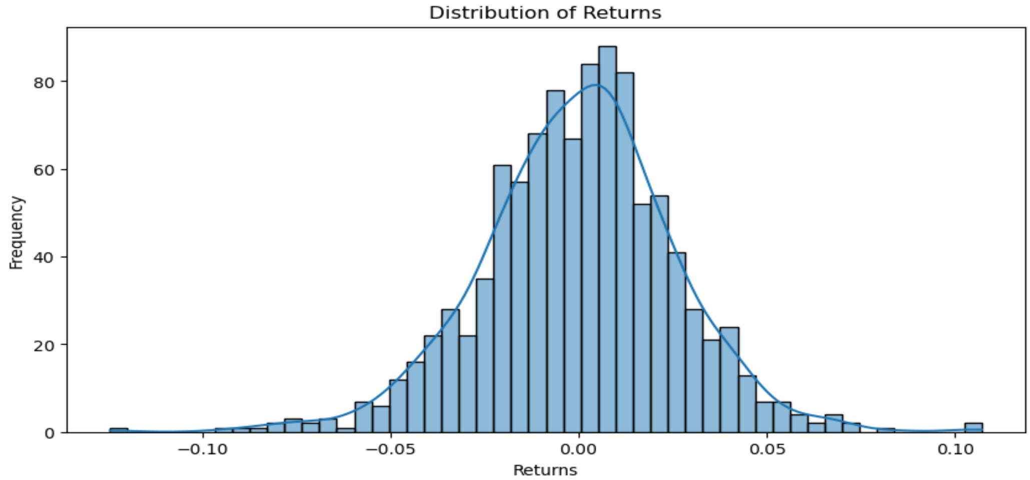
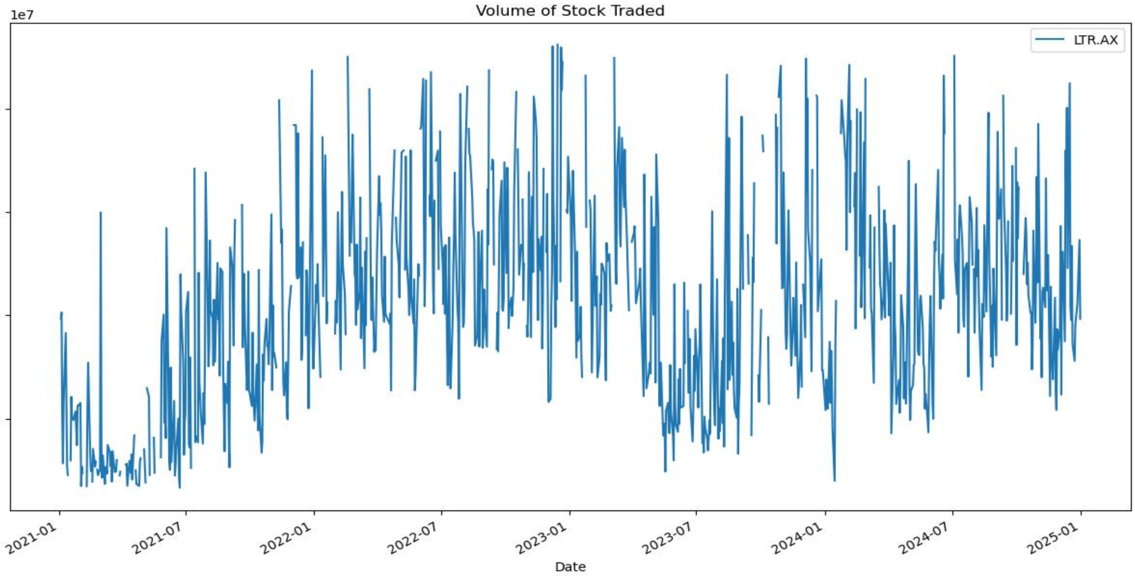
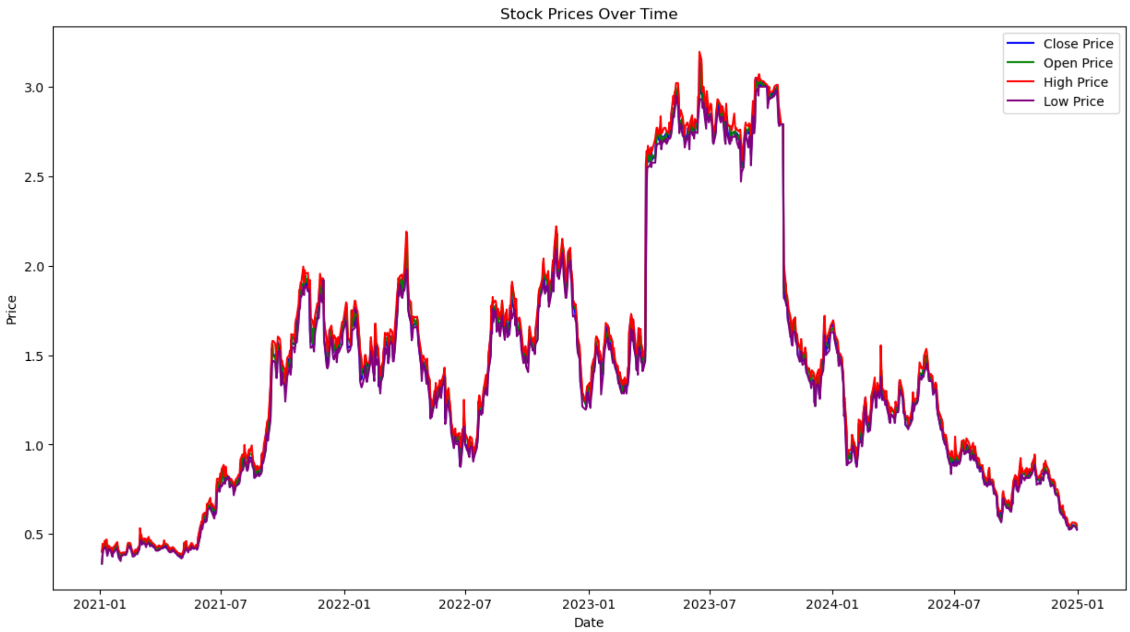


Figure 10. IGO.AX information about its volume, prices and returns





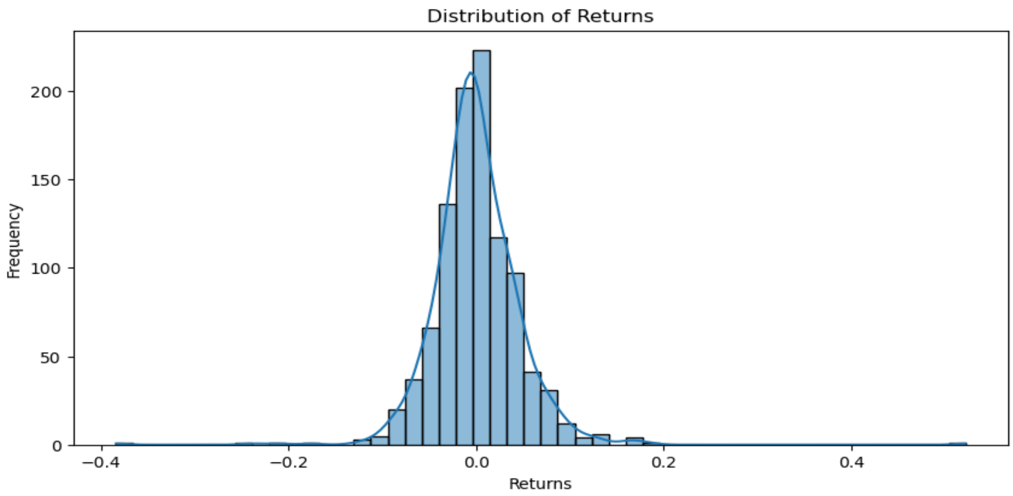
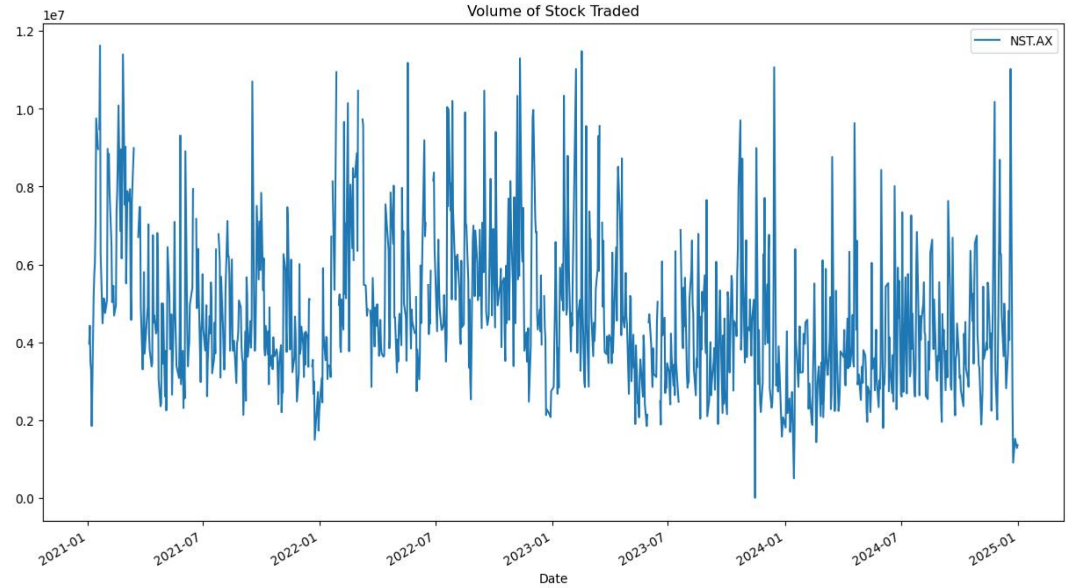
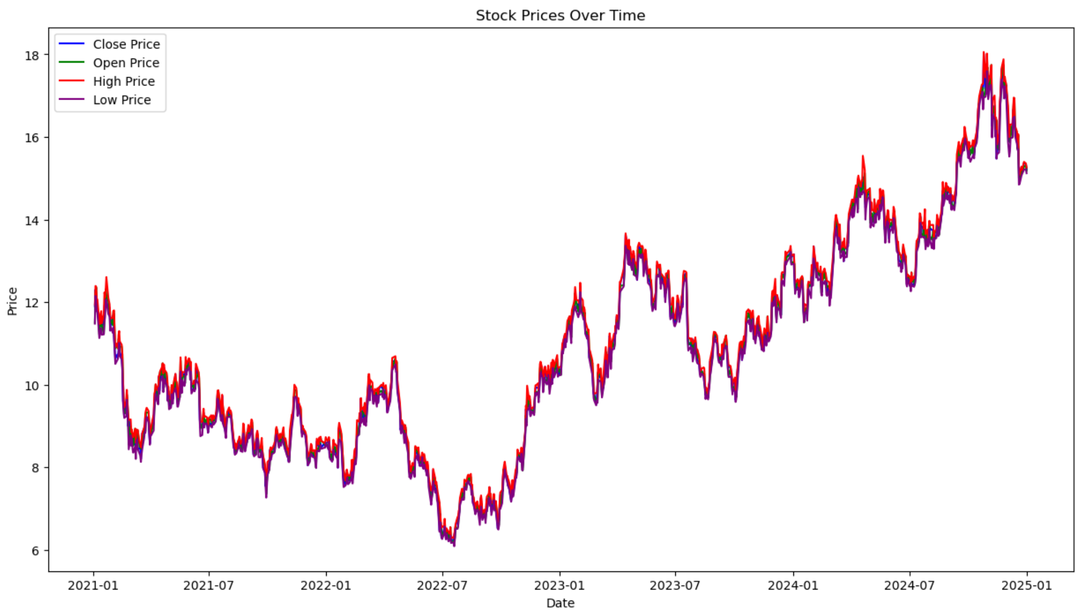


Figure 11. LTR.AX information about its volume, prices and returns





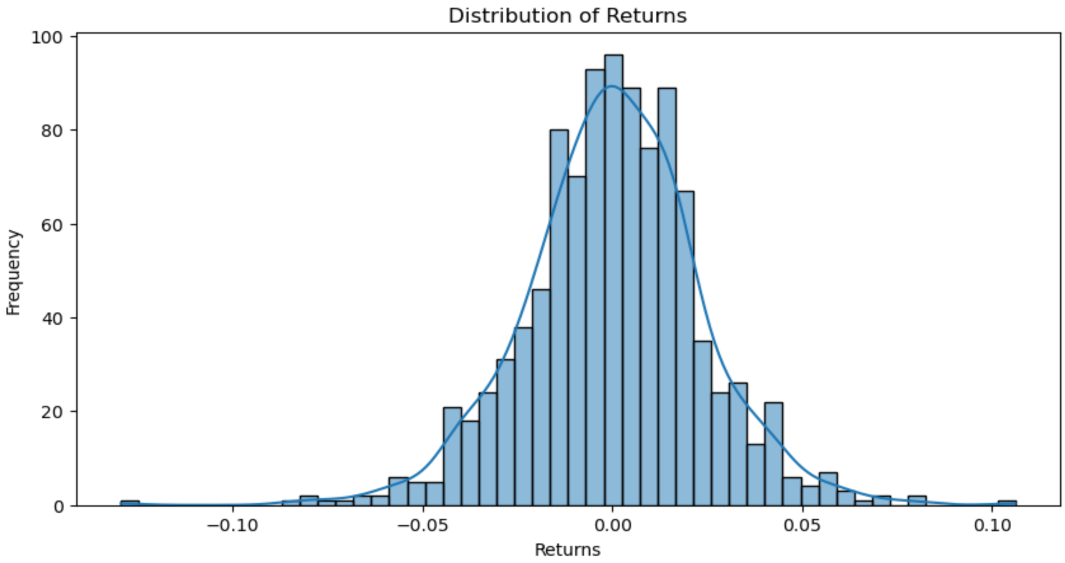
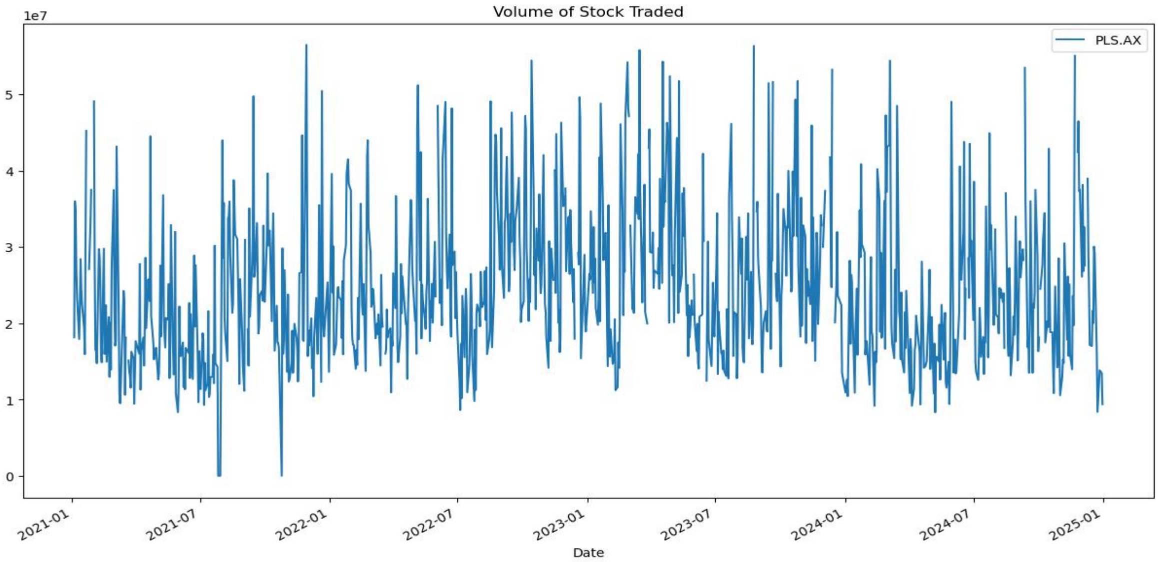
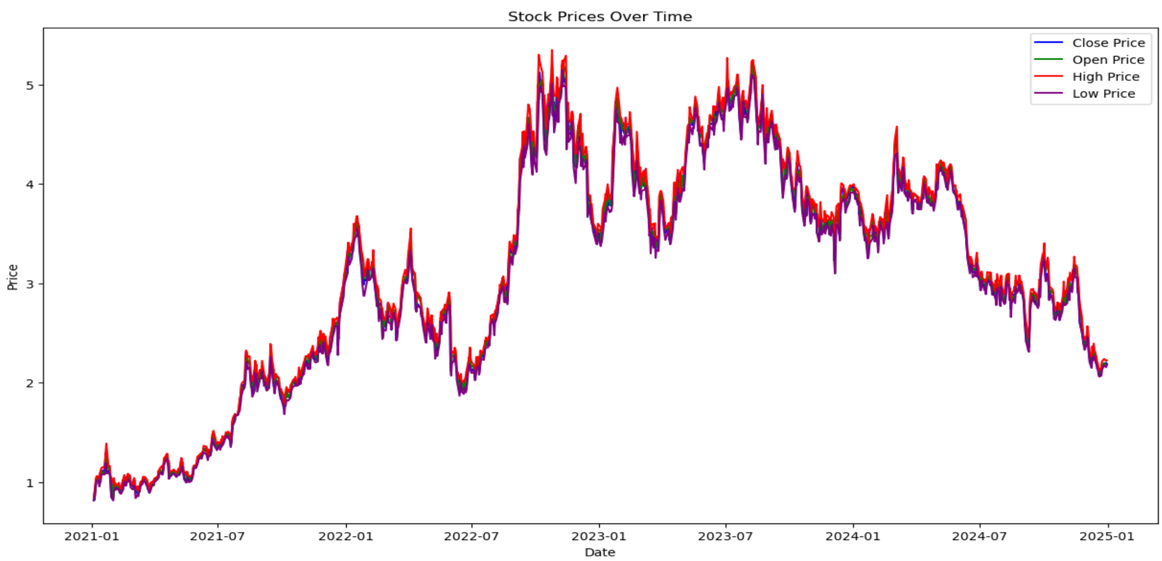
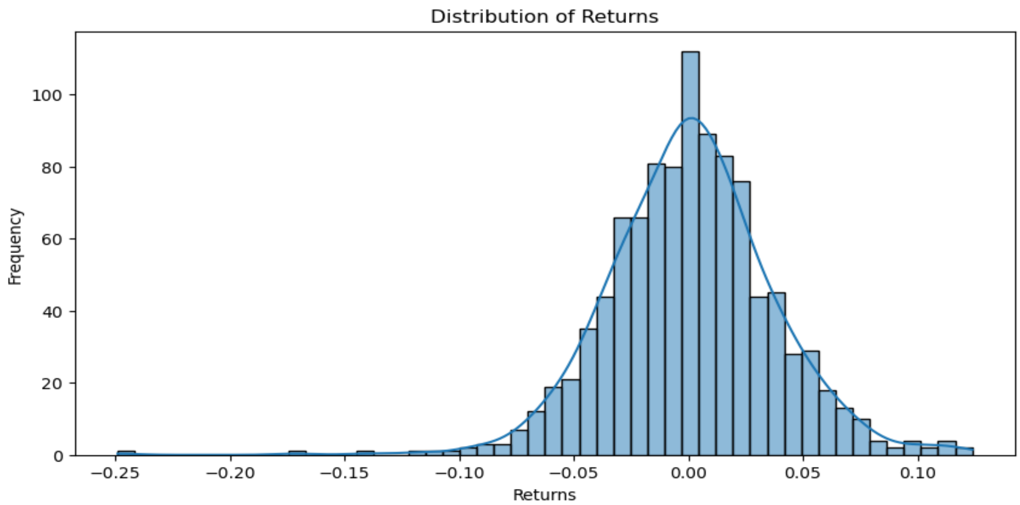


Figure 12. NST.AX information about its volume, prices and returns







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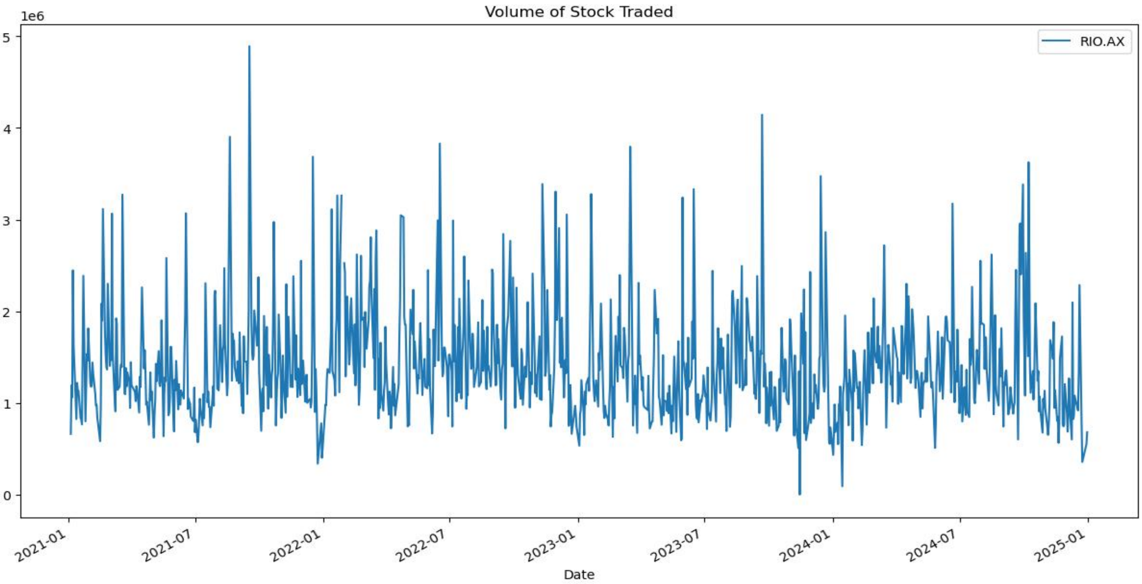
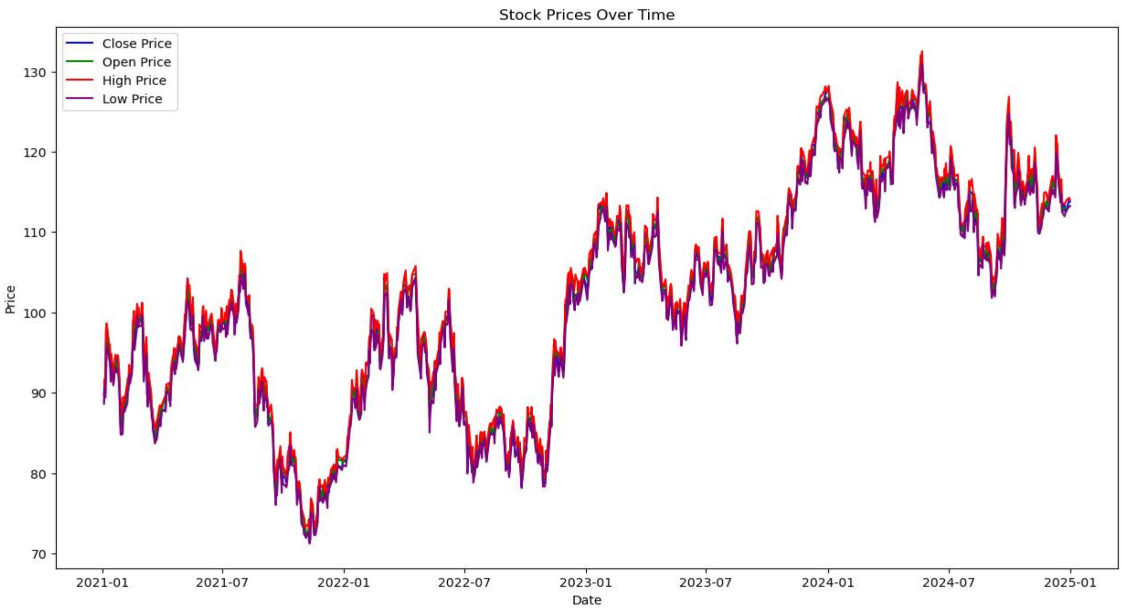




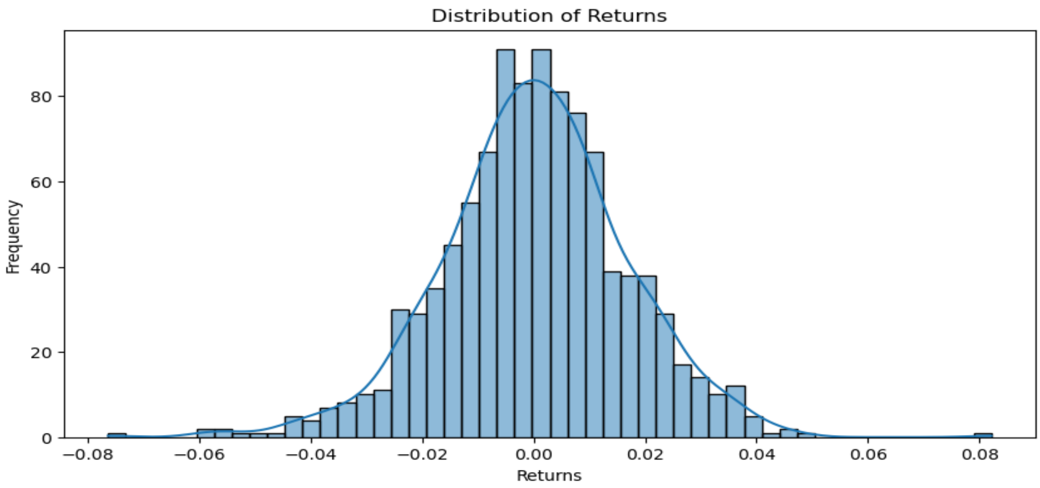
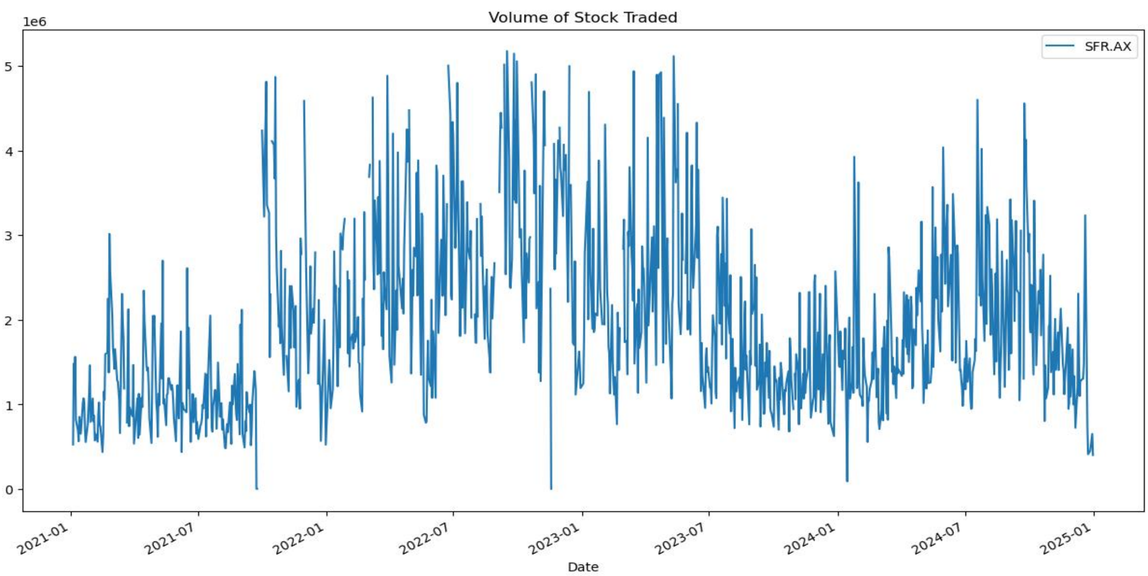
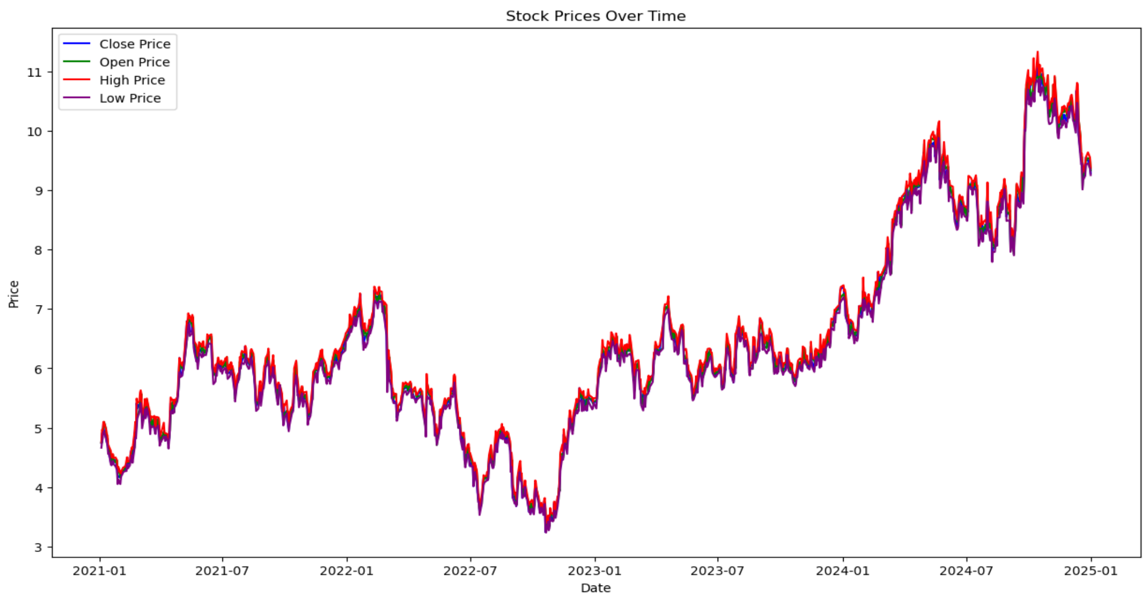
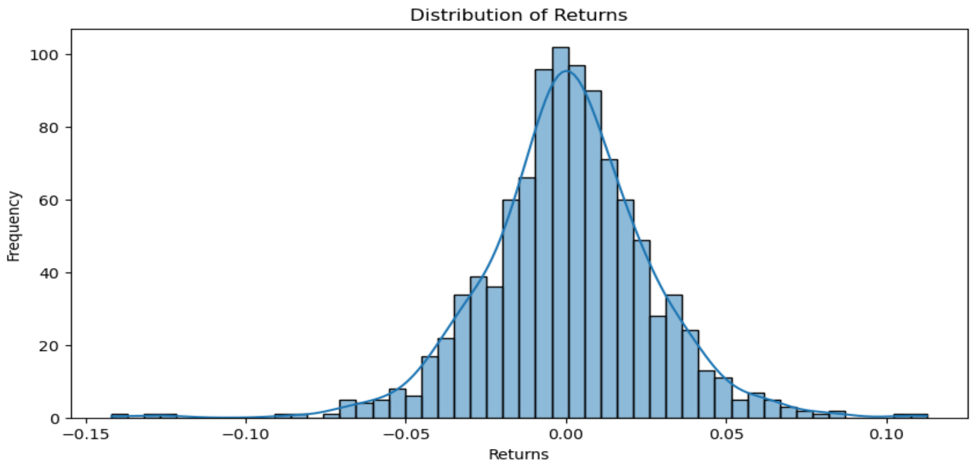


Figure 14. RIO.AX information about its volume, prices and returns







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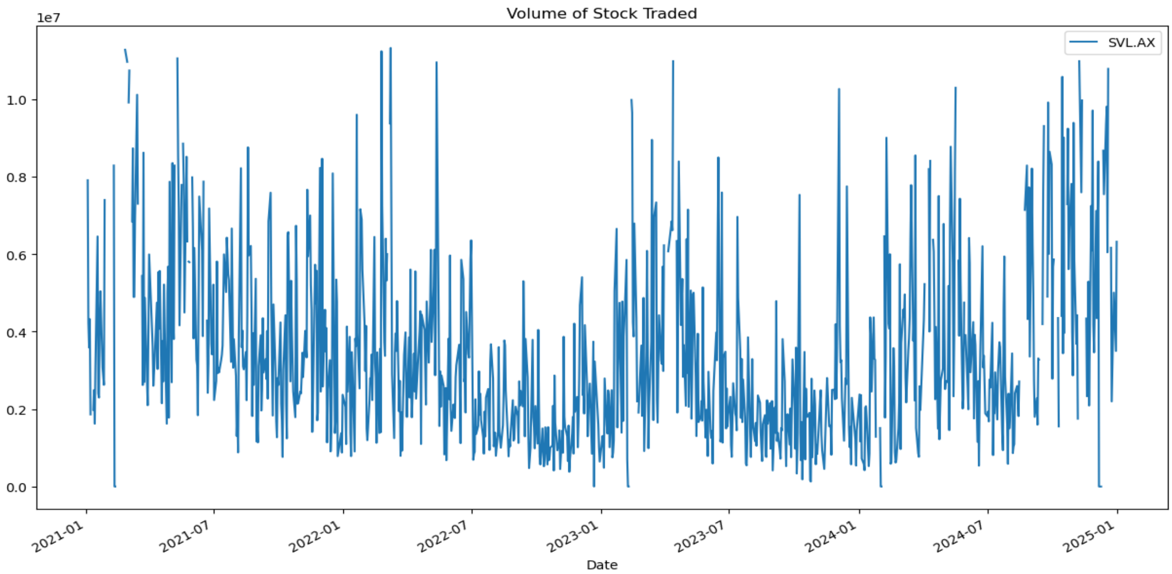

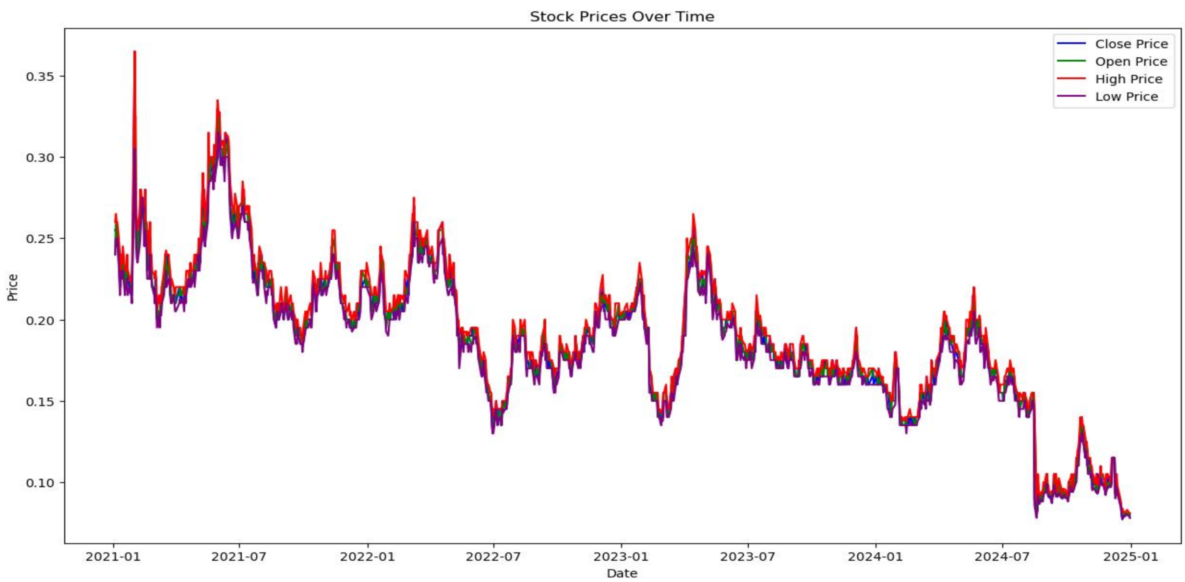

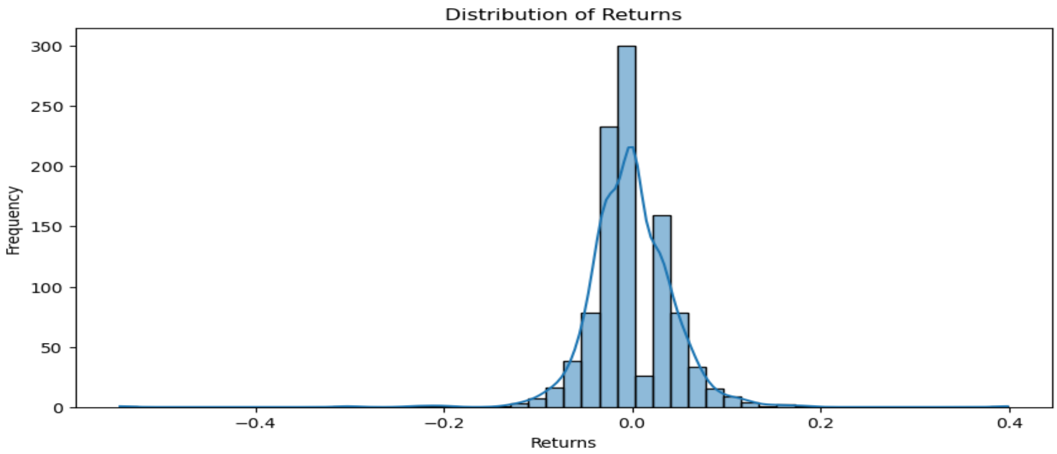

Figure 16. SVL.AX information about its volume, prices and returns