

Triple P Model for Thai's Equity Portfolio



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Financial Engineering

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Academic Year 2023



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SCHOOL OF ENGINEERING

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Thesis – Academic Year 2023

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Title: Triple P Model for Thai's Equity Portfolio

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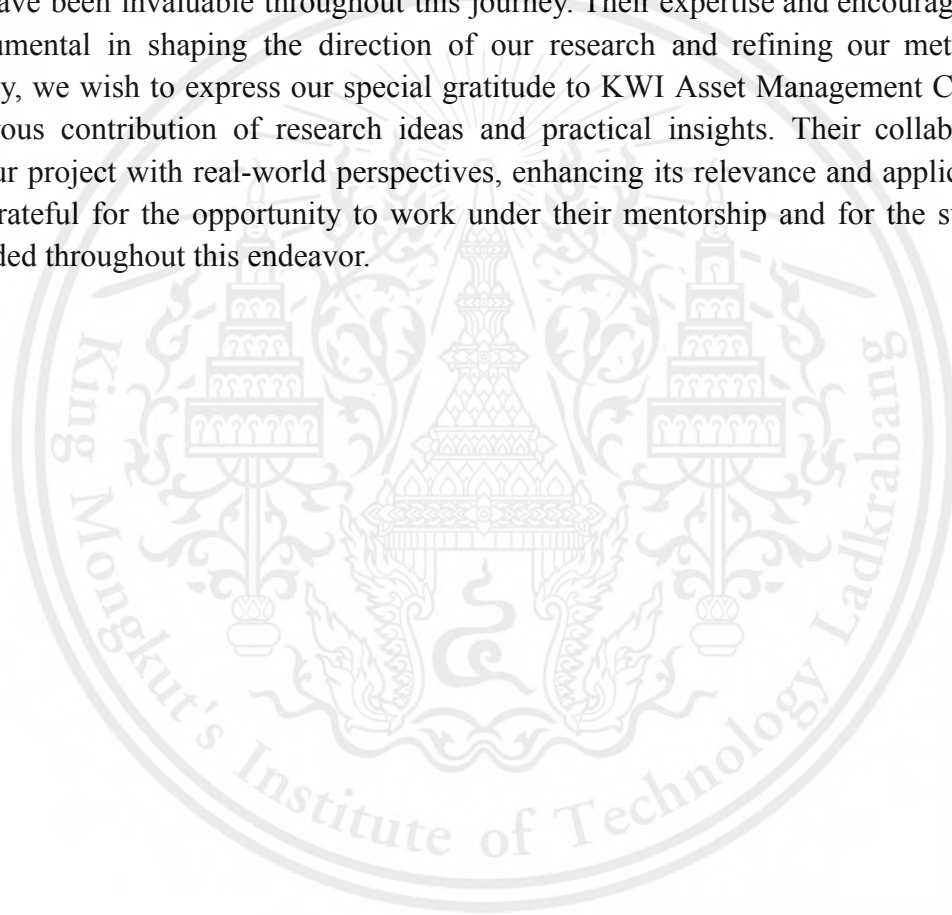
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Acknowledgement

We extend our heartfelt appreciation to Assoc. Prof. Nada Chunsom and Dr. Pimprapai Thainiam, our esteemed academic supervisors, whose unwavering support and guidance have been invaluable throughout this journey. Their expertise and encouragement have been instrumental in shaping the direction of our research and refining our methodologies. Additionally, we wish to express our special gratitude to KWI Asset Management Co., Ltd., for their generous contribution of research ideas and practical insights. Their collaboration has enriched our project with real-world perspectives, enhancing its relevance and applicability. We are truly grateful for the opportunity to work under their mentorship and for the support they have provided throughout this endeavor.



Abstract

This project aims to develop a sophisticated model for constructing an optimized portfolio of Thai equity stocks, with a focus on maximizing risk-adjusted returns. Leveraging advanced quantitative techniques and comprehensive market factor analysis, our goal is to create a tailored Triple P multi-factor investing model specifically designed for the Thai equity market. We explore a wide range of market factors including market risk, inflation, interest rates, GDP growth, size, profitability, value, investment, volatility, momentum, and quality. Through meticulous data collection, preprocessing, and model development, we aim to ensure the robustness and effectiveness of the model. The project includes factor validation and portfolio construction, providing valuable insights and practical strategies for investors navigating the dynamic Thai stock market landscape.

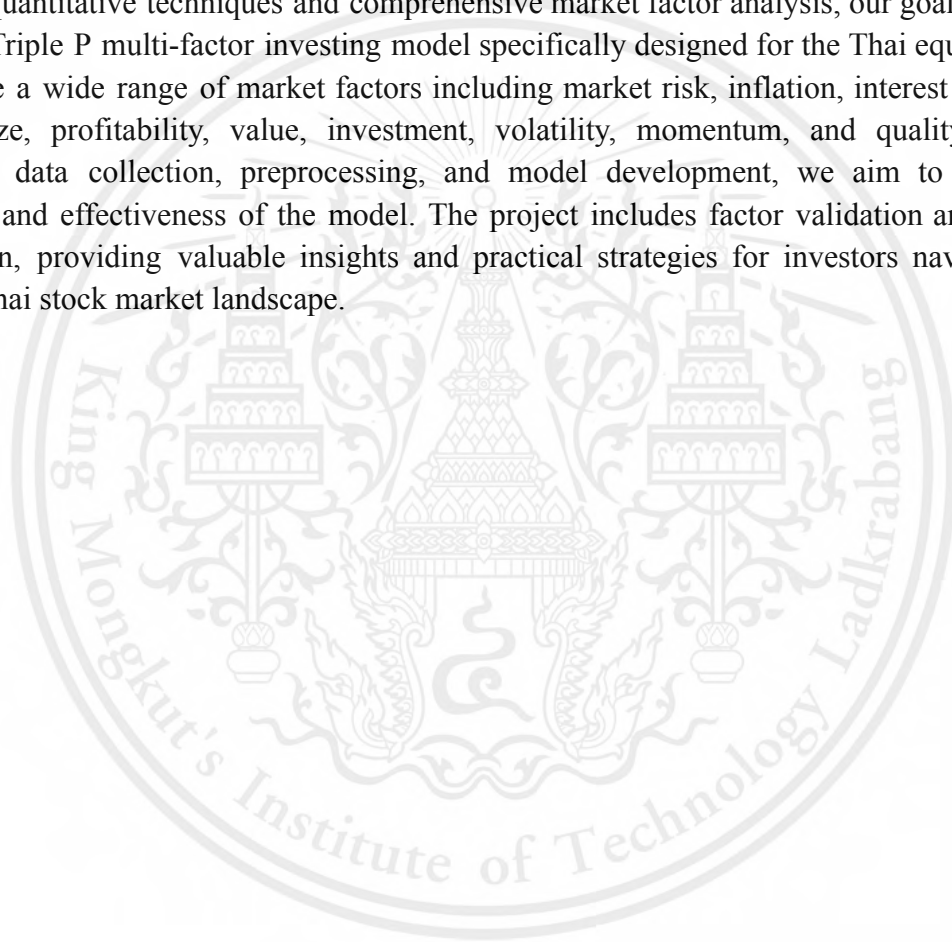


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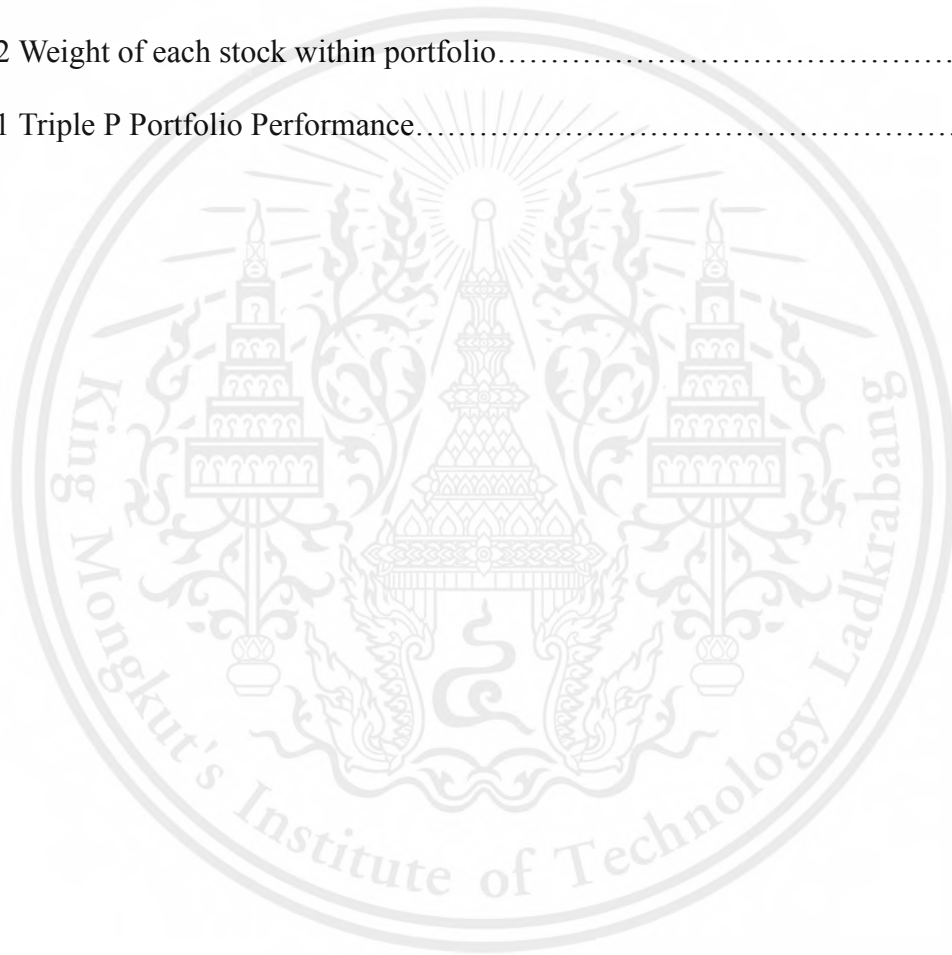
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Chapter 1

Introduction

1.1 Motivation

The motivation behind this study lies in the intricate nature of the Thai stock market, characterized by constant fluctuations and complexities that pose challenges for investors in making informed decisions. With numerous factors influencing stock prices and market conditions perpetually evolving, investors often find it daunting to identify the most suitable stocks and construct well-balanced portfolios that manage risk effectively. Traditional investment approaches may fall short in capturing the dynamic nuances of the Thai market, thus necessitating the development of more sophisticated tools and strategies. Recognizing these challenges and the growing demand for improved investment frameworks, this research endeavors to address the gap in existing literature regarding multi-factor investing models tailored specifically to the Thai context. By adapting and extending the renowned Fama-French five-factor model while incorporating additional variables such as style and macroeconomic factors, the study aims to enhance the model's explanatory power for the Thai equity market. Ultimately, this research seeks to provide investors with a comprehensive decision-making tool that not only navigates the complexities of the Thai market but also contributes to its development and sophistication, facilitating more informed and strategic investment decisions.

1.2 Objectives

The study aims to comprehensively investigate multi-factor investing within the Thai equity market, focusing specifically on employing the Fama-French five factors. Key objectives include evaluating historical factor performance, analyzing factor sensitivity unique to the Thai market, and examining risk-return relationships within multi-factor portfolios constructed using the Triple P model. Additionally, the study seeks to conduct performance attribution to delineate factor contributions, explore the influence of economic variables on factor dynamics, and investigate sector-specific interactions. Furthermore, comparisons between Fama-French factors and alternative metrics will be made, with considerations given to policy implications. The research also entails assessing the effectiveness of factor rotation strategies, conducting

out-of-sample testing for predictive power, and tailoring findings to inform both investment strategies and policy making within the Thai market. Ultimately, the study aims to enhance portfolio diversification, mitigate risk, and potentially deliver improved risk-adjusted returns, thus studying the impact of multi-factor investing on the Thai Stock Market.

1.3 Scope of Work

The scope of this project can be listed as follows:

1. To Gather and preprocess the data employed in the model.
2. To Construct the most precise values for each candidate factor.
3. To Examine the correlation between each candidate factor and the set total return index.
4. To Develop the Triple P multi-factor investing model for Thai equity.
5. Efficiently select stocks based on the developed model.
6. To Maximize the risk-reward (information ratio) of the portfolio derived from the chosen stocks.

1.4 Thesis Structure

This thesis consists of five chapters which are arranged as follows:

- Chapter 1 Introduction - refers to the motivation, objectives, scope of work of this study of the multi-factor investing model for Thai's equity portfolio, and the structure of this thesis.
- Chapter 2 Literature Review – encompasses various aspects, notably the multi-factor investing model, alongside intriguing factors such as interest rate dynamics, momentum trends, and key financial ratios.
- Chapter 3 Research Methodology – explains the process used to conduct this research. The research methodology employed begins with data collection, followed by the validation of constructed factors, which are then consolidated into our model. Subsequently, this model is utilized to identify and select stocks for the construction of a portfolio characterized by a high risk-adjusted return.

- Chapter 4 Results and Discussion – shows and discusses the results obtained from the research including the efficacy of the factors identified, the ranking of stocks based on our model, and the overall performance of the constructed portfolio

- Chapter 5 Conclusion and Recommendations – conclude all aspects of the study, including the literature review, research methodology, and results, it suggests avenues for further exploration, such as investigating interactions between factors and refining methodologies for deeper insights.



Chapter 2

Literature Review

This chapter introduces various multi-factor investing models, such as the Arbitrage Pricing Theory, Carhart Model, and Fama-French Model, alongside related factors like Inflation, Volatility, and Momentum. Through this comprehensive review, we aim to delve into existing research on multi-factor models, emphasizing the importance of these diverse factors in investment analysis and decision-making processes. By exploring these topics, our objective is to enhance our comprehension of the intricacies involved in portfolio management and identify opportunities for further exploration and advancement in the field.

2.1 Financial Models

2.1.1 Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model (CAPM) describes the linear relationship between expected return and risk in securities, illustrating that the expected return on a security equals the risk-free return plus a risk premium based on the security's beta. This finance model specifically outlines the correlation between systematic risk, reflecting general investment, and expected return for assets, especially stocks.

$$E(R)_i = R_f + \beta_i (E(R)_m - R_f) \quad (1)$$

2.1.2 Arbitrage Pricing Theory (APT)

Arbitrage Pricing Theory (APT) is a multifactor model for pricing assets that posits the predictability of an asset's returns by establishing a linear relationship between the expected return of the asset and various macroeconomic variables indicative of systematic risk. This model proves valuable in the examination of portfolios through a lens of value investing, aiding in the identification of securities that might be momentarily undervalued. However, a notable constraint of APT lies in its failure to prescribe specific factors for individual stocks or assets.

Sensitivity to factors varies between stocks, necessitating investors' ability to perceive risk origins and sensitivities.

$$E(R)_i = R_f + \beta_n (E(I) - R_f) \quad (2)$$

2.1.3 Fama and French Three-Factor Model (1993)

The Fama-French Three-factor Model developed in 1993, it is an extension of the Capital Asset Pricing Model (CAPM) by adding size risk and value risk factors to the market risk factor in CAPM. The size effect is that stocks with a small market cap earn higher returns than stocks with a large market cap, and was found to exist in the 1963-1990 period. The value effect refers to the enhanced performance of stocks with a low price-to-book ratio in contrast to stocks with a high price-to-book ratio. The rationale behind the model is that high value and small-cap companies tend to regularly outperform the overall market.

$$R_{it} - R_{ft} = a_i + \beta_i (R_{mt} - R_{ft}) + siSMB_t + hiHML_t + e_t \quad (3)$$

2.1.4 Carhart Four-Factor Model (1997)

The Carhart Four-Factor Model expands on the Fama-French Three-Factor Model by incorporating momentum as an additional factor. This model aims to explain stock returns by considering four factors: market risk, size effect (SMB), value effect (HML), and momentum (UMD). The factors account for the outperformance of small-cap stocks, high book-to-market value stocks, and stocks with recent positive performance.

$$R_{it} - R_{ft} = a_i + \beta_i (R_{mt} - R_{ft}) + siSMB_t + hiHML_t + miUMD_t + e_t \quad (4)$$

2.1.5 Hou, Xue, and Zhang q-Factor Model (2015)

The q-factor Model developed in 2015 by Hou, Xue, and Zhang. This model has market risk factor, size factor, investment-to-asset factor, and a return on equity (ROE) factor.

$$R_t - R_{ft} = a + \beta(R_{mt} - R_{ft}) + m(ME_t) + i(I/A_t) + r(ROE_t) + e_t \quad (5)$$

2.1.6 Fama and French Five-Factor Model (2015)

The Fama-French Three-factor Model developed in 2015, designed to encompass size, value, profitability, and investment tendencies in typical stock returns outperforms Fama and French's (1993) three-factor model. The primary drawback of the five-factor model lies in its inability to account for the lower average returns observed in small stocks, which exhibit similar return patterns to highly invested yet less profitable firms. Notably, the model's effectiveness remains consistent irrespective of how its factors are defined. The introduction of profitability and investment factors renders the value factor in the Fama and French three-factor model unnecessary for explaining average returns in the examined sample.

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + siSMB_t + hiHML_t + riRMW_t + ciCMA_t + e_t \quad (6)$$

2.2 Financial Factors

2.2.1 Market Risk Premium

Market risk premium is one of the factors from the Fama and French Five-Factor Model. It is the difference between the expected return of the market and the risk-free rate. It provides an investor with an extra return as recompense for the added volatility of returns beyond the risk-free rate. This factor can be computed as the expected return of the market minus the risk-free interest rate.

2.2.2 Real Interest Rate

Real Interest Rates play a crucial role in the Fama-French five-factor model by affecting discount rates, borrowing costs, and investment decisions. The impact is not uniform across factors, and the relationships can be influenced by broader economic conditions. It's important to consider the interplay of real interest rates with each factor and their implications for investment strategies in different market environments.

2.2.3 Headline Inflation Rate

High or unexpected inflation can impact the real returns of assets and may influence investor preferences for certain types of stocks. Inflation can impact the HML (High-book-value Minus Low-book-value) factor, which represents the historical excess returns of value stocks compared to growth stocks. In periods of high inflation, investors may favor value stocks with lower valuations because their future cash flows are less affected by inflation compared to growth stocks.

2.2.4 Market Capitalization (Size)

Market capitalization (market cap) is a measure of the total value of a company's outstanding shares of stock. It's calculated by multiplying the current stock price by the total number of outstanding shares. Market cap is widely used in finance as a metric to determine the size of a company. Market cap often correlates with the size of a company. Larger companies tend to have more influence on market indices because they represent a larger portion of the overall market. Therefore, changes in the market cap of these companies can have a significant impact on index returns.

2.2.5 Operating Profit (Profitability)

Operating profit represents a gauge of a company's profitability derived solely from its core operations, excluding non-operating expenditures like interest and taxes. This metric essentially reflects the efficiency and efficacy of a company's business model. Variations in operating profit can signify alterations in a company's competitive edge and profitability, consequently influencing investor confidence and market performance. Moreover, operating profit can function as an economic barometer, mirroring broader economic circumstances. Robust operating profits across various companies may indicate a robust economy, whereas dwindling operating profits could hint at economic downturns. Fluctuations in operating profit levels have the potential to alter investor expectations and market sentiment, thereby impacting index returns.

2.2.6 Capital Expenditure (Investment)

Capital expenditure represents the funds a company invests in acquiring or maintaining physical assets like property and equipment. High Capex levels suggest growth initiatives or technology upgrades. Changes in Capex can influence earnings and growth prospects, impacting investor sentiment and market returns. It also reflects efforts to enhance efficiency and competitiveness through technology and infrastructure investments. Analyzing

Capex's relationship with index returns offers insights into companies' investment decisions and their impact on financial performance and market trends.

2.2.7 Volatility

Volatility, measured as the standard deviation of returns, indicates the extent of price fluctuations in a stock over time. High volatility signifies larger price swings, impacting risk assessment and portfolio management decisions. In the Fama-French model, volatility affects factors like SMB and HML, reflecting historical returns of small-cap and value stocks. Understanding volatility helps optimize diversification and assess risk-adjusted performance.

2.2.8 Momentum

Momentum, or price momentum, shows assets' tendency to maintain past performance in the future. Momentum factors identify stocks with strong recent performance, influencing investment strategies. In the Fama-French model, momentum complements other factors, providing insights into return predictability and market dynamics. Momentum strategies capitalize on market inefficiencies, enhancing portfolio returns and managing risk effectively.

2.2.9 Return on Equity (ROE)

Return On Equity (ROE) is a crucial metric within the SET100 Index, representing the top 100 companies on the Thailand Stock Exchange. It serves as a key indicator of a company's profitability and efficiency in generating returns for shareholders. High ROE levels have been consistently associated with superior stock market performance. Within the SET100, ROE is paramount for evaluating constituent companies' financial health, management effectiveness, and growth potential. As such, it plays a vital role in investment decision-making and portfolio construction strategies. ROE formula shown as below:

$$\text{ROE} = \frac{\text{Net Income}}{\text{Shareholder's Equity}}$$

2.2.10 Earnings Per Share Ratio(EPS)

EPS reflects a company's profitability per share, crucial for evaluating financial performance and growth potential. Research consistently highlights EPS as pivotal for stock prices and investor returns. In the SET100, EPS is crucial for selecting firms with strong earnings potential. It also gauges corporate profitability and management efficiency, guiding

investment decisions and portfolio strategies. Overall, EPS is a key metric shaping investment choices in the Thailand Stock Exchange. EPS formula shown as below:

$$\text{EPS} = \frac{\text{Net Income} - \text{Preferred Dividends}}{\text{Weighted Average Shares Outstanding}}$$

2.2.11 Debt-to-Equity Ratio (D/E)

Debt-to-Equity Ratio (D/E) offers insights into companies' capital structure and financial leverage, aiding in risk assessment. Literature highlights the need for a balanced D/E ratio to ensure sustainable growth and mitigate financial risks. Within the SET100, D/E is vital for selecting firms with sound financial health. It serves as an indicator of a company's ability to meet debt obligations and generate shareholder returns. Overall, the D/E ratio plays a pivotal role in guiding investment decisions and portfolio strategies in the Thailand Stock Exchange. Assesses financial leverage by comparing total debt to shareholders' equity; lower ratio is generally less risky. D/E formula shown as below:

$$\text{D/E} = \frac{\text{Total Debt}}{\text{Total Shareholders Equity}}$$

2.3 Related Studies

2.3.1 The Efficiency Comparison among the Capital Asset Pricing Model, Three-Factor, and Five-Factor Asset Pricing Models with Case Study: Thailand by Miss Mesinee Kruealao (2017)

The research investigates and compares the key factors influencing the excess rate of return on the Stock Exchange of Thailand, employing the Capital Asset Pricing Model (CAPM) alongside the three and five-factor Fama-French Models. The study covers 175 stocks from December 2000 to December 2017, with continuous pricing data and no suspensions.

Evaluating the ability to describe variations in excess returns using Adjusted R² and security characteristics, including business size, book-to-market ratio, investment capability, and investment policy, the research finds that the five-factor model performs best, explaining 55% of the excess return variation and performing well for medium and small-sized stocks with

moderate book-to-market ratios and investment plans. The three-factor model ranks second, explaining 48% of excess return variation, particularly fitting large-sized stocks with large book-to-market ratios and moderate investment plans. The CAPM model has the least predictive power, explaining 38% of the excess return variation for large-sized stocks with low book-to-market ratios and moderate investment plans.

Additionally, the study identifies characteristics associated with the highest rate of return on the Stock Exchange of Thailand, highlighting that medium-cap stocks with large BE/ME or small-cap stocks with large BE/ME tend to provide the highest returns, while low returns are associated with stocks with low BE/ME ratios.

This research indicates that the Fama and French Five-Factor Model indicates superior performance, prompting our group to take a deeper exploration of this five-factor model.

2.3.2 The Story of Factor-Based Investing by Sunjiv Mainie, CFA, CQF Senior Director and Head of Research & Design (EMEA), (2015)

This study illuminates the evolution of portfolio construction, shifting from traditional market-cap weighted index funds to the nuanced approach of factor-based investing. Positioned between passive and active strategies, factor-based investing allows for targeted risk exposure while maintaining transparency and cost-effectiveness. Rooted in the Capital Asset Pricing Model (CAPM) and its multifactor extensions, this approach enables investors to systematically address specific risk factors beyond market beta.

Moreover, the paper delves into the economic intuition behind factor performance, emphasizing the role of risk premiums as compensation for bearing systematic risks. The discussion extends to pricing anomalies such as value, momentum, and quality, providing valuable insights into excess returns within the equity domain. The economic rationale behind factors is underscored, emphasizing the importance of testing strategies over various business cycles and economic regimes for robust portfolio construction.

As we embark on our study, these insights inform our consideration of factors, helping us understand their performance over time and under different conditions. The transparent and systematic nature of factor-based strategies, coupled with their relatively low costs, positions them as a compelling avenue for practitioners. Drawing from these learnings, we aim to tailor our model by incorporating factors that align with the economic rationale and have demonstrated historical relevance, ultimately contributing to the depth and sophistication of our factor-based investing framework.

2.3.3 Index Performance in Changing Economic Environment 18 by Gupta, Kassam, Suryanarayanan, and Varga (2014)

In the survey of related studies, Gupta's research on "Index Performance in Changing Economic Environment" (2014) stands out as a significant contribution. The study investigates the dynamic relationship between financial indices and changing economic conditions. Utilizing a quantitative methodology, Gupta assesses various indices, considering factors such as interest rates, inflation, and economic growth.

The research contributes to the literature by providing insights into the performance of indices under diverse economic scenarios. Gupta's findings offer valuable implications for investors, potentially guiding portfolio adjustments and risk management strategies. The study's selection of diverse indices and use of relevant performance metrics enhance its applicability to different asset classes.

While acknowledging potential limitations, Gupta's work opens avenues for future research, encouraging a deeper exploration of the intricate connections between economic variables and index performance. Overall, this study enriches the understanding of how financial indices respond to the ever-changing economic environment, contributing to the ongoing discourse in the field of financial markets and economic dynamics.

Chapter 3

Research Methodology

In this chapter, we provide relevant background knowledge to enhance the understanding of the project, segmented into six processes: data gathering, constructing variables, validating factors, summarizing the model, selecting stocks, and constructing the portfolio. Our aim is to build a Thai equity portfolio utilizing our developed model, with the objective of optimizing the risk-reward ratio, also referred to as the information ratio. This goal can be realized by adhering to the outlined steps below.

3.1 Data Collection

Data Sources:

We obtained financial data from reputable sources including Bloomberg, CEIC, and Datastream, ensuring access to comprehensive and accurate information on Thai equity stocks.

Timeframe:

Quarterly Data: The data collection spans from the fourth quarter of 2013 (2013Q4) to the third quarter of 2023 (2023Q3), providing a robust dataset for model development and analysis.

Data Selection:

Focus on SET100 Stocks: Our focus is on stocks listed in the SET100 index, ensuring representation of a diversified portfolio of Thai equities.

Minimum 5-Year Data History: Stocks with a minimum data history of 5 years, spanning from 2013Q4 to 2018Q3, are included in the modeling universe.

Exclusion Criteria: Stocks with less than a 5-year data record are excluded from the modeling universe to maintain consistency and reliability in data analysis.

Handling Initial N/A Values:

Identification: Stocks with no values at the beginning of the dataset are recognized as having initial N/A values.

Retention: These instances are retained as N/A values for the initial period, ensuring transparency and accuracy in data representation.

Missing Value Handling:

Identification: Missing values in the dataset are identified through systematic data inspection and validation procedures.

Treatment: The forward-fill (f-fill) method is employed to fill missing values in the dataset, ensuring continuity and completeness of data records.

3.2 Variable Construction

Dependent Variable:

The dependent variable in our model is the percentage change of the SET100 Total Return Index (Gross Dividend). This variable serves as a comprehensive measure of overall market performance, capturing both capital appreciation and dividend income for investors in the SET100 index.

Independent Variables:

The independent variables comprise the percentage change weighted average of candidate factors, representing key determinants influencing the performance of the SET100 Total Return Index. These factors are carefully selected based on their theoretical relevance and empirical significance in driving market dynamics. There are Market Risk Premium, Real Interest Rate, Headline Inflation Rate, Current Mkt Cap, Operating Profit, Capital Expenditure, Volatility, Momentum, Return on Equity, Earnings per Share, Debt-to-Equity Ratio.

Weighted Average Factor Value Formula:

$$\text{Weighted Average} = \frac{\sum_{i=1}^n (X_i \times \text{MarketCap}_i)}{\sum_{i=1}^n \text{MarketCap}_i}$$

X_i = Value of the factor for observation i

MarketCap_i = Market capitalization of observation i

n = Total number of observations

3.3 Factor Validation

Factor Validation involves confirming the validity of “**candidate factors**”, including Market Risk, Real Interest Rate, Headline Inflation Rate, Real GDP Rate, Size, Value, Profitability, Investment, Volatility, Momentum, and Quality factors. This process aims to assess which factors successfully meet the specified criteria, will be “**qualified factors**” and qualify for use in the subsequent step. The assessment criteria are described below:

- 1. Test the significance (t-test) of each factor:** Utilize the EViews application to analyze the significance of individual factors. If the p-value is greater than 0.05, consider the factor as significant, indicating its potential importance.
- 2. Identify favorable factors:** Select the factors with p-values exceeding 0.05 as favorable for further investigation. These factors are deemed statistically significant and warrant inclusion in subsequent analyses.
- 3. Conduct stepwise testing:** Employ stepwise testing techniques to determine the appropriate lag for the favorable factors. This step ensures the optimal inclusion of lagged variables, enhancing the accuracy and reliability of the factor validation process.
- 4. Refine the model:** Use the results of stepwise testing to refine the factor model, incorporating the appropriate lags for the selected factors. This iterative process helps improve the model's predictive power and ensures its suitability for factor validation.
- 5. Validate the factors:** Validate the refined factor model using appropriate statistical techniques to assess its robustness and reliability. This final step confirms the validity of the selected factors and their contribution to the overall analysis.

3.4 Model Summarization

We can conclude our model into the "**Triple P Model**", utilizing the qualified factors identified in the factor validation process.

Triple P Model:

SET100 Total Return Index (Gross Dividend) = a + b_{ij} CapEx(-1) + c_{ij} Market Cap(-1) + f_{ij} D/E + g_{ij} EPS + h_{ij} Market Risk Premium(-3) + e_t

3.5 Stock Selection

Designing a stock selection process that incorporates the Triple P Model. Below is a step-by-step guide to help determine such a stock selection process:

1. Estimate beta coefficient of all the factors for all stocks in the stock universe using a regression analysis of the Ordinary Least Squares (OLS). [Appendix A1] [Appendix A2]
2. Forecast the next value of each factor using the Auto Regressive Model. [Appendix A3] [Appendix A4]
3. Calculate forecasted close price of each stocks using the estimated beta coefficient in step1 with the forecasted value of factors by plugging in these values in Triple P Model. [Appendix A5]
4. Calculate the expected return of each stock using the historical close price and forecasted close price from step 3. [Appendix A5]
5. Ranking the expected return from each stock in descending order.

Flow Chart

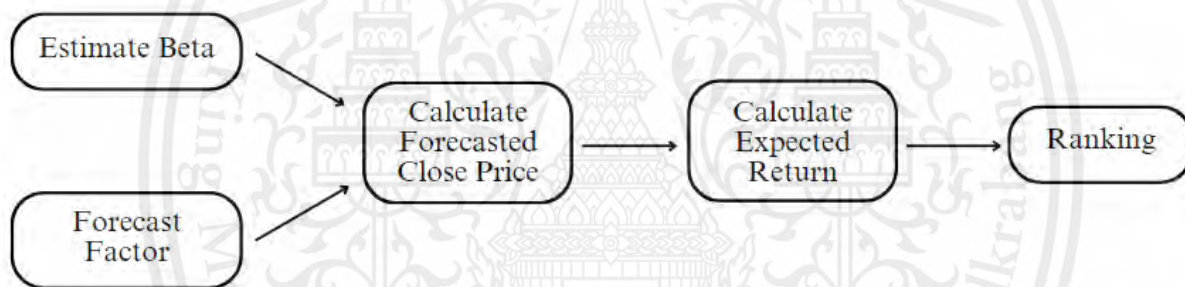


Figure 3.5.1 Stock Selection Process

We have adapted a selection of the top 30 stocks exhibiting the highest expected returns to comprise our portfolio. These stocks have been meticulously chosen based on their anticipated performance and potential contribution to achieving our investment objectives. By focusing on the highest-performing stocks, we aim to optimize the portfolio's overall return potential while carefully managing associated risks. This selection process ensures that our portfolio is well-positioned to capitalize on promising investment opportunities and deliver favorable outcomes for our investors.

3.6 Portfolio Construction

As we have acquired stocks through our stock selection process, our group strives for optimal portfolio performance. We are driven to construct a diversified investment portfolio that maximizes the risk-reward ratio or information ratio, ensuring the best possible returns for our investors. With a keen focus on risk management and meticulous research, our group aims to identify promising stocks that offer the potential for high returns while mitigating downside risks. By adhering to constraints such as maintaining a portfolio size of 1 Billion Baht, limiting individual stock weights from 1% to 10% of the Net Asset Value (NAV), and ensuring investments are below 1/3 of trading volume, we are committed to creating a robust portfolio that optimizes returns and safeguards against undue concentration risk. To construct a portfolio consisting of 28 stocks we can show as steps below:

1. Select 28 stocks for inclusion in the portfolio.
2. Create an Excel spreadsheet to organize the portfolio data. Using a historical 10-year return data of 28 stocks. *[Appendix B1]*
3. Utilize Excel Solver to determine the weight of each stock.
4. Set constraints to ensure that the weight of each stock equals 1% but does not exceed 10% of the total portfolio weight, and impose a constraint limiting each stock's weight to not exceed 1/3 of the trading volume. *[Appendix B2] [Appendix B3]*
5. Optimize the portfolio weight distribution using Solver to achieve the desired balance and diversification.
6. After obtaining the weights of each stock using Solver and combining them into a portfolio, we are attempting to find the tracking error, as shown below: *[Appendix B4]*

Tracking Error = Standard Deviation of (Our Portfolio - Benchmark)

7. Finally, after obtaining the tracking error, we proceed to maximize the information ratio of our portfolio using the formula shown below:

Information Ratio Formula = $(R_p - R_b) / \text{Tracking Error}$

R_p = Portfolio return

R_b = Benchmark return

Chapter 4

Results and Discussion

4.1 Qualified Factors

This is the result from the factor validation process in methodology.

Dependent Variable: SET100INDEX__GROSS_DVD_
 Method: Least Squares
 Date: 02/20/24 Time: 18:10
 Sample (adjusted): 4 40
 Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.024602	0.011195	2.197572	0.0361
CAPEX(-1)	0.119326	0.051157	2.332525	0.0268
CUR_MKT_CAP(-1)	-0.448849	0.125015	-3.590357	0.0012
D_E	-0.479526	0.123480	-3.883431	0.0005
EPS1	-0.025382	0.012297	-2.064019	0.0481
MKT_RISK_PREMIUM(-3)	0.008153	0.002735	2.981067	0.0058
OPERAING_PROFIT(-2)	0.026256	0.013476	1.948318	0.0611
REAL_INTEREST_RATE1	-0.026217	0.013925	-1.882826	0.0698
R-squared	0.584741	Mean dependent var		0.008919
Adjusted R-squared	0.484506	S.D. dependent var		0.088106
S.E. of regression	0.063258	Akaike info criterion		-2.494372
Sum squared resid	0.116047	Schwarz criterion		-2.146065
Log likelihood	54.14588	Hannan-Quinn criter.		-2.371577
F-statistic	5.833703	Durbin-Watson stat		2.052527
Prob(F-statistic)	0.000274			

Figure 4.1.1 Eview of qualified factors

This data suggests that there are five factors that exhibit statistical significance below the 95% confidence level (p-value less than 0.05). These factors include Capital Expenditure, Current Market Capitalization, Debt-to-Equity Ratio, Earnings-per-Share Ratio, and Market Risk Premium. Additionally, the model demonstrates an r-squared value of 0.58, indicating the proportion of the variance in the dependent variable that is predictable from the independent variables. However, upon considering a slightly lower confidence level of 93%, two more factors, Operating Profit and Real Interest Rate, also emerge as statistically significant. This underscores the sensitivity of the analysis to different confidence thresholds and highlights the

potential impact of including additional variables in the model. With a high R-squared value of 0.589741, the model effectively explains nearly 59% of the variance in the dependent variable, underscoring its predictive power. Moreover, the overall model significance, reflected by the F-statistic's low p-value of 0.000274, confirms the model's robustness and suitability for guiding investment strategies. These findings offer valuable opportunities for investors to capitalize on these significant factors and potentially optimize returns.

Dependent Variable: SET100INDEX_GROSS_DVD_
Method: Least Squares
Date: 04/03/24 Time: 13:14
Sample (adjusted): 2014Q3 2023Q3
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.021032	0.011997	1.753062	0.0895
CAPEX(-1)	0.110136	0.053497	2.058729	0.0480
CUR_MKT_CAP(-1)	-0.429953	0.134909	-3.186994	0.0033
D_E	-0.513233	0.132778	-3.865348	0.0005
EPS1	-0.017432	0.012801	-1.361744	0.1831
MKT_RISK_PREMIUM(...)	0.006636	0.002873	2.309891	0.0277
R-squared	0.481380	Mean dependent var		0.008919
Adjusted R-squared	0.397732	S.D. dependent var		0.088106
S.E. of regression	0.068375	Akaike info criterion		-2.380211
Sum squared resid	0.144931	Schwarz criterion		-2.118981
Log likelihood	50.03391	Hannan-Quinn criter.		-2.288116
F-statistic	5.754808	Durbin-Watson stat		2.112478
Prob(F-statistic)	0.000721			

Figure 4.1.2 Eview for selected factors

With a respectable R-squared value of 0.481380, the model effectively explains nearly 48% of the variance in the dependent variable, highlighting its predictive capability. Moreover, the overall model significance, evident through the F-statistic's low p-value of 0.000721, underscores the model's reliability for guiding investment decisions. These findings present promising opportunities for investors to leverage these significant factors and potentially enhance returns.

The regression analysis results demonstrate a promising relationship between several factors and the "SET100INDEX_GROSS_DVD_," indicating significant potential for informed investment decisions. Notably, variables such as "CAPEX(-1)," "CUR_MKT_CAP(-1)," "D_E," and "MKT_RISK_PREMIUM(-3)" exhibit statistically significant effects on the index, suggesting they play influential roles in predicting its performance with SET100 Index with gross dividends.

4.2 Stock Ranking

This is the result from ranking the expected return of each stock from the stock selection process in methodology in descending order.

rank	return	stock name	rank	return	stock name	rank	return	stock name
1	310.13%	EA	31	8.35%	SAWAD	61	-0.78%	CPN
2	129.69%	TQM	32	8.18%	SCB	62	-0.79%	MEGA
3	77.20%	VGI	33	7.95%	KTC	63	-0.88%	BCH
4	63.87%	BANPU	34	7.89%	CK	64	-1.04%	KKP
5	59.99%	THANI	35	7.52%	KBANK	65	-1.26%	BDMS
6	54.57%	ACE	36	7.27%	STA	66	-1.54%	STGT
7	50.64%	BCPG	37	7.11%	SCC	67	-2.23%	FORTH
8	34.18%	STEC	38	6.21%	SIRI	68	-2.71%	INTUCH
9	30.23%	TRUE	39	5.95%	BTS	69	-2.92%	ORI
10	27.52%	MTC	40	5.44%	BAM	70	-3.35%	BCP
11	26.27%	GPSC	41	5.30%	MINT	71	-3.97%	KCE
12	25.90%	BYD	42	5.16%	LH	72	-4.26%	CHG
13	25.86%	AWC	43	4.89%	JMART	73	-4.56%	KTB
14	22.28%	IRPC	44	4.41%	JMT	74	-5.93%	CENTEL
15	21.74%	NEX	45	4.26%	MBK	75	-7.36%	THG
16	20.25%	IVL	46	4.13%	CPALL	76	-7.61%	COM7
17	18.81%	BGRIM	47	3.22%	CBG	77	-7.86%	AAV
18	17.29%	SCGP	48	2.95%	BEM	78	-8.04%	GUNKUL
19	16.32%	RATCH	49	2.82%	SPALI	79	-8.16%	TCAP
20	16.01%	DELTA	50	2.75%	BBL	80	-9.64%	PLANB
21	15.67%	SJWD	51	2.71%	GULF	81	-9.83%	TTB
22	15.62%	RCL	52	2.48%	CRC	82	-10.04%	PTTEP
23	15.55%	OSP	53	2.41%	BH	83	-10.28%	ADVANC
24	14.39%	CPF	54	2.34%	DOHOME	84	-10.30%	HANA
25	13.59%	CKP	55	1.53%	HMPRO	85	-10.31%	AMATA
26	13.17%	SRPC	56	1.36%	TOP	86	-11.03%	GLOBAL
27	12.38%	TASCO	57	1.28%	ERW	87	-11.92%	AP
28	10.59%	EGCO	58	1.01%	PTT	88	-12.60%	WHA
29	8.96%	PSL	59	0.00%	TISCO	89	-14.72%	PTG
30	8.66%	TU	60	-0.70%	AOT			

Table 4.2.1 Estimated Return of each stock

Upon calculating the expected return for each stock, we identified over 7 stocks exhibiting expected returns exceeding 50%, with one particularly notable stock boasting an exceptionally high return of 310%. This anomaly can be attributed to the fact that many of these high-return stocks have All-Time-High (ATH) values significantly greater than their most recent values. For instance, take the case of EA, whose ATH stands at 97 THB, contrasting starkly with its Q3 2023 value of just 12 THB. It's evident that such substantial differences between ATH and

current values can greatly influence projected returns. Moreover, our analysis indicates that out of the total of 58 stocks assessed, the majority are expected to yield positive returns in the upcoming quarter, underscoring the overall optimistic outlook for our portfolio.

4.3 Triple P Portfolio

STOCK NAME	ANNUAL RETURN	STOCK NAME	ANNUAL RETURN
EA	20.293%	NEX	29.875%
SCB	-1.551%	IVL	7.733%
VGI	1.010%	BGRIM	9.739%
BANPU	-2.155%	SCGP	1.487%
KTC	35.360%	RATCH	-4.258%
TU	1.236%	DELTA	59.292%
STA	15.904%	SJWD	19.021%
STEC	0.630%	RCL	32.732%
TRUE	-0.529%	OSP	2.842%
SCC	-2.110%	CPF	-1.604%
GPSC	14.680%	CKP	9.916%
BYD	59.357%	SRPC	10.309%
AWC	-3.138%	TASCO	25.396%
IRPC	0.692%	EGCO	0.027%

Table 4.3.1 Historical Return of 28 Stocks

After conducting a thorough stock ranking process based on projected returns, our group chose 28 stocks ranging from rank number 1 to 30. However, it was observed that several of these selections lacked sufficient information to align with our predetermined constraints. Consequently, we augmented our portfolio by incorporating an additional 5 to 6 stocks. Notably, the annual return assessed pertains to a comprehensive 10-year historical performance analysis. Subsequent to the acquisition of the initial 28 stocks, our group proceeded to implement a portfolio weighting strategy to align with predetermined criteria.

Specifically, we elected to allocate weights to each stock, ensuring that they adhered to the stipulated criterion of 1% of the net asset value (NAV), with an upper limit set at 10%. This categorization enabled us to establish a structured approach to portfolio management, as outlined below:

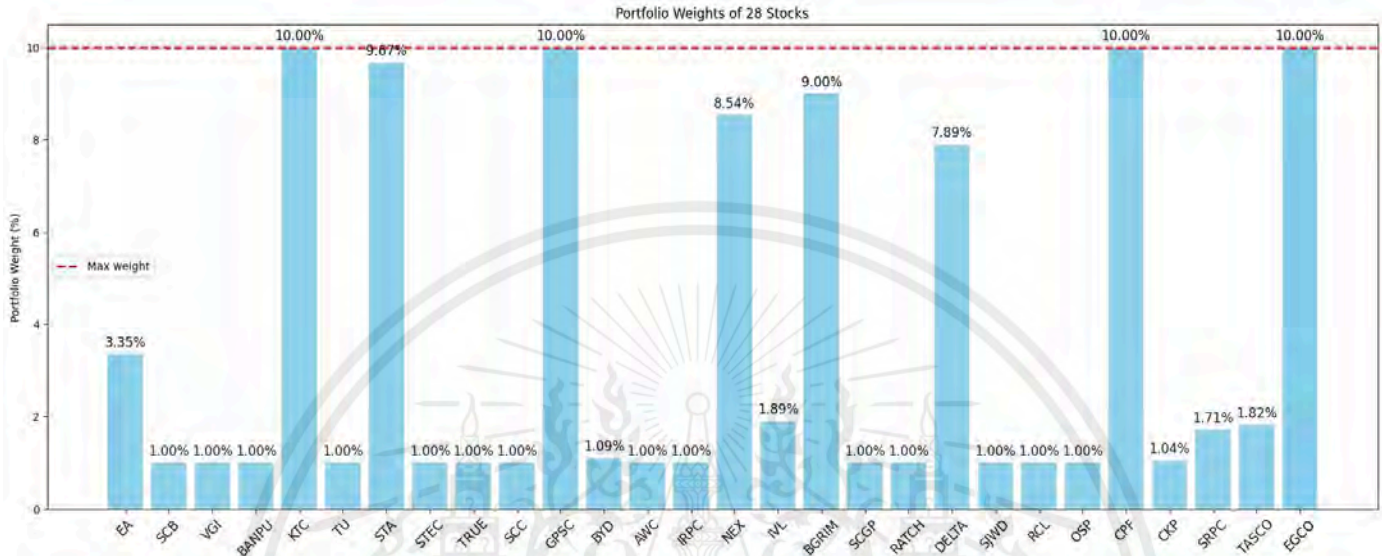


Figure 4.3.2 Weight of each stock within portfolio

The image illustrates the portfolio weights of 28 stocks, with each bar representing the percentage allocation of a particular stock within the portfolio. The horizontal axis lists the individual stocks, while the vertical axis represents the portfolio weight in percentage. The red dashed line across the graph indicates the maximum weight allowed for each stock, set at 10% of the net asset value (NAV) of the portfolio. This upper limit ensures diversification and risk management within the portfolio.

Observing the bars, it is evident that most stocks adhere to the prescribed maximum weight constraint, with percentages predominantly clustered around the 1% mark. However, a few stocks, such as "KTC", "STA", "GPSC", "NEX", "BGRIM", "DELTA", "CPF" and "EGCO" appear to slightly exceed the 5% threshold, although remaining below or equal the 10% cap. Overall, the distribution of portfolio weights demonstrates a balanced approach to asset allocation, with due consideration given to both diversification and maximizing information ratio.

4.4 Triple P Portfolio's Performance



Figure 4.4.1 Triple P Portfolio Performance

The image illustrates the cumulative return performance of the Triple P portfolio compared to the market return over time. The blue line represents the cumulative return of the portfolio, while the orange line depicts the market return.

From the graph, it is discernible that the portfolio's performance generally tracks alongside the market return despite experiencing fluctuations, particularly evident during Q1 2020, coinciding with the onset of the COVID-19 pandemic. Both the market and our portfolio encountered a downturn. However, by Q3 2020, a notable recovery was observed for both the market and our portfolio.

In the initial period, both the portfolio and the market return exhibit a gradual increase. However, around the midpoint, there is a noticeable divergence between the two lines, with the portfolio experiencing a more pronounced upward trajectory compared to the market return. This suggests that the portfolio outperformed the market during this period.

Towards the latter part of the timeline, particularly in the most recent quarters, both the portfolio and the market return display a significant uptick. However, it's worth noting that the portfolio's performance appears to fluctuate more prominently compared to the relatively stable trend of the market return.

To conclude, our portfolio has a performance such as a return to portfolio which is 17.16%, with a standard deviation of 24.19%, Sharpe ratio of 0.622, and information ratio of 1.034.

Chapter 5

Conclusion and Recommendations

5.1 Conclusion

In conclusion, this project has successfully developed a sophisticated multi-factor investing model tailored specifically for the Thai equity market. Through meticulous data collection, preprocessing, and model development, we have constructed the Triple P model, integrating a comprehensive set of factors including market risk, interest rates, inflation, GDP growth, size, profitability, value, investment, volatility, momentum, and quality. Our analysis has unveiled significant relationships between these factors and the performance of the SET100 Total Return Index (Gross Dividend), offering valuable insights into the dynamics of the Thai equity market.

The regression analysis results have highlighted a promising relationship between several factors and the SET100 Total Return Index (Gross Dividend), indicating significant potential for informed investment decisions. Notably, variables such as "CAPEX(-1)," "CUR_MKT_CAP(-1)," "D_E," and "MKT_RISK_PREMIUM(-3)" exhibit statistically significant effects on the index, suggesting their influential roles in predicting its performance with gross dividends.

Constructing the Triple P portfolio based on the model's recommendations has yielded promising performance. Comprising 28 carefully selected stocks, the portfolio has delivered a return of 17.16%, with a standard deviation of 24.19%. Additionally, the Sharpe Ratio stands at 0.622, indicating a favorable risk-adjusted return, while the Information Ratio reaches 1.034, underscoring the model's ability to generate excess returns relative to a benchmark. Despite encountering fluctuations, including during periods of market volatility such as the onset of the COVID-19 pandemic, the portfolio has demonstrated resilience and, at times, outperformed the market return. This reinforces the efficacy of our multi-factor approach in navigating diverse market conditions and maximizing portfolio performance.

5.2 Limitations

While this study has made significant strides in developing a robust multi-factor investing model for the Thai equity market, it is essential to acknowledge certain limitations:

Absence of Portfolio Back-Testing: Due to data constraints and time limitations, we were unable to conduct comprehensive back-testing of the Triple P portfolio, which could provide valuable insights into its historical performance under different market conditions.

Insufficient Time for Rebalancing: The limited timeframe of the project posed challenges in terms of regular portfolio rebalancing, which is essential for maintaining optimal asset allocation and risk management.

5.3 Recommendations

Based on our findings and the insights gleaned from this study, we offer the following recommendations:

Prioritize Data Acquisition for Back-Testing: Given the absence of portfolio back-testing due to insufficient data and time constraints, we recommend prioritizing efforts to acquire comprehensive historical data. Back-testing the portfolio against historical market data will provide valuable insights into its performance under various market conditions, allowing for the refinement and optimization of investment strategies.

Implement Forward-Testing Procedures: In addition to back-testing, implement forward-testing procedures to validate the robustness and effectiveness of the Triple P model in real-time market conditions. Forward-testing involves applying the model to current market data and tracking its performance over time. This will provide valuable insights into the model's predictive power and its ability to adapt to evolving market dynamics.

Regular Monitoring and Adjustment: Establish a systematic process for regularly monitoring the performance of the portfolio and making necessary adjustments based on market conditions and model outcomes. Continuous monitoring will enable timely identification of emerging trends and risks, allowing for proactive portfolio management and risk mitigation.

Further Research and Development: Continuous research and development efforts should be undertaken to refine the Triple P model, incorporating additional factors, refining methodologies, and exploring innovative approaches to factor analysis and portfolio construction.

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Appendix A



Appendix A1 Python Code for Beta Estimation

```
import pandas as pd
import numpy as np
import statsmodels.api as sm
from google.colab import files
uploaded = files.upload()

dfs_dict = pd.read_excel('/content/KWIAM Stocks Selection.xlsx',
sheet_name=None)
results_dict = {}
coefficients_df = pd.DataFrame()
# dfs_dict.items()
number_of_stock = 0
dfs_dict.keys()

#sheetname = key, df = value
for sheet_name, df in dfs_dict.items():
    dependent_variable = df.columns[1]
    # print(dependent_variable)
    # print(y)
    df['CapEx(-1)'] = df['CapEx(-1)'].shift(1)
    df['Cur Mkt Cap(-1)'] = df['Cur Mkt Cap(-1)'].shift(1)
    df['Mkt risk premium(-3)'] = df['Mkt risk premium(-3)'].shift(3)\

    df = df.dropna()

    y = df[dependent_variable]
    X = sm.add_constant(df[['CapEx(-1)', 'Cur Mkt Cap(-1)', 'D/E', 'EPS',
'Mkt risk premium(-3)']])

    model = sm.OLS(y, X).fit()
    results_dict[sheet_name] = model.summary()

    coefficients = model.params
    # print(coefficients)
    coefficients_df[sheet_name] = coefficients

# print(model.summary())

# print(sheet_name)
# print(df)
number_of_stock += 1
```

```
for sheet_name, result_summary in results_dict.items():
    print(f"Results for sheet '{sheet_name}':")
    print(result_summary)
    print()
    print()

coefficients_df = coefficients_df.T.reset_index()
coefficients_df.columns = ['Stock Name'] +
list(coefficients_df.columns[1:])
coefficients_df

coefficients_df.to_excel('Coefficient.xlsx', index=False)
files.download('Coefficient.xlsx')
```



Appendix A2 Result of Beta Estimation of each stock

Stock Name	Constant	CapEx	Current Mkt Cap*	D/E	EPS	Mkt Risk Premium
DELTA	-1.4733	-0.0046	0.6883	-2.1753	37.7262	-59.6290
PTT	18.4653	0.0000	0.2255	-0.1255	4.2007	-10.2360
AOT	6.9049	0.0006	0.6520	-0.0086	-2.3754	-3.1129
ADVANC	210.3217	0.0007	1.0531	-0.2270	-11.3455	17.3081
PTTEP	21.7814	-0.0010	1.6599	-0.0717	3.6204	-2.5498
GULF	7.7692	0.0005	0.6850	0.0074	12.5123	-1.3761
CPALL	22.6778	-0.0005	0.7296	-0.0144	0.8154	6.2465
BDMS	7.2671	-0.0001	0.4671	-0.0278	0.4122	-0.8984
SCC	18.3828	0.0004	6.7007	0.3463	4.6966	-68.1204
SCB	-1.7239	-0.0060	1.9541	0.4465	3.1535	25.5877
KBANK	-1.4088	-0.0033	3.4014	0.1054	5.3652	-4.0158
CPN	9.2562	0.0004	1.9019	-0.0033	1.2267	5.0474
BBL	10.2351	-0.0056	4.0910	0.0220	4.9009	-22.6516
KTB	-0.1748	0.0016	0.4988	0.0311	4.6679	-2.2152
CRC	-12.5539	-0.0061	0.6883	0.1403	2.0235	5.7650
INTUCH	21.7050	-0.0025	2.2334	-0.1301	-2.0301	-2.2459
TRUE	72.8952	0.0009	0.6883	-0.2724	4.9395	24.7009
BH	24.0359	-0.0005	9.2718	0.1629	22.7041	20.9790
EA	20.4311	-0.0006	2.2879	-0.0721	-4.3330	14.3272
HMPRO	7.2257	0.0006	0.5307	-0.0525	16.6420	-0.0667
SCGP	40.2910	0.0120	1.6856	-0.2323	8.8213	4.0812
CPF	21.1602	0.0005	0.4897	-0.0223	2.7473	4.0824
TTB	0.8258	0.0002	-0.0234	0.0079	11.5473	-0.0937
MINT	16.3074	-0.0003	1.3639	-0.0291	-1.0615	-4.3908
IVL	20.6560	-0.0006	1.0767	-0.0802	2.2195	-0.3962
GPSC	27.6046	0.0037	2.0355	0.0454	3.5248	10.7594
KTC	19.3311	-0.0548	2.8550	-0.0344	-0.1855	-14.5447
AWC	5.4761	-0.0002	-0.0289	-0.0136	22.7766	1.1283
TOP	42.7504	-0.0010	2.8016	-0.2588	1.9682	2.8495
BTS	4.2219	0.0007	0.4990	-0.0051	0.2181	-0.9668
MTC	12.1497	0.0483	2.5938	-0.0228	42.2105	10.8618
LH	6.0378	0.0001	0.4040	-0.0165	3.3181	-0.1221
GLOBAL	2.5545	0.0020	1.1422	0.0352	21.1657	2.2326
TISCO	-1.6903	-0.0022	4.1859	-0.0293	29.8116	-4.4059
CBG	19.7416	-0.0005	7.0241	-0.2713	37.5871	0.1275
WHA	1.5583	0.0000	0.4123	-0.0003	-0.3066	-0.0470
TU	7.2811	0.0021	1.3242	0.0068	3.4217	4.2202

BGRIM	27.0352	-0.0006	2.2001	-0.0580	3.1135	-9.1694
RATCH	21.6454	-0.0008	4.7192	-0.2436	3.0068	-8.2179
BANPU	28.8277	0.0002	-0.2070	-0.0917	1.0575	8.0163
KCE	5.3359	0.0027	5.7182	-0.1017	31.7792	2.7129
EGCO	1.5199	0.0003	16.8818	0.1669	1.0460	-44.0481
OSP	14.7581	0.0000	1.8110	-0.1622	9.2001	-4.7873
BCP	22.9543	0.0002	3.7538	-0.0890	1.0112	-1.2771
SAWAD	26.4441	0.0141	2.7592	-0.0638	20.3323	5.9982
CENTEL	7.2253	0.0036	5.8739	0.0212	2.5581	-3.5256
COM7	2.0884	0.0040	2.0821	-0.0274	58.6760	10.6042
BCH	5.0592	0.0017	3.0856	-0.0167	1.7263	-5.2870
THG	10.6862	0.0054	9.2767	-0.0344	17.6193	-18.0328
TCAP	15.4730	-0.0046	7.9853	-0.0609	-3.3585	-2.1449
HANA	8.2708	-0.0105	7.6650	-0.2029	5.5991	25.8014
JMT	13.0749	0.1124	4.8863	-0.0579	38.2942	7.5110
KKP	11.9326	0.0003	9.1671	-0.0373	4.0637	-4.2153
IRPC	0.1860	-0.0001	0.4225	0.0007	2.1745	-1.3350
DOHOME	2.3327	-0.0023	1.8707	-0.0087	40.5523	-2.7296
PLANB	4.2088	-0.0011	0.5033	0.0072	19.6237	1.4200
CK	3.1597	0.0004	3.9632	0.0172	5.4447	0.6961
SPALI	5.4338	0.0035	2.5550	0.0768	0.9956	0.1838
MEGA	6.8611	-0.0103	8.2214	-0.1273	9.7487	4.9178
SRPC	4.4353	0.0006	1.5052	-0.0434	1.4793	-0.3895
AP	4.2845	-0.0023	1.9203	-0.0248	3.2503	-0.9735
CHG	0.5142	0.0002	0.7331	0.0002	2.3244	-0.4156
MBK	3.3851	0.0002	3.9694	0.0064	4.2527	1.0309
AMATA	5.2949	-0.0005	6.4372	-0.0118	1.4003	-1.8069
JMART	0.7384	0.0000	5.6680	0.0118	23.2585	16.7552
SIRI	0.0989	0.0001	0.5385	0.0009	2.5950	-0.4632
BAM	-10.4852	-0.0383	2.8766	0.0466	7.9571	0.2437
CKP	-0.6242	0.0011	0.7690	0.0270	2.6131	0.8091
SJWD	3.6881	-0.0046	4.4435	0.0063	10.1974	-0.5445
BCPG	5.1784	0.0009	1.9308	0.0138	8.6572	-0.7006
TASCO	9.5149	-0.0034	2.7036	-0.0395	5.8607	1.2448
AAV	1.6915	0.0000	1.2789	-0.0043	-0.7224	0.0097
BYD	2.1164	-0.0294	1.5476	-0.0258	7.3608	1.8802
ERW	0.7804	-0.0002	1.8143	0.0008	1.9533	-0.4870
GUNKUL	9.9125	-0.0002	1.4910	-0.0010	6.3780	18.4606
STA	2.3359	-0.0002	0.4927	-0.0026	0.5969	2.4103
ORI	0.0848	0.0023	2.8131	0.0114	5.2692	1.7228
VGI	1.3541	-0.0011	0.7364	0.0102	23.3687	-0.2189
NEX	3.2697	0.0026	4.7108	-0.0475	-9.2870	9.1279
FORTH	1.2747	0.0082	10.5486	-0.0111	17.8417	2.5005
STGT	19.3206	0.5379	2.4304	0.5970	4.4716	-13.3179

TQM	22.6355	-0.0022	11.5599	-1.8001	1.4044	-17.5359
RCL	14.9771	0.0010	7.7716	-0.1913	0.7882	-12.3459
PTG	1.0380	0.0212	0.2668	-0.0012	34.7172	1.0675
THANI	10.1874	-0.0051	-2.1674	0.0099	20.2922	13.6891
ACE	-4.1845	0.0012	0.4425	0.1503	33.1235	0.5855
PSL	4.8404	-0.0011	3.4397	-0.0030	3.6378	-3.9211
STEC	3.6633	0.0009	5.3804	-0.0980	1.5235	-3.1907

Current Market Capitalization* unit in ten thousand



Appendix A3 Python Code for Factor Forecasting

```
import pip
pip.main(["install", "openpyxl"])
pip.main(["install", "statsmodels"])
from datetime import date, time
import pandas as pd
import numpy as np
from statsmodels.tsa.ar_model import AutoReg
excel_file = 'KWIAM Stocks Selection.xlsx'
sheet_names = pd.ExcelFile(excel_file).sheet_names

# Start from the second sheet and get the sheet names
sheet_names_list = sheet_names[1:]

# Initialize an empty list to store DataFrames for each sheet
predicted_values_list = []

# Define the lag for the autoregressive model
lag = 1

# Iterate over each sheet
for sheet_name in sheet_names_list:
    # Read the DataFrame for the sheet
    df = pd.read_excel(excel_file, sheet_name=sheet_name)

    # Drop missing values
    df.dropna(inplace=True)

    # Initialize a dictionary to store predicted values for this sheet
    predictions = {}
    # Iterate over each column
    for column in df.columns[2:]: # Exclude first two columns
        # Train an autoregressive model for each column
        model = AutoReg(df[column], lags=lag)
        model_fit = model.fit()

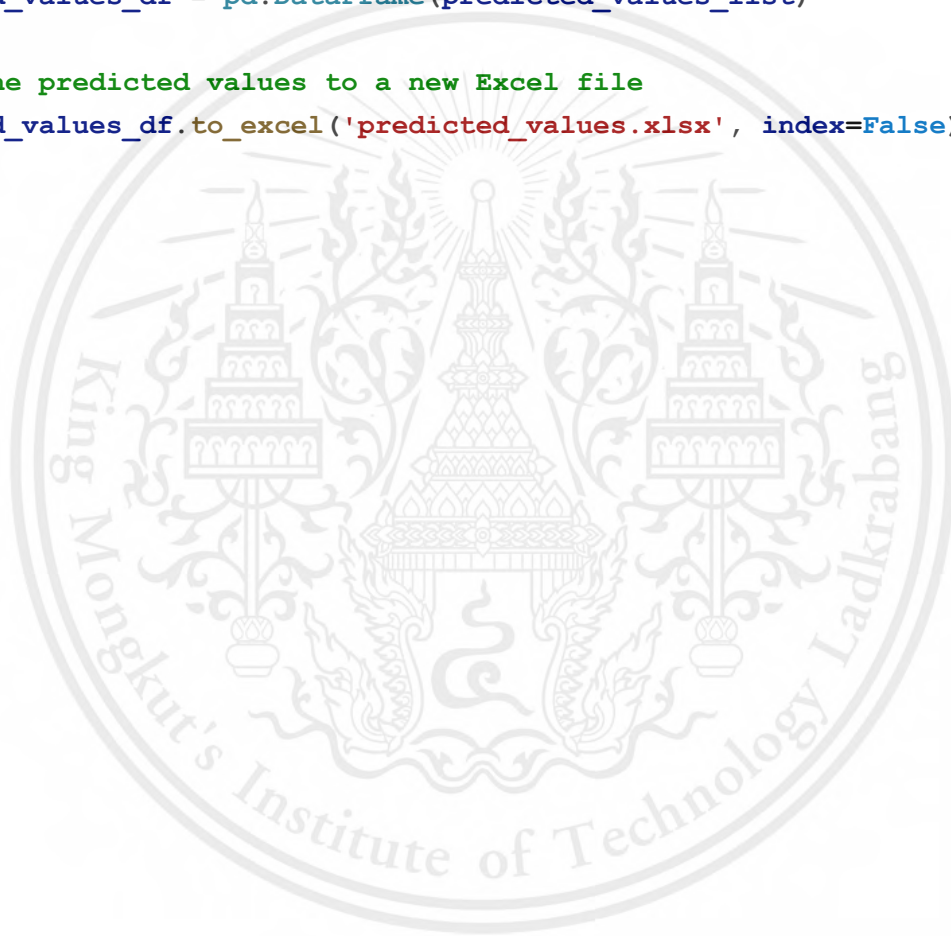
        # Predict the next value
        next_value = model_fit.predict(start=len(df), end=len(df))
```

```
# Store the predicted value
predictions[column] = next_value.values[0] # Extract value from
Series

# Append the predictions for this sheet as a new row in the DataFrame
predicted_values_list.append(predictions)

# Convert the list of dictionaries to a DataFrame
predicted_values_df = pd.DataFrame(predicted_values_list)

# Save the predicted values to a new Excel file
predicted_values_df.to_excel('predicted_values.xlsx', index=False)
```



Appendix A4 Result of Forecasted Value of Factors for each stock

Stock Name	CapEx	Current Mkt Cap*	D/E	EPS	Mkt Risk Premium
DELTA	-3143.4720	1030.2078	2.2693	0.4527	0.0016
PTT	-37448.7475	980.7499	72.6602	0.7933	0.0016
AOT	-2499.2460	995.7930	53.4532	0.2337	0.0016
ADVANC	-8258.0922	652.0448	167.9827	2.6801	0.0016
PTTEP	-16143.2417	649.9975	25.8685	2.5193	0.0016
GULF	-4207.6752	540.4966	193.4755	0.2137	0.0017
CPALL	-4968.7517	544.8430	176.2194	0.4532	0.0016
BDMS	-2025.8421	418.9623	21.7136	0.1513	0.0016
SCC	-9872.0731	374.5264	80.3830	6.1432	0.0016
SCB	-426.1647	355.0794	69.8418	2.9884	0.0016
KBANK	-1257.9236	308.8677	50.0756	4.1850	0.0016
CPN	-1677.1713	282.4713	129.6045	0.6507	0.0016
BBL	-532.4832	316.6184	106.2914	5.5171	0.0016
KTB	-543.5223	258.3454	104.8162	0.6523	0.0016
CRC	-3563.6523	230.1879	200.5537	0.1577	0.0268
INTUCH	-233.4956	230.2899	-0.3133	0.9881	0.0016
TRUE	-5050.9395	230.7337	107.0340	0.7282	0.0016
BH	-354.8932	211.0029	-0.3292	2.4063	0.0016
EA	-1814.3127	190.7430	162.4531	0.4875	0.0016
HMPRO	-1076.7135	164.3862	86.3057	0.1135	0.0016
SCGP	-1600.9100	183.3032	43.5872	0.3563	-0.0204
CPF	-6240.4362	190.0767	186.4917	0.2618	0.0016
TTB	-251.9955	131.0040	75.5522	0.0426	0.0016
MINT	-1842.5291	169.3253	229.9288	0.2893	0.0016
IVL	-5834.9529	151.6297	125.9492	0.3399	0.0016
GPSC	-1165.2359	129.3410	107.6305	0.5393	0.0059
BEM	-56.5760	129.4683	185.8893	0.0537	0.0124
KTC	-38.8665	113.6213	181.6489	0.6885	0.0016
AWC	-1102.8467	138.5481	79.2753	0.0310	0.0038
TOP	-3306.4069	115.3887	117.9083	1.7489	0.0016
BTS	-266.3323	102.8821	246.7373	0.0935	0.0016
MTC	-89.2965	79.1417	365.8219	0.6118	0.0046
LH	-811.5348	97.9230	139.2251	0.1715	0.0016
GLOBAL	-503.5744	82.3042	51.9804	0.1034	0.0016
TISCO	-68.3725	78.6789	48.4321	2.3071	0.0016
CBG	-304.3174	82.4987	48.4002	0.5304	0.0046
WHA	-947.8449	74.4017	121.9957	0.0496	0.0016
TU	-1157.3120	70.7997	83.2103	0.2758	0.0016

BGRIM	-2107.5622	82.7329	219.5708	0.1389	0.0046
RATCH	-696.8196	71.2281	90.2235	0.9277	0.0016
BANPU	-2998.6551	68.7800	152.5508	0.2584	0.0016
KCE	-220.4640	64.1639	23.2998	0.4406	0.0016
EGCO	-1498.6960	66.3690	98.7706	4.1035	0.0016
OSP	-356.9645	84.4636	19.5718	0.2195	0.0027
BCP	-2209.0928	55.8423	86.4298	3.7113	0.0016
SAWAD	-60.5087	60.1170	255.6783	1.0047	0.0051
CENTEL	-457.8834	60.9727	124.4996	0.0730	0.0016
COM7	-193.9794	74.5240	98.1090	0.2494	0.0100
BCH	-281.2047	47.9863	10.4456	0.1787	0.0016
THG	-372.5035	53.3782	96.4111	0.3185	0.0017
TCAP	-65.5053	51.2630	88.1667	1.6152	0.0016
HANA	-739.2681	44.9076	4.8014	0.6938	0.0016
JMT	-50.6284	69.9253	58.6709	0.3052	0.0016
KKP	-157.0254	46.6053	165.3037	1.5329	0.0016
IRPC	-2544.6410	45.7415	73.1747	0.0658	0.0016
DOHOME	-557.5435	35.5615	142.9827	0.0523	0.0004
PLANB	-183.1329	31.8049	56.7766	0.0480	0.0056
CK	-362.5195	35.9776	212.0113	0.2769	0.0016
SPALI	-18.0798	39.0387	60.2470	0.6991	0.0016
MEGA	-75.6901	38.2685	3.7517	0.5629	0.0077
SRPC	-175.1973	41.3103	16.1671	0.3151	0.0155
AP	-20.4100	35.2216	85.2908	0.4365	0.0016
CHG	-226.1992	35.3519	12.8211	0.0296	0.0023
MBK	-233.1231	33.4356	139.6018	0.2441	0.0016
AMATA	-663.8260	25.7531	69.7833	0.3472	0.0016
JMART	-1614.8783	32.5092	85.2368	0.1626	0.0016
SIRI	-293.7914	25.9834	166.3460	0.0661	0.0016
BAM	-19.7232	35.3389	199.6652	0.1681	0.0038
CKP	-20.3203	27.4281	78.6549	0.0442	0.0045
SJWD	-153.7901	25.6737	64.1807	0.0896	0.0100
BCPG	-288.3130	31.2416	117.5747	0.2175	0.0101
TASCO	-205.8615	26.1945	25.1266	0.3063	0.0016
AAV	-348.5077	30.2891	757.1517	-0.1119	0.0016
BYD	-1.8971	40.5249	3.6751	-0.0159	0.0077
ERW	-1265.2225	24.0542	240.7031	0.0201	0.0016
GUNKUL	-1187.1322	28.0963	54.3213	-0.1245	0.0016
STA	-647.9236	23.1346	112.8053	0.0453	0.0016
ORI	-419.1712	24.3255	154.0510	0.3600	0.0155
VGI	-129.1045	29.5712	6.9623	0.0186	0.0051
NEX	-25.9188	22.8970	3.6202	0.0079	0.0016

FORTH	-224.5714	26.8373	151.6113	0.1282	0.0016
STGT	-13.4842	12.7693	27.3564	0.3621	0.0103
TQM	-3350.4826	19.8674	20.9763	0.1611	0.0103
RCL	-1290.6239	17.8020	14.9820	0.7882	0.0016
PTG	-3.5901	17.6118	334.8597	0.0450	0.0023
THANI	-706.0462	17.3546	334.3856	0.0773	0.0023
ACE	-387.1064	21.7162	33.4286	0.0342	0.0038
PSL	-280.9747	15.4975	39.1692	0.0556	0.0016
STEC	-143.6202	17.0181	3.3872	0.1676	0.0016



Appendix A5 Historical and Forecasted Close Price with Expected Return of each stock

Stock Name	Historical Close Price	Forecasted Close Price	Return
DELTA	82.75	96.00	16.01%
PTT	33.50	33.84	1.01%
AOT	69.75	69.26	-0.70%
ADVANC	228.00	204.55	-10.28%
PTTEP	171.00	153.84	-10.04%
GULF	45.50	46.73	2.71%
CPALL	60.50	63.00	4.13%
BDMS	26.75	26.41	-1.26%
SCC	301.00	322.39	7.11%
SCB	102.50	110.88	8.18%
KBANK	126.00	135.47	7.52%
CPN	63.25	62.76	-0.78%
BBL	167.50	172.10	2.75%
KTB	19.00	18.13	-4.56%
CRC	38.75	39.71	2.48%
INTUCH	73.75	71.75	-2.71%
TRUE	34.50	44.93	30.23%
BH	268.00	274.47	2.41%
EA	12.50	51.27	310.13%
HMPRO	12.50	12.69	1.53%
SCGP	38.25	44.86	17.29%
CPF	20.70	23.68	14.39%
TTB	1.72	1.55	-9.83%
MINT	31.25	32.91	5.30%
IVL	26.00	31.26	20.25%
GPSC	44.75	56.50	26.27%
BEM	8.30	8.54	2.95%
KTC	44.00	47.50	7.95%
AWC	3.90	4.91	25.86%
TOP	50.50	51.19	1.36%
BTS	7.50	7.95	5.95%
MTC	36.00	45.91	27.52%
LH	7.80	8.20	5.16%
GLOBAL	16.80	14.95	-11.03%
TISCO	98.75	98.75	0.00%
CBG	82.00	84.64	3.22%
WHA	5.25	4.59	-12.60%
TU	14.50	15.76	8.66%
BGRIM	28.75	34.16	18.81%
RATCH	31.50	36.64	16.32%
BANPU	8.00	13.11	63.87%

KCE	55.25	53.06	-3.97%
EGCO	121.00	133.81	10.59%
OSP	25.00	28.89	15.55%
BCP	41.00	39.63	-3.35%
SAWAD	42.75	46.32	8.35%
CENTEL	47.00	44.21	-5.93%
COM7	31.25	28.87	-7.61%
BCH	19.70	19.53	-0.88%
THG	65.25	60.45	-7.36%
TCAP	50.00	45.92	-8.16%
HANA	59.50	53.37	-10.30%
JMT	47.75	49.86	4.41%
KKP	55.25	54.68	-1.04%
IRPC	2.06	2.52	22.28%
DOHOME	10.90	11.15	2.34%
PLANB	8.15	7.36	-9.64%
CK	20.80	22.44	7.89%
SPALI	20.10	20.67	2.82%
MEGA	44.50	44.15	-0.79%
SRPC	9.10	10.30	13.17%
AP	11.80	10.39	-11.92%
CHG	3.26	3.12	-4.26%
MBK	17.80	18.56	4.26%
AMATA	24.40	21.89	-10.31%
JMART	22.80	23.92	4.89%
SIRI	1.69	1.79	6.21%
BAM	10.50	11.07	5.44%
CKP	3.26	3.70	13.59%
SJWD	14.80	17.12	15.67%
BCPG	9.60	14.46	50.64%
TASCO	16.10	18.09	12.38%
AAV	2.58	2.38	-7.86%
BYD	6.55	8.25	25.90%
ERW	5.50	5.57	1.28%
GUNKUL	14.70	13.52	-8.04%
STA	3.12	3.35	7.27%
ORI	9.95	9.66	-2.92%
VGI	2.36	4.18	77.20%
NEX	11.30	13.76	21.74%
FORTH	29.00	28.35	-2.23%
STGT	33.50	32.98	-1.54%
TQM	6.65	15.27	129.69%
RCL	21.80	25.20	15.62%
PTG	3.04	2.59	-14.72%

THANI	9.35	14.96	59.99%
ACE	1.60	2.47	54.57%
PSL	9.70	10.57	8.96%
STEC	9.40	12.61	34.18%





Appendix B1 28 Stocks Spreadsheet with 10-year (Quarterly return) table

Weight	3.347210%	1.000000%	1.000000%	1.000000%	10.000000%	1.000000%	9.669265%
Date	EA	SCB	VGI	BANPU	KTC	TU	STA
Q1 2013		-0.008264463	0.42154084	-0.084964836	0.308451613	-0.114555556	0.534900808
Q2 2013	-0.161490683	-0.044444444	-0.004531448	-0.36073951	0.030864198	-0.086271803	-0.172809957
Q3 2013	-0.007407407	-0.139534884	-0.008375819	0.141093131	-0.125748503	-0.12449358	-0.12962963
Q4 2013	0.141791045	-0.030405405	-0.136246787	0.100011391	-0.184931507	0.406901961	-0.303856383
Q1 2014	0.294117647	0.097560976	0.163265306	-0.074401988	0.168067227	-0.041810681	0.324737345
Q2 2014	0.848484849	0.06984127	0.131578947	0.05358841	0.26618705	-0.054572958	0.441961067
Q3 2014	0.322404372	0.080118694	0.07751938	0	0.551136364	0.138461539	0.4585
Q4 2014	0.033057851	0	-0.151079137	-0.155933103	-0.062271062	0.222972973	0.163181351
Q1 2015	0.01	-0.021978022	-0.076271186	0.184740219	0.51171875	-0.11160221	0.175361037
Q2 2015	-0.069306931	-0.126404494	-0.082568807	-0.13559862	0.015503876	0.084577114	0.007522568
Q3 2015	-0.085106383	-0.138263666	-0.3	-0.215711566	-0.045801527	-0.155963303	-0.255599801
Q4 2015	0.046511628	-0.108208955	0.057142857	-0.200015663	0.042666667	-0.065217391	0.074557004
Q1 2016	-0.008888889	0.179916318	0.291948198	0.043759178	-0.109974425	0.215116279	0.226820162
Q2 2016	-0.044843049	-0.014184397	0.25517542	0.161695742	0.140804598	0.052631579	0.005325894
Q3 2016	0.208920188	0.064748201	-0.075	0.068060714	0.486146096	-0.027272727	-0.160191726
Q4 2016	0.155339806	0.030405405	0.009090909	0.222919344	-0.06440678	-0.018691589	0.212376089
Q1 2017	-0.067226891	0.068852459	-0.089285714	0.031215231	-0.014492754	0.019047619	-0.053270565
Q2 2017	0.243243243	-0.04601227	0.117647059	-0.16160163	-0.117647059	-0.014018692	-0.110180581
Q3 2017	0.108695652	-0.01607717	0.00877193	0.060270251	-0.058333333	-0.052132701	-0.014705882
Q4 2017	0.37254902	-0.019607843	0.139130435	0.107956844	0.646017699	-0.005	-0.014925373
Q1 2018	-0.166666667	-0.046666667	0.190839695	0.041020023	0.650537634	-0.050251256	-0.121212121
Q2 2018	-0.251428571	-0.171328671	-0.012820513	-0.039403683	0.146579805	-0.164021164	-0.218275862
Q3 2018	0.473282443	0.257383966	0.032467532	-0.020510012	0.022727273	0.132911392	0.15438906
Q4 2018	-0.119170985	-0.104026846	-0.018667925	-0.225177085	-0.152777778	-0.094972067	-0.108521208
Q1 2019	0.129411765	-0.011235955	0.16025641	0.094627105	0.155737705	0.191358025	0.107158166
Q2 2019	0.161458333	0.056818182	-0.005524862	-0.074065934	0.226950355	-0.051813472	0.238869532
Q3 2019	-0.139013453	-0.154121864	0.094328704	-0.213308015	-0.011560694	-0.087431694	-0.03125
Q4 2019	-0.088541667	0.033898305	-0.03035431	0.008448154	-0.076023392	-0.191616767	-0.038709677
Q1 2020	-0.228571429	-0.432377049	-0.403141361	-0.554602573	-0.310126582	0.022222222	-0.261744966
Q2 2020	0.162962963	0.046931408	0.315789474	0.150918048	0.100917431	-0.065217391	0.181818182
Q3 2020	0	-0.103448276	-0.153333333	-0.04922179	0.158333333	0.085271318	-0.138461539
Q4 2020	0.254777707	0.346153846	0.047244094	0.89666462	0.712230216	-0.028571429	0.125
Q1 2021	0.258883249	0.274285714	0.090225564	0.145431007	0.327731092	0.080882353	0.484126984
Q2 2021	-0.016129032	-0.121076233	-0.165517241	0.238014505	-0.151898734	0.346938776	0.252032086
Q3 2021	0.004098361	0.244897959	0.008264463	-0.056603774	-0.182835821	0.095959596	0.029661017
Q4 2021	0.567346939	0.040983607	0.081967213	-0.14516129	0.082191781	-0.101382489	0.152263375
Q1 2022	0.020833333	-0.102362205	-0.195075758	0.037735849	0.037974684	-0.030769231	0.089285714
Q2 2022	-0.168367347	-0.087719298	-0.023529412	0.145454546	-0.073170732	-0.095238095	-0.073770492
Q3 2022	0.082822086	0	-0.196787149	-0.023809524	0.00877193	0.093567251	-0.07079646
Q4 2022	0.099150142	0.028846154	0.1	0.113821138	0.026086957	-0.096256684	0
Q1 2023	-0.216494845	-0.042056075	-0.109090909	-0.211678832	-0.080508475	-0.165680473	-0.230476191
Q2 2023	-0.25	0.03902439	-0.224489796	-0.180555566	-0.087557604	-0.085106383	-0.212871287
Q3 2023	-0.780701754	-0.037558685	-0.223684211	-0.096045198	-0.111111111	0.124031008	-0.018867925

Weight	1.000000%	1.000000%	1.000000%	10.000000%	1.092403%	1.000000%	1.000000%
Date	STEC	TRUE	SCC	GPSC	BYD	AWC	IRPC
Q1 2013	0.356451993	0.010714286	0.113636364		0.529770992		-0.04368932
Q2 2013	-0.32173913	-0.024734982	-0.089795918		0.384730539		-0.162436548
Q3 2013	0.164102564	0.079710145	-0.044843049		-0.312432432		-0.048484848
Q4 2013	-0.418502203	0.060402685	-0.061032864		0.09067086		0.038216561
Q1 2014	0.21969697	-0.085443038	0.045		-0.240269101		0.055214724
Q2 2014	0.416149068	-0.065743945	0.081339713		0.033523087		-0.01744186
Q3 2014	0.184210526	-0.096296296	-0.004424779		0		0.017751479
Q4 2014	-0.137037037	-0.159836066	-0.004444444		-0.052019584		-0.110465116
Q1 2015	-0.08583691	0.019512195	0.142857143		-0.185280826		0.405228758
Q2 2015	0.093896714	0.325358852	0.015625		-0.274167987		0.041860465
Q3 2015	0.038626609	-0.223826715	-0.107692308	-0.150023745	-0.267467249		-0.160714286
Q4 2015	0.033057851	-0.069767442	-0.00862069	0.00452052	-0.348733234		0.143617021
Q1 2016	-0.092	0.21	0.013043478	0.182434141	0.04805492		0.174418605
Q2 2016	0.04845815	-0.020661157	0.021459227	0.276202694	0.441048035		-0.057425743
Q3 2016	-0.008403361	-0.008438819	0.084033613	0.089565742	-0.193939394		0.025210084
Q4 2016	0.175847458	0.072340426	-0.03875969	0.020543101	0.140977444		-0.016393443
Q1 2017	-0.135135135	0.162698413	0.088709677	-0.093958114	0.087314662		0.072916667
Q2 2017	0.15625	-0.064846416	-0.066666667	0.074067915	-0.015151515		0.038834951
Q3 2017	-0.072072072	0.124087591	-0.007936508	0.275871679	-0.049230769		0.177570094
Q4 2017	-0.091262136	0.103896104	-0.032	0.556755576	0		0.119047619
Q1 2018	-0.183760684	0.111764706	0.033057851	0.05554776	-0.035598706		0.04964539
Q2 2018	-0.052356021	-0.227513228	-0.172	-0.088810445	-0.196308725		-0.216216216
Q3 2018	0.375690608	0.113013699	0.077294686	-0.021671827	0.133611691		0.172413793
Q4 2018	-0.180722892	-0.123076923	-0.022421525	-0.136523295	-0.038674033		-0.154411765
Q1 2019	0.181372549	-0.056140351	0.105504587	-0.029914038	0		0
Q2 2019	0.12033195	-0.048327138	-0.020746888	0.237889906	0.224137931		-0.130434783
Q3 2019	-0.259259259	-0.16015625	-0.13559322	0.122491372	-0.533646322		-0.264
Q4 2019	-0.29	0.060465116	-0.039215686	0.220640569	0.177852349		0
Q1 2020	-0.197183099	-0.464912281	-0.173469388	-0.335276968	-0.452991453	-0.442735043	-0.418478261
Q2 2020	0.333333333	0.516393443	0.135802469	0.289473684	0.5	0.18404908	0.224299065
Q3 2020	-0.256578947	-0.151351351	-0.125	-0.217687075	0.545138889	-0.093264249	-0.267175573
Q4 2020	0.123893805	0.49044586	0.173913044	0.282608696	-0.260674157	0.302857143	0.9375
Q1 2021	0.244094488	0.072649573	0.055555556	0.044067797	2.765957447	0.118421053	0
Q2 2021	-0.139240506	-0.059760956	0.082706767	-0.051948052	2.743341404	-0.149019608	0.032258065
Q3 2021	0	0.072033898	-0.069444444	0.034246575	-0.062095731	0.073732719	0.083333333
Q4 2021	0.080882353	-0.071146245	-0.039800995	0.175496689	1.337011494	-0.004291845	-0.076923077
Q1 2022	-0.088435374	-0.136170213	-0.007772021	-0.185915493	0.010328546	0.099137931	-0.072916667
Q2 2022	-0.089552239	-0.103448276	-0.023498695	-0.107266436	0.148865739	-0.043137255	-0.095505618
Q3 2022	-0.06557377	-0.087912088	-0.128342246	-0.011627907	0.161016949	0.18852459	-0.031055901
Q4 2022	0.192982456	0.138554217	0.049079755	0.145098039	-0.02919708	0.086206897	-0.032051282
Q1 2023	-0.073529412	-0.031746032	-0.078947368	-0.068493151	-0.334586466	-0.079365079	-0.132450331
Q2 2023	-0.301587302	-0.18579235	0.022222222	-0.202205882	-0.305084746	-0.148275862	-0.129770992
Q3 2023	0.068181818	-0.073825503	-0.065217391	-0.175115207	0.06504065	-0.210526316	-0.096491228

Weight	8.535853%	1.892786%	8.999079%	1.000000%	1.000000%	7.891685%	1.000000%
Date	NEX	IVL	BGRIM	SCGP	RATCH	DELTA	SJWD
Q1 2013	0.066776587	-0.073267327			-0.004196839	0.1796875	
Q2 2013	-0.302936631	-0.235042735			-0.134443067	0.059602649	
Q3 2013	-0.027716186	0.217877095			-0.029133762	0.23125	
Q4 2013	-0.099201824	-0.082568807			-0.019998314	0.086294416	
Q1 2014	-0.046835443	0.145			0.056122998	0.102803738	
Q2 2014	-0.008632138	0.211790393			0.048315179	0.059322034	
Q3 2014	0.075016745	-0.081081081			0.092157396	-0.008	
Q4 2014	-0.077258567	-0.207843137			-0.008429214	0.137096774	
Q1 2015	0.478730587	0.287128713			0.042540218	0.067375887	
Q2 2015	-0.119178082	-0.067307692			-0.065300786	0.202657807	
Q3 2015	-0.122861586	-0.171171171			-0.065501058	-0.027624309	
Q4 2015	-0.124704492	-0.073913043			-0.112159288	-0.130681818	0.590249085
Q1 2016	-0.092505064	0.070422535			0.068432377	0.137254902	-0.065548215
Q2 2016	-0.027529762	0.271929825			0.004920483	-0.215517241	-0.157928186
Q3 2016	-0.009946442	-0.025862069			-0.004896391	0.161172161	-0.150943396
Q4 2016	1.404173107	-0.185840708			-0.014782212	0.028391167	-0.133333333
Q1 2017	0.18997107	0.052238806			0.00499431	0.073619632	0.230769231
Q2 2017	-0.042139384	0.078014184			0.034828374	-0.008571429	-0.09375
Q3 2017	0.008742245	0.111842105			0.033656184	0.005763689	0.321839081
Q4 2017	-0.147609729	0.26035503	0.295045045		0.009311352	-0.160458453	0.052173913
Q1 2018	-0.24499836	0.075117371	-0.104347826		-0.036862958	-0.071672355	-0.223140496
Q2 2018	0.129887055	-0.043668122	-0.114563107		-0.019136923	-0.139705882	-0.356382979
Q3 2018	0.076509035	0.077625571	0.271929825		0.009744865	0.192307692	0.272727273
Q4 2018	-0.155714286	-0.080508475	-0.086206897		-0.019321999	-0.003584229	-0.090909091
Q1 2019	0.089678511	-0.082949309	0.179245283		0.152701075	0.021582734	0.178571429
Q2 2019	-0.236801242	-0.055276382	0.144		0.141027719	-0.042253521	0.066666667
Q3 2019	0.152085453	-0.308510638	0.20979021		0.071174883	-0.272058824	0
Q4 2019	0.239293598	0.076923077	0.213872832		-0.038461538	0.080808081	-0.096590909
Q1 2020	-0.002493766	-0.388571429	-0.242857143		-0.170911877	-0.364485981	-0.34591195
Q2 2020	0.378571429	0.296728972	0.34591195		0.092092129	0.580882353	0.173076923
Q3 2020	0.093264249	-0.23963964	-0.210280374		-0.192772512	1.911627907	0.262295082
Q4 2020	-0.004739336	0.753554502	0.147928994		0.054727307	2.10543131	0.084415584
Q1 2021	0.5	0.202702703	-0.056701031	0.126506024	-0.033001332	-0.403292181	0.02994012
Q2 2021	0.063492063	-0.084269663	-0.081967213	0.326203209	-0.107316873	0.993103448	0.825581395
Q3 2021	0.231343284	0.09202454	-0.023809524	-0.024193548	-0.010939407	-0.186851211	-0.038216561
Q4 2021	1.363636364	-0.028089888	-0.012195122	0.144628099	-0.005518558	-0.123404255	0.456953642
Q1 2022	-0.025641026	0.075144509	-0.12962963	-0.126353791	-0.022220141	-0.058252427	-0.177272727
Q2 2022	-0.094736842	0.010752688	-0.007092199	-0.082644628	-0.084051724	-0.141752577	-0.237569061
Q3 2022	0.029069767	-0.170212766	-0.035714286	-0.063063063	0.071895425	0.963963964	0.210144928
Q4 2022	0.033898305	0.044871795	0.177777778	0.096153846	0.042682927	0.26911315	0.245508982
Q1 2023	-0.25136612	-0.153374233	0.018867925	-0.188596491	-0.099415205	0.375903615	-0.038461538
Q2 2023	-0.291970803	-0.007246377	-0.141975309	-0.194594595	-0.071428571	-0.194395797	-0.21
Q3 2023	0.164948454	-0.240875912	-0.172661871	0.026845638	-0.118881119	-0.100543478	-0.063291139

Weight	1.000000%	1.000000%	10.000000%	1.040000%	1.711631%	1.820000%	10.000000%
Date	RCL	OSP	CPF	CKP	SRPC	TASCO	EGCO
Q1 2013	0.04964539		-0.02962963			0.605714286	0.033112583
Q2 2013	-0.20945946		-0.213740458			-0.145907473	-0.134615385
Q3 2013	0.085470085		-0.067961165			-0.108333333	-0.081481481
Q4 2013	-0.007874016		0.333333333	-0.039782245		-0.046728972	-0.012096774
Q1 2014	0.023809524		-0.125	0		-0.049019608	0.069387755
Q2 2014	0.03875969		-0.026785714	0.066724815		0.298969072	0.057251908
Q3 2014	0.582089552		0.110091743	0.421913328		-0.027777778	0.19133574
Q4 2014	-0.202830189		-0.099173554	-0.02213916		0.06122449	0.015151515
Q1 2015	0.076923077		-0.174311927	-0.061746545		0.615384615	-0.095522388
Q2 2015	0.065934066		0.066666667	-0.078658728		1.180952381	0.01320132
Q3 2015	-0.278350516		-0.1375	-0.163265306		0.288209607	-0.003257329
Q4 2015	-0.257142857		-0.115942029	-0.195121951		0.372881356	-0.009803922
Q1 2016	-0.153846154		0.333333333	0.151515152	0.20441989	-0.382716049	0.178217822
Q2 2016	-0.025		0.178278689	0.263157895	-0.123853211	0.09	0.050420168
Q3 2016	-0.145299145		0.104347826	0.138888889	0.130890052	-0.299082569	0.058666667
Q4 2016	0.03		-0.070866142	0.085365854	0.148148148	-0.005235602	0.002518892
Q1 2017	0.388349515		-0.059322034	-0.095505618	0.056451613	0.355263158	0.075376884
Q2 2017	0.097902098		-0.106306306	0.024844721	0.114503817	-0.122330097	0
Q3 2017	-0.006369427		0.078629032	0.078787879	0.212328767	0.066371681	0.098130841
Q4 2017	0.108974359		-0.102803738	0.134831461	-0.033898305	-0.074688797	-0.080851064
Q1 2018	-0.132947977		0.052083333	-0.03960396	-0.064327485	-0.224215247	0.074074074
Q2 2018	-0.36		-0.041584158	-0.030927835	-0.1875	-0.208092486	-0.034482759
Q3 2018	0.291666667		0.04338843	0.42287234	0.146153846	0.182481752	0.053571429
Q4 2018	-0.232258065		-0.025742574	-0.072897196	-0.355704698	-0.104938272	0.050847458
Q1 2019	-0.042016807	0.12244898	0.036585366	-0.008064516	0.135416667	0.089655172	0.177419355
Q2 2019	-0.057017544	0.263636364	0.107843137	0.432926829	-0.073394495	0.310126582	0.113013699
Q3 2019	-0.051162791	0.071942446	-0.07079646	-0.184397163	-0.079207921	0.019323672	0.104615385
Q4 2019	-0.132352941	0.087248322	0.047619048	-0.137391304	0.150537634	0.004739336	-0.086350975
Q1 2020	-0.485875706	-0.117283951	-0.116363636	-0.403225807	-0.586915888	-0.188679245	-0.295731707
Q2 2020	0.747252747	0.062937063	0.306584362	0.391891892	0.504524887	0.453488372	0.069264069
Q3 2020	0.77672956	-0.078947368	-0.118110236	0.40776699	-0.165413534	-0.392	-0.24291498
Q4 2020	1.513274336	0.014285714	-0.044642857	-0.231034483	0.450450451	0.15131579	0.029411765
Q1 2021	0.795774648	-0.007042254	0.102803738	0.094170404	0.118012422	0.182857143	-0.036363636
Q2 2021	1.156862745	0.070921986	-0.101694915	0.12704918	0.077777778	-0.072463768	-0.056603774
Q3 2021	-0.15	-0.099337748	-0.028301887	-0.018181818	0.015463918	-0.041666667	-0.005714286
Q4 2021	0.053475936	0.007352941	-0.009708738	-0.074074074	-0.005076142	-0.016304348	0.008620669
Q1 2022	-0.116751269	0.094890511	-0.054901961	0.04	-0.015306122	-0.082872928	-0.031339031
Q2 2022	-0.114942529	-0.086666667	0.078838174	0.067307692	0.25388601	-0.036144578	0.038235294
Q3 2022	-0.246753247	-0.204379562	-0.038461538	-0.09009009	-0.123966942	0.03125	-0.065155807
Q4 2022	0.060344828	0.036697248	-0.008	-0.097029703	0.009433962	0.024242424	0.045454545
Q1 2023	-0.138211382	0.088495575	-0.14516129	-0.092105263	0.009345794	0.159763314	-0.098550725
Q2 2023	-0.105660377	-0.032520325	-0.070754717	-0.154589372	-0.25462963	-0.045918367	-0.160771704
Q3 2023	-0.080168776	-0.159663866	0.050761421	-0.068571429	0.130434783	-0.139037433	-0.072796935

Appendix B2 Set constraints using Excel Solver

Stock Name	Portfolio Weight	Volume Limit
EA	0.0335	0.7890
SCB	0.0100	1.8524
VGI	0.0100	0.0529
BANPU	0.0100	1.0269
KTC	0.1000	0.1590
TU	0.0100	0.3070
STA	0.0967	0.1620
STEC	0.0100	0.0491
TRUE	0.0100	0.5466
SCC	0.0100	0.5546
GPSC	0.1000	0.3937
BYD	0.0109	0.0383
AWC	0.0100	0.2571
IRPC	0.0100	0.0775
NEX	0.0854	0.0876
IVL	0.0189	0.4006
BGRIM	0.0900	0.4075
SCGP	0.0100	0.3934
RATCH	0.0100	0.1660
DELTA	0.0789	7.6434
SJWD	0.0100	0.0298
RCL	0.0100	0.0258
OSP	0.0100	0.3474
CPF	0.1000	0.2035
CKP	0.0104	0.0104
SRPC	0.0171	
TASCO	0.0182	0.0182
EGCO	0.1000	0.1040

Appendix B3 Utilize Excel Solver

Solver Parameters ×

Set Objective: ↑

To: Max Min Value Of:

By Changing Variable Cells: ↑

Subject to the Constraints:

\$AG\$58:\$AG\$85 <= 0.1	Add Change Delete Reset All Load/Save
\$AG\$58:\$AG\$85 >= 0.01	
\$AG\$87 = 1	
\$AH\$58 <= \$AI\$58	
\$AH\$59 <= \$AI\$59	
\$AH\$60 <= \$AI\$60	
\$AH\$61 <= \$AI\$61	
\$AH\$62 <= \$AI\$62	
\$AH\$63 <= \$AI\$63	
\$AH\$64 <= \$AI\$64	
\$AH\$65 <= \$AI\$65	

Make Unconstrained Variables Non-Negative

Select a Solving Method: Options

Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Help Solve Close

Appendix B4 Tracking Error calculation table

Date	Portfolio	Market Return	TE = RP-RM
Q3 2013	-0.02492322	-0.0330	0.0081
Q4 2013	-0.0151836	-0.0656	0.0504
Q1 2014	0.06042291	0.0727	-0.0123
Q2 2014	0.12227322	0.0839	0.0384
Q3 2014	0.15921703	0.0756	0.0836
Q4 2014	-0.00420885	-0.0553	0.0511
Q1 2015	0.10738981	0.0113	0.0961
Q2 2015	0.03489301	0.0020	0.0329
Q3 2015	-0.09257712	-0.1106	0.0180
Q4 2015	-0.02046958	-0.0567	0.0362
Q1 2016	0.09486749	0.1146	-0.0197
Q2 2016	0.05913817	0.0318	0.0273
Q3 2016	0.07109782	0.0414	0.0297
Q4 2016	0.14818384	0.0322	0.1160
Q1 2017	0.02219748	0.0390	-0.0168
Q2 2017	-0.02048507	0.0104	-0.0309
Q3 2017	0.05580407	0.0823	-0.0265
Q4 2017	0.12354425	0.0603	0.0632
Q1 2018	0.02293233	0.0272	-0.0043
Q2 2018	-0.06980014	-0.0958	0.0260
Q3 2018	0.11704733	0.1203	-0.0033
Q4 2018	-0.0855983	-0.1076	0.0220
Q1 2019	0.08723453	0.0568	0.0304
Q2 2019	0.09938037	0.0697	0.0297
Q3 2019	-0.00827548	-0.0499	0.0416
Q4 2019	0.04827893	-0.0201	0.0684
Q1 2020	-0.2613646	-0.2889	0.0275
Q2 2020	0.27016355	0.2032	0.0670
Q3 2020	0.07669753	-0.0996	0.1763
Q4 2020	0.36668184	0.1631	0.2036
Q1 2021	0.1653676	0.0909	0.0745
Q2 2021	0.11808065	-0.0043	0.1224
Q3 2021	-0.01072097	0.0179	-0.0286
Q4 2021	0.18207502	0.0333	0.1488
Q1 2022	-0.04080129	0.0305	-0.0713
Q2 2022	-0.04301953	-0.0603	0.0173
Q3 2022	0.0518315	0.0071	0.0447
Q4 2022	0.07506181	0.0513	0.0238
Q1 2023	-0.07635208	-0.0275	-0.0489
Q2 2023	-0.16247691	-0.0554	-0.1071
Q3 2023	-0.08309786	-0.0099	-0.0732
Average Return Q.	0.0419636	0.0095	0.0325
Average Return Y.	0.16785439	0.037882927	0.12997147
S.D. Q.	0.11116199	0.085029244	0.06280311
S.D. Y.	0.22232397	0.170058488	0.12560621

*TE = Tracking Error