Thailand Statistician
October 2025; 23(4): 875-892
http://statassoc.or.th
Contributed paper

Unleashing the Potential: Exploring Cashless Investment Strategies through Short-Selling Techniques and Modern Portfolio Theory

Wichai Witayakiattilerd [a]* , Chalermpol Neaimsri [b], Thanyamas Atthaphichan [a], Chatsiya Boontam [a] and Panya Senarat [a]

[a] Department of Mathematics and Statistics, Faculty of Science and Technology, Thammasat University, Pathum Thani, Thailand

[b] Trinity Securities Co., Ltd.

*Corresponding author; wichai@mathstat.sci.tu.ac.th

Received: Received: 10 February 2025
Revised: Revised: 23 May 2025
Accepted: Accepted: 24 June 2025

Abstract

This research paper investigates cashless investment strategies using the short-selling technique and the principles of Markowitz's Portfolio Theory and Modern Portfolio Theory (MPT). The study examines the linear relationship between securities in the SET50 index group using correlation coefficient and beta coefficient values and creates a portfolio of two stocks with a negative correlation. Using short-selling techniques, we develop a model to identify suitable investment portfolios for cashless investment strategies and analyze five years of daily closing prices of 41 securities in the SET50 index group. We use the cross-exponential moving average 2 lines (Cross EMA) to set buy-sell signals and evaluate performance using Shape Ratio, Success Rate, and Net Margin Profit. The results show 72 suitable investment portfolios for cashless investment strategies using short-selling techniques, ranked by their net margin profit, providing investors with valuable insights and recommendations. We discuss the implications of our findings and outline areas for future research while acknowledging the study's limitations. This study demonstrates the potential of cashless investment strategies using the short-selling technique and the value of applying Markowitz's Portfolio Theory and MPT to portfolio construction.

Keywords: Short selling, technical analysis, moving average, modern portfolio theory.

1. Introduction

Investing in securities carries inherent risks, which stem from the unpredictable price volatility of these assets. Effective portfolio management and investment strategies can help mitigate such risks, enabling investors to achieve higher returns within acceptable risk parameters. However, there is no one-size-fits-all approach to portfolio management, and various theories have emerged over the years to guide investment decision-making. These include the Markowitz diversification theory, the modern portfolio theory, the capital management separation theory, and the creation of lending and borrowing portfolios. Numerous investment strategies exist, and investors typically select those that align with their personal investment goals and risk tolerance. Some popular strategies include value investing, growth investing, and balanced investing. Investors can also enhance their investment performance

and generate more opportunities for profit by utilizing various techniques and tools. Short selling, for instance, enables investors to profit from securities that are expected to decline in value. However, as with any investment strategy, short selling carries risks, and investors must carefully assess these before implementing such a technique.

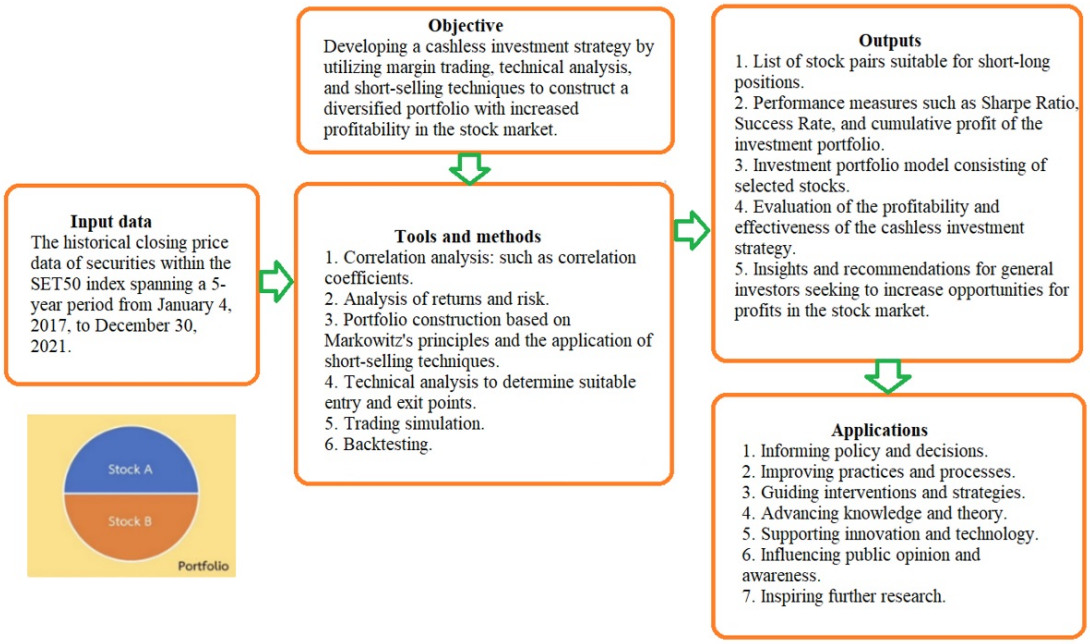


Figure 1 Diagram illustrating the research framework

This research seeks to explore the development of an efficient investment strategy that combines the application of the Markowitz diversification theory and short-selling techniques. A cashless investment strategy is also proposed and tested using a simple investment portfolio composed of two securities that exhibit inverse correlations. Daily closing prices of 41 securities traded in the SET50 index over five years from January 4, 2017, to December 30, 2021, are used for the analysis. The data is divided into four years for model development and one year for testing. The research framework is illustrated in Figure 1. This research provides a practical and effective investment strategy to help investors manage risk and achieve higher returns. By combining portfolio management theories with short-selling and cashless investment techniques, investors can maximize profit opportunities, even in bearish market conditions.

2. Literature Review

Investment strategies have evolved significantly with the emergence of cashless investment mechanisms, short-selling techniques, and portfolio optimization methodologies based on Modern Portfolio Theory (MPT). This section reviews existing research related to these aspects, providing insights into the relationship between securities, investment risk management, and technical analysis methodologies that contribute to the development of effective investment strategies.

Tilak et al. (2012) analyzed stock market seasonality and development using intraday data from the CAC40 index in the French stock market. Their study employed Multidimensional Scaling (MDS) to visualize market evolution, demonstrating fluctuations and correlations among different stocks. The findings highlight the significance of intraday patterns in investment decision-making, emphasizing the importance of analyzing short-term price movements.

Short-selling strategies play a crucial role in enhancing market liquidity and price efficiency. Diether et al. (2009) examined short-selling transactions in the US stock market, finding that these transactions constituted 24% of the NYSE market and 31% of the Nasdaq market. Their study concluded that short-selling enhances investment flexibility and contributes to price efficiency, aligning with daily stock price movements.

Technical analysis is fundamental in investment decision-making. Achelis (2001) provided an extensive overview of technical indicators, focusing on methodologies for identifying buy and sell signals, stock price trends, and price movement predictions. Exponential Moving Averages (EMA) were emphasized as a crucial tool for trend determination, aiding investors in optimizing market entry and exit points.

Markowitz (1952) pioneered the concept of portfolio optimization, introducing the Efficient Frontier, which highlights the importance of diversification for risk reduction. Subsequent studies by Bodie et al. (2002) expanded on these principles, focusing on asset allocation, market efficiency, and risk-adjusted returns. Their research underscores the role of beta coefficients in assessing securities' volatility relative to the overall market.

Investor behavior and financial education also influence investment performance. Grinblatt and Keloharju (2001) established a positive correlation between investor education and investment outcomes, demonstrating that informed investors make better decisions. Similarly, Barber et al. (2001) examined the effects of overconfidence on trading behavior, revealing that excessive trading often results in lower returns.

Empirical studies on the Thai stock market provide additional context for this research. The Stock Exchange of Thailand (2014) outlined financial market mechanisms and investment strategies relevant to Thai investors. **?** explored quantitative financial analysis, discussing the application of mathematical models in stock investment.

Fama and French (1993) investigated common risk factors in stock and bond returns, providing insights into asset pricing models. Engle (1982) introduced the Autoregressive Conditional Heteroscedasticity (ARCH) model, essential for financial market volatility analysis. Campbell (1997) contributed to financial econometrics, highlighting the importance of statistical methodologies in market analysis.

Additional research supports technical analysis methodologies. Angsanaakul (2020) examined insights into stock analysis, while Adrian and Rosenberg (2008) analyzed short- and long-term components of market risk. Lo and MacKinlay (1988) provided evidence against the random walk hypothesis in stock market prices.

Recent studies expand the scope of financial market analysis. Danila (2023) applied the GARCH-MIDAS approach to financial volatility in the Indonesian Islamic Stock Market. Pangestuti et al. (2022) investigated factors affecting firm value, while Kusumah et al. (2022) examined relationships between Asia-Pacific markets. Andini and Falianty (2022) explored financial system stability in ASEAN-5 economies.

This study extends prior research by investigating cashless investment strategies using short-selling techniques and MPT principles. Specifically, the study examines the linear relationship between securities in the SET50 index using correlation and beta coefficients. A portfolio comprising two negatively correlated stocks is constructed to optimize investment returns using short-selling strategies. Five years of daily closing price data from 41 securities in the SET50 index are analyzed, utilizing the cross-exponential moving average (Cross EMA) method to generate buy-sell signals. Portfolio performance is evaluated using the Sharpe Ratio, Success Rate, and Net Margin Profit, leading to the identification of 72 optimal investment portfolios ranked by profitability.

The findings provide valuable insights into the feasibility of cashless investment strategies, reinforcing the effectiveness of short-selling and portfolio diversification in portfolio construction. This study contributes to investment strategy development, highlighting the practical applications of MPT and technical analysis in optimizing investment performance. Future research opportunities and study limitations are discussed to enhance financial decision-making in the evolving investment landscape.

3. Preliminaries

This section provides fundamental concepts and key financial principles necessary for understanding the investment strategies and risk assessments in this research. It covers essential topics such as short selling, risk and return analysis, investment portfolio performance, and technical indicators like exponential moving averages. These concepts establish a foundation for the subsequent analysis and methodology used in the study.

3.1. Short selling

Short selling is a trading strategy where investors benefit from declining stock prices. It involves borrowing shares, selling them at a higher price, and repurchasing them at a lower price to make a profit. While short selling can be lucrative in a bear market, it should be approached cautiously due to the potential for rising stock prices. Additionally, fees associated with borrowing shares can impact potential profits. It's important to note that short selling is not universally permitted and is considered a controversial strategy as it involves profiting from a decline in stock value.

3.2. Risk and Return

Return: This research measures the return on investment solely based on the difference in stock prices without considering the stocks dividend payments. The calculation can be derived from the formula,

$$R_t^k = \frac{P_t^k - P_{t-1}^k}{P_{t-1}^k} \tag{1}$$

where R_t^k is the rate of return of the security k, and P_t^k is the price on date t of the security k.

Risk: The risk, in this case, refers to the chance that investors will not receive the expected returns, which can be calculated using the standard deviation,

$$\sigma_k = \sqrt{\frac{\sum_{t=1}^{n} \left(R_t^k - \overline{R_k}\right)^2}{n}} \tag{2}$$

where σ_k represents the standard deviation of the rate of return of investing in security k, R_t^k represents the rate of return on date t of security k, $\overline{R_k}$ represents the average rate of return of security k, and n represents the number of data points in the past for security k.

Systematic risk assessment: Systematic risk can be measured using the beta coefficient (β). Systematic risk refers to the possibility of unexpected events occurring and the impact that those events may have, which can affect a company broadly. The impact can vary depending on the specific nature of each company. Compared to the overall market risk, the beta coefficient can be used to measure a companys sensitivity to systematic risk. The calculation of beta coefficient (β_k) for security k can be computed as follows:

$$\beta_k = \frac{\operatorname{cov}(R_k, R_m)}{\operatorname{var}(R_m)} = \frac{\sigma_{km}}{\sigma_m^2} \tag{3}$$

where $\sigma_{km} = \operatorname{cov}(R_k, R_m)$ is the covariance between the rate of return on security i and the market rate of return, and $\sigma_m^2 = \operatorname{var}(R_m)$ is the variance of the market rate of return. Theoretically, the beta coefficient of the market (β_m) equals 1. Therefore, if $\beta_k > 1$, it means that security k has a greater rate of return change than the market rate, resulting in a higher systematic risk than the market. If $\beta_k < 1$, it means that security k has a smaller rate of return change than the market rate, resulting in a lower systematic risk than the market.

3.3. Return on investment and risk of an investment portfolio

Considering investment portfolio P, which consists of n securities. Define the symbol $W = \langle w_1, ..., w_n \rangle$ as a vector that represents the proportion of investment money in each security of the investment portfolio$P$, $E[R] = \langle E[R_1], ..., E[R_n] \rangle$ is a vector that represents the expected return of the investment portfolio P,

$$\text{cov} = [\sigma_{kj}]_{n \times n} \tag{4}$$

where

$$\sigma_{kj} = \text{cov}(R_k, R_j) = \frac{\sum_{i=1}^{n} \left(R_t^k - \overline{R_k}\right)\left(R_t^j - \overline{R_j}\right)}{n} \tag{5}$$

is the covariance matrix among the securities in portfolio P.

The return rate of the investment portfolio P, represented by $E[R_P]$, can be calculated from,

$$E[R_P] = W^T E[R] = \sum_{k=1}^{n} (w_k E[R_k]). \tag{6}$$

The risk of investment portfolio P, represented by σ_P can be calculated from

$$\sigma_P = \sqrt{W^T \text{cov}\, W} = \sqrt{\sum_{k}^{n} \sum_{j}^{n} (w_k w_j \sigma_{kj})} \tag{7}$$

when A^T refers to the transpose of matrix A.

3.4. Analysis of correlation coefficient of returns

The Correlation Coefficient of the return rate is an indicator of the direction and level of correlation between each pair of variables, which in this case refers to the return rate or the price change rate of each security, indicating how much the return rate moves in the same or opposite direction, and to what degree, as the price changes. The Correlation Coefficient between securities k and j is represented by ρ_{kj} and calculated by

$$\rho_{kj} = \frac{\sigma_{kj}}{\sigma_k \sigma_j} \tag{8}$$

where σ_{kj} is the covariance between the prices of securities k and j, σ_k and σ_j are the standard deviations of the prices of securities k and j, respectively. If $\rho_{kj} \to +1$, it indicates that the return rate or price change rate of securities k and j move in the same direction and have a complete correlation. If $\rho_{kj} \to -1$, it indicates that the return rate or price change rate of securities k and j move in opposite directions and have a complete negative correlation. If $\rho_{kj} \to 0$, it indicates that the return rate or price change rate of securities k and j do not have a linear correlation.

3.5. Markowitz diversification

The principle of Markowitz diversification, or modern portfolio theory, is a concept of investment diversification that allocates investment funds to suitable securities, developed by Harry Markowitz, under the assumption that the market is perfectly competitive. The principle can be summarized as follows:

Suppose that investment portfolio P consists of securities A_1, $A_2, ..., A_n$, and w_k represents the weight or proportion of the investment. Let $E[R_k]$ and σ_k be the expected return and risk of security k , $k = 1, ..., n$, respectively.

1) Investors do not know the exact returns of securities or specific groups of securities, therefore they must consider possible returns or expected returns using the standard deviation as a measure of risk based on the distribution of expected returns. From formulas (6) and (7), the boundaries of the expected return and risk of the investment portfolio can be determined as follows: The range of expected returns,

$$\min_{W\in\mathbb{R}^n}\left(W^T E\left[R\right]\right) \leq E\left[R_P\right] \leq \max_{W\in\mathbb{R}^n}\left(W^T E\left[R\right]\right) \tag{9}$$

The range of risk,

$$\min_{W\in\mathbb{R}^n}\sqrt{W^T \operatorname{cov} W} \leq \sigma_P \leq \max_{W\in\mathbb{R}^n}\sqrt{W^T \operatorname{cov} W} \tag{10}$$

2) To reduce the overall risk of the investment portfolio, investors should diversify their investments into securities or groups of securities that are not correlated or negatively correlated with each other, as determined by the correlation coefficient between each security ($\rho \leq 0$).
3) Under the assumption of equal expected returns (R_0), investors aim to find the portfolio with the lowest possible risk, which corresponds to the minimum variance problem: Minimize:

$$\text{Minimize:} \quad \sigma_P = \sqrt{W^T \operatorname{cov} W} \tag{11}$$

$$\text{Subject to:} \quad \begin{cases} W^T E\left[R\right] \geq R_0 \\ \sum_{i=1}^{n} w_i = 1. \end{cases} \tag{12}$$

4) Under the same level of risk tolerance σ_0, investors aim to find a portfolio that provides the highest expected return, which is consistent with the problem of maximizing returns:

$$\text{Maximize:} \quad E\left[R_P\right] = W^T E\left[R\right] \tag{13}$$

$$\text{Subject to:} \quad \begin{cases} \sqrt{W^T \operatorname{cov} W} \leq \sigma_0 \\ \sum_{i=1}^{n} w_i = 1 \end{cases} \tag{14}$$

where $w_k > 0$ means an investor opens a long position in security k, $w_k = 0$ means an investor does not invest in security k,and $w_k < 0$means an investor opens a short position by borrowing security k.

3.6. Exponential moving average

Exponential Moving Average (EMA) is a popular tool in technical analysis, giving more weight to recent price data. It reacts quickly to market changes, making it useful for short-term trading. EMA is calculated using a selected period and a smoothing factor. Traders use EMA crossovers and their relationship with price to generate trading signals. It helps capture short-term price movements and provides insights into market trends. The average of n days of Exponential Moving Average at a specific date t, represented by the symbol $EMA_n(t)$, can be calculated using the following formula,

$$EMA_n(t) = \frac{2}{n+1}\left(P_{t-1} - EMA_n(t-1)\right) + EMA_n(t-1), \quad t > n \tag{15}$$

where $EMA_n(n) = \frac{\sum_{i=1}^{n} P_i}{n}$, and P_t represents the close price on day t. The buy and sell signals are determined by the crossover of two moving average lines: the short-term moving average line ($EMA_{short}(t)$) and the long-term moving average line ($EMA_{long}(t)$). The signals are generated as follows:

- A buy signal is generated when the short-term moving average line ($EMA_{short}(t)$) crosses above the long-term moving average line ($EMA_{long}(t)$), as illustrated in Figure 2.
- A sell signal is generated when the short-term moving average line ($EMA_{short}(t)$) crosses below the long-term moving average line ($EMA_{long}(t)$), as illustrated in Figure 2.

In this research, $EMA_5(t)$ is used as the short-term moving average line, while $EMA_{10}(t)$ is used as the long-term moving average line.



Figure 2 Illustrates the determination of buy (B) and sell (S) signals through the crossover of the short-term and long-term moving average lines

3.7. Measurement of investment portfolio performance

Evaluating the performance of an investment portfolio allows investors to assess its effectiveness. In this research, three performance indicatorsSharpe ratio, success rate, and cumulative profit rateare employed to measure the portfolio's efficiency.

Trading Agreement: When initiating a long position, the investor purchases a specified quantity of stocks upon receiving a buy signal. Subsequently, upon receiving a sell signal, the investor is required to sell all the purchased stocks. Conversely, when entering a short position, the investor borrows and sells a specified quantity of stocks (short selling) upon receiving a sell signal. Then, upon receiving a buy signal, the investor must repurchase all the borrowed stocks.

1) **Sharpe Ratio:** To measure investment portfolio performance, various metrics are commonly used, including the Sharpe Ratio, Treynor Ratio, and Jensen's Model. In this study, the Sharpe Ratio is chosen as it evaluates risk-adjusted returns. A higher Sharpe Ratio indicates better returns relative to overall risk. It can be calculated using a specific formula.

$$SR_P = \frac{R_P - R_f}{\sigma_P} \tag{16}$$

when R_P represents the portfolio's rate of return, R_F represents the risk-free rate of return, and σ_P represents the portfolio's risk.

2) **Success Rate:** Success Rate in trading refers to the ratio that indicates the proportion of profitable trades compared to the total number of trades. It represents the percentage of successful trades, where a successful trade implies making a profit (short sell $>$ buyback). The Success Rate (SuR) can be calculated using the following equation.

$$SuR\ (\%)\ = \frac{\#(sell > buy)}{\#(buy\ \ \&\ \ sell)} \times 100 \tag{17}$$

when $\#(sell > buy)$ represents the number of profitable trades, and $\#(buy \ \ \& \ \ sell)$ represents the total number of trades.

3) **Cumulative profit rate:** The cumulative profit rate (CPR) of an investment portfolio is a measure of its ability to generate profits over the investment period. It is calculated as the ratio of cumulative profits of the investment portfolio compared to the initial borrowed capital.

$$CPR\ \% = \frac{\text{cumulative profit}}{\text{cost of short selling}} \times 100. \tag{18}$$

4. Research Methodology and Steps

This research is divided into 7 main steps, as follows:

Step 1: Stock Data Collection,

Step 2: Calculation of Beta, Expected Return, and Risk Measures,

Step 3: Analysis of Inter-asset Correlations,

Step 4: Construction of Investment Portfolio,

Step 5: Simulating Investment using Borrowing and Short Signals from Technical Indicators,

Step 6: Evaluation of Portfolio Performance, and

Step 7: Ranking of Investment Portfolios.

The research steps can be summarized in Figure 3. Each step is further detailed as follows:

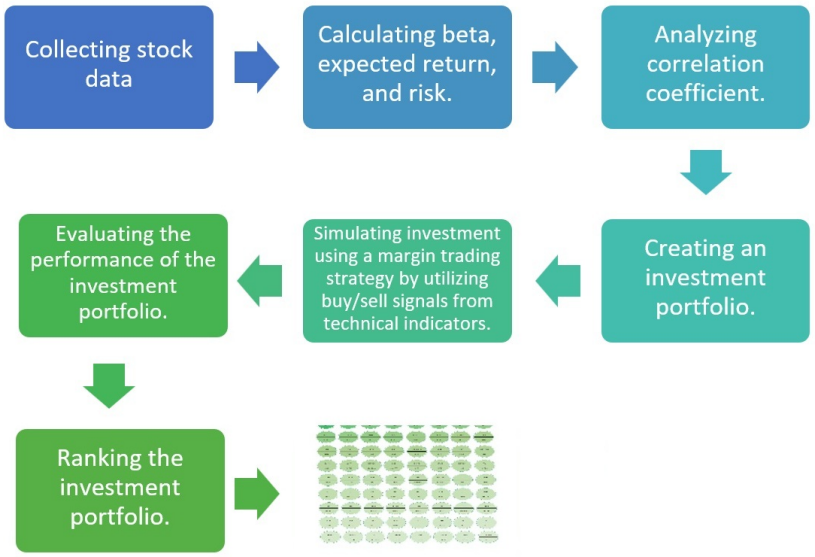


Figure 3 Summarizes the steps of the operating procedure

Step 1: Stock Data Collection

This research conducts a case study on stocks in the SET50 index. The data is collected from January 4, 2017, to December 30, 2021, ensuring comprehensive historical data. The collected data includes the closing prices of 41 stocks and the SET50 index. The data is divided into two sets:

- **Dataset 1:** Complete historical data from January 4, 2017, to December 30, 2020, used for constructing the investment portfolio model for the borrowing and short-selling strategy.
- **Dataset 2:** Complete historical data from January 4, 2021, to December 30, 2021, used for testing the investment portfolio model for the borrowing and short-selling strategy.

Calculate the daily returns from the closing prices in Dataset 1, where $R_t^k = \frac{P_t^k - P_{t-1}^k}{P_{t-1}^k}$, $k = 1, 2, ..., 41$, and $R_t^m = \frac{P_t^{SET50} - P_{t-1}^{SET50}}{P_{t-1}^{SET50}}$.

Step 2: Calculation of Beta

Calculate the beta values from $\beta_k = \frac{\text{cov}(R_k, R_m)}{\text{var}(R_m)} = \frac{\sigma_{km}}{\sigma_m^2}$, when $R_k = R_t^k$ and $R_m = R_t^m$, using Dataset 1. The results are displayed in Table 1.

Step 3: Analysis of Inter-asset Correlations

Calculate the inter-asset correlation matrix, $\rho_{kj} = \frac{\sigma_{kj}}{\sigma_k \sigma_j}$, using the daily data from each month in Dataset 1. The resulting matrix will represent the monthly inter-asset correlation and will be presented in Table 2.

Step 4: Construction of Investment Portfolio

In this step, we create an investment portfolio consisting of 2 securities, where each pair must have a negative inter-asset correlation value of zero from the monthly inter-asset correlation matrix. The total number of pairs with a combined inter-asset correlation of at least 40% (approximately 19 months out of 48 months) is 72 portfolios. The results are displayed in Table 3.

Step 5: Simulating Investment Using Borrowing and Short-Selling Strategy with Technical Indicator Signals

Simulate the trading using the borrowing and short-selling strategy for each of the 72 portfolios. The process starts with:

Step 5.1: Selection of Stocks for the Strategy

The stocks chosen as the primary assets for the borrowing and short-selling strategy are based on their beta values. Specifically, if $\beta_i < \beta_j$, stock i is designated as the stock to be short selling, indicating a negative beta value. Furthermore, stock i will be selected as the benchmark for opening short-selling positions and setting trading signals. Conversely, stock j is designated as the stock to be held long or bought, representing a positive beta value.

Step 5.2: Simulate Trading

Simulate trading using dataset 2 under the specified trading conditions as follows:

- Set the initial capital for short-selling positions to 1,000 Baht (indicating that the investor must borrow stock j and sell it for 1,000 Baht). The borrowing fee is set at 4.95% per year.
- The number of shares traded can include decimal values.
- All proceeds from short-selling stock i will be used to purchase stock j.
- Set the trading signals based on the intersection of lines x and y for the stock with an open short-selling position. Specifically: - Establish a short-selling signal when the short-term moving average line $EMA_5(t)$ crosses below the long-term moving average line $EMA_{10}(t)$. - Establish a buy-back signal when the short-term moving average line $EMA_5(t)$ crosses above the long-term moving average line $EMA_{10}(t)$.

Step 6: Evaluation of Investment Portfolio Performance To evaluate the performance of all 72 portfolios, follow these steps:

Step 6.1: Calculate the Sharpe ratio The Sharpe ratio, $SR_P = \frac{R_P - R_F}{\sigma_P}$, where $R_F = 2.26\ \%$ is the annual average return of government bonds with maturities of 3 years, 4 years, 5 years, 10 years, and 15 years in the year 2021. $R_P$and σ_P represent the average and standard deviation of the portfolio returns, respectively.

Step 6.2: Calculate the Success Rate The Success Rate, $SuR\ (\%) = \frac{\#(\text{sell}>\text{buy})}{\#(\text{buy \& sell})} \times 100$.

Step 6.3: Calculate the Cumulative Profit Rate The Cumulative Profit Rate, $CPR\ \% = \frac{\text{cumulative profit}}{\text{cost of short selling}} \times 100$. The results are presented in Table 4.

Step 7): Ranking Investment Portfolios Rank the investment portfolios among the 72 portfolios by ordering them based on the cumulative profit rate $CPR\ \%$ and success rate $SuR\ (\%)$ display it using a color-coded bar chart to facilitate ease of use for investors. The results are presented in Figure 6.

5. Numerical Results

The results obtained from the operation conducted according to step 4 are as follows: The results from calculating the beta value of securities in the SET50 index group, consisting of 41 securities, are shown in Table 1.

Table 1 The beta values of securities in the SET50 index group with complete and accurate data for 4 years from January 4, 2017, to December 30, 2020. The table consists of a total of 41 securities

Stock	Beta	Stock	Beta	Stock	Beta	Stock	Beta	Stock	Beta
IVL	1.77	PTTEP	1.61	PTTGC	1.59	TOP	1.58	MINT	1.48
BANPU	1.44	PTT	1.38	IRPC	1.38	JMART	1.38	MTC	1.37
EA	1.36	CPN	1.36	GPSC	1.35	KCE	1.35	CBG	1.30
KTC	1.26	KBANK	1.25	HMPRO	1.12	TRUE	1.09	JMT	1.08
GLOBAL	1.06	KTB	1.05	EGCO	1.02	BEM	0.99	LH	0.98
BBL	0.95	CPF	0.95	BLA	0.94	SCC	0.91	BDMS	0.88
BH	0.76	INTUCH	0.69	ADVANC	0.63	CPALL	0.63	TU	0.56
SAWAD	1.45	TTB	1.36	AOT	1.28	DTAC	1.06	BTS	0.97
TISCO	0.85								

The beta values of the 41 securities listed in Table 1 will be used to determine the benchmark stocks for implementing short-selling strategies in each of the 72 portfolios. The securities with the lowest beta values in each portfolio will be designated as the benchmark stocks for opening short-selling positions and setting trading signals. The results of the correlation analysis for the 41 securities are presented in Figure 4.



Figure 4 The correlation matrix of the 41 securities in the SET50 index group for January 2017 (01/2017) (partial data)

ADVANC	BLA	2017	-0.64	0.81	0.04	-0.2	-0.14	0.18	-0.76	-0.09	0.24	-0.57	-0.55	-0.79
		2018	-0.15	-0.52	-0.72	0.72	0.57	0.83	0.72	0.59	0.49	0.83	-0.03	0.62
		2019	0.59	-0.47	-0.39	0.41	0.31	-0.62	-0.22	-0.8	0.2	-0.7	-0.51	0
		2020	0.28	0.17	0.32	0.26	0.36	0.63	-0.03	0.02	-0.77	0.6	0.33	0.78
ADVANC	GLOBAL	2017	0.37	-0.87	-0.2	-0.51	-0.44	-0.8	-0.76	0.66	0.5	0.62	0.1	-0.27
		2018	0.05	-0.12	0.38	0.25	0.06	0.13	0.49	0.12	0.52	0.75	-0.38	0.34
		2019	-0.15	-0.19	0.53	0.61	0.19	0.58	-0.3	-0.65	0.39	-0.38	-0.61	-0.62
		2020	0.49	-0.08	-0.1	0.34	-0.52	0.11	-0.53	-0.74	0	0.11	0.3	0.06
ADVANC	JMT	2017	-0.64	0.45	0.28	0.52	-0.38	0.78	0.69	0.29	0.14	0.83	0.32	-0.77
		2018	-0.06	-0.45	0.35	0.46	0.78	0.41	-0.57	0.39	-0.19	0.82	-0.64	0.61
		2019	0.15	0.02	0.06	0.28	0.53	0.85	0.39	0.28	0.48	0.68	-0.6	-0.48
		2020	-0.11	-0.06	0.01	0.32	-0.5	-0.46	-0.3	-0.67	-0.07	0.6	-0.62	-0.58
ADVANC	KCE	2017	-0.77	-0.61	0.71	-0.09	-0.3	0.7	-0.55	-0.2	0.56	-0.62	0.85	-0.01
		2018	0.16	-0.2	0.55	0.47	0.09	-0.85	0.25	-0.38	-0.11	0.83	0.82	0.38
		2019	-0.63	0.19	-0.56	0.24	-0.15	0.65	-0.23	0.14	0.1	-0.79	-0.71	0.42
		2020	0.77	0.39	0.21	0.19	-0.2	-0.54	-0.53	-0.18	-0.6	-0.21	-0.45	0.51
AOT	KCE	2017	-0.83	0.56	0.48	-0.24	-0.35	0.62	-0.84	-0.36	0.77	0.26	-0.18	-0.2
		2018	0.17	-0.34	0.03	0.19	0.08	-0.83	-0.76	-0.54	-0.5	0.63	0.26	0.45
		2019	0.29	0.46	0.15	0.27	0.76	0.69	0.61	0.55	0.19	-0.83	-0.23	0.01
		2020	0.36	-0.36	0.97	0.64	0.38	-0.48	-0.76	0.76	0.24	-0.71	-0.53	0.43
BANPU	JMT	2017	-0.08	0.7	0.49	-0.04	0.74	-0.48	0.01	-0.11	-0.25	0.19	0.13	-0.74
		2018	0.48	-0.73	-0.09	-0.09	-0.34	0.62	-0.63	0.65	0.26	0.94	-0.76	0.89
		2019	0.55	-0.55	0.07	0.53	0.32	0.34	-0.66	-0.18	0.5	-0.74	-0.71	-0.49
		2020	-0.15	0.82	0.79	-0.04	0.8	-0.34	-0.73	0.22	0.21	-0.09	-0.3	0.42
BBL	CBG	2017	-0.34	0.54	-0.38	0.3	0.37	-0.62	-0.56	-0.45	-0.26	0.33	-0.76	0.65
		2018	-0.51	-0.2	0.02	0.42	-0.07	0.61	0.48	0.34	0.42	0.19	-0.12	0.84
		2019	0.84	-0.21	0.37	-0.31	-0.58	0.06	-0.75	0.3	-0.66	-0.19	-0.05	0.13
		2020	-0.73	0.87	0.88	0.24	0.17	-0.49	-0.73	-0.39	0.23	0.01	0.48	0.4
BBL	JMT	2017	-0.64	-0.41	0.28	0.07	0.47	0.73	0.08	-0.15	0.32	0.75	-0.03	0.34
		2018	0.36	-0.44	-0.18	0.64	-0.04	0.7	-0.37	-0.08	-0.5	0.34	-0.83	0.73
		2019	0.65	-0.24	-0.1	-0.81	-0.19	-0.25	-0.66	-0.18	-0.52	-0.04	0.01	0.1
		2020	-0.32	0.88	0.89	0.39	0.28	-0.58	-0.62	-0.03	0.02	0.43	-0.5	-0.5
BDMS	DTAC	2017	-0.28	-0.4	0.73	0.17	-0.43	0.29	-0.8	-0.49	0.03	-0.63	-0.58	-0.51
		2018	0.28	-0.06	-0.07	-0.37	-0.81	0.26	0.65	-0.22	-0.6	-0.11	-0.24	0.51
		2019	0.38	0.42	0.17	-0.49	-0.82	-0.09	-0.52	-0.54	-0.38	-0.01	-0.79	0.25
		2020	0.41	0.88	0.43	0.62	0.85	0.81	0.03	0.7	0.72	0.53	0.83	0.93

Figure 5 Investment portfolios consist of 2 securities, where each pair must have a correlation coefficient of zero based on the correlation matrix of cumulative monthly returns, not less than 40% (partial results)

The results of constructing investment portfolios consisting of 2 securities, where each pair must have a negative correlation coefficient of at least zero based on the correlation matrix of cumulative monthly returns, not less than 40% (approximately 19 months out of a total of 48 months), can generate a total of 72 portfolios in this research.

From the simulated trading using the short selling technique in each of the 72 portfolios, a reference stock is selected for each portfolio based on having a lower beta and being eligible for short selling. The initial capital for opening a short position is set at 1,000 baht, with a borrowing fee of 4.95% per year. The number of shares traded can be in decimal form, and the funds obtained from short selling are used to purchase another stock within the portfolio. The trading signals are determined based on the intersection of lines $EMA_5(t)$ and $EMA_{10}(t)$ in the correlation matrix. The results are shown in Figure 5.

The results of evaluating the performance of all 72 investment portfolios are as shown in Table 4 (partial display). The Sharpe ratio in Table 4 indicates the excess return per unit of overall risk. If the Sharpe ratio of a security is higher than the Sharpe ratio of the market, it signifies better performance than the market. Conversely, if the Sharpe ratio of a security is lower than the Sharpe ratio of the market, it indicates inferior performance compared to the market.

The result of ranking investment portfolios in order from the portfolio with the highest cumulative returns to the portfolio with the lowest cumulative returns is presented in Figure 6.

Table 2 Results from simulated trading using the short-selling technique in some of the 72 portfolios

ADVANC, BLA

Times	Open date	Status	Stock	Units	Open price	Close date	Close price	Value	Action	Return	Total profit	Cumulative profit	Success rate
1	18/1/2021	Short	ADVANC	5.59	179.00	8/2/2021	173.00	969.27	Repurchase	78.44	407.02	42.82%	50%
		Long	BLA	41.49	24.10		25.25	1047.72	Sold short				
2	18/2/2021	Short	ADVANC	5.76	173.50	9/3/2021	168.50	971.18	Repurchase	108.82			
		Long	BLA	40.00	25.00		27.00	1080.00	Sold short				
3	7/4/2021	Short	ADVANC	5.88	170.00	16/4/2021	168.00	988.24	Repurchase	-6.93			
		Long	BLA	7.38	26.75		26.25	981.31	Sold short				
4	28/4/2021	Short	ADVANC	5.83	171.50	1/6/2021	169.50	988.34	Repurchase	259.19			
		Long	BLA	39.60	25.25		31.50	1247.52	Sold short				
5	1/6/2021	Short	ADVANC	5.83	171.50	29/6/2021	170.50	994.17	Repurchase	-2.79			
		Long	BLA	34.48	29.00		28.75	991.38	Sold short				
6	8/10/2021	Short	ADVANC	5.17	193.50	1/11/2021	188.50	974.16	Repurchase	-29.72			
		Long	BLA	31.75	31.50		29.75	944.44	Sold short				

ADVANC , GLOBAL

Times	Opening date	Status	Stock	Units	Opening price	Closing date	Closing price	Value	Action	Portfolio return on investment	Total profit	Cumulative profit	Success rate
1	18/1/2021	Short	ADVANC	5.59	179.00	8/2/2021	173.50	969.27	Repurchase	204.75	278.07	29.26%	50%
		Long	GLOBAL	61.27	16.32		19.16	1174.02	Sold short				
2	18/2/2021	Short	ADVANC	5.76	173.50	9/3/2021	168.50	971.18	Repurchase	98.93			
		Long	GLOBAL	52.71	18.97		20.30	1070.11	Sold short				
3	7/4/2021	Short	ADVANC	5.88	170.00	16/4/2021	168.00	988.24	Repurchase	54.70			
		Long	GLOBAL	49.93	20.03		20.89	1042.94	Sold short				
4	28/4/2021	Short	ADVANC	5.83	171.50	1/6/2021	169.50	988.34	Repurchase	-28.04			
		Long	GLOBAL	46.17	21.66		20.80	960.30	Sold short				
5	22/6/2021	Short	ADVANC	5.83	171.50	29/6/2021	170.50	994.17	Repurchase	-27.14			
		Long	GLOBAL	49.21	20.32		19.65	967.03	Sold short				
6	8/10/2021	Short	ADVANC	5.17	193.50	1/11/2021	188.50	974.16	Repurchase	-25.12			
		Long	GLOBAL	48.08	20.80		19.74	949.04	Sold short				

Table 3 The results of evaluating the performance of investment portfolios using the Sharpe ratio (partial display)

Portfolio	Short	Long	Return	Standard Deviation	Sharpe Ratio
1	TU	JMT	56.27%	22.53%	2.40
2	LH	KCE	44.84%	20.63%	2.06
3	DTAC	KCE	58.61%	25.03%	2.25
4	DTAC	GLOBAL	30.63%	21.03%	1.35
5	ADVANCE	KCE	54.31%	21.41%	2.43
6	KCE	JMART	95.63%	30.09%	3.10
7	HMPRO	KCE	43.41%	22.14%	1.86
8	CBG	KCE	43.94%	26.40%	1.58
9	AOT	KCE	40.86%	22.06%	1.75
10	EGCO	KCE	36.20%	20.59%	1.65
63	BH	KTC	11.71%	25.88%	0.37
64	BH	MTC	11.59%	20.72%	0.45
65	CPF	MTC	14.34%	19.43%	0.62
66	BTS	MTC	3.29%	20.50%	0.05
67	BDMS	MTC	7.99%	18.98%	0.30
68	EGCO	KTC	12.43%	23.98%	0.42
69	BOMS	TOP	2.79%	18.02%	0.03
70	TISCO	CPF	7.38%	14.14%	0.36
71	BH	SAWAD	8.58%	22.62%	0.28
72	BEM	KTC	3.81%	25.14%	0.06
	Market		12.87%	11.73%	0.90

Table 4 Results from the evaluation of portfolio performance using Cumulative Profit Rate (%), Success Rate (%), and Sharpe Ratio (partial display)

Portfolio	Short	Long	Cumulative profit (Bath)	Accumulated profit(%)	Success rate (%)	Sharpe Ratio
1	TU	JMT	816.65	85.92%	100%	2.40
2	LH	KCE	700.84	73.73%	100%	2.06
3	DTAC	KCE	653.95	68.80%	100%	2.25
4	DTAC	GLOBAL	646.61	68.03%	83%	1.35
5	ADVANC	KCE	635.78	66.89%	83%	2.43
6	KCE	JMART	621.38	65.37%	60%	3.10
7	HMPRO	KCE	599.08	63.03%	100%	1.86
8	CBG	KCE	574.94	60.49%	80%	1.58
9	AOT	KCE	569.19	59.88%	100%	1.75
10	EGCO	KCE	559.62	58.88%	86%	1.65
60	KTB	JMART	145.46	15.30%	75%	2.34
61	JMT	IVL	144.51	15.20%	40%	1.55
62	TU	CBG	143.36	15.08%	100%	0.96
63	BH	KTC	129.05	13.58%	75%	0.37
64	BH	MTC	103.44	10.88%	75%	0.45
65	TISCO	CPF	102.68	10.80%	60%	0.36
66	BDMS	TOP	101.78	10.71%	60%	0.03
67	BH	SAWAD	101.39	10.67%	50%	0.28
68	EGCO	KTC	101.19	10.65%	57%	0.42
69	BEM	KTC	101.05	10.63%	20%	0.06
70	CPALL	MTC	95.86	10.09%	67%	0.62
71	BTS	MTC	89.11	9.37%	67%	0.05
72	BDMS	MTC	74.40	7.83%	60%	0.30

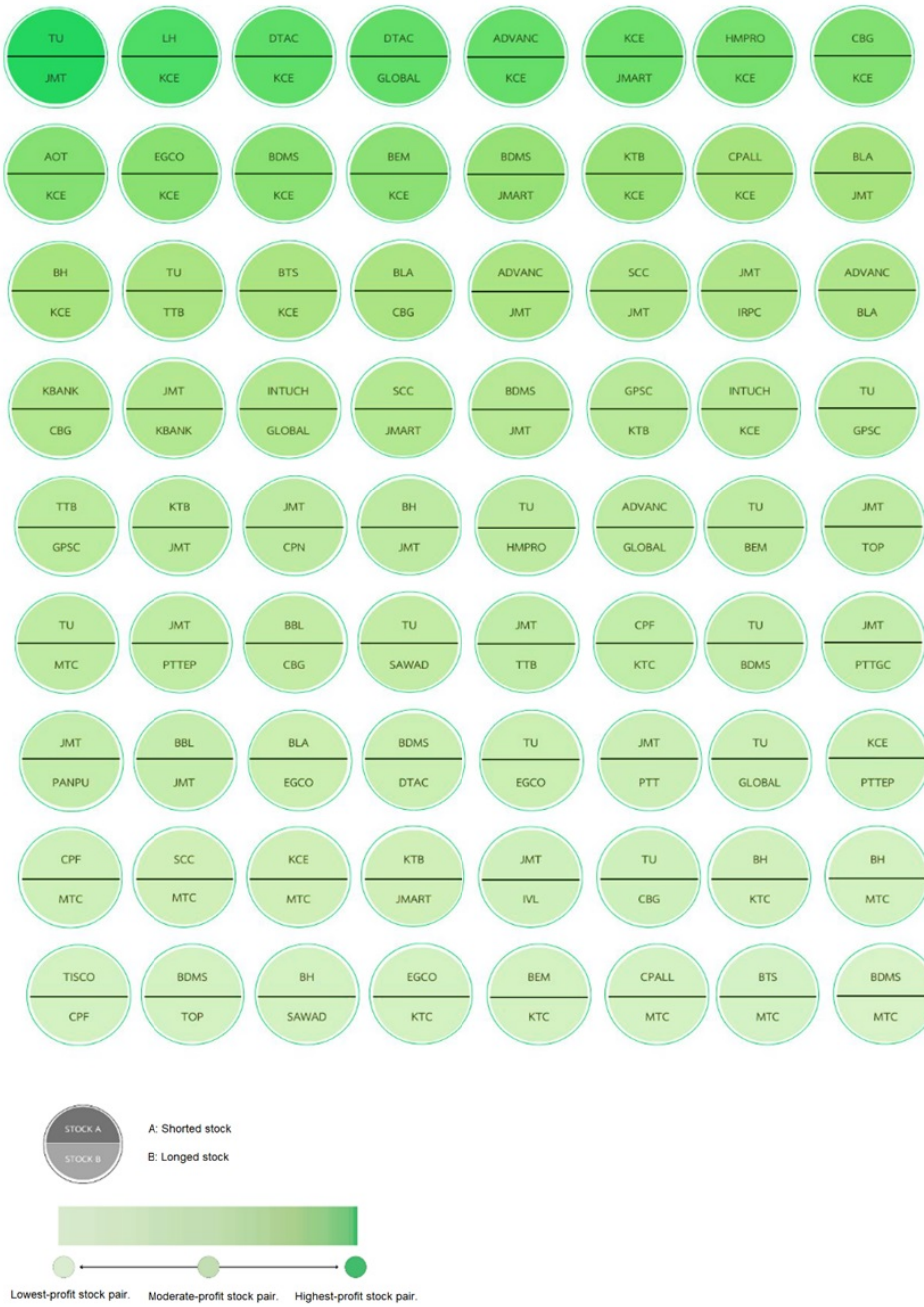


Figure 6 Ranking investment portfolios by arranging them in order from portfolios with high cumulative returns to portfolios with low cumulative returns

6. Application of Investment Portfolio Management Results

The Two-fund Separation Theorem proposes the division of a portfolio into two components: a risk-free asset and risky assets. By utilizing the findings obtained from this theorem, investors can effectively allocate funds among 72 portfolios by combining risk-free assets such as government bonds with risky portfolios. Through the evaluation of portfolio performance using metrics such as Cumulative Profit Rate (%), Success Rate (%), and Sharpe Ratio (as shown in Table 4 and Figure 6)), investors can diversify their portfolio and manage risk while still achieving their desired returns. This approach empowers investors to make well-informed decisions based on their risk preferences and return expectations. By comprehending this example, investors can optimize their portfolio allocation and potentially enhance their investment outcomes.

Example 1 An investor selects a balanced portfolio composed of two pairs: Pair1: TU (short) & JMT (long), Pair2: LH (short) & KCE (long). Additionally, they include a bond investment with an AAA rating that offers a 5% annual return. The condition is that 50% of the investment must be allocated to the bond. The simulation of portfolio investment can be based on the data and conditions provided in Table 5.

Table 5 Expected Returns, Risk of Securities Pair1 and Pair2 (from Figure 6), and Example of Investment Portfolio Allocation consisting of Securities Pair1, Pair2, and Bond: AAA

Stock	Pair 1	Pair 2	AAA
Expected return $E[R]$ (per year)	56.27%	44.85%	5.00%
Risk σ (per year)	22.53%	20.63%	0.00%
Investment weight W (per year)	38%	12%	50%
Expected return of portfolio$E[R_P]$ (per year)	29.22%		
Risk of portfolio σ_P (per year)	10.00%		

In this research, a total of 10,000 investment portfolios will be simulated to estimate the approximate range of returns and risks for the investment portfolios. The results will be shown in Table 6.

Table 6 presents the overall boundaries of return and risk obtained from this simulation, representing the minimum and maximum values of the feasible set

Boundaries	σ_P (per year)	$E[R_P]$ (per year)
Minimum	5.38%	27.61%
Maximum	11.26%	30.63%

When plotted on a graph, showing the feasible investment portfolio (Feasible Portfolio) as depicted in Figure 7.



Figure 7 Illustration of the investment portfolio available from the simulation of 10,000 portfolios

An example of portfolio allocation to achieve the highest expected returns at various levels of risk is shown in Table 7.

Table 7 provides the corresponding investment proportions that achieve the maximum expected return at various risk levels, derived from portfolios along the upper boundary of Figure 7

	Risk levels	5.38%	6%	8%	10%	11%	11.26%
	Expected returns	27.61%	28.42%	29.42%	30.19%	30.54%	30.63%
Investment proportions	Pair 1	24%	31%	39%	46%	49%	50%
	Pair 2	26%	19%	11%	4%	1%	0%
	Bond: AAA	50%	50%	50%	50%	50%	50%

An example of a portfolio allocation with the minimum risk at various expected return levels is shown in Table 8.

Table 8 presents the investment allocations that achieve the minimum risk for various levels of target return, corresponding to portfolios along the lower boundary of Figure 7

	Expected return	27.61%	28%	29%	30%	30.63%
	Risk exposure	5.38%	5.53%	7.04%	9.49%	11.26%
Investment proportions	Pair 1	24%	27%	36%	44%	50%
	Pair 2	26%	23%	14%	6%	0%
	Bond: AAA	50%	50%	50%	50%	50%

7. Summary of Study Findings and Evaluation of Results

This section summarizes the key findings obtained from the empirical analysis of the proposed short-selling investment strategy using negatively correlated stock pairs in the SET50 market. It presents both the main results derived from the simulation and the interpretation of those results in the context of portfolio performance, risk-return characteristics, and investment decision-making implications.

7.1. Conclusion from experimental results

From the study on cashless investment strategies, employing margin trading techniques and technical analysis, the following conclusions can be drawn:

1) The study constructed simple investment portfolios consisting of two stocks using daily closing price data of 41 securities listed in the SET50 index from January 4, 2017, to December 30, 2021. A total of 820 possible stock pairs were analyzed through rolling correlation matrices. From this, 72 pairs with consistently negative monthly correlation over the 48-month period were selected for portfolio simulation under short-selling strategies.

2) The best-performing portfolio was TU and JMT, which generated a total profit of 816.65 baht, an accumulated return of 85.92%, a 100% success rate, and a Sharpe ratio of 2.40. TU had a beta value of 0.56, which is significantly lower than the market average (beta = 1), while JMT had a beta of 1.08, which is close to the market level. These beta characteristics indicate different sensitivities to market movement, with TU being more defensive. This pairing proved highly effective under the short-selling strategy. The second and third best-performing pairs were LHKCE and DTACKCE, with accumulated returns of 73.73% and 68.80%, and Sharpe ratios of 2.06 and 2.25, respectively. On the other hand, the lowest-performing portfolio, BDMS and MTC, yielded only 7.83% accumulated profit, with a 60% success rate and a Sharpe ratio of 0.30.

7.2. Discussion and recommendations

1) The selection of negatively correlated stock pairs allowed for effective short-selling strategies in a cashless portfolio context. However, it should be noted that some portfolios generated lower returns, suggesting that not all negatively correlated pairs yield optimal outcomes under all market conditions.
2) The fixed 40% threshold used for selecting negative correlation pairs may not be universally optimal. Future studies should conduct a sensitivity analysis with varying thresholds (e.g., 30%, 50%, 60%) to assess the impact on portfolio performance and improve the robustness of the selection process.
3) A correlation-based sensitivity analysis was performed by simulating asset pairs with varying correlation levels (+0.9, +0.3, 0, -0.5, -0.9). The results show that more negative correlation leads to higher Sharpe ratios and lower portfolio risk, whereas positive correlation increases volatility. These findings emphasize the importance of correlation in constructing risk-efficient portfolios.
4) While this study used a cashless margin-based investment approach, the results suggest that investors may extend the model to mixed strategies that include both short-selling and long positions using real capital. This can allow for better diversification and risk-return optimization tailored to individual investor preferences.
5) Market conditions during the study period, particularly the economic downturn starting in late 2019 due to COVID-19, may have influenced portfolio performance. Although the proposed approach remained profitable overall, future studies may incorporate macroeconomic variables or adaptive models that respond to shifting market regimes.

Acknowledgements

We sincerely thank the Faculty of Science and Technology Research Fund (SciGR 30/2567) and the Thammasat University Research Unit in Mathematical Sciences and Applications for their financial support. Special appreciation goes to the Department of Mathematics and Statistics, Thammasat University, for their invaluable guidance and encouragement.

References

Achelis SB. Technical analysis from A to Z. New York: McGraw-Hill; 2001. p.199-200.

Adrian T, Rosenberg J. Stock returns and volatility: pricing the short-run and long-run components of market risk. J Finance. 2008; 63(6): 2997-3030.

Andini SA, Falianty TA. Property price, capital inflows, and financial system stability in ASEAN-5 economies: a simultaneous analysis. J Indones Econ Bus. 2022; 37(1): 1-16.

Angsanaakul S. The wonders of technical analysis: insights into stock analysis. Bangkok: CEDU Publication; 2020.

Barber BM, Odean T. Boys will be boys: gender, overconfidence, and common stock investment. Q J Econ. 2001; 116(1): 261-92.

Bodie Z, Kane A, Marcus AJ. Portfolio management. New York: McGraw-Hill/Learning Solutions; 2015. p.811.

Boonprasurt P, Sampaokit P, Witayakiattilerd W. MACD indicator with the modified signal line and trading weight inference in fuzzy environment. Thail Stat. 2022; 20(1): 98-123.

Campbell JY, Lo AW, MacKinlay CA. The econometrics of financial markets. Princeton (NJ): Princeton University Press; 1997.

Danila N. Revisiting financial volatility in the Indonesian Islamic stock market: GARCHMIDAS approach. J Indones Econ Bus. 2023; 38(2): 166-177.

Diether KB, Lee KH, Werner IM. Short-sale strategies and return predictability. Rev Financ Stud. 2009; 22(2): 575-607.

Engle RF. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica. 1982; 50(4): 987-1007.

Fama EF, French KR. Common risk factors in the returns on stocks and bonds. J Financ Econ. 1993; 33(1): 3-56.

Grinblatt M, Keloharju M. What makes investors trade? J Finance. 2001; 56(2): 589-616.

Kesamoon C, Witayakiattilerd W. Hierarchy analysis process under fuzzy environment: a positive way of selecting stocks into portfolio under ambiguity in stock information. Sci Technol Asia. 2019; 24(2): 1-11.

Kusumah H, Asri M, Setiawan K, Setiyono B. The relationship between Asia Pacific markets during the financial crisis: VAR-Granger causality analysis. J Indones Econ Bus. 2022; 37(2): 162-87.

Lo AW, MacKinlay CA. Stock market prices do not follow random walks: evidence from a simple specification test. Rev Financ Stud. 1988; 1(1): 41-66.

Markowitz H. Portfolio selection. J Finance. 1952; 7(1): 77-91.

Pangestuti DC, Muktiyanto A, Geraldina I. Role of profitability, business risk, and intellectual capital in increasing firm value. J Indones Econ Bus. 2022; 37(3): 311-38.

Stock Exchange of Thailand Knowledge Development Center. Financial markets and securities investment. 21st ed. Bangkok: Stock Exchange of Thailand; 2014.

Tilak G, Szll T, Chicheportiche R, Chakraborti A. Study of statistical correlations in intraday and daily financial return time series. In: Abergel F, Chakrabarti BK, Chakraborti A, Ghosh A, editors. Econophysics of systemic risk and network dynamics. Milano: Springer Milan; 2013. p.77-104.

Witayakiattilerd W. Fuzzy quantitative analysis method for stock selection into portfolio. Chiang Mai J Sci. 2019; 46(4): 799-811.

Witayakiattilerd W, Reunprot N, Limpanawannakul W, Phuphon J. Analyzing stock performance in the banking sector: unveiling value-at-risk and conditional value-at-risk strategies. Thail Stat. 2024; 22(4): 877-93.

Yodmun S, Witayakiattilerd W. Stock selection into portfolio by fuzzy quantitative analysis and fuzzy multicriteria decision making. Adv Oper Res. 2016; 2016: 9530425.