Establishment of Hong Kong stock evaluation index

-- From the perspective of the Mundellian Trilemma

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Abstract. The purpose of this thesis is to analyze the future trend of the Hong Kong stock market and propose a corresponding forecast model. First, we collect and organize the Hong Kong stock market data for 2019-2024, including stock price, turnover, price-earnings ratio and other indicators. Then, we put forward the hypothesis: under the condition that the inflation rate remains unchanged, we introduce the theory of Mundellian Trilemma to discuss its application to the stock market, construct three dynamic indicators, namely, risk rate, return rate, and liquidity, and then according to the AHP method and the CRITIC method are assigned subjectively and objectively, respectively, and then the final assignment is determined based on 0.4×AHP+0.6×CRITIC. Finally, due to the existence of positive and negative indicators, we consider the established TOPSIS model to score Hong Kong stocks and obtain stock indices. The results of this study are of reference value to investors and market regulators, helping them to better understand and grasp the trend of the Hong Kong stock market.

Keywords: Stock evaluation index, Mundellian Trilemma, Amihud indicator, AHP-CRITIC-TOPSIS

1 INTRODUCTION

The objective of this study is to analyze the future trend of the Hong Kong stock market and construct a forecasting model to provide investors with relevant decision-making references. By collecting stock market data for 2019-2024, including stock price, turnover and P/E ratio, we propose a novel stock evaluation index. In terms of methodology,

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we adopted the Mondelli cloverleaf theory to analyze the stock market from the perspective of triangulation theory, and combined with the hierarchical analysis method (AHP) and the criticism method to determine the weights of each index. Finally, stocks are scored and ranked by approximating the ideal solution ranking method (TOPSIS). In the recent related research situation, it is shown that inflation rate, monetary policy, and freedom of capital flow are important factors affecting the stock market. The innovation of this paper is to disregard the effect of inflation and introduce the Mondelli cloverleaf theory to analyze the stock market more comprehensively. With the established evaluation indicators, investors and market regulators can better understand and grasp the development trend of the Hong Kong stock market and thus make more rational investment decisions.

2 DATA ANALYSIS

The AIA stock data analyzed in this study were sourced from Yahoo Finance Hong Kong, a trustworthy financial website celebrated for its comprehensive coverage and real-time updates on global financial markets. Everyday stock price data encompassing essential metrics such as opening and closing prices, high and low prices as well as trading volumes, were systematically collected from the historical stock data available on the Yahoo Finance Hong Kong platform.

The selected AIA stock data sample for this study range from June 3, 2019 to February 9, 2024, covering a comprehensive time span that allows for a thorough analysis of trends and patterns in the specified period. In order to make sure of the accuracy and reliability of the dataset, a thorough data cleaning process was employed. We implement rigorous procedures to address any inconsistencies, outliers or missing values, with validation and cross-referencing conducted against multiple data points available on the Yahoo Finance Hong Kong website.

The data collection process strictly comply with the rules, respecting the terms of use and privacy policies developed by Yahoo Finance Hong Kong. No personal or sensitive information was accessed or utilized in violation of ethical standards, which ensures the integrity and ethical conduct of the research.

Based on the data we have got, it is palpable to see that AIA's stock exhibited a relatively steady performance throughout the time span from 2019 to 2024, characterized by a lack of significant volatility. This stability may be suggestive of the company's flexible response to market dynamics, potentially highlighted by a relatively stable macroeconomic environment. AIA deserves to be praised for its stock’s stability during the period from 2019 to 2024, because it provides the investors a relatively reliable investment option.

However, the stock still experienced moderate fluctuations. To gain a better insight into the ups and downs, we use the database to create two graphs to visualize the changes of the opening and closing price as well as the volumes of AIA’s stock. As show in figure 1.

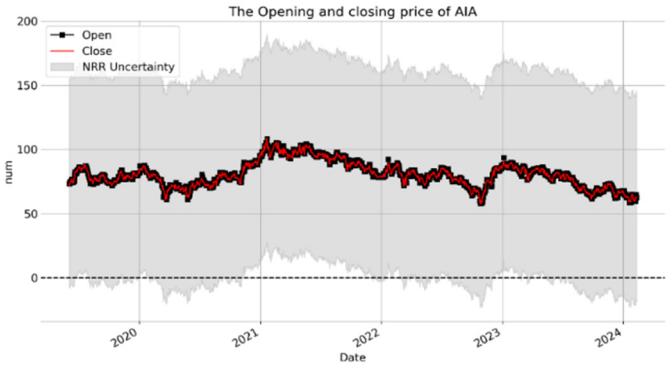

Fig. 1. Caption 1. The opening and closing price of AIA (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

To start our investigation, we will first focus on the insights provided by the first diagram demonstrating the changes of the opening and closing price of AIA's stock. The price experienced a decrease in the first half of 2020 which may be influenced by the pandemic. During the second half of 2020, AIA's stock price rebounded and achieved its peak value in the beginning of 2021. Then the stock price continued to decrease over the long time span from the beginning of 2021 to October,2022. Then it rebounded again and achieved another peak value when 2023 started. Later the price has been on a continuous decline since the start of 2023. As show in figure 2.

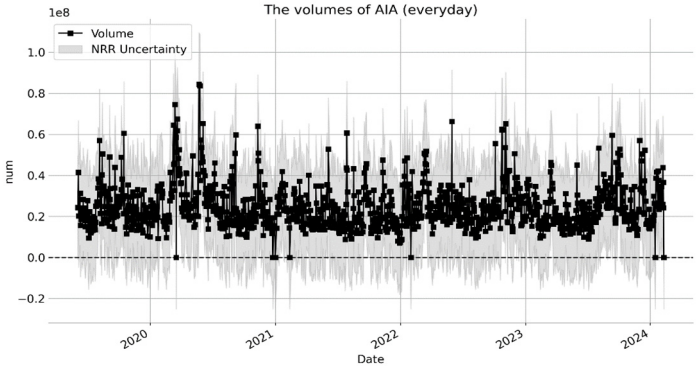

Fig. 2. Caption 2. The volums of AIA (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

We are now going to look at the other diagram representing the changes of volumes of AIA's stock. We can find that the volumes reach the highest point when the opening and closing price of the stock reaches either the highest point or the lowest point as we discussed in the first diagram. When stock prices rise, people's buying interest typically

increases. Investors who are optimistic about the particular stock such as AIA are more willing to make purchases, thereby driving an increase in trading volumes. Also, the positive economic data like the increase price of stock can boost investor confidence, prompting more participation in the market and increasing the volume of buying and selling. When stock prices decline, investors may feel worried and disappointed, leading to more selling pressure and an increase in trading volume as a result. What's more, panic selling tends to increase during market downturns when stock price declines, as investors rush to sell stocks to avoid potential losses, causing a sharp increase in trading volume.

3 REASONABLE ASSUMPTION

It is well known that inflation is an important macroeconomic factor that affects stock market prices. The impact of this factor on stock market trends is complex. It not only stimulates the stock market, but also suppresses the stock market. Inflation is primarily caused by increasing the money supply too much. There is generally a direct relationship between money supply and stock prices, that is, an increase in money supply causes stock prices to rise; conversely, a decrease in money supply causes stock prices to fall. But under special circumstances there is an opposite tendency.

However, it is generally believed that when the inflation rate is very low (such as within 5%), the harm is not great and it can still promote the stock price.

As Wayne proposed that Idealizing the stock market, stock market prices continue to grow by around 1% to 3% a year, which is low to moderate inflation[4]. This "healthy" environment means that the value of the dollar remains stable, demand for goods and services remains stable, and prices are predictable. Therefore, we can make the reasonable assumption of not considering the impact of inflation on the stock market and focus more on the stock itself.

4 STOCK CORRELATION ANALYSIS BASED ON MUNDELLIAN TRILEMMA PERSPECTIVE

4.1 Mundellian Trilemma Theory

The Mundellian Trilemma paradox, also known as the triangle of impossibility, is a well-known theory in international finance. The theory argues that monetary policy independence, exchange rate stability, and free flow of capital cannot be achieved at the same time[6]. Theoretically, monetary policy independence helps to achieve low inflation and stable economic growth; a stable or even fixed exchange rate regime reduces exchange rate risk, contributes to price stability, and promotes international trade and investment; and free capital mobility diversifies financial risks in the country. Therefore, all three objectives are very attractive to the government. As show in figure 3.

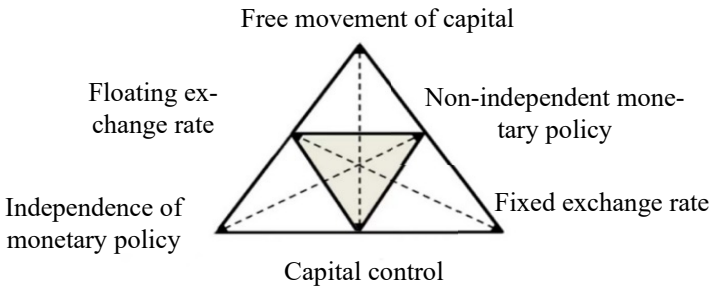

Fig. 3. Caption 3. Ternary Paradox Theory (It comes from Paul Krugman's Mundell triangle)

The triadic paradox in financial investment is usually characterized by risk, return and liquidity. Long-term investing, short-term volatility and market efficiency as well as asset allocation, diversification and risk management. Investors usually seek high returns, but high returns are often accompanied by higher risks. In general, high-yield, low-risk assets may be less liquid, while liquid assets may have lower returns and higher risks. Diversified investment portfolio is an important way to reduce the overall portfolio risk. However, there are times when different asset classes in the market may experience increased correlation, making the diversification strategy less effective. Investors need to consider how to effectively manage various risks in their portfolios, including market risk, credit risk, liquidity risk, etc. The existence of the Ternary Paradox suggests that there may not be a simple investment strategy that satisfies all needs at the same time, but rather that trade-offs and adjustments need to be made on a case-by-case basis.

4.2 Application of the Ternary Paradox to the stock market

In conjunction with a stock market in which stocks and related services can flow more freely across national borders to achieve optimal resource allocation and maximum economic efficiency, the openness of linking the domestic economy to the international market as a whole is emphasized. Mapping the ternary paradox idea to the stock market, the ternary paradox triangle of stock finance is constructed as in Figure Caption 4.

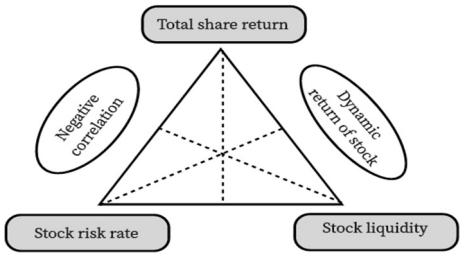

Fig. 4. Caption 4. Ternary paradox of stock finance

Here are the formulas for each indicator:

Risk rate (negative indicator, the smaller the better): consider day i

For a stock evaluation, the stock price variance from day 1 to day i can be considered as a global stock risk evaluation. Then, consider the absolute value of the difference between day i-1 and day i as a local volatility evaluation, i.e., there is the following indicator:

$$\sigma_i = \alpha * \left(\frac{1}{i}\sum_1^i (x_i - \bar{x}_{1\sim i})^2\right) + (1-\alpha) * |x_i - x_{i-1}| \quad i \geq 2 \tag{1}$$

where $\alpha \in (0, 1)$, x_i is the stock price on day i, approximate $\sigma_1 = 0$

Rate of return (yield) (positive indicator, the larger the better):

The rate of return on the purchase of individual stocks by investors in the stock market = (money received from the sale of individual stocks - money spent on the purchase of individual stocks) / money spent on the purchase of individual stocks x 100%

The rate of return on an investor's stock account = (money in the stock war chest at the end of the period - money in the stock account at the beginning of the period) / money in the Gupoio account at the beginning x 100%

Considering day i, for a stock evaluation, one can consider the stock return from day 1 ~ day i as a global return evaluation, and then, consider day i-1 with day i as a localized return evaluation

$$y_{1i} = \left(\beta * \frac{(x_i - x_1)}{x_1} + (1-\beta) * \frac{x_i - x_{i-1}}{x_{i-1}}\right) * 100\% \quad i \geq 2 \tag{2}$$

Liquidity: (negative indicator, the smaller the better)

In the process of calculating liquidity we introduce the Amihud indicator based on the daily trading data metric. the Amihud indicator is the ratio of the stock's return over time to the trading volume, which measures the sensitivity of the stock price to the trading volume: if the change in the trading volume of the stock brings about sharp fluctuations in the stock price (skyrocketing and plummeting), the bigger the Amihud indicator is, the more illiquid the stock is; and vice versa, if the changes in trading volume have a smaller impact on stock price changes, the more liquid the stock is. Since Amihud is an illiquidity indicator, in order to visualize liquidity more intuitively, we take the negative logarithmic value of this indicator, which is calculated as follows:

$$Amihud_{i,t} = \frac{1}{D_i}\sum_{d=1}^{D_i} -log\left(\frac{|R_{i,d}|}{|Volume_{i,d}|}\right) \tag{3}$$

where i stands for stock, t stands for year, and d stands for trading day; R stands for stock return (%); and Volume stands for submission amount (million dollars).

Based on the above three formulas, the three indicators of risk ratio, return, and liquidity are constructed.

4.3 Correlation Analysis

In the correlation analysis first use the KS test Kolmogorov-Smirnov test (KS test) to determine whether the data conforms to a normal distribution. The basic principle of

the KS test is to compare the maximum difference between the observed distribution of the data (the empirical distribution function) and the theoretical distribution (usually a normal distribution or other specific distribution) of the cumulative distribution function (CDF). The test of significance obtained using the K-S test Pvalue= 1.864 x 10-268, which is less than $\alpha = 0.05$, and the results shown in Figure Caption 5 indicate that this set of data does not satisfy the normal distribution. So we consider using Spearman correlation coefficient to analyze the indicator correlation. The result is shown in Figure Caption 6.

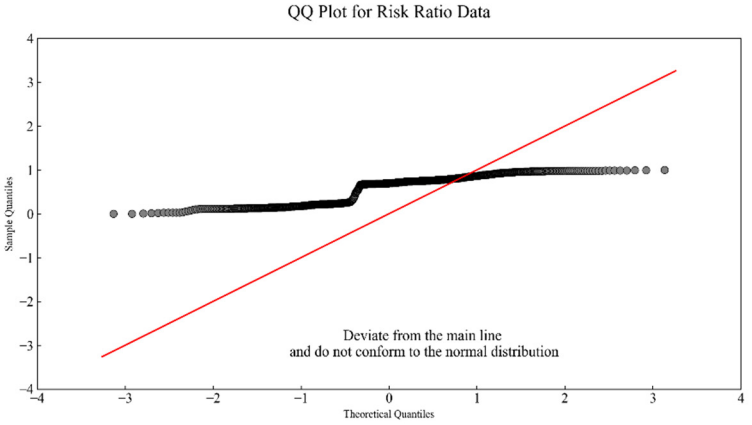

Fig. 5. Caption 5. KS test of data (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

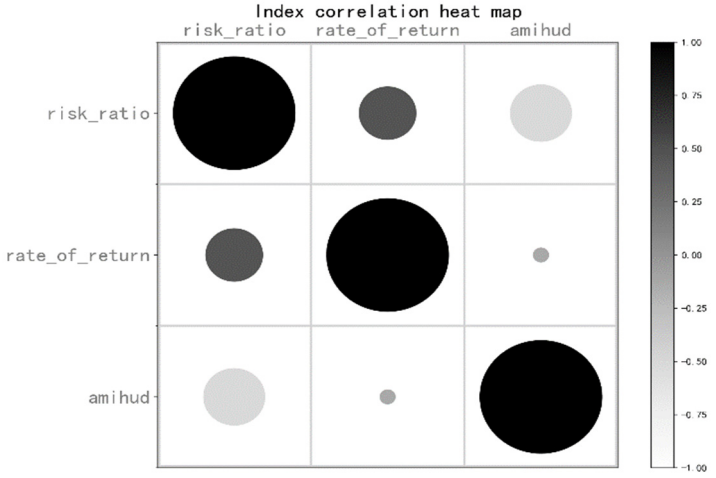

Fig. 6. Caption 6. Spearman correlation coefficient analysis

5 AHP AND CRITIC METHOD OF COMPREHENSIVE EMPOWERMENT

5.1 AHP hierarchical analysis method subjective assignment

Hierarchical analysis according to the nature of the problem and the overall goal to be achieved, the problem is decomposed into different components, and according to the interrelated impact of the factors and affiliation of the factors according to the different levels of aggregation and combination, the formation of a multilevel analytical structural model, which ultimately makes the problem boils down to the lowest level (for decision-making programs, measures, etc.) relative to the highest level (the overall goal) of the relative importance of determining the relative importance of the weight or the ranking of the relative advantages and disadvantages (the order of relative advantages and disadvantages). ranking of relative advantages and disadvantages[1]. The following is the process of determining subjective weights using AHP hierarchical analysis for Hong Kong stock data in this thesis. As show in figure 7 and table 1.

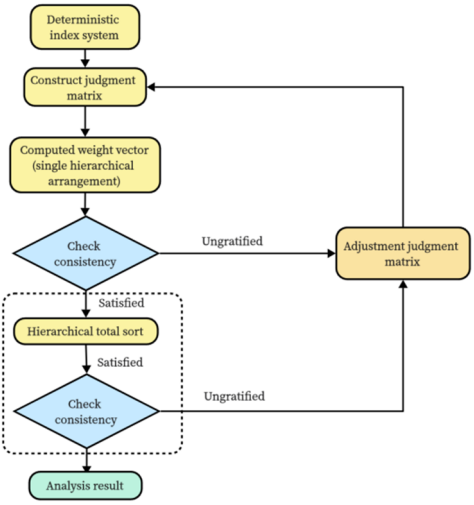

Fig. 7. Caption 7. AHP hierarchical analysis process

First, the AHP decision matrix is determined:

Table 1. Caption 1. AHP decision matrix (Data source: MSN website Hong Kong Stock Exchange stock data for 2020-2024)

Indicator	risk_ratio	rate_of_return	amihud_adj
Risk_ratio	1	4	3
Rate_of_return	0.25	1	1
Amihud_adj	0.33	1	1

Next, AHP hierarchical analysis is performed, show in table 2.:

Table 2. Caption 2. Results of AHP hierarchical analysis (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

AHP hierarchical analysis results				
Indicator	Eigenvector	Weight value(%)	Maximum eigenvalue	CI value
Risk_ratio	1.898	63.275	3.009	0.005
Rate_of_return	0.525	17.485		
Amihud_adj	0.577	19.24		

Finally, the consistency result test is conducted: the final CR value is less than 0.1 to pass the consistency test. As show in table 3.

Table 3. Caption 3. Consistency test results (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

Consistency test results				
Maximum eigenvalue	CI value	RI value	CR value	Consistency test result
3.009	0.005	0.525	0.009	passes

(CR = CI/RI = 0.009 < 0.1, passes consistency test)

5.2 CRITIC method objective assignment

The CRITIC method is based on evaluating the comparative strength of the indicators and the conflict between the indicators to comprehensively measure the objective weights of the indicators. Considering the size of the indicator variability while taking into account the correlation between the indicators, it is not the case that the larger the number means the more important it is, and it is completely utilizing the objective attributes of the data itself to carry out scientific evaluation. Comparative intensity refers to the size of the difference in values between various evaluation programs for the same indicator, which is expressed in the form of standard deviation [2]. The larger the standard deviation, the greater the fluctuation, i.e., the larger the difference in values between the programs, the higher the weight will be; the conflict between the indicators, expressed in terms of the correlation coefficient, if there is a strong positive correlation between the two indicators, it means that their conflict is less, the lower the weight will be.

First of all, data standardization, each indicator is not the same order of magnitude, they need to be reduced to the same range to compare.

$$\mathcal{X}_{ij'}=\frac{max(x_j)-x_{ij}}{max(x_j)-min(x_j)} \tag{4}$$

(Set the standardized data matrix elements for $\mathcal{X}_{ij'}$, if $\mathcal{X}_j$ is a positive indicator)

For the CRITIC method, when the standard deviation is certain, the smaller the conflict between the indicators, the smaller the weight; the larger the conflict, the larger the weight; in addition, when the degree of positive correlation between the two indicators is larger, (the closer the correlation coefficient Q is to 1), the smaller the conflict, which indicates that there is a greater similarity of the information reflected by these two

indicators in the evaluation of the strengths and weaknesses of the program, and the results are shown in Table 4.

Table 4. Caption 4. CRITIC objective weighting method results

Results of CRITIC objective weighting method	
Index	Weight
risk_ratio	0.501
rate_of_return	0.223
Amihud_adj	0.276

5.3 Determination of final weight based on 0.4×AHP+0.6×CRITIC

Risk_ratio : 0.6327*0.4 + 0. 5009*0.6 = 0.55362 = 55.362%
Rate_of_return : 0.1749*0.4 + 0. 2231*0.6 = 0.20382 = 20.382%
Amihud_adj : 0.1924*0.4 + 0. 276*0.6 = 0.24256 = 24.256%
As show in table 5.

Table 5. Caption 5. Comprehensive weighting results (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

Comprehensive weighting results	
Index	Weight (%)
Risk_ratio	55.362%
Rate_of_return	20.382%
Amihud_adj	24.256%

5.4 Objective analysis of weights

From the perspective of finance, risk appetite has been categorized into three types: risk averse, risk neutral, and risk loving. However, it should first be noted that the state of most people is usually considered to be risk averse, or alternatively, in terms of marginal benefit considerations, people's aversion to losing a unit of gain is much greater than their expectation of gaining a unit of gain. In the trade-off process between the cost of risk reduction and the benefit, risk averse investors are more inclined to make low risk ratio choices [6]. Therefore, there is an objective basis for Risk_ratio risk rate weighting. At the same time, the rate of return and liquidity compared to the stock return is naturally important, but if the liquidity is not high, can not be realized quickly, the implicit risk borne is also relatively higher, at this time the pursuit of liquidity of the stock is higher than the return of the stock itself, so the weight Rate_of_return < Amihud_adj is also in line with the objective facts.

6 TOPSIS COMPREHENSIVE EVALUATION TO CONSTRUCT STOCK INDEX

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is first developed by Ching-Lai Hwang and Yoon in 1981, while Yoon made advances in 1987 as well as Hwang, Lai and Liu in 1993. It is a decision analysis method of compensatory aggregation that compares a set of alternatives, using different standards normalizing scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion.

The whole TOPSIS process can be divided into 7 steps in general [3]:

Create a matrix consisting of M alternatives and N criteria. This matrix is usually called an "evaluation matrix".

$$\left(a_{ij}\right)_{M\times N} \tag{5}$$

Normalize evaluation matrix:

$$a_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{M}(a_{ij})^2}} \tag{6}$$

Each metric j for each company i is normalized to be in between 0 and 1. The higher its value the better the metric.

Calculate the weighted normalized decision matrix. It is important to note that each criterion should have its own weight so that all of them will sum up to 1. The weights can be derived randomly (not recommended) or based on expert knowledge (industry standard).

$$\begin{cases} \mathcal{X}_{ij} = a_{ij} * \omega_j \\ \varpi_j = \frac{\omega_j}{\sum_{i=1}^{M}(\omega_j)^2} \\ \sum_{j=1}^{N}\varpi_j = 1 \end{cases} \tag{7}$$

After we assign a weight to each financial metric, we need to normalize those so that these sum up to 1. Then we need to multiply each normalized metric from step 2 by corresponding normalized weight.

Determine the best and the worst alternative for each criterion:

$$\begin{cases} \mathcal{X}_j^b = \max\limits_{1\le i\le M} \mathcal{X}_{ij} \\ \mathcal{X}_j^\omega = \min\limits_{1\le i\le M} \mathcal{X}_{ij} \end{cases} \tag{8}$$

We want to find the maximum and minimum value of each financial metric among all companies.

Calculate the Euclidean distance between the target alternative and the best/worst alternative:

$$\begin{cases} d_i^b = \sqrt{\sum_{j=1}^{N}(x_{ij} - x_j^b)^2} \\ d_i^\omega = \sqrt{\sum_{j=1}^{N}(x_{ij} - x_j^\omega)^2} \end{cases} \tag{9}$$

This is a calculation of the geometric distance between the value of each financial metric for a given company i and the best/worst value of such a metric among all companies.

For each alternative calculate the similarity to the worst alternative. The results are our TOPSIS scores.

$$s_i = \frac{d_i^\omega}{d_i^\omega + d_i^b} \tag{10}$$

We compute a score for each company that is based on distances obtained in a step before.

Rank alternatives according to the TOPSIS score by descending order.

Some of the results are presented below (The positive ideal solution is represented by P, and the Negative ideal solution is called N):

Table 6. Caption 6. The results presentation of TOPSIS (Data source: MSN website Hong Kong Stock Exchange stock data for 2019-2024)

Date	Risk	Recall	Amihud	P	N	Index
2019/6/4	0.10002	-0.00345	3.92307	51.53329	1.93425	0.03618
2019/6/5	0.80566	0.01935	5.0444	50.99423	2.55645	0.04774
2019/6/6	0.59324	0.0183	5.64239	51.14711	2.81441	0.05215
…	…	…	…	…	…	…
2022/1/4	61.54589	0.08467	0.46148	6.66318	45.79427	0.87298
2022/1/5	61.61555	0.07082	0.47206	6.61572	45.84612	0.87389
2022/1/6	61.64097	0.09083	0.48222	6.59667	45.86507	0.87426
…	…	…	…	…	…	…

As show in table 6. Since then, we can use the obtained dynamic stock evaluation index to help us complete stock price prediction and stock selection decisions.

7 CONCLUSION

In this paper, we draw on the Mundellian Trilemma for Hong Kong stocks (AIA as an example), mapping the return, risk and liquidity of the stock itself, and constructing a triple dynamic index based on the triple paradox triangle. We use the AHP-CRITIC method to assign subjective and objective weights to the three indices. At the same time, we combine the real factors such as risk aversion to explain the relevance of the weights, and construct the final stock evaluation index based on the TOPSIS algorithm. The evaluation index constructed in this paper can, to a certain extent, comprehensively reflect the return rate, risk rate and liquidity of the stock itself, and relatively objectively and comprehensively evaluate the advantages and disadvantages of the stock.

Therefore, based on the index in this paper, the machine learning model can be used for stock prediction, and at the same time, dynamic planning is constructed to complete the evaluation of multiple stocks for portfolio investment decisions.

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