Improving portfolio liquidity: MCDM approach to share selection on the Zagreb Stock Exchange

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Abstract. This article describes how investors on the Zagreb Stock Exchange (ZSE) can use Multiple Criteria Decision Making (MCDM) to select shares for investment. Both financial and market liquidity criteria are used to compare different shares. Market liquidity criteria include the average number of daily trades and the average daily turnover on the regular market. These criteria help to determine the liquidity of shares in the secondary market, which is the main contribution of this research.The investment selection proposal is based on the PROMETHEE. The performance of the portfolio constructed using the Modern Portfolio Theory (MPT) was tested. Predictably, the inclusion of liquidity criteria in the share selection process resulted in an increase in the liquidity of the portfolio, an effect that is clearly evident after 2019. However, such a portfolio does not provide significantly different returns compared to a scenario where liquidity criteria are excluded from share selection process. Reading this paper provides an insight into how to make investment decisions based on criteria consistent with investors' objectives in an developing capital market.

Keywords: developing capital markets, multiple criteria decision making, share/stock selection, Zagreb stock exchange

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1. Introduction

Identifying shares that seamlessly align with investment objectives is a critical process, which requires a rigorous assessment of a wide range of factors. These include, but are not limited to, the company's financial performance, its level of stability, and the liquidity of its shares. Liquidity indicates how easily a share can be sold, a factor that can significantly influence the investment decision-making process. It is crucial for developing markets to consider how much the share is traded. Analysis determines the success of an investment in the capital market. Failure to evaluate the numerous factors when selecting shares can result in missed opportunities and financial losses. Therefore, a structured and analytical approach that considers various criteria and factors is crucial. MCDM enables the consideration of multiple criteria with varying weights when evaluating different alternatives and provides the ability to make data-driven and informed decisions about which shares to purchase, improving investor decision-making. It provides a structured framework for decision making that reduces judgment errors.

Considering the Croatian capital market, it is evident that it has encountered obstacles in fulfilling its fundamental functions, which is confirmed by low liquidity [8, 23]. Despite existing attempts to raise the level of development, the progress of the market has remained modest [19]. The degree of illiquidity is reflected in the extended duration of trading inactivity. This

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poses a challenge to the effective distribution of investments in the Croatian capital market, which imposes constraints and obstacles for its participants. In order to support the arguments regarding liquidity challenges, Graph 1 and Table 1 are presented. Data reveals that the turnover on CROBEX between January 1, 2010 and March 30, 2023 did not exceed EUR 150,000 on the vast majority of trading days (70%) [27].

Figure 1: *Movement of the CROBEX market index and trading volume achieved.*

This observation highlights the potential challenges and constraints posed by insufficient levels of liquidity. Such a phenomenon can potentially hinder the effective functioning and growth of the CROBEX capital market.

	Turnover less than 150,000 EUR	Turnover less than 200,000 EUR	Turnover less than 300,000 EUR	Turnover higher than 1 mil. EUR
% in the total number of traded days	69.53%	81.95%	92.00%	0.48%

Table 1: *Proportion of trading days with different levels of turnover of CROBEX.*

In the complex context of developing capital markets, the use of the MCDM approach to share selection and the MPT approach to portfolio optimization provides a sophisticated approach to investing. This presents an interesting question for scholars, leading to the central research question of this article: "How effectively can MCDM methods and MPT be used for shares selection and portfolio optimization in developing capital markets, and what is the role of incorporating liquidity criteria in these decision-making processes?" Exploring this research question is not only of theoretical interest; its practical implications have the potential to reshape real-world investment strategies and outcomes. The insights gained from answering this question can contribute to academic discourse and investment practice.

The article is divided into a series of sections that include a literature review, methodology, results, discussion, and conclusion. The focus is on the MCDM approach that enables the evaluation and ranking of shares based on financial and market liquidity criteria. This multi-layered evaluation process facilitates the identification of shares that exhibit the highest liquidity and the potential for growth and profitability.

2. Literature Review

Liquidity is an essential characteristic of capital markets and plays a crucial role in their development and functionality [23]. It generally implies the ability to execute large trades quickly, inexpensively, and without significant negative price movements. The critical dimensions of share liquidity include market depth and immediacy, which allow transactions to be executed without undue influence on prices and ensure low transaction costs [16]. Various factors, such as efficient market infrastructure, a large number of buyers and sellers and asset characteristics can affect market liquidity. Insufficient liquidity can hinder market development, increase investment risks, and limit capital inflows [4]. An empirical study of liquidity at the ZSE using three specific measures: zero rates returns, price pressure, and turnover, led to the conclusion that liquidity levels in the Croatian market are notably low [16]. Companies with higher market capitalization tend to have higher liquidity than companies with lower market capitalization [6].

Ehrgott et al. [6] proposed a model for portfolio optimization that combines multi-criteria utility theory with classical MPT. The model addresses the criticisms of MPT and allows for a more personalized and accurate portfolio optimization by taking into account individual investor preferences. Albadvi et al. [1] proposed a decision model based on industry and company evaluation to select superior shares. The PROMETHEE method is used for sensitivity analysis. Xidonas et al. [26] proposed a portfolio construction method that incorporates the preferences and experiences of portfolio management experts. It involves the integration of multiple criteria methods and a non-linear optimization model, which together allow the selection of shares with optimal characteristics. MPT has been used with certain limitations to create optimized portfolios. Kou et al. [14] proposed an approach to remove inconsistencies between MCDMs. The approach is based on Spearman's rank correlation coefficient and was applied to five MCDMs, including PROMETHEE. The results show that the proposed approach can provide a compatible ranking when different MCDM techniques disagree.

Vetschera and Almeida [22] findings suggest that PROMETHEE is suitable for portfolio construction. Poklepović and Babić [17] and Vuković et al. [16] evaluated CROBEX shares on the ZSE using five MCDMs, including PROMETHEE. Both studies propose a hybrid MCDM that employs Spearman's rank correlation coefficient for obtaining the final rankings. Basilio et al. [2] used the PROMETHEE method to diversify investment portfolios to reduce the risks of individual assets and achieve expected returns. The evaluation criteria consisted of 21 financial indicators reduced to 5 by principal component analysis. Suroso et al. [20] used the PROMETHEE incorporating elements of sustainability certification with beta, a risk indicator, to facilitate the identification of leading shares.

Future research in this area should further explore and expand the application of relevant MCDM techniques to keep up with the dynamic nature of share selection. This study emphasizes the context of low liquidity in the market and its significance in investment decisions. Further exploration of MCDMs, including PROMETHEE, would provide valuable insights into the complexities of share selection and offer practical solutions for investors and financial analysts. It is particularly noteworthy that this study includes the variable of trading frequency in addition to the trading turnover discussed so far, thus covering two dimensions of share liquidity that are particularly important to consider in developing markets.

3. Data and Methodology

3.1. Data

The analysis is performed using data from the ZSE, which represents the Croatian capital market. Although the ZSE includes stock and bond markets, this analysis focuses on shares traded

on the secondary market. Despite its potential, the Croatian capital market has not developed as an alternative to the prevailing banking system for financing business ventures, resulting in a limited number of shares available for trading and low trading turnover. Ten non-financial sector shares that were part of the CROBEX from 2015 to 2022 were also considered. The same data is used to build an investment portfolio and conduct a comparative analysis of the portfolios. Eight indicators were used as criteria for ranking the shares.

Investor's objective	Criteria (Label)	Description*	References
The share is regularly traded on the market	C1	Indicates how many transactions occur in the market on an average day. This is an important measure of market liquidity, as a higher number of daily transactions generally indicates a more active and liquid share.	Derived from: [3]
	C2	Indicates the average daily value of trades on the market. The higher the daily turnover, the higher the liquidity.	Derived from: [16, 17]
Undervalued share	C3	Compares a company's share price to its revenue per share. A high value for this indicator suggests that the market perceives the share issuer as a quality provider and thus views the share as promising. Investing in a share with a high P/S ratio is less likely to yield returns from price differences because the share price has reached a high level.	[3, 16, 17]
	C2	Indicates the average daily value of trades on the market. The higher the daily turnover, the higher the liquidity.	Derived from: [16, 17]
The investment is secured (collateralized with booked value)	C5	Compares the share price with the book value of the company. An indicator evaluates possible alternatives and shows the invested capital's coverage (bankruptcy potential). The goal is to minimize this indicator, which indicates a greater financial coverage of invested funds by the book value.	[16, 17]
The issuer of the share is efficient in business operations	C6	Measures the frequency of total asset turnover within a year. It provides information on the relative amount of revenue that can be generated by using the company's assets. Shares whose issuers report higher values for this coefficient are preferred.	[17]
The issuer of the share is liquid	C7	Compares a company's short-term assets with its short-term liabilities. Indicates the ability to maintain liquidity as it relates the company's assets, which can be quickly converted into cash, to its liabilities that are due shortly.	[2, 16]
The investment is characterized by a low level of risk	C8	The beta coefficient is a measure of systematic risk. Measures the sensitivity of an investment's returns to changes in overall market returns (presented by CROBEX).	[16, 17]

Note: * Based on [5, 24]

Table 2: *Decision making objectives and criteria used for share selection.*

The selected criteria are related to the investor's objectives. Consequently, these objectives and criteria relate to the ease of trading the share, the undervaluation of the share at the time of purchase, the coverage of the investment, the efficiency of the share issuer, liquidity, and low systemic risk.

C	C1	C2	C3	C4	C5	C6	C7	C8
Criteria	Average number of daily trades on regular market	Average daily turnover on regular market	Price to sales ratio (P/S)	Price to earnings ratio (P/E)	Price to book ratio (P/B)	Total asset turnover	Quick ratio	Beta
Measure	Days	000 EUR*	/	/	/	/	/	/
Criteria type	max	max	min	min	min	max	max	min
ADPL	12.08	26.30	0.29	9.96	0.22	0.75	0.81	3.13
ADRS2	13.65	61.19	0.78	10.99	0.20	0.25	1.05	0.56
ARNT	4.89	29.06	3.33	48.82	0.46	0.14	1.54	1.38
ATGR	6.50	40.33	0.97	16.19	1.03	1.06	1.08	0.85
ATPL	54.00	92.63	1.10	1.17	0.29	0.27	1.01	1.26
ERNT	10.85	45.19	1.11	13.82	2.04	1.84	1.12	0.77
HT	28.08	100.22	2.00	24.18	0.99	0.49	3.14	0.46
KOEI	5.21	34.92	0.66	10.95	0.52	0.78	1.52	1.00
PODR	13.46	116.36	0.97	14.12	0.91	0.94	1.23	0.96
RIVP	28.62	96.62	2.52	38.26	0.60	0.24	1.47	1.34

Note: Data for 2021 were presented; however, data from 2017 to 2021 had to be calculated for the analysis.

Table 3: *An initial overview of 2021 data according to alternatives and criteria.*

This set of criteria is unique compared to previous studies and is particularly relevant for investments in developing markets, given that liquidity criteria are considered. The article focuses on the tradability of the share, taking into account both the average number of daily trades (change in share ownership) and the average daily turnover, including the frequency and significance of the trades.

A fundamental requirement for the implementation of MCDM is the transformation of all criteria into mutually comparable data [20]. While it is possible to use qualitative criteria in research, this study specifically used quantitative data measured using an interval scale. Adopting such a scale is consistent with a rigorous analytic approach, as it provides a way to collect and analyse numerical data in a standardized and precise manner.

3.2. Methodology

The PROMETHEE method uses pairwise comparisons and outranking relationships to determine the best alternatives ([2], [18]). The final decision is determined by summarizing the positive and negative flow of each alternative. The positive preference flow indicates how one alternative outperforms all the other alternatives, while the negative preference flow indicates how one alternative is outperformed by all the other alternatives [17]. Additionally, PROMETHEE includes a preference function to compare the contribution of the alternatives with respect to

each criterion [22], and according to Brans et al. [7]. there are six generalized functions: usual, quasi or U-shaped, linear or V-shaped, level, linear with indifference and Gaussian. The decision maker chooses one of the available generalized criteria in terms of intensity and direction of preference, and for each criterion, it is necessary to define parameters, each of which has a real economic significance. Thus, the following parameters differ: q is a threshold of indifference, p is a threshold of strict preference, and s is an intermediate value between them. In this research, the PROMETHEE method was applied using the Decision Lab software.

The TOPSIS method is based on the idea that the chosen alternative is closest to the ideal solution, while it is farthest from the negative-ideal solution. According to Hwang and Yoon [13], this method simultaneously considers the distances to the ideal solution and the negative-ideal solutions by evaluating the relative proximity to the ideal solution, and finally ranking the final alternatives. According to Chen and Hwang [9], this method involves six steps: 1) calculating the normalized decision matrix, 2) calculating the weighted normalized decision matrix, 3) determining the positive and negative ideal solutions, 4) calculating the distribution measures, 5) calculating the proximity to the ideal solution, and 6) ensuring that the decision criteria are measurable and comparable. It is important to convert the criteria into values that can be compared. An effective technique to accomplish this is vector normalization. This process converts the criteria into values that can be compared using the TOPSIS method. The criteria vary in importance to the decision maker, so information about the relative importance (weighting) of each criterion is required. The evaluation of the relevance of the criteria is made by an intentionally selected panel of five financial professionals, each of whom has an average of more than five years of experience trading on the ZSE.

With the aim of creating a portfolio that provides an optimal solution, MPT was applied. The method begins with identifying the expected returns and risks associated with each share in the portfolio. Weekly return data was used, taking into account a historical period of the last three years. These metrics are then aggregated to evaluate the overall risk and return potential of a portfolio. This method allows investors to balance risk and return [12].

In the first step of the data analysis, the five most promising shares are selected from a pool of ten shares using the PROMETHEE and TOPSIS methods. Subsequently, each of these selected shares receives a base allocation of 10% within the portfolio. This strategy not only ensures the diversification of the portfolio, but also keeps half of the portfolio value in shares that have exceptional characteristics according to the selected criteria and the MCDM.

4. Results and Discussion

4.1. Results

A group of experts was assigned to evaluate the relative significance of the selected criteria. The weights were determined using the simple average method.

Weightings according to the scenario	C1	C2	C3	C4	C5	C6	C7	C8
$W_{\text{liquidity criteria-ON}}$	0.16	0.16	0.14	0.14	0.13	0.09	0.09	0.09
$W_{\text{liquidity criteria-OFF}}$	/	/	0.22	0.22	0.21	0.12	0.12	0.11

Table 4: *Weightings for each criterion.*

In the first scenario, the share's liquidity criterion is given the most importance (C1, C2), which means that shares with high liquidity are generally considered more attractive for investment. In the second scenario, the liquidity criterion is excluded, which means that share selection is based on other factors. This comparison of the effectiveness of shares selection with and without liquidity criteria can provide insights into the importance of taking liquidity criteria into account.

YEAR	LABEL	PROMETHEE		TOPSIS		YEAR	LABEL	PROMETHEE		TOPSIS	
		LIQUIDITY CRITERIA - ON	LIQUIDITY CRITERIA - OFF	LIQUIDITY CRITERIA - ON	LIQUIDITY CRITERIA - OFF			LIQUIDITY CRITERIA - ON	LIQUIDITY CRITERIA - OFF	LIQUIDITY CRITERIA - ON	LIQUIDITY CRITERIA - OFF
2022	ADPL	0.00%	10.00%*	10.00%*	0.00%	2019	ADPL	10,00%*	10,00%*	10.00%*	8.90%
2022	ADRS2	0.00%	10.00%*	10.00%*	10.00%*	2019	ADRS2	10.00%*	10.00%*	10.00%*	8.90%
2022	ARNT	0.00%	0.00%	0.00%	0.00%	2019	ARNT	9.47%	0.00%	0.00%	10.00%*
2022	ATGR	4.73%	0.00%	0.00%	0.00%	2019	ATGR	7.59%	9.41%	8.76%	7.92%
2022	ATPL	10.00%*	10.00%*	10.00%*	10.00%*	2019	ATPL	9.47%	9.41%	8.76%	10.00%*
2022	ERNT	31.98%*	50.00%	50.00%	60.00%	2019	ERNT	10.00%*	9.92%	9.19%	8.27%
2022	HT	12.05%*	0.00%	10.00%*	0.00%	2019	HT	10.00%*	10.00%*	10.00%*	10.00%*
2022	KOEI	14.20%*	10.00%*	0.00%	10.00%*	2019	KOEI	7.95%	10.00%*	9.26%	8.32%
2022	PODR	27.03%*	10.00%*	10.00%*	10.00%*	2019	PODR	16.04%*	31.25%*	24.03%*	17.69%*
2022	RIVP	0.00%	0.00%	0.00%	0.00%	2019	RIVP	9.47%	0.00%	10.00%*	10.00%*
Annual portfolio return in 2022		-4.47%	-12.88%	-12.93%	-6.30%	Annual portfolio return in 2019		16.21%	19.31%	17.43%	16.00%
Annual portfolio turnover 2022 (mil)		21.16 EUR	14.81 EUR	18.19 EUR	13.90 EUR	Annual portfolio turnover 2019 (mil)		19.14 EUR	18.31 EUR	20.28 EUR	19.65 EUR
2021	ADPL	10.00%*	10.00%*	10.00%*	10.00%*	2018	ADPL	10.00%*	10.00%*	10.00%*	9.76%
2021	ADRS2	0.00%	0.00%	0.00%	0.00%	2018	ADRS2	10.00%*	10.00%*	10.00%*	9.76%
2021	ARNT	0.00%	0.00%	0.00%	0.00%	2018	ARNT	0.00%	0.00%	0.00%	0.00%
2021	ATGR	0.00%	10.00%*	0.00%	10.00%*	2018	ATGR	10.00%*	10.00%*	10.00%*	9.76%
2021	ATPL	10.00%*	10.00%*	10.00%*	10.00%*	2018	ATPL	9.37%	9.37%	8.65%	10.00%*
2021	ERNT	0.00%	0.00%	0.00%	0.00%	2018	ERNT	9.87%	9.87%	9.08%	8.89%
2021	HT	10.00%*	0.00%	10.00%*	0.00%	2018	HT	10.00%*	10.00%*	10.00%*	10.00%*
2021	KOEI	10.00%*	10.00%*	0.00%	10.00%*	2018	KOEI	10.00%*	10.00%*	9.19%	10.00%*
2021	PODR	50.00%	60.00%*	60.00%*	60.00%*	2018	PODR	30.76%	30.76%	23.08%	21.82%*
2021	RIVP	10.00%*	0.00%	10.00%*	0.00%	2018	RIVP	0.00%	0.00%	10.00%*	10.00%*
Annual portfolio return in 2021		29.03%	32.51%	27.52%	32.51%	Annual portfolio return in 2018		1.45%	1.45%	-1.99%	-3.56%
Annual portfolio turnover 2021 (mil)		26.93 EUR	23.60 EUR	28.93 EUR	23.60 EUR	Annual portfolio turnover 2018 (mil)		16.83 EUR	16.82 EUR	19.34 EUR	19.14 EUR
2020	ADPL	10.00%*	10.00%*	10.00%*	9.23%						
2020	ADRS2	10.00%*	10.00%*	10.00%*	9.23%						
2020	ARNT	0.00%	0.00%	0.00%	10.00%*						
2020	ATGR	9.47%	10.00%*	9.45%	10.00%*						
2020	ATPL	10.00%*	10.00%*	10.00%*	10.00%*						
2020	ERNT	0.00%	0.00%	0.00%	0.00%						
2020	HT	10.00%*	9.97%	10.00%*	10.00%*						
2020	KOEI	9.47%	9.45%	8.96%	8.35%						
2020	PODR	41.05%*	40.58%*	31.59%	23.95%*						
2020	RIVP	0.00%	0.00%	10.00%*	9.23%						

Annual portfolio return in 2020	-14.44%	-14.44%	-17.28%	-17.55%
Annual portfolio turnover 2020 (mil)	22.40 EUR	22.38 EUR	25.54 EUR	24.79 EUR

Note: * According to the results of the PROMETHEE or TOPSIS method, it is required that the share in the portfolio is represented by at least 10%

Table 5: *The portfolio composition and performance for the 2018-2022 period.*

Regardless of the number of criteria considered and the method used to rank the shares, Podravka d.d. (PODR) and Ericsson Nikola Tesla d.d. (ERNT) are the most common shares in the portfolio composition. PODR operates in the food and pharmaceutical industries, while ERNT provides communication products and services in the operator segment. A distinctive feature of the specified shares is that their issuing companies are leaders in their regional markets and are valued for the high quality of their products and services. PODR in particular has shown a robust performance, attributed mainly to its successful penetration into new markets. At the same time, there was an upward trend in the technology sector, reflected in ERNT. The least represented share was Arena Hospitality Group d.d. (ARNT). With the introduction of the liquidity criterion, the portfolio presence of the share Hrvatski Telekom d.d. (HT) has increased significantly, which means that the share of HT is identified as an important contributor to portfolio liquidity due to the introduction of the liquidity criterion.

   The graph shows the performance of the portfolio in two different scenarios. The introduction of liquidity criteria in the ranking of shares ensured a higher level of portfolio liquidity after 2019. Despite this, the analysis highlighted the fluctuations in the portfolio's returns, making it difficult to reach a consensus. From the perspective of the portfolio's return performance, the elimination of liquidity criteria is confirmed as a better portfolio selection only in 2021, the very year marked by a strong recovery after the COVID-19 downturn. The overall market experienced a recovery, which included shares that were less frequently traded. From an earnings performance perspective, not taking liquidity criteria into account seemed to lead to better portfolio selection, because the less traded shares were the ones that performed exceptionally well during the market recovery
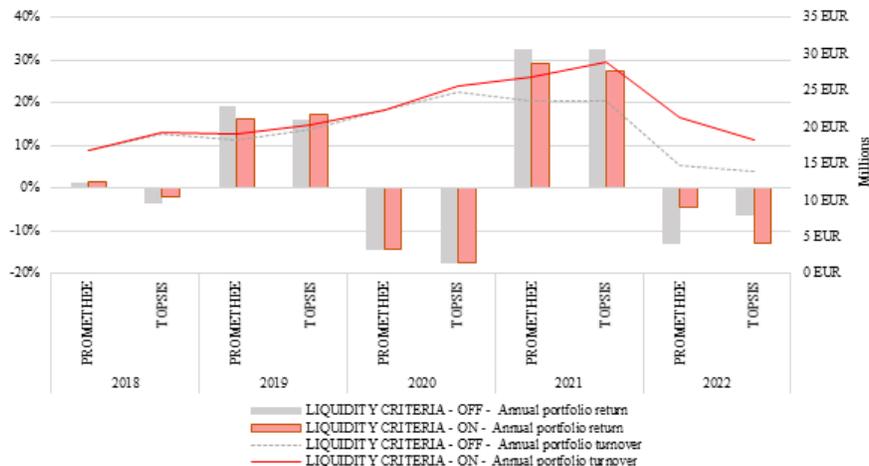
Figure 2: *The portfolio performance for the 2018-2022 period.*

4.2. Discussion

Following the approach proposed by [1, 6, 26], which combines MCDM with MPT, this research emphasizes the importance of individual investor preferences. By integrating multiple criteria, especially the role of share liquidity, this study paves the way for a more tailored and efficient portfolio optimization in the context of an developing market. The process of share selection follows a multi-criteria approach, where the importance assigned to each criterion is derived from expert insights.

Like [22], this research also recognizes the suitability of the PROMETHEE method for determining integral shares within portfolios. In line with [17] and [25], the research also performs a comparative analysis with the TOPSIS method, which confirms the robustness of the estimation. It is confirmed that portfolio liquidity is more favourable regardless of the method used. Although a negative relationship between liquidity risk and return is expected [10], which manifests itself in the fact that the focus on liquidity could lead investors to miss potentially profitable opportunities in less liquid assets associated with a higher risk premium, this relationship does not seem to be strongly confirmed in the case of the ZSE. The observed phenomenon can be attributed to the emphasis on the importance of criteria that reveal the undervaluation of shares or to the restriction of the analysis to the stable components of the CROBEX. Therefore, it is suggested to apply the liquidity criteria to a broader group of shares not to limit them to the components of the CROBEX index.

It should be noted that the criterion of belonging to the industry and the evaluation of the industry's perspective were not considered. It is recommended to include the criterion of industry affiliation in which the issuer operates, which will contribute to making more informed investment decisions.

5. Conclusion

This article addresses the question of how capital market investors can decide which shares to select for investment based on multiple criteria, using the example of the ZSE. In the context of the developing capital market, this article uses MCDM to compare different shares based on various financial and market liquidity criteria, with the weights determined by a group of experts.

Regardless of the criteria or method used to rank the shares, PODR and ERNT were the most common shares in the portfolio composition. The use of two liquidity criteria resulted in higher portfolio liquidity after 2019, and HT is critical to ensuring portfolio liquidity. However, the analysis highlighted variations in the indicators used to measure portfolio returns, which pose challenges to achieving consensus.

Overall, the study contributes to the literature on investment decision making in developing capital markets. It offers practical insights into the application of MCDM and MPT theory in share selection and portfolio optimization, while emphasizing the importance of considering liquidity criteria in the investment process. Further research can build on this study by examining the effectiveness of other criteria or methods in other developing capital markets or in a particular industry. A recommendation is to consider the Sharpe ratio as a criterion in portfolio optimization, which could provide a different perspective and contribute to a more sophisticated understanding of portfolio performance.

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