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THE VERIFICATION OF THE APPLICATION OF THE TMAI METHOD FOR SELECTING COMPANIES FOR THE INVESTMENT PORTFOLIO DURING THE COVID-19 PANDEMIC

Monika MIŚKIEWICZ-NAWROCKA

University of Economics in Katowice; monika.miskiewicz@ue.katowice.pl, ORCID: 0000-0002-2766-1322

Purpose: The aim of the conducted research is to examine the effectiveness of portfolios composed of companies classified using the taxonomic measure of investment attractiveness TMAI in the following quarters in the years 2018-2023.
Design/methodology/approach: To achieve the goal, the TMAI measure was used, which allows for the assessment of the examined objects and their comparison in terms of the analyzed phenomenon**.**
Findings: The analysis carried out allowed for the creation of rankings of companies in terms of their financial situation and the construction of portfolios based on these rankings. The TMAI measure allowed for the identification of a group of companies forming portfolio 4, which allows systematically to obtain a higher rate of return than the reference portfolio. The outbreak of the Covid-19 pandemic and the wars in Ukraine significantly influenced the rates of return of investment portfolios. In the case of the strongest restrictions related to the pandemic, portfolio 5 brought positive rates of return. The study showed that during the period under review, the highest-rated companies did not create portfolios with the highest rate of return, but limited to the first 3 quarters of the pandemic, these portfolios achieved the highest rates of return.
Research limitations/implications: The financial condition of a company, estimated using the TMAI measure, is a variable that is not directly measurable. Its value is generated by observations of diagnostic variables that are directly measurable. The choice of diagnostic variables is a subjective choice of the researcher and should be carried out reliably, preceded by a study of the relevant literature.
Practical implications: The proposed method of assessing companies allows you to indicate a portfolio that systematically gives a better result than the reference portfolio containing all the analyzed companies. The existence of such a portfolio allows the use of TMAI for the initial selection of companies for the portfolio.
Social implications: What will be the impact on society of this research? How will it influence public attitudes? How will it influence (corporate) social responsibility or environmental issues? How could it inform public or industry policy? How might it affect quality of life? Not all papers will have social implications.

Originality/value: Showing that the use of the TMAI method to assess the financial condition of companies is possible and allows their classification in terms of building an investment portfolio even in "difficult" times, i.e. the COVID-19 pandemic. The article, the use of the method is useful for entrepreneurs and investors.

Keywords: TMAI measure, linear ordering, investment portfolio.

Category of the paper: research paper.

1. Introduction

The outbreak of the COVID-19 pandemic was a shock for the global economy, and its consequences in the form of restrictions, restrictions and sanitary regimes were and still are felt in various sectors of the economy. Emotional factors accompanying the pandemic also have a significant impact on investors' decisions on financial markets. The taxonomic measure of investment attractiveness TMAI proposed by W. Tarczyński (1994) is a linear ordering method based on a synthetic variable. Its values are estimated on the basis of financial indicators describing the examined companies. The estimated values of the synthetic variable allow for ranking companies in terms of their financial condition. In this article, such rankings of companies will allow them to be assigned to one of five quantile portfolios, the structure of which will not be optimized.

The selection of appropriate financial indicators allows for the assessment of the analyzed companies in terms of portfolio construction. Research conducted by Łuniewska (2003), Tarczyński (2004), Węgrzyn (2013a, 2014), prove that a synthetic development measure such as TMAI allows for the accurate selection of companies for the optimal portfolio. When constructing the TMAI measure, Tarczyński and Łuniewska (2003) take into account four areas of the company's activity, i.e. profitability, debt level, liquidity and management efficiency. In addition to the nominal values of financial indicators, Węgrzyn (2013b, 2015) also considers the dynamics of selected indicators. In 2017, Tarczyński and colleagues proposed measuring the fundamental strength of a company using the scoring method. This approach does not require standardization of diagnostic variables, but depending on the range in which the variable is located, it receives a specific number of points. In turn, Lisek and Luty (2019) propose simplifying the classic TMAI measure by using less data. Their index eliminates the influence of extreme and unusual values on the linear ordering of the examined objects. Moreover, Tarczyński's (1994) research on the stability of the TMAI measure over time shows that company rankings prepared using this measure are stable over time.

The constructed quantile portfolios will enable the achievement of the aim of the work, which is to assess the effectiveness of investment portfolios composed of companies included in the Wig30 and mWIG40 indices listed on the Warsaw Stock Exchange. In this way, an attempt will be made to answer the question whether using the TMAI measure during the

pandemic and immediately after it, it is possible to build an optimal portfolio that gives better results than the reference portfolio composed of all the analyzed companies. To assess the effectiveness of companies, the expected rate of return, realized rate of return, portfolio risk and the Sharpe ratio will be used.

2. TMAI measure

TMAI is a linear ordering method. The linear ordering procedure includes the following stages: determining the nature of variables, determining variable weights, normalizing variables, determining pattern coordinates in the case of pattern aggregation, patternless or pattern aggregation, classification of ranked objects and recognition of development types (Bąk, 2016).

The construction of TMAI is based on estimating the distance of each object from the reference object using the formula (Tarczyński, 2002):

$$d_i = \left[\frac{\sum_{j=1}^{m} \left(y_{ij} - y_{0j} \right)^2}{m} \right]^{1/2}, \quad i = 1, ..., n, \tag{1}$$

where:

d_i - distance of the i-th object from the pattern object,

y_{0j} - pattern object given by following formula.

$$y_{0j} = \max_i \{ y_{ij} \}, \tag{2}$$

where: y_{ij} , m – as above.

The final step is TMAI normalization:

$$TMAI_i = 1 - \frac{d_i}{d_0}, \quad i = 1, ..., n, \tag{3}$$

where:

$TMAI_i$ - a taxonomic measure of the attractiveness of the i-th object,

d_0 - a standard ensuring that $TMAI_i$ accepts values in the range $[0,1]$,

$$d_0 = \bar{d} + 2S_d, \tag{4}$$

where: $\bar{d}, S_d$ - arithmetic mean and standard deviation d_i.

3. Empirical analysis

The study covered companies listed on the Stock Exchange in Warsaw, included in the indices: WIG30 and mWIG40, in the period from October 1, 2018 to March 31, 2023. Companies from the financial sector and companies that were not listed during the entire period under consideration or had missing data were excluded from the study. 51 companies were qualified for the study (Table 1).

Table 1.
List of companies participating in the study

Amica	Ciech	Enea	Kety	PGE
Amrest	CIGames	Energa	KGHM	PKNOrlen
Asbis	Comarc	EuroCash	KrukSA	PKPCargo
Assecopol	Cormay	Forte	LiveChat	Playway
Azoty	CyfPolsat	GPW	Mercator	Polimex
Benefit	Datawalk	Grenevia	Mobruk	Stalprod
Bogdanka	Develia	GTC	Neuca	Tauron
Boryszew	DinoPL	Intercars	OrangePL	Trakcja
Budimex	Domdevel	JSW	Pak	TSGames
Bumech	Echo	Kernel	Pep	VRG
CDProjekt				

The study used financial indicators from the Notoria database: operating profit margin, gross profit margin, net profit margin, return on equity (ROE), return on assets (ROA), current ratio, quick ratio, increased ratio liquidity, receivables turnover, inventory turnover, operating cycle, liabilities turnover, cash conversion cycle, current assets turnover, asset turnover, asset coverage ratio, debt ratio.

For each company, the above-mentioned financial indicators were taken into account for each quarter in the period October 1, 2018 - April 1, 2023 (18 quarters), on the basis of which synthetic measures were determined. Then, for each quarter, companies were sorted in the TMAI ranking, based on which they were classified into one of five portfolios according to the rule:

- Portfolio 1 – 20% of the highest-ranked companies in the TMAI ranking (positions 1-10),
- Portfolio 2, Portfolio 3 and Portfolio 4 – companies that were placed in subsequent positions and were not included in the portfolio with a higher number, i.e. positions 11-20, positions 21-30 and positions 31-40, respectively,
- Portfolio 5 – remaining lowest-ranked companies, positions 41-50.

In each quarter in the period from October 1, 2018 to March 31, 2023, 5 proportional portfolios were built, the portfolio structure was not optimized (90 portfolios in total). Each portfolio was purchased on the 1st day of the quarter and sold on the 1st day of the following quarter at closing prices. A reference portfolio was also built, i.e. a proportional portfolio containing all companies covered by the survey in a given quarter (18 portfolios). To assess the effectiveness of the portfolios, the following factors were used: expected rate of return, portfolio risk, realized rate of return and Sharpe ratio. Since the estimation of the Sharpe ratio requires knowledge of the risk-free interest rate for each period, its value was assumed at the level of the WIBOR 3M rate on the date of construction of subsequent portfolios.

Table 2 presents the expected rates of return for portfolios built on the basis of individual rankings in subsequent quarters of 2018 - 2023. Expected rates of return that were higher than the expected rate of return of the reference portfolio in a given quarter are marked in bold.

Table 2.
Expected rates of return of the constructed portfolios

	Q4.2018	**Q1.2019**	**Q2.2019**	**Q3.2019**	**Q4.2019**	**Q1.2020**	**Q2.2020**	**Q3.2020**	**Q4.2020**
portfolio 1	-0,09%	**0,19%**	**0,12%**	**0,05%**	0,15%	-0,22%	**0,82%**	**0,54%**	0,09%
portfolio2	**0,02%**	0,06%	-0,08%	-0,22%	0,07%	**-0,39%**	0,49%	0,10%	**0,34%**
portfolio 3	-0,08%	0,16%	-0,02%	-0,27%	0,08%	**-0,60%**	0,52%	0,01%	**0,35%**
portfolio 4	**-0,05%**	**0,24%**	-0,11%	**-0,04%**	**0,38%**	-0,23%	**0,75%**	0,01%	**0,42%**
portfolio 5	-0,10%	**0,19%**	**0,02%**	**0,14%**	0,07%	-0,27%	0,52%	0,10%	**0,32%**
reference portfolio	-0,06%	0,17%	-0,01%	-0,07%	0,15%	-0,35%	0,61%	0,15%	0,29%
	Q1.2021	**Q2.2021**	**Q3.2021**	**Q4.2021**	**Q1.2022**	**Q2.2022**	**Q3.2022**	**Q4.2022**	**Q1.2023**
portfolio 1	0,06%	0,03%	-0,04%	**0,04%**	-0,06%	**-0,07%**	**0,03%**	0,20%	0,07%
portfolio2	**0,19%**	0,09%	**0,45%**	-0,07%	**0,21%**	-0,15%	-0,14%	0,21%	-0,02%
portfolio 3	**0,27%**	**0,25%**	0,10%	-0,06%	-0,05%	**-0,01%**	-0,17%	**0,31%**	0,03%
portfolio 4	0,10%	**0,18%**	0,10%	-0,13%	**0,06%**	-0,08%	-0,10%	0,21%	**0,21%**
portfolio 5	0,16%	**0,20%**	0,04%	-0,07%	0,02%	-0,11%	**-0,08%**	0,21%	**0,11%**
reference portfolio	0,16%	0,13%	0,14%	-0,06%	0,03%	-0,08%	-0,10%	0,22%	0,07%

A comparison of the expected rates of return obtained from individual portfolios with the rate of return from the reference portfolio indicates that Portfolio 4 had a higher expected rate of return than the reference portfolio nine times. Portfolio 3 and Portfolio 2 had a higher expected rate of return than the reference portfolio 6 times over the period considered.

Table 3 presents the risk of portfolios built on the basis of individual rankings in the subsequent quarters of 2018-2023. The risk of portfolios that were higher than the risk of the reference portfolio in a given quarter is marked in bold.

Table 3.
Risk of constructed portfolios

	Q4.2018	**Q1.2019**	**Q2.2019**	**Q3.2019**	**Q4.2019**	**Q1.2020**	**Q2.2020**	**Q3.2020**	**Q4.2020**
portfolio 1	**17,18%**	14,43%	15,08%	12,83%	12,88%	19,44%	**19,09%**	**19,11%**	**18,78%**
portfolio2	14,76%	14,11%	14,65%	**14,30%**	**15,00%**	19,78%	17,28%	16,13%	15,26%
portfolio 3	14,44%	13,78%	15,14%	14,13%	**14,34%**	**20,96%**	18,29%	16,56%	16,72%
portfolio 4	**16,09%**	14,23%	**15,92%**	**14,50%**	**14,80%**	**21,15%**	**19,80%**	16,74%	**19,04%**
portfolio 5	**16,49%**	**16,11%**	**17,19%**	**15,35%**	14,00%	**20,94%**	**19,22%**	**20,42%**	**18,29%**
reference portfolio	15,84%	14,59%	15,45%	14,28%	14,18%	20,54%	18,73%	17,98%	17,70%
	Q1.2021	**Q2.2021**	**Q3.2021**	**Q4.2021**	**Q1.2022**	**Q2.2022**	**Q3.2022**	**Q4.2022**	**Q1.2023**
portfolio 1	**15,73%**	**15,71%**	13,85%	**17,91%**	18,06%	**17,95%**	**18,24%**	**16,85%**	**14,82%**
portfolio2	14,97%	14,00%	**17,42%**	15,02%	**20,20%**	16,16%	16,26%	14,94%	14,26%
portfolio 3	**16,67%**	**14,92%**	13,31%	**15,87%**	18,62%	15,34%	16,81%	**17,03%**	13,58%
portfolio 4	15,39%	14,58%	15,25%	14,76%	**19,10%**	16,51%	**17,18%**	15,01%	**14,96%**
portfolio 5	**16,47%**	**15,46%**	**14,73%**	15,63%	17,96%	**17,53%**	16,17%	15,32%	**15,62%**
reference portfolio	15,72%	14,79%	15,14%	15,86%	18,85%	16,83%	16,82%	15,90%	14,71%

Based on the data presented in Table 3, it can be seen that Portfolio 2 and Portfolio 3 were 15 and 13 times lower in risk than the reference portfolio, respectively. Other portfolios - 6 times in the period under review.

Table 4 shows the realized rates of return for portfolios built on the basis of individual rankings in subsequent quarters of 2018-2023. The realized rates of return that were higher than the realized rate of return of the reference portfolio in a given quarter are marked in bold.

Table 4.
Realized rates of return of the constructed portfolios

	Q4.2018	**Q1.2019**	**Q2.2019**	**Q3.2019**	**Q4.2019**	**Q1.2020**	**Q2.2020**	**Q3.2020**	**Q4.2020**
portfolio 1	**16,04%**	**12,72%**	**3,47%**	9,61%	**4,98%**	**57,06%**	**34,29%**	-5,18%	-2,84%
portfolio2	8,15%	-11,72%	-8,12%	5,39%	-22,88%	34,52%	14,90%	**23,67%**	**12,37%**
portfolio 3	10,19%	**-2,04%**	-8,64%	8,39%	-17,63%	28,89%	5,07%	**14,30%**	**8,80%**
portfolio 4	**24,72%**	-24,87%	**7,43%**	**19,76%**	-19,23%	26,16%	-2,11%	**20,97%**	**8,17%**
portfolio 5	6,45%	**13,36%**	**19,06%**	10,37%	**-1,42%**	**42,64%**	5,47%	3,92%	0,79%
reference portfolio	11,56%	-7,07%	2,28%	11,58%	-11,33%	39,41%	14,19%	8,54%	3,37%
	Q1.2021	**Q2.2021**	**Q3.2021**	**Q4.2021**	**Q1.2022**	**Q2.2022**	**Q3.2022**	**Q4.2022**	**Q1.2023**
portfolio 1	-5,29%	**1,90%**	-9,89%	-9,35%	-19,10%	**0,85%**	**13,60%**	9,20%	4,04%
portfolio2	**13,31%**	-4,91%	-7,68%	-5,37%	**-9,70%**	-17,09%	13,42%	10,19%	3,72%
portfolio 3	**8,80%**	**5,22%**	-8,87%	**-1,83%**	**-8,60%**	-9,75%	**19,42%**	5,06%	6,28%
portfolio 4	**11,10%**	**5,96%**	**1,01%**	**-1,63%**	**-5,51%**	-7,02%	**24,10%**	**30,98%**	**26,45%**
portfolio 5	**13,48%**	-3,66%	-8,61%	**-2,42%**	**-7,87%**	**-6,22%**	4,20%	-6,02%	**17,57%**
reference portfolio	6,33%	0,16%	-7,61%	-4,92%	-10,97%	-7,66%	13,49%	12,70%	12,69%

The analysis of realized rates of return showed that Portfolio 4 achieved a higher rate of return than the reference portfolio by 14 times, and portfolio 2 - by 4 times. The remaining portfolios generated a higher rate of return than the reference portfolio by 8-9 times over the 18 quarters considered.

Table 5 shows the cumulative rate of return, the geometric mean of realized rates of return and the average risk for portfolios built on the basis of individual rankings in subsequent quarters of 2018 - 2023. Values that were higher than the values obtained for the reference portfolio in a given quarter are marked in bold.

Table 5.
Cumulative rate of return, average geometric rate of return and average risk for the constructed portfolios

	Cumulative rate of return	**Average geometric rate of return**	**Average risk**
portfolio 1	**146,65%**	**5,14%**	**16,55%**
portfolio2	39,88%	1,88%	15,81%
portfolio 3	67,05%	2,89%	15,92%
portfolio 4	**232,37%**	**6,90%**	16,39%
portfolio 5	**138,89%**	**4,96%**	**16,83%**
reference portfolio	107,70%	4,14%	16,33%

The analysis of cumulative rates of return (Table 5) showed that portfolios 1, 4 and 5 were characterized by a higher cumulative rate of return than the reference portfolio, in particular for portfolio 4 the difference was nearly 125 percentage points. Portfolios 2 and 3 achieved the lowest cumulative rates of return, which were significantly lower than the cumulative rate for the reference portfolio. Based on the geometric mean rates of return (Table 5), it can be seen that Portfolio 1, Portfolio 4 and Portfolio 5 produced higher geometric mean rates of return than the reference portfolio. The lowest geometric mean was obtained for portfolio 2, which was also characterized by the lowest average risk. It should be noted, however, that the average risks obtained for the constructed portfolios are similar to each other and have values in the range (15.81%, 16.83%). Portfolios 2 and 3 had an average risk level lower than the reference portfolio. Portfolio 4, which achieved the highest cumulative and geometric mean rate of return, had an average portfolio risk higher by only 0.06 percentage points.

Table 6 presents the Sharpe ratios for portfolios built on the basis of individual rankings in the subsequent quarters of 2018-2023. The Sharpe ratios that were higher than the Sharpe ratios of the reference portfolio in a given quarter are marked in bold.

Table 6.
Sharpe ratios of the constructed portfolios

	Q4.2018	**Q1.2019**	**Q2.2019**	**Q3.2019**	**Q4.2019**	**Q1.2020**	**Q2.2020**	**Q3.2020**	**Q4.2020**
portfolio 1	**0,83**	**0,76**	**0,12**	0,61	**0,25**	**2,88**	**1,78**	-0,28	-0,16
portfolio2	0,44	-0,95	-0,67	0,26	-1,64	1,69	**0,85**	**1,45**	**0,80**
portfolio 3	0,59	**-0,27**	-0,68	0,47	-1,35	1,32	0,26	**0,85**	**0,51**
portfolio 4	**1,43**	-1,87	**0,36**	**1,24**	-1,41	1,18	-0,12	**1,24**	**0,42**
portfolio 5	0,29	**0,72**	**1,01**	0,56	**-0,22**	1,98	0,27	0,18	0,03
reference portfolio	0,62	-0,60	0,04	0,69	-0,92	1,86	0,74	0,46	0,18
	Q1.2021	**Q2.2021**	**Q3.2021**	**Q4.2021**	**Q1.2022**	**Q2.2022**	**Q3.2022**	**Q4.2022**	**Q1.2023**
portfolio 1	-0,35	**0,11**	-0,73	-0,66	-1,32	**-0,35**	0,35	0,13	-0,19
portfolio2	**0,88**	-0,37	**-0,45**	-0,53	**-0,72**	-1,49	**0,38**	0,21	-0,22
portfolio 3	**0,52**	**0,34**	-0,68	**-0,28**	**-0,72**	-1,10	**0,73**	-0,12	-0,04
portfolio 4	**0,71**	**0,39**	**0,05**	**-0,28**	**-0,54**	**-0,85**	**0,98**	**1,60**	**1,31**
portfolio 5	**0,81**	-0,25	-0,60	**-0,32**	**-0,70**	**-0,76**	-0,19	-0,85	**0,68**
reference portfolio	0,39	0,00	-0,52	-0,47	-0,84	-0,87	0,37	0,36	0,39

Based on the data in Table 6, it can be seen that the reference portfolio had a positive Sharpe ratio value in 12 of the 18 quarters analyzed, which means that only in these quarters did it bring a rate of return higher than the risk-free rate. The constructed portfolios had a positive Sharpe ratio of 9-12 times. Portfolio 4 had a higher Sharpe ratio than the reference portfolio 14 times, including 11 times when the ratio was positive. At the same time, the reference portfolio was characterized by a twice higher positive value of the indicator than portfolio 4.

Conclusion

The study analyzes the financial condition of selected companies listed on the Warsaw Stock Exchange using the TMAI measure. Based on the research conducted, companies were assigned to one of five portfolios in the analyzed quarters. Then, an attempt was made to assess whether the proposed method of assessing companies allows for identifying a portfolio that systematically gives a better result than the reference portfolio containing all the analyzed companies. The existence of such a portfolio would allow the use of the TMAI measure for the initial selection of companies for the portfolio.

The conducted research allows for the following conclusions to be drawn: The obtained values of the Sharpe ratios allow us to conclude that the "best" portfolio is portfolio 4 in the analyzed period. The analysis of geometric mean rates of return of the constructed portfolios indicates that portfolios 1, 4 and 5 brought higher geometric means than the reference portfolio. Based on the research conducted, it can be seen that the outbreak of the Covid-19 pandemic and the war in Ukraine significantly influenced the rates of return of investment portfolios. In the case of the strongest restrictions related to the pandemic, portfolio 5 generated positive

rates of return. The study showed that during the period under review, the highest-rated companies did not create portfolios with the highest rates of return, but in the first 3 quarters of the pandemic, these portfolios achieved the highest rates of return. It should be noted that the stage of selecting companies for the portfolio is an initial stage, and the next stage is the optimization of the portfolio structure - e.g. the classic Markowitz approach.

To sum up, it can be said that the TMAI measure allowed to identify a group of companies forming portfolio 4, which allowed to obtain a higher rate of return than the reference portfolio. It should be emphasized that the portfolios constructed are not optimal portfolios. It can be expected that optimizing the portfolio structure would improve the results. However, the aim of the research was to analyze the suitability of the proposed method as a tool for selecting companies for the portfolio, and not to build optimal portfolios.

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