SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 240

APPLICATION OF PORTFOLIO THEORY TO MINIMISE INVESTMENT RISK IN THE EQUITY MARKET

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Purpose: This article examines the utility of Markowitz portfolio theory in the context of minimum risk portfolio construction in minimising investment risk using a two-component stock portfolio as an example. The paper will present an example of an investment strategy that minimizes investment risk.
Design/methodology/approach: The study covered 18 companies included in the Warsaw Stock Exchange's main index, the WIG20. Two-component portfolios were constructed based on PKN Orlen, as the company with the highest capitalisation. As a result, 17 two-component portfolios were considered by determining the shares of companies in portfolios with minimum risk. A simulation was applied to verify whether the recommended shares determined on the basis of historical data actually led to a reduction in investment risk in the analysed period. Measures of descriptive statistics used in the calculations required obtaining data on monthly returns for the period January 2020-March 2023, and the portfolio analysis itself concerned the period January 2021-March 2023.
Findings: The simulation showed that investing in a recommended portfolio, i.e. one in which we review the composition and/or shares of the companies in the portfolio each month, generally performed better in terms of risk than investing throughout the period in a two-component portfolio with a given composition but modified only by the shares of the companies in the portfolio.
Practical implications: As a result of the simulation, the application of Markowitz portfolio theory to minimise investment risk was confirmed. The analysis period covering the years 2020-2023, characterised by high uncertainty, further confirms the validity of building an investment portfolio based on the assumptions of selecting companies for the minimum variance portfolio (MVP).
Originality/value: The paper gives an example of an investment strategy based on adjusting from period to period the composition and/or holdings of companies in a two-component portfolio based on the assumptions of minimum-risk portfolio construction.
Keywords: portfolio theory, minimum variance portfolio, investment risk, Harry Markowitz, investment decisions.
Category of the paper: research paper.
JEL Classification Codes: G11.

Introduction

At the beginning of the second half of the 20th century, the investment community struggled with the lack of risk measures. At that time, H. Markowitz developed a basic portfolio model that specified an expected rate of return for a portfolio of assets and an expected risk measure. He pointed out that the variance of returns previously used was an incorrect measure of portfolio risk. Markowitz introduced a formula for calculating the variance of a portfolio, thus indicating how to effectively diversify the portfolio and how to determine the importance of investment diversification in reducing the total risk in a portfolio. The model is based on numerous assumptions about investor behaviour concerning, among other things, probability distribution, utility maximisation and a preference for higher expected returns.

Portfolio theory facilitates decision-making under conditions of uncertainty in securities investments, as it is based on two criteria: return and risk. The choice in constructing an investment portfolio relates to the degree of risk acceptance relative to the expected rate of return, whereas the greater the risk, the greater the return. Investment preferences vary from investor to investor, they depend on, among other things:

- the profit increment and the rate of return,
- the holding time of the invested capital and the liquidity of the investment,
- the economic, social and political environment,
- the individual characteristics of the investor.

Portfolio theory allows the shares of companies in a minimum variance portfolio (MVP) to be determined. An investor focused on achieving returns with the lowest possible risk will consider efficient portfolios dominant over inefficient portfolios. Figure 1 shows MVP and an example of portfolio A dominating (efficient) and portfolio B (inefficient).

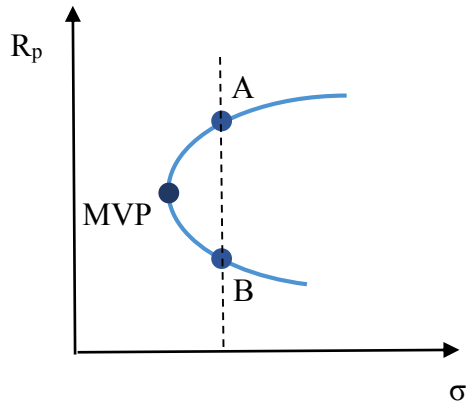

Figure 1. Minimum variance portfolio (MVP), efficient portfolio and inefficient portfolio.
Source: Bielska (2023).

Figure 1 shows MVP and an example of portfolio A dominating (efficient) and portfolio B (inefficient). Portfolios A and B have the same risk (σ), but portfolio A achieves a higher return (R_p) and therefore dominates portfolio B (stochastic portfolio dominance).

Portfolio theory and its modifications

Portfolio theory is considered to have originated in 1952, when Harry Markowitz published an article detailing the phenomenon. He is widely recognised as the forerunner of this theory. According to some researchers, in doing so, Markowitz opened a new chapter in the history of financial development. The basic idea of this theory is to aim for an investment portfolio with the highest possible rate of return and with the smallest possible spread of investment outcomes (Markowitz, 1952).

Markowitz assumed the rationality of the investor's behaviour, who makes decisions by maximising his utility. Maximising the utility function is done by maximising the portfolio mean (i.e. return) or minimising the portfolio standard deviation (i.e. risk).

Markowitz's portfolio theory assumes that the means and covariances of the returns on the underlying assets are known, so one would have to rely on forecast data. In practice, these are unknown and must be estimated from historical data. In the absence of normality, researchers have proposed modifications to portfolio analysis models. Lai (1991) defined portfolio selection with skewness based on solving a polynomial objective programming problem that incorporates investor preferences. Various risk measures have also been proposed: for example, mean absolute deviation risk (Konno, Yamazaki, 1991) and conditional VaR (Rockafellar, Uryasev, 2000) which allows the formulation and solution of a portfolio selection problem using linear programming techniques. Goldfarb & Iyengar (2003) proposed the use of uncertainty structures, to deal with the sensitivity of optimal portfolios to statistical errors in market parameter estimates.

In addition, limitations associated with mean-variance (MV) optimisation include: concentrated asset class allocation, inability to account for skewness and kurtosis, and lack of risk diversification. Numerous modifications have been developed in response to these limitations, among which it is worth mentioning: the stochastic linear-quadratic (LQ) control proposed by Zhou and Li (2000), the inclusion of the time dimension by Fahmy (2020). Ötken et al. (2019), on the other hand, added further constraints to the MV concept: cardinality, sector capitalisation and tracking error. King extended the model with asymmetric risk measures (King, 1993), Cesarone et al. explored the Markowitz limited asset model by introducing cardinality constraints (Cesarone et al., 2013), and Guerard et al. extended the model with a multi-objective portfolio optimisation problem (Guerard et al., 2018). In addition, some authors have suggested that portfolio selection is a multi-criteria choice problem

(Ogryczak, 2000), and some have included environmental and social issues in portfolio optimisation (Liagkouras et al., 2020).

Despite the development of more sophisticated models, the model based on Markowitz's portfolio theory is still widely used in practice for active portfolio management. Fabozzi et al. provided an overview of the contributions to portfolio choice theory from an operations research and finance perspective. In their paper, Fabozzi et al. examined the classical mean-variance problem, the mean-VaR model and the mean-CVaR model, and reviewed optimal estimation methods together with a robust Bayesian approach (Fabozzi et al., 2010).

According to the authors, given the risks that have occurred in recent years, namely the coronavirus pandemic and the increased political risk associated with the war in Ukraine, it was reasonable to test the effectiveness of a model based on minimum-risk portfolio construction in the context of investment risk minimisation.

Methodology/Research methods

The aim of the study was to investigate the application of Harry Markowitz's portfolio theory to minimise investment portfolio risk. The study set out a research hypothesis as follows: an investment strategy built on the basis of Harry Markowitz's portfolio theory reduces investment risk.

We determine the shares of companies in the minimum-risk portfolio by calculating the vector w by multiplying the inverse variance-covariance matrix and the vector I:

$$w = C^{-1}I \tag{1}$$

where:

w – a vector with n+1 components, of which the first n components are the shares in the MVP,

I – a vector with n+1 components, of which the first n components are 0 and the last one is 1,

C^{-1} – inverse matrix C,

C – variance-covariance matrix of dimension (n+1) x (n+1), the elements of which are defined as follows:

$$c_{ii} = 2\sigma_i^2, \qquad i = 1, \dots, n; \tag{2}$$

$$c_{ij} = 2\sigma_i\sigma_j\rho_{ij}, \qquad i, j = 1, \dots, n, \quad i \neq j \tag{3}$$

$$c_{i,n+1} = c_{n+1,i} = 1 \qquad i = 1, \dots, n; \tag{4}$$

$$c_{n+1,n+1} = 0 \tag{5}$$

In the case of a two-component portfolio, we can apply the formulas:

$$w_1 = \frac{\sigma_2^2 - \sigma_1\sigma_2\rho_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_1\sigma_2\rho_{12}} \tag{6}$$

$$w_2 = \frac{\sigma_1^2 - \sigma_1\sigma_2\rho_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_1\sigma_2\rho_{12}} \tag{7}$$

We determine the portfolio variance according to the formula:

$$V_p = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} w_i w_j \rho_{ij} \quad (8)$$

where:

V_p – variance of portfolio returns,

σ_i – standard deviation of the return on shares of the i-company,

ρ_{ij} – the correlation coefficient of the i-th and j-th company's share returns.

The portfolio's rate of return is represented by the formula:

$$R_p = \sum_{i=1}^{n} w_i E(r_i) \quad (9)$$

where:

R_p – expected rate of return of the portfolio,

W_i – share of i-th company in the portfolio,

$E(r_i)$ – expected rate of return of the i-th company's shares.

The period of analysis was taken as: January 2020 to March 2023. The portfolio analysis itself concerned the period: January 2021 to March 2023. The subject of the analysis was the monthly returns of companies included in the main index of the Warsaw Stock Exchange - WIG20. Only those companies that were continuously included in the WIG20 index during the period under study were included in the study. Allegro.EU SA and Pepco Group N.V. were therefore excluded. The portfolio analysis was conducted on the basis of 18 companies (table 1).

Table 1.
Companies included in the WIG20 index

Full name of the company	Short name of the company	3-letter abbreviation
Polski Koncern Naftowy Orlen S.A.	PKN ORLEN	PKN
Alior Bank S.A.	ALIOR	ALR
Mbank S.A.	MBANK	MBK
Bank Polska Kasa Opieki S.A.	PEKAO	PEO
Powszechna Kasa Oszczędności Bank Polski S.A.	PKO BP	PKO
Santander Bank Polska S.A.	SANPL	SPL
Powszechny Zakład Ubezpieczeń S.A.	PZU	PZU
Dino Polska S.A.	DINOPL	DNP
Pepco Group N.V.	PEPCO	PCO
Allegro.eu S.A.	ALLEGRO	ALE
KGHM Polska Miedź S.A.	KGHM	KGH
Jastrzębska Spółka Węglowa S.A.	JSW	JSW
LPP S.A.	LPP	LPP
CD Projekt S.A.	CDPROJEKT	CDR
Asseco Poland S.A.	ASSECOPOL	ACP
Grupa Kęty S.A.	KETY	KTY
Kruk S.A.	KRUK	KRU
Orange Polska S.A.	ORANGEPL	OPL
Cyfrowy Polsat S.A.	CYFRPLSAT	CPS
PGE Polska Grupa Energetyczna S.A.	PGE	PGE

Source: Bielska (2023).

The possibility of minimising risk by constructing two-component portfolios with minimal risk was examined first. The study was limited to two-component portfolios containing the shares of PKN Orlen SA. Thus, 17 binary portfolios were analysed by determining the shares of the respective companies in the MVP, the minimum risk of these portfolios and the average return of the MVP were calculated. A simulation was then carried out, which consisted of selecting the portfolio with the lowest minimum risk among the portfolios analysed in a given month and taking it as a recommendation for investment in the following month. In each month, the composition of the portfolio and/or the share of companies in the MVP was changed. Thus, it was checked what rate of return the recommended portfolio would realise in order to finally count the standard deviation of the monthly returns of the recommended portfolio to assess risk. The risk analysis procedure for the two-component portfolios is presented in table 2.

Table 2.
Analysis steps for applying Markowitz theory to two-component portfolios

I. Selection of portfolio companies
– one of the portfolio companies is assumed to be PKN Orlen SA, – the second company in the portfolio would be a company listed in the WIG20 index continuously between January 2020 and March 2023, – thus, 17 two-component portfolios were analysed.
II. Analysis period
– January 2020 - March 2023, – analysis on a monthly basis, – analysis of two-component portfolios for the period January 2021-March 2022, – average return, standard deviation of returns and correlation coefficient were calculated for each month for the period of the last 12 months.
III. Calculation of basic measures of descriptive statistics
– monthly rate of return was calculated for each company, followed by average monthly returns and standard deviation of returns, – the correlation coefficients of the returns of PKN Orlen with the other companies in the WIG20 index were calculated.
IV. Structuring two-component portfolios with minimal risk
– the shares of companies in the minimum-variance portfolio were determined for each of the 17 two-component portfolios, – the average return of the minimum-variance portfolio was determined.
V. Simulation
– for each month in the period January 2021 - March 2023, out of the 17 analysed two-component portfolios with minimum risk, the one with the lowest minimum risk was selected, – determined shares of companies in the selected minimum-variance portfolio were accepted as recommended to the investor and it was checked what rate of return this portfolio would have realised in a given month, – in each month of the portfolio analysis the composition of the portfolio and shares of portfolio companies were verified.
VI. Analysis of effectiveness
– on the basis of the calculated rates of return realised by the selected portfolio at the recommended shares, the standard deviation of the returns of the recommended portfolio for the period January 2021 - March 2023 was determined, – for each of the 17 minimum-variance two-component portfolios, the monthly rates that would have been achieved with the recommended shares as well as the standard deviation of the returns for each of the two-component portfolios over the analysed period were calculated, – the standard deviation of the returns of the portfolio chosen by the investor (step 5) was compared with the other minimum-variance two-component portfolios, – for each of the portfolios, the standard deviation of the realised returns of the portfolio was compared with the standard deviations of the returns of the companies included in that portfolio.

Source: Bielska (2023).

The application of Markowitz theory required the calculation of returns and standard deviations of the returns of the companies studied, as well as the correlation of returns. The analysis was based on monthly returns. Average returns, standard deviations and return correlations were calculated for the last twelve months. Quoted return data for the surveyed companies comes from stooq.com.

Results

On the basis of measures of descriptive statistics, the shares of companies in the two-component portfolios with minimum risk were determined and the minimum risk for the individual portfolios for the period: January 2021-March 2023 was determined. It is worth noting that the minimum portfolio risk thus determined was lower than the risk of the individual companies as measured by the standard deviation of returns. The average returns of the minimum risk portfolios were also calculated as weighted averages of the shares of these companies in the minimum risk portfolio and the average return of the individual companies. Similarly, the returns of the portfolios were calculated taking into account the recommended shares of the minimum-risk portfolios (calculated on historical data) and the returns obtained by the companies concerned in a particular month. The shares of the companies in the MVP were therefore a recommendation to the investor, who, by spreading capital across the companies, achieved a specific rate of return on the two-component portfolio. Then, for each month, the portfolio that had the lowest minimum risk out of the 17 portfolios analysed was selected and treated as a recommendation for the risk-minimising investor.

Table 3 summarises the standard deviations of the returns of the two-component portfolios realised in the period January 2021-March 2023 on the basis of the recommended shares of companies calculated for the MVPs. In addition, the standard deviations of the returns of the company that constituted the two-component portfolio alongside PKN Orlen are presented.

Table 3.
Risk of two-component portfolios compared to the return risk of the companies in the portfolios

Portfolio	**I company in the portfolio**	**II company in the portfolio**	**standard deviation of the returns of the two-component portfolio realised between January 2021 and March 2023**	**standard deviation of returns of shares of a company included in the two-component portfolio with PKN realised in the period January 2021-March 2023**
Portfolio 1.	PKN	ALR	0,0998	0,1595
Portfolio 2.	PKN	ACP	0,0572	0,0535
Portfolio 3.	PKN	CDR	0,0829	0,1282
Portfolio 4.	PKN	CPS	0,0684	0,0709
Portfolio 5.	PKN	DNP	0,0851	0,0883
Portfolio 6.	PKN	KTY	0,0715	0,0808

Cont. table 3.

Portfolio 7.	PKN	JSW	0,0972	0,2006
Portfolio 8.	PKN	KGH	0,0841	0,0963
Portfolio 9.	PKN	KRU	0,0948	0,1325
Portfolio 10.	PKN	LPP	0,0980	0,1541
Portfolio 11.	PKN	MBK	0,1003	0,1476
Portfolio 12.	PKN	OPL	0,0614	0,0684
Portfolio 13.	PKN	PEO	0,1148	0,1167
Portfolio 14.	PKN	PGE	0,0978	0,1405
Portfolio 15.	PKN	PKO	0,1077	0,0965
Portfolio 16.	PKN	PZU	0,0858	0,0919
Portfolio 17.	PKN	SPL	0,1049	0,1050

Source: Bielska (2023).

In the vast majority of cases (15 out of 17 portfolios), the construction of a two-component portfolio by including PKN Orlen in the portfolio reduced the risk of the investment. Only in the case of Asseco Poland S.A. and PKO BP Bank Polski S.A. did the risk of a two-component portfolio increase compared with the risk achieved by individual companies. The risk of an investment involving a monthly adjustment of the portfolio was also examined according to the assumption that the investor chooses the binary portfolio that for a given month achieves the lowest minimum risk among the analysed portfolios.

Table 4 shows the monthly adjustments to the composition and shares of the companies in the MVP, so as to invest in the portfolio with the lowest minimum risk among the two-component portfolios analysed, as recommended. The monthly return of this portfolio was also determined. The standard deviation of the returns of the portfolio constructed in this way was 0.0658. Comparing this result with the data in Table 3, we can conclude that the investment strategy of adjusting the composition and/or shares of the companies in the two-component portfolio on a monthly basis proved to be effective in terms of risk. Risk measures were presented in figure 2.

Table 4.

Composition of two-component portfolios for the month based on recommended shares in the portfolio with the lowest MVP among the portfolios analysed

month	**I company in the portfolio**	**II company in the portfolio**	**PKN Orlen's share**	**II company share**	**portfolio return for the recommended shares**
III 2023	PKN	ACP	-3%	103%	-0,0464
II 2023	PKN	ACP	7%	93%	0,0363
I 2023	PKN	ACP	5%	95%	0,0472
XII 2022	PKN	ACP	4%	96%	-0,0095
XI 2022	PKN	ACP	10%	90%	0,0651
X 2022	PKN	OPL	36%	64%	0,1111
IX 2022	PKN	OPL	32%	68%	-0,1297
VIII 2022	PKN	OPL	43%	57%	-0,0860
VII 2022	PKN	OPL	54%	46%	0,0430
VI 2022	PKN	OPL	55%	45%	-0,0440
V 2022	PKN	KTY	16%	84%	-0,0343
IV 2022	PKN	OPL	35%	65%	-0,1005
III 2022	PKN	OPL	35%	65%	0,0322
II 2022	PKN	OPL	36%	64%	-0,0191
I 2022	PKN	OPL	33%	67%	-0,0714

Cont. table 4.

XII 2021	PKN	OPL	33%	67%	-0,0012
XI 2021	PKN	ACP	7%	93%	-0,1194
X 2021	PKN	ACP	-4%	104%	0,1358
IX 2021	PKN	ACP	-5%	105%	0,0332
VIII 2021	PKN	ACP	1%	99%	0,0445
VII 2021	PKN	ACP	-3%	103%	0,0439
VI 2021	PKN	ACP	-4%	104%	0,0509
V 2021	PKN	ACP	-1%	101%	0,0387
IV 2021	PKN	CPS	-2%	102%	-0,0022
III 2021	PKN	CPS	-2%	102%	0,0308
II 2021	PKN	CPS	-11%	111%	-0,0757
I 2021	PKN	CPS	-12%	112%	0,0147

Source: Bielska (2023).

The recommended portfolio is the one in which there was a monthly adjustment of the composition and share of companies in the portfolio. The purple color represents the standard deviation of this portfolio's returns, while the yellow color represents the standard deviation of PKN Orlen's returns

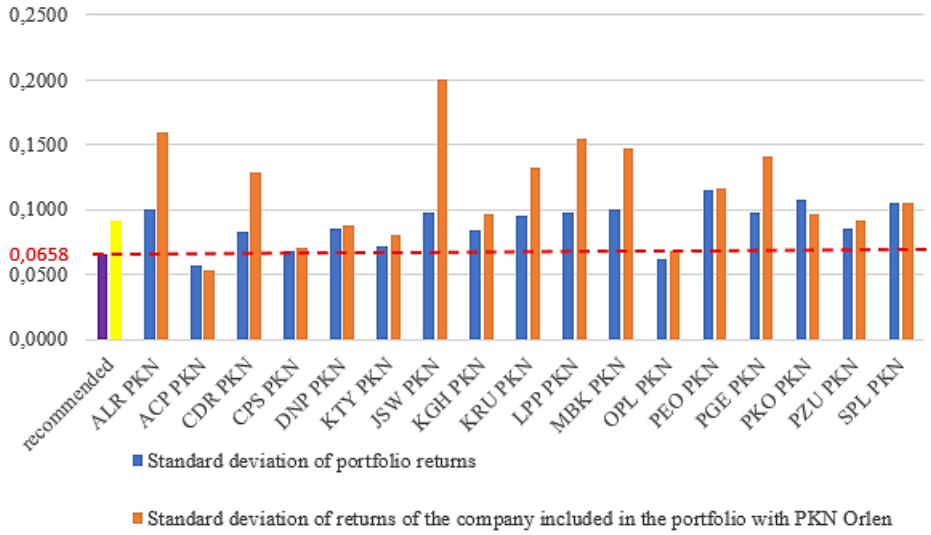

Figure 2. Standard deviations of the returns of the analysed two-component portfolios and the recommended portfolio with monthly adjustments to the composition and/or holdings of the portfolio companies.

Source: Bielska (2023).

Investing for the entire period in a given two-component portfolio out of the 17 portfolios analysed would have given a better result only in the case of two portfolios composed of shares of PKN Orlen and Asseco and PKN Orlen and Orange. In the case of 15 portfolios, maintaining a constant composition of companies in the portfolio would give a worse result in terms of risk than a strategy of monthly selection of the composition and/or shares of companies in the portfolio (Figure 2.).

Discussion

The research carried out showed that Markowitz's portfolio theory in the sense of MVP construction leads to a reduction in investment risk. In the vast majority of cases, two-component portfolios performed better in terms of risk than the individual companies included in these portfolios. In addition to the selection of appropriate shares of companies in the portfolio, the diversification of the portfolio itself as a result of increasing the number of portfolio companies is also important here. In the study, a simulation was carried out using the strategy of selecting for each month of the period January 2021 - March 2023 the portfolio with the lowest MVP among the portfolios analysed. This therefore represents a proposed solution to the dilemma of which portfolio an investor should opt for. The risk, as measured by the standard deviation of returns from such a strategy, turned out to be one of the lowest compared to the strategy of continuous investment in one of the 17 portfolios analysed. Only in the case of continuous investment in binary portfolios composed of shares of PKN Orlen and Asseco and PKN Orlen and Orange would better results be achieved in terms of minimising investment risk.

In this paper, the analysis was performed on a limited number of companies. In addition, the portfolios analysed were limited to those containing PKN Orlen. Two companies that were not listed in the WIG20 index for the entire period under study were excluded from the analysis. By constructing two-component portfolios, we would obtain 190 portfolios from all companies included in the WIG20 index. The subject of the analysis was therefore only 8.9% of all possible portfolios. Extending the analysis to multi-component portfolios to a greater extent than was done in this study could provide interesting conclusions. Risk minimisation is also related to the procedure of selecting companies for the portfolio itself. Additional correlations can be used here, such as industry affiliation, company-specific risk, values of financial ratios, company ratings, etc.

The analysis covered a limited period of time and was carried out on a monthly rate basis, which still posed a huge analytical challenge. Recent years have been a period of high uncertainty in the financial markets and in the global economy which needs to be taken into account. An analysis taking into account bull and bear market periods would most likely have provided additional insights in terms of adjusting investment risk minimisation strategies. Similarly, shortening the interval to weekly or daily data could inspire further research.

It is also worth noting the different attitudes of investors towards risk (risk aversion), psychological factors (e.g. emotions), experience and the purpose of investing (securing capital or seeking above-average returns).

Conclusion

Several researchers have analyzed the stability of the risk minimization approach for some risk measures (Cesarone et al., 2020). The results obtained confirm the usefulness of Markowitz's theory in minimising investment risk and therefore do not allow the research hypothesis to be rejected.

The simulation carried out was of an exemplary nature, concerned a limited period and analysed a limited number of companies, additionally assuming the presence of one of them in all analysed two-component portfolios. The proposed approach based on the selection of the portfolio with the lowest minimum risk proved to be successful and can be further tested in other periods and on a different set of portfolio companies.

In further research, it makes sense to analyse risk in relation to the rate of return. There is a distinct lack of studies on the stability of portfolio theory in terms of portfolio diversification or the optimisation of the risk-return ratio.

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Appendix

Essential calculations and simulation results (tables A1-A14).

Table A1.
Monthly returns of companies included in the WIG20 index, part 1/2

	PKN	ALR	ACP	CDR	CPS	DNP	KTY	JSW	KGH
III 2023	-0,1263	-0,0526	-0,0488	-0,1691	-0,0379	0,0457	0,0600	-0,1435	-0,0567
II 2023	0,0265	0,0360	0,0370	-0,0509	-0,0574	-0,0520	-0,0050	-0,1842	-0,0965
I 2023	0,0106	0,1436	0,0489	0,0800	0,0420	0,0421	0,0813	0,1573	0,1097
XII 2022	-0,0237	-0,0611	-0,0089	-0,0253	-0,0673	0,0209	-0,2306	-0,0607	0,0580
XI 2022	0,1686	0,2265	0,0541	0,0273	0,0328	0,1549	0,1891	0,4399	0,1923
X 2022	0,0258	0,2755	-0,0036	0,2710	0,1049	0,0473	0,0207	0,2456	0,1046
IX 2022	-0,1162	-0,1028	-0,0369	0,1929	-0,1769	-0,1118	-0,1257	-0,2966	0,0018
VIII 2022	-0,1923	0,0399	-0,0138	-0,0580	-0,0339	-0,0506	0,0055	-0,0656	-0,2334
VII 2022	0,1106	-0,0820	-0,0431	-0,0481	-0,0575	0,1343	-0,0939	-0,1994	-0,0158
VI 2022	-0,0728	-0,1812	-0,0308	-0,1246	-0,0693	0,0777	-0,0226	-0,0354	-0,1800
V 2022	-0,0186	-0,0749	-0,0109	-0,0931	-0,0915	0,0382	-0,0374	-0,0048	0,0243
IV 2022	-0,0182	-0,1980	-0,0430	-0,3047	-0,1325	-0,1526	0,0525	-0,1320	-0,1621
III 2022	0,0677	-0,0148	0,0768	0,0220	0,0168	0,1426	0,0557	0,4407	0,0384
II 2022	-0,0062	-0,1706	-0,1009	-0,0711	-0,1435	-0,0629	-0,0574	0,2305	0,1713
I 2022	-0,0470	0,0159	-0,0607	-0,0665	-0,1017	-0,1467	-0,0210	0,1268	-0,0085
XII 2021	0,0178	-0,0595	-0,0159	0,0510	-0,0057	0,0803	0,0517	-0,1648	-0,0313
XI 2021	-0,1648	-0,0932	-0,1162	0,0372	-0,0223	-0,0537	-0,0750	-0,1941	-0,0659
X 2021	0,0591	0,4846	0,1326	-0,0872	0,0045	0,0774	-0,0063	-0,0582	-0,0167
IX 2021	0,1009	-0,0227	0,0367	0,1216	-0,0332	0,0253	-0,0378	0,3797	-0,1093
VIII 2021	0,0068	0,1810	0,0448	-0,0772	0,0690	0,0529	-0,0541	0,1526	-0,0891
VII 2021	-0,0525	0,1077	0,0416	-0,0019	0,1274	0,0909	0,0611	-0,0114	0,0351
VI 2021	-0,0614	-0,0122	0,0468	0,1851	-0,0235	-0,0241	0,0384	-0,0377	-0,0733
V 2021	0,2176	0,1922	0,0405	-0,0370	0,0417	0,1476	0,0113	0,1999	0,0254
IV 2021	0,0507	0,2065	0,0376	-0,0874	-0,0014	-0,0664	0,0924	0,0236	0,0242
III 2021	0,0577	0,0097	0,0090	-0,1976	0,0314	0,0399	0,0769	-0,1847	-0,0158
II 2021	0,0414	0,2759	-0,0206	-0,2255	-0,0641	-0,0786	0,0873	0,0926	-0,0388
I 2021	-0,0495	0,0074	-0,0044	0,1038	0,0079	-0,1000	-0,0264	0,2174	0,0134
XII 2020	0,0126	0,0217	0,0303	-0,2999	0,1470	0,1457	0,0685	0,0380	0,2208
XI 2020	0,4367	0,4457	0,0263	0,1336	0,0801	0,1527	0,1308	0,5838	0,2616
X 2020	-0,1775	-0,1554	-0,0777	-0,1955	-0,0960	-0,0589	-0,1028	-0,4180	-0,0030
IX 2020	-0,0985	-0,0240	-0,0225	-0,0458	-0,0519	0,0170	-0,0387	0,6332	-0,1449
VIII 2020	-0,0542	-0,0680	0,1094	0,0963	0,0375	0,0699	0,1002	-0,0762	0,0793
VII 2020	-0,1543	-0,0975	-0,0347	0,0164	0,0626	0,0484	-0,0159	-0,1226	0,3919
VI 2020	-0,0764	0,1062	-0,1081	-0,0249	0,0000	0,0926	0,2659	0,1000	0,0294
V 2020	0,0919	-0,0269	0,0912	0,1504	0,0124	0,0735	-0,0725	0,2442	0,1504
IV 2020	0,1548	0,1792	0,1554	0,2614	0,0785	0,1121	0,1498	0,1408	0,3047
III 2020	-0,0943	-0,4161	-0,0397	0,0042	-0,0518	0,1057	-0,0982	-0,1421	-0,1916
II 2020	-0,2231	-0,2170	-0,0486	-0,0075	-0,0728	-0,1220	0,0028	-0,2803	-0,2316
I 2020	-0,1253	-0,0784	0,0071	-0,0014	-0,0272	0,1261	0,0585	-0,1400	-0,0555

Source: Bielska (2023).

Table A2.
Monthly returns of companies included in the WIG20 index, part 2/2

	KRU	LPP	MBK	OPL	PEO	PGE	PKO	PZU	SPL
III 2023	-0,0717	0,0191	-0,0613	0,0113	-0,0542	-0,0688	-0,0906	-0,0428	-0,0162
II 2023	-0,0575	-0,0645	0,0250	-0,0394	-0,0273	-0,1093	-0,0348	-0,0049	0,0411
I 2023	0,1233	-0,0498	0,0736	0,0474	0,0598	0,0874	0,0544	0,0373	0,1133
XII 2022	0,0368	0,0985	-0,0773	0,0276	0,0049	0,0494	0,0517	0,1121	-0,0567
XI 2022	0,0688	0,1428	0,1674	0,0446	0,0688	0,1658	0,0816	0,1747	0,0688
X 2022	0,1847	0,0375	0,3407	0,1587	0,2944	-0,1382	0,1992	0,1507	0,2930
IX 2022	-0,2165	-0,0835	-0,0600	-0,1360	-0,0662	-0,1161	-0,0667	-0,1729	-0,0738
VIII 2022	0,1284	-0,1480	-0,0269	-0,0043	-0,1141	-0,3064	-0,1104	-0,0709	-0,0877
VII 2022	0,0923	0,1107	-0,0178	-0,0369	-0,0999	-0,0291	-0,0643	0,0100	-0,0101
VI 2022	-0,1263	-0,1343	-0,1938	-0,0095	-0,1272	0,0591	-0,1269	-0,0747	-0,0754
V 2022	0,0646	0,0840	-0,0720	-0,0778	-0,0466	0,0311	-0,0242	0,0510	-0,0459
IV 2022	-0,1827	-0,1941	-0,1596	-0,1447	-0,1362	0,0637	-0,1848	-0,0971	-0,1248
III 2022	0,1917	0,3214	-0,1385	0,0128	-0,0204	0,1130	-0,0126	0,0581	-0,0139
II 2022	-0,1994	-0,4557	-0,1156	-0,0263	-0,1500	0,0595	-0,1633	-0,1357	-0,1187
I 2022	0,0086	-0,0788	0,0680	-0,0835	0,1070	-0,0567	0,0549	0,0226	0,0003
XII 2021	-0,0382	0,2845	-0,1181	-0,0105	0,0167	-0,0289	0,0218	-0,0194	-0,0271
XI 2021	0,0126	-0,0643	-0,1461	0,0963	-0,1041	-0,1669	-0,1112	-0,0992	-0,0342
X 2021	0,0413	-0,0198	0,3911	-0,0305	0,2917	0,1070	0,1614	0,0986	0,2236
IX 2021	0,0150	0,0678	0,0960	-0,0302	-0,0401	-0,1141	0,0045	-0,1010	-0,0060
VIII 2021	0,0306	0,0050	0,1493	0,0767	0,1296	0,1571	0,1037	0,0772	0,1774
VII 2021	0,1901	0,0646	-0,0214	0,1323	0,0114	-0,0815	-0,0047	0,0242	0,0027
VI 2021	-0,0226	0,1430	0,0691	0,0037	-0,0310	-0,0590	-0,0675	-0,0097	-0,0472
V 2021	0,3991	0,1336	0,2868	-0,0177	0,1929	-0,0132	0,1463	0,1333	0,1914
IV 2021	-0,0066	0,2114	0,0930	0,0389	0,1273	0,4853	0,0688	-0,0447	0,0313
III 2021	0,0011	0,0227	-0,0360	0,0428	0,0247	0,0116	0,0766	0,1458	0,0311
II 2021	0,0945	0,0222	0,1124	-0,0344	0,0594	0,0039	0,0498	-0,0227	0,1592
I 2021	0,1782	-0,0953	0,0867	-0,0091	0,0617	-0,0085	0,0056	-0,0782	-0,0273
XII 2020	-0,0173	0,2060	0,1728	0,0427	0,0682	0,1246	0,0769	0,2665	0,0672
XI 2020	0,2285	0,3314	0,2940	0,0377	0,3347	0,2316	0,3764	0,1486	0,4066
X 2020	-0,1372	-0,2120	-0,3178	-0,1131	-0,1659	-0,3010	-0,1163	-0,1346	-0,1488
IX 2020	-0,1253	-0,0869	-0,1102	-0,0624	-0,0448	0,0700	-0,0226	-0,0929	-0,0649
VIII 2020	0,1329	0,0338	-0,0084	0,0299	0,0336	-0,0939	-0,0115	0,0026	0,0066
VII 2020	0,1906	0,1405	-0,1831	0,1402	-0,0605	-0,0425	-0,0469	-0,0699	-0,1406
VI 2020	0,0599	-0,1220	0,0550	-0,0496	0,0094	0,4164	0,0128	-0,0357	0,0566
V 2020	0,2831	0,0719	-0,0209	-0,0461	0,0306	0,1911	0,0281	0,0013	0,0194
IV 2020	0,2052	0,2683	0,0018	0,1995	-0,0583	0,1051	-0,0174	-0,0232	-0,0417
III 2020	-0,5254	-0,2571	-0,2704	-0,0668	-0,3755	-0,1900	-0,3003	-0,1197	-0,3337
II 2020	-0,1534	-0,1878	-0,1989	-0,1248	-0,1053	-0,3559	-0,0797	-0,1321	-0,1218
I 2020	-0,0233	-0,0315	-0,0358	-0,0162	-0,0258	-0,1425	-0,0198	-0,0064	-0,0641

Source: Bielska (2023).

Table A3.
Correlation coefficients of monthly returns of PKN Orlen with other companies under study, part 1/2

	ALR	ACP	CDR	CPS	DNP	KTY	JSW	KGH
III 2023	0,3831	0,4830	0,0797	0,4564	0,6637	0,4059	0,5359	0,6703
II 2023	0,3613	0,3885	0,0884	0,4360	0,6848	0,4036	0,5707	0,6553
I 2023	0,3493	0,4129	0,0901	0,4553	0,6626	0,4021	0,5522	0,6593
XII 2022	0,3401	0,4171	0,1002	0,4601	0,6664	0,4874	0,5082	0,6651
XI 2022	0,0932	0,3913	-0,0002	0,2372	0,5810	0,2508	0,3930	0,5275
X 2022	0,2274	0,4644	-0,1895	0,2303	0,5974	0,2309	0,3173	0,4905
IX 2022	0,1936	0,5074	0,1826	0,1342	0,5340	0,0307	0,3738	0,4389
VIII 2022	0,3169	0,6183	0,2108	0,2244	0,5325	0,1290	0,3668	0,1826
VII 2022	0,3593	0,6991	0,1952	0,0974	0,3758	0,2843	0,6228	0,1213
VI 2022	0,3036	0,6239	-0,0031	0,0545	0,4692	0,1956	0,6239	0,0300
V 2022	0,3941	0,5475	-0,0388	0,1902	0,5964	0,1816	0,5731	0,1487
IV 2022	0,4042	0,5478	-0,1839	0,1681	0,5739	0,2500	0,5564	0,1322
III 2022	0,4183	0,5242	-0,2439	0,1728	0,5666	0,2486	0,4588	0,0998
II 2022	0,4314	0,5388	-0,2597	0,1291	0,5131	0,2498	0,5160	0,2403
I 2022	0,4341	0,5173	-0,3352	0,0189	0,5248	0,2556	0,4621	0,2026
XII 2021	0,4517	0,5251	-0,2755	0,0037	0,4753	0,2466	0,4925	0,0974
XI 2021	0,5691	0,0083	0,1850	0,1052	0,5369	0,3802	0,7056	0,5426
X 2021	0,7831	0,3963	0,2886	0,3122	0,5968	0,5457	0,7896	0,5128
IX 2021	0,8497	0,4320	0,2525	0,4013	0,5889	0,6371	0,4991	0,6285
VIII 2021	0,8660	0,2612	0,1926	0,4012	0,5609	0,5913	0,5163	0,6080
VII 2021	0,8948	0,3618	0,1575	0,4233	0,5537	0,6406	0,5388	0,2142
VI 2021	0,8687	0,4302	0,2371	0,4139	0,4891	0,3435	0,5207	0,1938
V 2021	0,8224	0,4120	0,2770	0,3939	0,4203	0,3329	0,5308	0,2663
IV 2021	0,8425	0,4715	0,3711	0,4449	0,5166	0,3770	0,5312	0,3519
III 2021	0,7683	0,4931	0,4104	0,4694	0,4609	0,4084	0,6029	0,4170
II 2021	0,8185	0,5399	0,4712	0,5903	0,6337	0,4029	0,6558	0,5370
I 2021	0,8208	0,5309	0,4852	0,6013	0,6279	0,3831	0,6812	0,5504

Source: Bielska (2023).

Table A4.
Correlation coefficients of monthly returns of PKN Orlen with other companies under study, part 2/2

	KRU	LPP	MBK	OPL	PEO	PGE	PKO	PZU	SPL
III 2023	0,3438	0,6582	0,3695	0,3161	0,3784	0,6421	0,4547	0,6834	0,4474
II 2023	0,3330	0,5038	0,3587	0,3282	0,3650	0,6792	0,4294	0,6403	0,4242
I 2023	0,3268	0,5118	0,3242	0,3417	0,3034	0,6881	0,3860	0,6268	0,4209
XII 2022	0,3228	0,5127	0,3003	0,3599	0,3128	0,6967	0,4135	0,6680	0,4156
XI 2022	0,2407	0,4546	0,1779	0,0149	0,2788	0,6545	0,3409	0,5580	0,3193
X 2022	0,2060	0,4301	0,2700	-0,1465	0,3559	0,7715	0,4054	0,6120	0,4200
IX 2022	0,0944	0,4406	0,3433	-0,3106	0,3208	0,5935	0,4350	0,3901	0,3964
VIII 2022	0,3813	0,4138	0,4199	-0,2489	0,2489	0,2774	0,3735	0,3447	0,2952
VII 2022	0,1711	0,3505	0,4554	-0,3015	0,3680	0,4154	0,4504	0,2945	0,3270
VI 2022	0,1076	0,2558	0,3581	-0,3163	0,3222	0,5025	0,4194	0,2403	0,3070
V 2022	0,5360	0,3077	0,5383	-0,2944	0,4865	0,3469	0,5653	0,4982	0,5168
IV 2022	0,5288	0,3119	0,5439	-0,4137	0,4988	0,3067	0,6100	0,4680	0,5205
III 2022	0,4908	0,2655	0,6098	-0,3923	0,5262	0,2828	0,6464	0,4584	0,5491
II 2022	0,5362	0,3467	0,6265	-0,4219	0,5639	0,2853	0,7538	0,4682	0,5751
I 2022	0,4355	0,3524	0,6179	-0,5595	0,5929	0,2699	0,7867	0,5186	0,5831
XII 2021	0,4445	0,3899	0,6642	-0,5685	0,5973	0,2644	0,7785	0,3850	0,6028
XI 2021	0,5012	0,6222	0,5684	-0,1577	0,6997	0,2818	0,8898	0,3458	0,8093
X 2021	0,6090	0,7329	0,7664	0,1743	0,8593	0,4587	0,9337	0,4806	0,8838
IX 2021	0,6636	0,7583	0,7854	0,2759	0,9288	0,4769	0,9641	0,5915	0,9243
VIII 2021	0,6323	0,7577	0,8066	0,2840	0,9463	0,5092	0,9781	0,6032	0,9635
VII 2021	0,5661	0,6729	0,8251	0,1475	0,9495	0,5057	0,9747	0,6351	0,9674
VI 2021	0,5529	0,7174	0,8250	0,1831	0,9482	0,3364	0,9799	0,6408	0,9487
V 2021	0,4620	0,7143	0,7705	0,1930	0,9233	0,4300	0,9674	0,5885	0,9270
IV 2021	0,5239	0,7499	0,7408	0,3064	0,8189	0,4685	0,8883	0,5617	0,8490
III 2021	0,4717	0,7417	0,7428	0,3321	0,7069	0,5043	0,7958	0,5926	0,7889
II 2021	0,5124	0,7718	0,7690	0,4390	0,7064	0,5935	0,7864	0,6363	0,8001
I 2021	0,5349	0,7734	0,7845	0,4392	0,7128	0,6067	0,7808	0,6220	0,7982

Source: Bielska (2023).

Table A5.
Standard deviations of monthly returns of the surveyed companies, part 1/2

	PKN	ALR	ACP	CDR	CPS	DNP	KTY	JSW	KGH
III 2023	0,0929	0,1442	0,0397	0,1424	0,0755	0,0950	0,1030	0,2334	0,1245
II 2023	0,0925	0,1511	0,0472	0,1430	0,0807	0,0958	0,1039	0,2304	0,1314
I 2023	0,0931	0,1438	0,0456	0,1409	0,0770	0,1063	0,0999	0,2295	0,1279
XII 2022	0,0933	0,1438	0,0456	0,1424	0,0784	0,1082	0,0791	0,2357	0,1268
XI 2022	0,0863	0,1223	0,0471	0,1427	0,0747	0,1004	0,0576	0,2120	0,1120
X 2022	0,0887	0,1725	0,0656	0,1141	0,0599	0,1020	0,0564	0,1983	0,1047
IX 2022	0,0917	0,1714	0,0673	0,1028	0,0506	0,0967	0,0476	0,2101	0,1055
VIII 2022	0,0742	0,1804	0,0694	0,1031	0,0612	0,0956	0,0483	0,2108	0,0910
VII 2022	0,0679	0,1824	0,0701	0,1040	0,0777	0,0919	0,0476	0,1987	0,0931
VI 2022	0,0671	0,1743	0,0708	0,1195	0,0769	0,0903	0,0490	0,1988	0,0832
V 2022	0,0918	0,1788	0,0714	0,1178	0,0765	0,0983	0,0479	0,2012	0,0832
IV 2022	0,0920	0,1698	0,0702	0,0844	0,0681	0,0884	0,0525	0,1921	0,0727
III 2022	0,0915	0,1689	0,0676	0,0999	0,0687	0,0810	0,0545	0,1740	0,0713
II 2022	0,0916	0,1608	0,0600	0,1146	0,0580	0,0823	0,0550	0,1653	0,0448
I 2022	0,0917	0,1612	0,0560	0,1199	0,0489	0,0756	0,0554	0,1716	0,0461
XII 2021	0,0917	0,1557	0,0551	0,1405	0,0612	0,0821	0,0564	0,1608	0,0829
XI 2021	0,1331	0,1670	0,0357	0,1477	0,0613	0,0861	0,0563	0,2006	0,1090
X 2021	0,1495	0,1561	0,0351	0,1535	0,0707	0,0891	0,0676	0,2461	0,1086
IX 2021	0,1538	0,1562	0,0362	0,1448	0,0721	0,0892	0,0677	0,2791	0,1126
VIII 2021	0,1555	0,1611	0,0445	0,1511	0,0709	0,0897	0,0654	0,2831	0,1088
VII 2021	0,1622	0,1684	0,0461	0,1517	0,0647	0,0880	0,0669	0,2880	0,1475
VI 2021	0,1629	0,1670	0,0552	0,1352	0,0639	0,0885	0,0925	0,2859	0,1423
V 2021	0,1535	0,1653	0,0600	0,1476	0,0634	0,0828	0,0984	0,2876	0,1432
IV 2021	0,1586	0,1634	0,0731	0,1697	0,0656	0,0805	0,1018	0,2870	0,1545
III 2021	0,1607	0,2094	0,0745	0,1609	0,0684	0,0823	0,1095	0,2836	0,1724
II 2021	0,1717	0,2036	0,0758	0,1463	0,0693	0,0886	0,1087	0,3033	0,1916
I 2021	0,1740	0,2040	0,0757	0,1440	0,0702	0,0793	0,1076	0,3056	0,1943

Source: Bielska (2023).

Table A6.
Standard deviations of monthly returns of the surveyed companies, part 2/2

	KRU	LPP	MBK	OPL	PEO	PGE	PKO	PZU	SPL
III 2023	0,1332	0,1426	0,1433	0,0800	0,1143	0,1280	0,1001	0,1003	0,1099
II 2023	0,1458	0,1921	0,1456	0,0797	0,1201	0,1257	0,1077	0,1086	0,1140
I 2023	0,1420	0,1926	0,1453	0,0798	0,1236	0,1239	0,1078	0,1083	0,1079
XII 2022	0,1421	0,2087	0,1470	0,0785	0,1239	0,1228	0,1062	0,1031	0,1074
XI 2022	0,1406	0,2039	0,1376	0,0835	0,1224	0,1161	0,1021	0,0894	0,1042
X 2022	0,1295	0,2030	0,1498	0,0634	0,1218	0,1191	0,0947	0,0814	0,0867
IX 2022	0,1150	0,2041	0,1550	0,0560	0,1215	0,1190	0,0958	0,0733	0,0861
VIII 2022	0,1089	0,2004	0,1633	0,0630	0,1269	0,0929	0,1020	0,0777	0,1004
VII 2022	0,1193	0,1985	0,1633	0,0757	0,1244	0,0961	0,1016	0,0782	0,1004
VI 2022	0,1134	0,1989	0,1562	0,0758	0,1193	0,0968	0,0978	0,0762	0,0990
V 2022	0,1565	0,2008	0,1730	0,0728	0,1291	0,0965	0,1078	0,0847	0,1110
IV 2022	0,1428	0,1965	0,1637	0,0592	0,1225	0,1658	0,0943	0,0811	0,1023
III 2022	0,1369	0,1787	0,1561	0,0598	0,1211	0,1641	0,0952	0,0895	0,1014
II 2022	0,1175	0,1050	0,1472	0,0603	0,1054	0,1638	0,0767	0,0792	0,0951
I 2022	0,1205	0,1069	0,1472	0,0532	0,1046	0,1625	0,0772	0,0834	0,0968
XII 2021	0,1190	0,0950	0,1361	0,0526	0,1038	0,1638	0,0777	0,1089	0,0934
XI 2021	0,1243	0,1137	0,1222	0,0484	0,1142	0,1594	0,1082	0,1054	0,1279
X 2021	0,1395	0,1389	0,1543	0,0598	0,1209	0,1888	0,1183	0,1162	0,1390
IX 2021	0,1499	0,1460	0,1630	0,0623	0,1212	0,1833	0,1195	0,1155	0,1426
VIII 2021	0,1504	0,1452	0,1620	0,0595	0,1198	0,1844	0,1201	0,1150	0,1392
VII 2021	0,1505	0,1468	0,1738	0,0610	0,1236	0,1827	0,1222	0,1182	0,1486
VI 2021	0,1476	0,1540	0,1737	0,0630	0,1219	0,2081	0,1180	0,1189	0,1463
V 2021	0,1293	0,1521	0,1568	0,0643	0,1144	0,2086	0,1145	0,1138	0,1398
IV 2021	0,1316	0,1580	0,1549	0,0843	0,1141	0,1719	0,1153	0,1131	0,1413
III 2021	0,2154	0,1793	0,1724	0,0867	0,1589	0,1851	0,1466	0,1101	0,1729
II 2021	0,2217	0,1887	0,1746	0,0935	0,1595	0,2155	0,1475	0,1149	0,1682
I 2021	0,2171	0,1866	0,1703	0,0936	0,1574	0,2197	0,1475	0,1137	0,1686

Source: Bielska (2023).

Table A7.
Shares of companies in two-component portfolios with minimal risk (portfolio 1-9)

	Portfolio 1		**Portfolio 2**		**Portfolio 3**		**Portfolio 4**		**Portfolio 5**		**Portfolio 6**		**Portfolio 7**		**Portfolio 8**		**Portfolio 9**	
	PKN	ALR	PKN	ACP	PKN	CDR	PKN	CPS	PKN	DNP	PKN	KTY	PKN	JSW	PKN	KGH	PKN	KRU
III 2023	0,18	0,82	1,03	-0,03	0,28	0,72	0,68	0,32	0,47	0,53	0,41	0,59	-0,07	1,07	0,10	0,90	0,25	0,75
II 2023	0,16	0,84	0,93	0,07	0,28	0,72	0,62	0,38	0,45	0,55	0,40	0,60	-0,10	1,10	0,06	0,94	0,20	0,80
I 2023	0,20	0,80	0,95	0,05	0,29	0,71	0,67	0,33	0,31	0,69	0,44	0,56	-0,08	1,08	0,09	0,91	0,22	0,78
XII 2022	0,20	0,80	0,96	0,04	0,28	0,72	0,66	0,34	0,28	0,72	0,66	0,34	-0,06	1,06	0,09	0,91	0,22	0,78
XI 2022	0,32	0,68	0,90	0,10	0,27	0,73	0,59	0,41	0,32	0,68	0,75	0,25	0,01	0,99	0,24	0,76	0,21	0,79
X 2022	0,14	0,86	0,76	0,24	0,40	0,60	0,74	0,26	0,33	0,67	0,77	0,23	0,06	0,94	0,34	0,66	0,28	0,72
IX 2022	0,17	0,83	0,79	0,21	0,43	0,57	0,80	0,20	0,44	0,56	0,79	0,21	0,03	0,97	0,38	0,62	0,38	0,62
VIII 2022	0,04	0,96	0,59	0,41	0,30	0,70	0,62	0,38	0,24	0,76	0,73	0,27	-0,01	1,01	0,38	0,62	0,22	0,78
VII 2022	0,01	0,99	0,45	0,55	0,26	0,74	0,43	0,57	0,27	0,73	0,73	0,27	-0,14	1,14	0,33	0,67	0,20	0,80
VI 2022	0,03	0,97	0,43	0,57	0,24	0,76	0,43	0,57	0,24	0,76	0,69	0,31	-0,14	1,14	0,39	0,61	0,23	0,77
V 2022	0,07	0,93	0,76	0,24	0,38	0,62	0,61	0,39	0,42	0,58	0,84	0,16	-0,08	1,08	0,56	0,44	0,04	0,96
IV 2022	0,09	0,91	0,78	0,22	0,54	0,46	0,67	0,33	0,55	0,45	0,82	0,18	-0,05	1,05	0,63	0,37	0,10	0,90
III 2022	0,08	0,92	0,79	0,21	0,47	0,53	0,67	0,33	0,64	0,36	0,80	0,20	0,04	0,96	0,64	0,36	0,15	0,85
II 2022	0,09	0,91	0,89	0,11	0,41	0,59	0,74	0,26	0,61	0,39	0,80	0,20	0,03	0,97	0,88	0,12	0,25	0,75
I 2022	0,09	0,91	0,92	0,08	0,40	0,60	0,78	0,22	0,70	0,30	0,80	0,20	0,05	0,95	0,86	0,14	0,27	0,73
XII 2021	0,10	0,90	0,94	0,06	0,34	0,66	0,69	0,31	0,61	0,39	0,79	0,21	0,06	0,94	0,56	0,44	0,28	0,72
XI 2021	0,25	0,75	0,93	0,07	0,44	0,56	0,85	0,15	0,90	0,10	0,98	0,02	-0,06	1,06	0,71	0,29	0,57	0,43
X 2021	0,40	0,60	1,04	-0,04	0,48	0,52	0,92	0,08	1,00	0,00	1,06	-0,06	-0,27	1,27	0,80	0,20	0,59	0,41
IX 2021	0,45	0,55	1,05	-0,05	0,54	0,46	0,96	0,04	1,01	-0,01	1,14	-0,14	0,04	0,96	0,88	0,12	0,54	0,46
VIII 2021	0,37	0,63	0,99	0,01	0,52	0,48	0,97	0,03	0,99	0,01	1,11	-0,11	0,02	0,98	0,90	0,10	0,55	0,45
VII 2021	0,32	0,68	1,03	-0,03	0,54	0,46	1,01	-0,01	1,01	-0,01	1,15	-0,15	0,02	0,98	0,56	0,44	0,59	0,41
VI 2021	0,41	0,59	1,04	-0,04	0,62	0,38	1,01	-0,01	0,96	0,04	0,86	0,14	0,04	0,96	0,58	0,42	0,61	0,39
V 2021	0,29	0,71	1,01	-0,01	0,53	0,47	0,99	0,01	0,92	0,08	0,80	0,20	0,00	1,00	0,55	0,45	0,66	0,34
IV 2021	0,40	0,60	1,01	-0,01	0,45	0,55	1,02	-0,02	1,01	-0,01	0,82	0,18	0,02	0,98	0,52	0,48	0,69	0,31
III 2021	0,00	1,00	1,02	-0,02	0,50	0,50	1,02	-0,02	0,97	0,03	0,80	0,20	-0,03	1,03	0,44	0,56	0,24	0,76
II 2021	0,06	0,94	1,06	-0,06	0,65	0,35	1,11	-0,11	1,10	-0,10	0,84	0,16	-0,09	1,09	0,38	0,62	0,25	0,75
I 2021	0,08	0,92	1,06	-0,06	0,68	0,32	1,12	-0,12	1,12	-0,12	0,84	0,16	-0,12	1,12	0,38	0,62	0,27	0,73

Source: Bielska (2023).

Table A8.
Shares of companies in two-component portfolios with minimal risk (portfolio 10-17)

	Portfolio 10		**Portfolio 11**		**Portfolio 12**		**Portfolio 13**		**Portfolio 14**		**Portfolio 15**		**Portfolio 16**		**Portfolio 17**	
	PKN	LPP	PKN	MBK	PKN	OPL	PKN	PEO	PKN	PGE	PKN	PKO	PKN	PZU	PKN	SPL
III 2023	-0,01	1,01	0,19	0,81	0,61	0,39	0,34	0,66	0,10	0,90	0,43	0,57	0,38	0,62	0,35	0,65
II 2023	-0,01	1,01	0,19	0,81	0,61	0,39	0,30	0,70	0,08	0,92	0,37	0,63	0,28	0,72	0,32	0,68
I 2023	-0,02	1,02	0,20	0,80	0,62	0,38	0,30	0,70	0,09	0,91	0,38	0,62	0,30	0,70	0,37	0,63
XII 2022	-0,04	1,04	0,21	0,79	0,63	0,37	0,30	0,70	0,09	0,91	0,39	0,61	0,35	0,65	0,38	0,62
XI 2022	-0,02	1,02	0,24	0,76	0,52	0,48	0,27	0,73	0,11	0,89	0,37	0,63	0,46	0,54	0,36	0,64
X 2022	0,00	1,00	0,18	0,82	0,64	0,36	0,27	0,73	-0,05	1,05	0,44	0,56	0,61	0,39	0,52	0,48
IX 2022	0,00	1,00	0,16	0,84	0,68	0,32	0,30	0,70	0,20	0,80	0,46	0,54	0,68	0,32	0,55	0,45
VIII 2022	-0,02	1,02	0,02	0,98	0,57	0,43	0,19	0,81	0,35	0,65	0,26	0,74	0,47	0,53	0,30	0,70
VII 2022	0,00	1,00	-0,02	1,02	0,46	0,54	0,11	0,89	0,23	0,77	0,17	0,83	0,40	0,60	0,23	0,77
VI 2022	0,03	0,97	0,04	0,96	0,45	0,55	0,14	0,86	0,17	0,83	0,20	0,80	0,42	0,58	0,24	0,76
V 2022	0,07	0,93	-0,01	1,01	0,59	0,41	0,20	0,80	0,46	0,54	0,32	0,68	0,58	0,42	0,31	0,69
IV 2022	0,08	0,92	0,01	0,99	0,65	0,35	0,23	0,77	0,14	0,86	0,47	0,53	0,62	0,38	0,39	0,61
III 2022	0,13	0,87	-0,02	1,02	0,65	0,35	0,22	0,78	0,15	0,85	0,44	0,56	0,52	0,48	0,39	0,61
II 2022	0,40	0,60	0,00	1,00	0,64	0,36	0,34	0,66	0,15	0,85	0,84	0,16	0,63	0,37	0,46	0,54
I 2022	0,38	0,62	0,01	0,99	0,67	0,33	0,34	0,66	0,16	0,84	0,88	0,12	0,60	0,40	0,44	0,56
XII 2021	0,47	0,53	0,01	0,99	0,67	0,33	0,35	0,65	0,16	0,84	0,85	0,15	0,36	0,64	0,48	0,52
XI 2021	0,70	0,30	0,60	0,40	0,85	0,15	0,75	0,25	0,38	0,62	1,29	-0,29	0,67	0,33	0,60	0,40
X 2021	0,64	0,36	0,43	0,57	0,91	0,09	1,15	-0,15	0,29	0,71	1,76	-0,76	0,73	0,27	0,81	0,19
IX 2021	0,61	0,39	0,37	0,63	0,94	0,06	1,71	-0,71	0,34	0,66	2,38	-1,38	0,82	0,18	0,98	0,02
VIII 2021	0,64	0,36	0,39	0,61	0,96	0,04	2,00	-1,00	0,33	0,67	2,85	-1,85	0,85	0,15	1,80	-0,80
VII 2021	0,65	0,35	0,31	0,69	0,92	0,08	2,07	-1,07	0,38	0,62	2,68	-1,68	0,89	0,11	1,71	-0,71
VI 2021	0,60	0,40	0,32	0,68	0,92	0,08	2,06	-1,06	0,32	0,68	2,76	-1,76	0,89	0,11	1,44	-0,44
V 2021	0,52	0,48	0,45	0,55	0,91	0,09	1,74	-0,74	0,25	0,75	2,46	-1,46	0,83	0,17	1,10	-0,10
IV 2021	0,51	0,49	0,55	0,45	0,87	0,13	1,21	-0,21	0,42	0,58	1,49	-0,49	0,85	0,15	0,87	0,13
III 2021	0,29	0,71	0,36	0,64	0,88	0,12	0,52	0,48	0,36	0,64	0,72	0,28	0,90	0,10	0,33	0,67
II 2021	0,30	0,70	0,46	0,54	0,93	0,07	0,62	0,38	0,23	0,77	0,84	0,16	0,96	0,04	0,55	0,45
I 2021	0,35	0,65	0,55	0,45	0,94	0,06	0,67	0,33	0,22	0,78	0,86	0,14	0,97	0,03	0,58	0,42

Source: Bielska (2023).

Table A9.
Minimal risk of two-component portfolios, part 1/2

	PKN ALR	PKN ACP	PKN CDR	PKC CPS	PKN DNP	PKN KTY	PKN JSW	PKN KGH	PKN KRU
III 2023	0,0894	0,0396	0,0806	0,0701	0,0857	0,0817	0,0917	0,0925	0,0870
II 2023	0,0893	0,0468	0,0807	0,0726	0,0863	0,0817	0,0906	0,0923	0,0881
I 2023	0,0887	0,0455	0,0808	0,0711	0,0895	0,0806	0,0917	0,0927	0,0879
XII 2022	0,0886	0,0454	0,0815	0,0721	0,0902	0,0731	0,0925	0,0929	0,0880
XI 2022	0,0735	0,0464	0,0738	0,0627	0,0816	0,0529	0,0863	0,0830	0,0805
X 2022	0,0851	0,0626	0,0632	0,0545	0,0840	0,0521	0,0879	0,0821	0,0797
IX 2022	0,0866	0,0651	0,0744	0,0466	0,0823	0,0428	0,0915	0,0827	0,0749
VIII 2022	0,0739	0,0644	0,0658	0,0521	0,0713	0,0427	0,0742	0,0624	0,0706
VII 2022	0,0679	0,0635	0,0616	0,0536	0,0632	0,0437	0,0639	0,0579	0,0630
VI 2022	0,0669	0,0620	0,0585	0,0519	0,0641	0,0430	0,0630	0,0530	0,0604
V 2022	0,0910	0,0689	0,0710	0,0640	0,0846	0,0453	0,0908	0,0660	0,0916
IV 2022	0,0909	0,0680	0,0562	0,0589	0,0799	0,0499	0,0916	0,0606	0,0911
III 2022	0,0907	0,0655	0,0587	0,0592	0,0756	0,0513	0,0913	0,0589	0,0897
II 2022	0,0905	0,0595	0,0617	0,0517	0,0751	0,0517	0,0915	0,0434	0,0880
I 2022	0,0907	0,0557	0,0597	0,0435	0,0713	0,0521	0,0914	0,0441	0,0863
XII 2021	0,0907	0,0548	0,0660	0,0510	0,0741	0,0527	0,0914	0,0644	0,0862
XI 2021	0,1282	0,0345	0,1075	0,0577	0,0853	0,0562	0,1328	0,1035	0,1111
X 2021	0,1439	0,0346	0,1216	0,0697	0,0891	0,0672	0,1433	0,1054	0,1291
IX 2021	0,1490	0,0354	0,1180	0,0719	0,0892	0,0656	0,1535	0,1116	0,1384
VIII 2021	0,1525	0,0444	0,1184	0,0708	0,0897	0,0639	0,1554	0,1081	0,1381
VII 2021	0,1604	0,0459	0,1192	0,0647	0,0880	0,0641	0,1622	0,1202	0,1378
VI 2021	0,1592	0,0549	0,1154	0,0639	0,0884	0,0899	0,1626	0,1169	0,1359
V 2021	0,1509	0,0599	0,1202	0,0634	0,0821	0,0935	0,1535	0,1177	0,1188
IV 2021	0,1543	0,0730	0,1356	0,0656	0,0805	0,0979	0,1585	0,1286	0,1238
III 2021	0,1607	0,0744	0,1351	0,0684	0,0822	0,1049	0,1606	0,1398	0,1535
II 2021	0,1715	0,0753	0,1343	0,0675	0,0875	0,1054	0,1705	0,1580	0,1642
I 2021	0,1738	0,0753	0,1341	0,0681	0,0775	0,1043	0,1721	0,1608	0,1660

Source: Bielska (2023).

Table A10.
Minimal risk of two-component portfolios, part 2/2

	PKN LPP	**PKN MBK**	**PKN OPL**	**PKN PEO**	**PKN PGE**	**PKN PKO**	**PKN PZU**	**PKN SPL**
III 2023	0,0929	0,0890	0,0694	0,0841	0,0924	0,0821	0,0882	0,0849
II 2023	0,0925	0,0887	0,0694	0,0848	0,0922	0,0836	0,0892	0,0851
I 2023	0,0930	0,0883	0,0700	0,0842	0,0927	0,0826	0,0892	0,0837
XII 2022	0,0930	0,0880	0,0697	0,0846	0,0929	0,0831	0,0889	0,0835
XI 2022	0,0862	0,0785	0,0605	0,0789	0,0857	0,0760	0,0775	0,0760
X 2022	0,0887	0,0841	0,0478	0,0824	0,0886	0,0767	0,0759	0,0739
IX 2022	0,0917	0,0887	0,0402	0,0834	0,0896	0,0793	0,0670	0,0741
VIII 2022	0,0741	0,0742	0,0417	0,0701	0,0652	0,0693	0,0622	0,0673
VII 2022	0,0679	0,0679	0,0423	0,0667	0,0647	0,0660	0,0582	0,0637
VI 2022	0,0669	0,0669	0,0416	0,0651	0,0656	0,0644	0,0560	0,0625
V 2022	0,0906	0,0918	0,0481	0,0889	0,0771	0,0867	0,0761	0,0863
IV 2022	0,0907	0,0919	0,0386	0,0883	0,0890	0,0835	0,0734	0,0841
III 2022	0,0887	0,0915	0,0395	0,0884	0,0880	0,0846	0,0773	0,0843
II 2022	0,0799	0,0916	0,0388	0,0859	0,0880	0,0761	0,0723	0,0827
I 2022	0,0807	0,0917	0,0313	0,0865	0,0877	0,0769	0,0759	0,0837
XII 2021	0,0778	0,0917	0,0307	0,0864	0,0877	0,0773	0,0822	0,0829
XI 2021	0,1090	0,1125	0,0428	0,1115	0,1153	0,1067	0,0952	0,1238
X 2021	0,1335	0,1426	0,0582	0,1203	0,1400	0,1099	0,1101	0,1384
IX 2021	0,1401	0,1490	0,0618	0,1134	0,1422	0,0978	0,1133	0,1426
VIII 2021	0,1402	0,1505	0,0592	0,1052	0,1450	0,0854	0,1134	0,1348
VII 2021	0,1400	0,1593	0,0594	0,1061	0,1483	0,0868	0,1173	0,1456
VI 2021	0,1464	0,1597	0,0617	0,1032	0,1472	0,0725	0,1181	0,1445
V 2021	0,1414	0,1459	0,0627	0,1039	0,1454	0,0863	0,1118	0,1397
IV 2021	0,1481	0,1461	0,0820	0,1125	0,1410	0,1088	0,1113	0,1409
III 2021	0,1566	0,1547	0,0847	0,1476	0,1481	0,1440	0,1094	0,1567
II 2021	0,1678	0,1628	0,0929	0,1521	0,1665	0,1465	0,1148	0,1612
I 2021	0,1688	0,1626	0,0930	0,1519	0,1695	0,1466	0,1136	0,1622

Source: Bielska (2023).

Table A11.
Expected rate of return of minimal risk portfolios, part 1/2

	PKN ALR	PKN ACP	PKN CDR	PKC CPS	PKN DNP	PKN KTY	PKN JSW	PKN KGH	PKN KRU
III 2023	-0,0021	0,0023	-0,0046	-0,0288	0,0099	-0,0054	-0,0048	-0,0038	0,0043
II 2023	-0,0073	-0,0091	-0,0069	-0,0318	0,0074	-0,0087	-0,0117	-0,0045	-0,0016
I 2023	-0,0136	-0,0181	-0,0139	-0,0435	-0,0047	-0,0154	-0,0158	-0,0094	-0,0071
XII 2022	-0,0109	-0,0185	-0,0096	-0,0383	-0,0013	-0,0014	-0,0100	-0,0069	-0,0057
XI 2022	-0,0406	-0,0334	-0,0296	-0,0493	-0,0249	-0,0241	-0,0343	-0,0334	-0,0286
X 2022	-0,0324	-0,0242	-0,0373	-0,0583	-0,0220	-0,0249	-0,0316	-0,0345	-0,0281
IX 2022	-0,0164	-0,0153	-0,0301	-0,0474	-0,0036	-0,0151	-0,0124	-0,0270	-0,0082
VIII 2022	0,0020	-0,0052	-0,0141	-0,0283	0,0066	-0,0141	0,0027	-0,0122	0,0007
VII 2022	-0,0106	-0,0076	-0,0206	-0,0197	-0,0039	-0,0084	-0,0206	-0,0179	-0,0084
VI 2022	-0,0090	-0,0044	-0,0131	-0,0175	-0,0060	-0,0047	-0,0195	-0,0153	-0,0052
V 2022	0,0117	0,0077	-0,0011	-0,0064	0,0120	0,0030	0,0047	-0,0089	0,0111
IV 2022	0,0203	0,0141	0,0068	0,0011	0,0191	0,0068	0,0117	0,0005	0,0194
III 2022	0,0193	0,0094	-0,0010	0,0018	0,0139	0,0083	0,0160	-0,0027	0,0181
II 2022	0,0272	0,0151	-0,0021	0,0062	0,0147	0,0188	0,0191	-0,0244	0,0291
I 2022	0,0268	0,0193	0,0040	0,0126	0,0168	0,0184	0,0194	-0,0217	0,0338
XII 2021	0,0277	0,0229	-0,0040	0,0220	0,0202	0,0194	0,0202	0,0039	0,0343
XI 2021	0,0907	0,0373	0,0214	0,0375	0,0415	0,0375	0,0657	0,0338	0,0831
X 2021	0,0711	0,0162	0,0021	0,0259	0,0272	0,0276	0,0384	0,0264	0,0668
IX 2021	0,0646	0,0116	-0,0188	0,0227	0,0265	0,0283	0,0349	0,0197	0,0512
VIII 2021	0,0479	0,0181	-0,0117	0,0199	0,0280	0,0431	0,0284	0,0315	0,0538
VII 2021	0,0341	0,0115	-0,0164	0,0142	0,0245	0,0376	0,0196	0,0427	0,0524
VI 2021	0,0414	-0,0019	-0,0329	0,0162	0,0335	0,0491	0,0200	0,0482	0,0574
V 2021	0,0219	0,0029	-0,0221	0,0137	0,0263	0,0390	0,0069	0,0472	0,0505
IV 2021	0,0319	0,0128	0,0001	0,0205	0,0430	0,0452	0,0168	0,0615	0,0677
III 2021	0,0027	0,0088	0,0003	0,0138	0,0468	0,0303	-0,0006	0,0409	0,0134
II 2021	-0,0194	0,0080	0,0036	0,0163	0,0511	0,0222	-0,0277	0,0162	-0,0077
I 2021	-0,0258	0,0093	-0,0033	0,0140	0,0746	0,0273	-0,0340	0,0097	-0,0160

Source: Bielska (2023).

Table A12.
Expected rate of return of minimal risk portfolios, part 2/2

	PKN LPP	PKN MBK	PKN OPL	PKN PEO	PKN PGE	PKN PKO	PKN PZU	PKN SPL
III 2023	-0,0028	-0,0044	-0,0090	-0,0077	-0,0035	-0,0101	0,0038	-0,0009
II 2023	-0,0052	-0,0087	-0,0094	-0,0122	-0,0047	-0,0147	-0,0029	-0,0072
I 2023	-0,0099	-0,0130	-0,0180	-0,0143	-0,0101	-0,0180	-0,0064	-0,0140
XII 2022	-0,0066	-0,0110	-0,0190	-0,0116	-0,0075	-0,0170	-0,0074	-0,0110
XI 2022	-0,0346	-0,0390	-0,0280	-0,0353	-0,0355	-0,0400	-0,0331	-0,0316
X 2022	-0,0317	-0,0350	-0,0355	-0,0333	-0,0322	-0,0408	-0,0342	-0,0320
IX 2022	-0,0137	-0,0171	-0,0239	-0,0202	-0,0154	-0,0287	-0,0246	-0,0208
VIII 2022	0,0031	0,0025	-0,0112	-0,0004	0,0076	-0,0053	-0,0066	0,0007
VII 2022	-0,0106	-0,0104	-0,0094	-0,0101	-0,0056	-0,0129	-0,0129	-0,0090
VI 2022	-0,0090	-0,0093	-0,0084	-0,0080	-0,0077	-0,0115	-0,0102	-0,0076
V 2022	0,0105	0,0099	0,0031	0,0124	0,0046	0,0054	0,0019	0,0127
IV 2022	0,0185	0,0162	0,0143	0,0224	0,0183	0,0162	0,0062	0,0219
III 2022	0,0163	0,0139	0,0156	0,0223	0,0165	0,0191	0,0111	0,0229
II 2022	0,0376	0,0186	0,0166	0,0348	0,0191	0,0383	0,0177	0,0370
I 2022	0,0363	0,0190	0,0206	0,0333	0,0196	0,0356	0,0127	0,0350
XII 2021	0,0370	0,0192	0,0234	0,0349	0,0213	0,0389	0,0234	0,0401
XI 2021	0,0843	0,1119	0,0283	0,0939	0,0691	0,0874	0,0581	0,0880
X 2021	0,0654	0,0631	0,0172	0,0668	0,0450	0,0686	0,0377	0,0657
IX 2021	0,0503	0,0440	0,0127	0,0866	0,0386	0,0932	0,0340	0,0642
VIII 2021	0,0510	0,0367	0,0084	0,0851	0,0282	0,0875	0,0280	0,0698
VII 2021	0,0526	0,0245	0,0091	0,0838	0,0244	0,0887	0,0201	0,0530
VI 2021	0,0361	0,0236	0,0049	0,0918	0,0354	0,1115	0,0181	0,0607
V 2021	0,0258	0,0089	0,0020	0,0644	0,0275	0,0922	0,0071	0,0358
IV 2021	0,0321	0,0091	0,0149	0,0263	0,0339	0,0436	0,0100	0,0254
III 2021	0,0093	-0,0040	0,0054	-0,0034	0,0170	0,0028	-0,0116	0,0007
II 2021	-0,0113	-0,0296	-0,0030	-0,0214	-0,0119	-0,0098	-0,0222	-0,0235
I 2021	-0,0122	-0,0400	-0,0039	-0,0286	-0,0197	-0,0122	-0,0166	-0,0281

Source: Bielska (2023).

Table A13.
Portfolio return realised based on recommended shares of companies in the portfolio, part 1/2

	PKN ALR	PKN ACP	PKN CDR	PKC CPS	PKN DNP	PKN KTY	PKN JSW	PKN KGH	PKN KRU
III 2023	-0,1128	-0,0464	-0,1384	-0,0658	-0,0459	-0,0492	-0,1250	-0,1192	-0,1129
II 2023	0,0280	0,0363	0,0050	-0,0255	-0,0085	0,0138	0,0468	0,0191	0,0101
I 2023	0,0371	0,0472	0,0304	0,0316	0,0203	0,0418	-0,0016	0,0192	0,0348
XII 2022	-0,0313	-0,0095	-0,0241	-0,0523	-0,0110	-0,1598	-0,0215	-0,0162	-0,0105
XI 2022	0,1869	0,0651	0,1307	0,0879	0,1642	0,1840	0,1704	0,1743	0,1474
X 2022	0,0615	0,0033	0,1228	0,0841	0,0329	0,0219	0,0397	0,0527	0,0697
IX 2022	-0,1139	-0,0535	0,0168	-0,1648	-0,1142	-0,1237	-0,1219	-0,0717	-0,1541
VIII 2022	-0,1824	-0,0873	-0,1518	-0,0937	-0,1577	-0,0480	-0,1931	-0,2078	-0,1229
VII 2022	0,1095	0,0416	0,0701	0,0389	0,1170	-0,0392	0,1537	0,0692	0,1069
VI 2022	-0,0765	-0,0548	-0,0853	-0,0713	-0,0369	-0,0383	-0,0780	-0,1148	-0,0853
V 2022	-0,0226	-0,0127	-0,0471	-0,0631	0,0050	-0,0343	-0,0197	0,0053	-0,0152
IV 2022	-0,0339	-0,0375	-0,1718	-0,0952	-0,0916	0,0400	-0,0122	-0,1093	-0,0349
III 2022	0,0611	0,0749	0,0464	0,0337	0,1156	0,0581	0,0843	0,0491	0,0864
II 2022	-0,0217	-0,0908	-0,0329	-0,1081	-0,0406	-0,0472	0,0006	0,1497	-0,0536
I 2022	-0,0412	-0,0596	-0,0548	-0,0898	-0,1166	-0,0261	-0,0385	-0,0141	-0,0320
XII 2021	0,0101	-0,0139	0,0291	0,0015	0,0556	0,0446	0,0071	-0,0095	0,0023
XI 2021	-0,1470	-0,1194	-0,0766	-0,0432	-0,0646	-0,0769	-0,1631	-0,0945	-0,0639
X 2021	0,2296	0,1358	-0,0113	0,0090	0,0774	-0,0102	0,0907	-0,0016	0,0486
IX 2021	0,0455	0,0332	0,1121	-0,0281	0,0247	-0,0568	0,1115	-0,0834	0,0547
VIII 2021	0,0709	0,0445	-0,0367	0,0672	0,0523	-0,0606	0,0104	-0,0795	0,0197
VII 2021	-0,0006	0,0439	-0,0252	0,1295	0,0922	0,0777	-0,0517	-0,0034	0,0898
VI 2021	-0,0413	0,0509	0,0915	-0,0231	-0,0255	0,0248	-0,0605	-0,0683	-0,0377
V 2021	0,2102	0,0387	0,0835	0,0433	0,1530	0,0528	0,2176	0,1124	0,3367
IV 2021	0,1137	0,0375	-0,0109	-0,0022	-0,0671	0,0847	0,0503	0,0369	0,0112
III 2021	0,0577	0,0081	-0,0697	0,0308	0,0405	0,0730	0,0655	0,0254	0,0441
II 2021	0,0563	-0,0243	-0,1316	-0,0757	-0,0905	0,0798	0,0369	0,0107	0,0548
I 2021	-0,0447	-0,0018	0,0546	0,0147	-0,1062	-0,0301	-0,0805	-0,0257	0,0125

Source: Bielska (2023).

Table A14.
Portfolio return realised based on recommended shares of companies in the portfolio, part 2/2

	PKN LPP	PKN MBK	PKN OPL	PKN PEO	PKN PGE	PKN PKO	PKN PZU	PKN SPL
III 2023	-0,1274	-0,1138	-0,0426	-0,1019	-0,1204	-0,1109	-0,0945	-0,0877
II 2023	0,0278	0,0262	-0,0137	0,0102	0,0160	0,0039	0,0176	0,0312
I 2023	0,0117	0,0234	0,0332	0,0256	0,0174	0,0273	0,0187	0,0490
XII 2022	-0,0286	-0,0348	0,0087	-0,0151	-0,0170	0,0058	0,0239	-0,0363
XI 2022	0,1690	0,1683	0,1045	0,1414	0,1683	0,1360	0,1714	0,1322
X 2022	0,0258	0,0840	0,1111	0,0977	0,0339	0,1029	0,1020	0,1645
IX 2022	-0,1161	-0,1075	-0,1297	-0,1011	-0,1162	-0,0934	-0,1546	-0,0928
VIII 2022	-0,1932	-0,1892	-0,0860	-0,1777	-0,2321	-0,1709	-0,1358	-0,1614
VII 2022	0,1106	0,1132	0,0430	0,0877	0,0790	0,0803	0,0702	0,0824
VI 2022	-0,0746	-0,0771	-0,0440	-0,0805	-0,0505	-0,0839	-0,0736	-0,0734
V 2022	-0,0110	-0,0183	-0,0534	-0,0241	0,0044	-0,0204	0,0217	-0,0270
IV 2022	-0,0321	-0,0203	-0,1005	-0,0457	-0,0066	-0,0961	-0,0669	-0,0598
III 2022	0,1000	0,0722	0,0322	0,0480	0,0747	0,0320	0,0627	0,0360
II 2022	-0,1844	-0,0056	-0,0191	-0,0553	0,0040	-0,1382	-0,0882	-0,0575
I 2022	-0,0592	-0,0464	-0,0714	0,0055	-0,0486	0,0427	-0,0054	-0,0264
XII 2021	0,1435	0,0162	-0,0012	0,0174	0,0102	0,0212	0,0043	-0,0036
XI 2021	-0,0942	-0,1536	0,0567	-0,1195	-0,1656	-0,0957	-0,1207	-0,0859
X 2021	0,0089	0,2028	-0,0226	0,3277	0,0731	0,2390	0,0879	0,1915
IX 2021	0,0808	0,0991	-0,0229	-0,1395	0,0287	-0,1282	-0,0652	-0,0038
VIII 2021	0,0057	0,0630	0,0739	0,2526	0,0565	0,2833	0,0664	0,3147
VII 2021	0,0238	-0,0430	0,1169	0,0797	-0,0635	0,0756	0,0156	0,0417
VI 2021	0,0611	-0,0197	-0,0014	0,0011	-0,0606	-0,0784	-0,0153	-0,0409
V 2021	0,1743	0,2490	0,0043	0,1747	0,1605	0,0421	0,1474	0,1887
IV 2021	0,1321	0,0738	0,0404	0,1434	0,2351	0,0777	-0,0301	0,0339
III 2021	0,0474	0,0235	0,0445	0,0405	0,0411	0,0714	0,1373	0,0489
II 2021	0,0357	0,0743	-0,0291	0,0526	0,0326	0,0485	-0,0203	0,1063
I 2021	-0,0654	0,0253	-0,0117	0,0252	-0,0405	-0,0023	-0,0772	-0,0367

Source: Bielska (2023).