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Balkan Stock Exchanges – Consideration of the Length of the Estimation Window in Similar Markets

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Abstract:

Purpose: *We study if capital markets in the Balkan are closely and positively related in terms of rate of return, risk, efficiency, and maximum cumulative loss in relation to different lengths of the estimation window.*
Design/Methodology/Approach: *The research was carried out for the period from 01/01/2017 to 31/12/2019 using portfolio analysis. It was divided into an estimation window (01/01/2019 to 31/12/2019) and another with observations from the remaining days. The results were compared with a naive strategy. Four-element portfolios, consisting of three investments in companies from a given stock exchange and one investment in gold as a haven, were created. After determining all possible combinations of portfolios for each stock exchange and for all lengths of estimation window, the obtained results for rate of return, risk, efficiency, for each length of estimation window were averaged and were subjected to correlation analysis.*
Findings: *In Balkan capital markets, a change in the length of the estimation window (optimal length 120 observations) had the same impact on the results for investment portfolio risk, efficiency, and maximum cumulative loss, but not for the rate of return.*
Practical Implications: *An investor from one of the Balkan countries using a strategy based on portfolio theory would not be able to gain a competitive advantage over another investor from this region if he built a portfolio based on the same number of observations from the past. The investor should construct an investment portfolio based on historical data from the previous six months. Longer estimation periods are not recommended, as the results for the studied portfolio were worse than a naive strategy.*
Originality/Value: *The study concentrates on the unique region of Europe, which was the subject of system transformation latest therefore it should not be compared directly to the current achievements in the stock changes which tradition of operation is longer.*

Keywords: *Portfolio theory, capital market, estimation window, minimal risk, maximum efficiency, the Balkan region.*

JEL classification: *G1, G11, G170.*

Paper Type: *Research study.*

1. Introduction

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Numerous scientific studies emphasize that financial (mainly capital) markets are closely related (Gjika and Horváth, 2013; Majewska and Olbryś, 2017; Yang, Chen, Niu, and Li, 2014). The following study examines whether there is a strong link between the stock exchanges of countries in the Balkans. The study checks whether the change in rate of return, risk, efficiency, and maximum cumulative loss are the same for each of the analyzed stock exchanges in the Balkans for lengths of estimation windows. Due to the strong relationship between those markets and their geographical proximity, it was believed in advance of this study that the strength of the relationship between the stock exchanges would be significant and positive.

The following research hypothesis was adopted: capital markets of the Balkan countries are closely and positively related in terms of rate of return, risk, efficiency, and maximum cumulative loss. The results of the study should prove valuable to investors constructing investment portfolios. If there are no grounds for rejecting the hypothesis adopted in the paper, it can be stated that investors should not limit themselves to investing only in the markets of the analyzed region, but for a successful portfolio, they should focus on broader geographical diversification. If the research hypothesis is rejected, it can be assumed that the analyzed capital markets are heterogeneous and thus the Balkan region is so diverse that it is possible to build satisfactory investment portfolios based only on the shares of companies from this region. Moreover, an investor from one stock exchange will be able to obtain better or worse investment results using the same investment methods, based on the same number of past observations.

The paper compares rate of return, risk, efficiency and maximum cumulative loss for different lengths of estimation windows for portfolio theory with the results that would be achieved using a naive strategy with an equal distribution of capital into the investments included in the portfolio. It also considers whether a particular number of observations from the past increase the chances for the portfolio theory strategy to give the investor better results than the naive strategy.

The article is divided into four further sections. The economic background is given in section 2, a literature review is provided in section 3, the research methodology and data are described in section 4, and section 5 presents the results. The paper is summarized with the conclusions of the research.

2. Economic Background and Stock Markets in the Region

Balkan stock markets have a short history compared to mature European and US markets. These markets began trading in the mid-1980s and mid-1990s with a small number of shares, many of which were illiquid. The first stock exchange in the Western Balkan States was launched in December 1989 – Ljubljanska borza in Ljubljana, which was then part of Yugoslavia and is now the capital of Slovenia. The first listing took place in this market in March 1990. In 1900-1993, stock exchanges

were established in Serbia and Montenegro. The third wave of creating organized capital markets in this region occurred in the second half of the nineties when a stock exchange was established in North Macedonia. The youngest stock exchanges are in Bosnia and Herzegovina, where they were launched only in 2002, simultaneously in Sarajevo and Banja Luka. Since the creation of the Sarajevo stock exchange, at least one formalized securities market has functioned in all Western Balkan States. Table 1 presents the launch dates of each stock exchange in the region.

Table 1. *Launch dates of the stock exchanges in the Western Balkan Region*

Country	City	Current name of the leading exchange	Date of the first listing
Slovenia	Ljubljana	Ljubljana Stock Exchange Ljubljanska borza	29.03.1990
Serbia	Belgrade	Belgrade Stock Exchange Београдска берза	1990
Croatia	Zagreb	Zagreb Stock Exchange Zagrebačka burza	1991
Montenegro	Podgorica	Montenegro Stock Exchange Montenegroberza	1993
North Macedonia	Skopje	Macedonian Stock Exchange Македонска берза	28.03.1996
Bosnia and Herzegovina	Sarajevo	Sarajevo Stock Exchange Sarajevska Berza	12.04.2002
	Banja Luka	Banja Luka Stock Exchange Стратегија Развоја Бањалучке Берзе	14.03.2002

Source: *Own study based on data from stock exchange websites: http://www.ljse.si/cgi-bin/jve.cgi?doc=1468; https://www.belex.rs/eng/; https://zse.hr/default.aspx?id=122; http://www.montenegroberza.com/code/navigate.asp?Id=59; https://www.mse.mk/en; http://www.sase.ba/v1/en-us/; https://www.blberza.com/Pages/Default.aspx.*

These stock markets differ in terms of structure and forms of integration with the global financial system. The dominant structure is a concentrated market. Only in Bosnia and Herzegovina can we speak of a dispersed market with a significant share of Turkish foreign capital – 20% in the shareholding. Although in Montenegro the share of this capital is even greater and reaches 25% of the shareholding, the remaining part of the shareholding remains in the hands of local investors. Internationalization through regional alliances is underway in the markets of Croatia, North Macedonia, and Serbia.

Due to the short functioning of capital markets in the region, their share in financial systems is smaller than in countries where these markets have been developing continuously for 150 years. Over the past decade, impressive changes have occurred in the Balkans. Since 2000, the Balkan economies have been in a transition phase of structural adjustment towards a market-oriented economic system. They have also been building their market economy system from scratch to recover from the effect of the subprime mortgage crisis. This process of economic transformation has been accompanied by the growth of the stock exchanges. Nevertheless, there are large differences in the level of capital market development; e.g. in Serbia, North Macedonia, and Slovenia in 2018, stock market capitalization in relation to GDP did

not exceed 30%, while in Montenegro, this ratio exceeded 72% of GDP. Although these markets are still in their early stages, the capital market in Croatia is growing significantly faster than those in other countries. It is noteworthy that in addition to relevant regulations, governments can also influence the capital market through, e.g., the pension system or the debt market. At the same time, financial institutions other than banks usually play only a minor or complementary role.

After 2008, the annual GDP growth rate slowed, often reaching negative values. Countries experienced deflation, and the public finance deficit increased because of increased public spending on measures to hedge the effects of the crisis. The period of 2017-2019 was a period of relative economic stability. Table 2 presents key economic data for the Balkan region for those years.

Table 2. *Economic background and market capitalization in the Balkan region*

Country	Year	GDP growth y/y (%)	Inflation (%)	FDI (% GDP)	Market capitalization (% GDP)
BH	2017	3.215	-1.584	1.85	27.52
	2018	3.114	0.81	2.57	24.97
	2019	3.624	1.417	2.42	22.6
Croatia	2017	3.536	-1.125	3.61	37.73
	2018	2.921	1.129	3.69	34.67
	2019	2.63	1.5	2.11	36.97
North Macedonia	2017	2.949	-0.239	5.15	22.11
	2018	4.716	1.352	3.28	24.64
	2019	4.9	1.458	5.12	26.58
Montenegro	2017	2.848	-0.258	5.18	72.78
	2018	0.241	2.373	11.57	66.41
	2019	2.665	2.604	8.82	65.3
Serbia	2017	3.34	1.122	5.8	11.54
	2018	2.049	3.131	6.56	10.31
	2019	4.302	1.96	8.12	10.58
Slovenia	2017	3.122	-0.052	3.24	12.27
	2018	4.833	1.432	2.47	13.88
	2019	4.118	1.735	2.82	14.72

Source: *Own study based on data from https://tradingeconomics.com; https://www.ceicdata.com.*

Between 2017 and 2019, the average growth measured as a percentage of GDP exceeded 3% in the Balkan region. Inflation continued to fall to a single-digit annual rate throughout the region. The worst situation was recorded in 2016, when deflation was recorded in almost all countries. The simultaneous rise and fall of inflation increased the inflow of foreign direct investment (FDI) capital. This was particularly evident in Montenegro and Serbia, where the share of FDI in GDP reached 8% and more.

3. Literature Review

Markowitz's portfolio theory is based on the concept of reasonable investor decisions regarding the relationship between return on investment and risk, which is measured by variance and/or standard deviation (Markowitz, 1952; Fabozzi et al., 2007). Further research has shown that a decrease in risk occurs with diversification and portfolio creation. The main assumption of portfolio theory is the possibility of maximizing return by estimating future returns based on past data, and for portfolios with the same return, the one with the lower risk is chosen (Radukić and Radović, 2014, p. 6). Markowitz's portfolio theory has been tested mainly on developed, mature, and liquid capital markets (Fama and French, 2004). It has been the subject of research on different periods of development, and this has shown that optimal portfolio creation is not the same in all periods (Agustini, 2016).

Occasionally, portfolio theory is employed to examine stock market performance in Central East Europe. Markowitz's theory was used by Janková (2019) to compare modern and postmodern portfolio theory on a small capital market with relatively low liquidity, such as the Czech stock market. The results of the study showed that measuring risk using standard deviation is inappropriate in modern portfolio theory. It also confirmed that the more the the values of standard deviation deviates from normal distribution, the greater the differences in risk will be.

Using Sharpe's model and Markowitz's model, as well as using selected portfolio analysis methods, for companies in the raw materials, fuels and energy sectors, Mastalerz-Kodzis and Pośpiech (2016) assessed the risk and efficiency of investing on the Warsaw Stock Exchange in Poland. They concluded that investing in the above sectors is attractive as it gives high rates of return. In Sharpe's model, the slope of a straight line (beta coefficient) is appointed (using closing stock prices and the market index). However, depending on the chosen market index, the values of the coefficient are different. In the article, the values of estimated beta coefficients were examined and compared.

The Western Balkan region is not a frequent subject of research on capital markets, and as such, the number of studies is limited. Most often, these capital markets are subject to research on co-integration (Syllignakis and Kouretas 2011) and infection (Samarakoon, 2011; Savva and Aslanidis, 2010; Kenourgios and Samitas, 2011; Horváth, Lyócsa and Baumöhl, 2016).Very often, these markets are compared to markets from Central and Eastern Europe or even to the developed markets in Western Europe or the USA (e.g., Wang and Moore, 2008 or Büttner and Hayo, 2011).

Scientific research that focuses on local stock markets tends to be shallow and pays attention mainly to the performance of the stock exchange in general, and may also analyze the results of individual companies and the possibility of including companies in the investment portfolio (Bekaert et al. 2014). Studies by Syriopoulos and Roumpis (2009) and Syriopoulos (2011) showed that correlations between stock markets in the Balkans and developed markets are small and become stable over time. In contrast, Guidi and Ugur (2014) estimated that correlations between the markets of Central and

Southeastern Europe and the markets of the USA and Germany differ over time, and have a tendency to increase during periods of financial turmoil. Horvath and Petrovski (2013), using the GARCH models for the period from 2006 to 2011, compared the integration of the stock markets in Central Europe (i.e. the Czech Republic, Hungary, and Poland) and Southeastern Europe (i.e. Croatia, North Macedonia, and Serbia). The results showed that correlation is much higher for equity markets in Central Europe than in Southeastern Europe. The correlation is essentially zero for stock markets in Southeastern Europe with developed markets, except for Croatia, which has a slightly higher integration with Western Europe, although this is lower than the Central European markets.

Benaković and Posedel (2010) used a factor model to analyze the returns of fourteen shares from the Croatian capital market in 2004-2009. Kovačić (2007) investigated the behavior of the twists and turns on the Macedonian Stock Exchange. Bogdan, Bareša, and Ivanović (2010) analyzed a portfolio consisting of shares from the Zagreb Stock Exchange and asked if there were opportunities for diversifying selected securities in this market. They identified the correlation coefficients between the selected shares.

Markowitz's portfolio theory has been applied in only a few studies. Jakšić (2007) used Markowitz's theory to build effective portfolios covering the period between December 31, 1999, and July 1, 2005, on the Croatian market. The author assessed that the CROBEX market index does not perform as the reference, in contrast to the index on developed markets, such as the S&P index for NJSE. Marovitz's theory was also used by Radović, Radukić, and Njegomir (2016) for the Serbian capital market. They proved that this model allows investors to choose an effective portfolio, but only for liquid assets, and the efficiency of the portfolio depends on the risk they are willing to accept. However, the low level of liquidity on the Serbian market and the insufficient number of shares to diversify by sector hinder the practical application of their research results. Markowitz's theory is not only necessary in theoretical considerations of the functioning of capital markets but is also used by many portfolio managers when making investment decisions on capital markets.

4. Research Methodology and Data

This study applied the portfolio theory of Harry Max Markowitz (Markowitz, 1952). The author of this theory received the Nobel Prize in Economic Sciences in 1990. The basis for all calculations was logarithmic daily rates of return, calculated as (Jajuga and Jajuga, 2006):

$$i_t = lnP_t - lnP_{t-1}$$

where
i_t – daily logarithmic rate of return on day "t",
Pt – stock price on day "t",
Pt-1 – stock price on day "t - 1".

The rate of return, risk (measured by standard deviation), and efficiency (measured with the Sharpe ratio) for the portfolio were calculated as presented below, respectively (Dębski, 2007):

$$i_{MPT} = \sum_{k=1}^{n} i_k w_k$$

$$\sigma_{MPT} = \sqrt{\sum_{k=1}^{n} w_k^2 \sigma_k^2 + 2 \sum_{k=1}^{n-1} \sum_{m=k+1}^{n} w_k w_m \sigma_k \sigma_m p_{km}}$$

$$S_{MPT} = \frac{i_p - i_f}{\sigma_p}$$

Results for these calculations were marked with "MPT" (Markowitz's portfolio theory). For the calculations, two additional assumptions regarding full investment constraints and not using short selling were also made:

$$\sum_{k=1}^{n} w_k = 1 \wedge w_k \geq 0$$

where

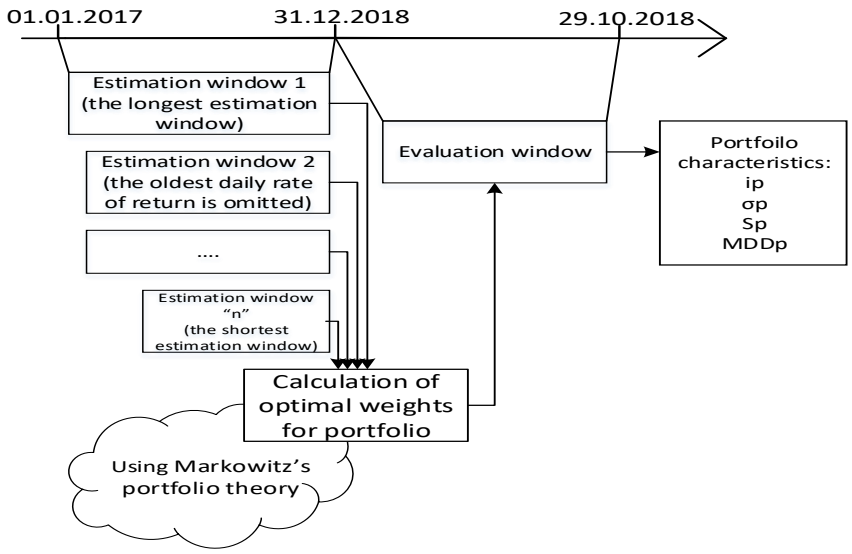
i_{MPT} – portfolio rate of return,
i_k – rate of return from investment "k",
w_k – weight of investment "k" in the portfolio,
σ_{MPT} – portfolio risk (standard deviation of the rate of return),
σ_k – risk of investment "k" (standard deviation of the rate of return),
pkm – coefficient of correlation of return rates on investment "k" and investment "m",
S_{MPT} – efficiency (Sharpe ratio),
i_f – risk-free rate of return (the work assumed a risk-free rate of return of 2% per year for all calculations)
n – number of investments in the portfolio.

The maximum cumulative loss (MDD_{MPT}) was defined as the maximum loss an investor can suffer in the investment by buying at the highest point and selling at the lowest point (Bacon, 2004).

The research period for this study was 01/01/2017 to 31/12/2019. This period was divided into two windows – an estimation window and an evaluation window. The evaluation window always covered the period from 01/01/2019 to 31/12/2019. Observations from the remaining days of the research period constituted the estimation window. The longest estimation window included all observations from 2017 and 2018. Using the data from these two years, calculations compatible with portfolio theory were made, and optimal investment weights were calculated. Weights were determined for the portfolio with maximum efficiency, and the optimization criterion was to maximize the Sharpe ratio. It was assumed that these weights would

be used in 2019, and the portfolio thus determined was evaluated using data from 2019 (i.e. the evaluation window). In the next step, the oldest observation from the estimation window was omitted, thus the length of the new estimation window was shorter by one observation and the entire estimation and evaluation procedure was repeated until the estimation window consisted of only the three newest observations from 2018. This procedure is presented in Figure 1.

Figure 1. *Diagram of the research*



Source: *Own study.*

The results obtained from this method were then compared with those that an investor would have obtained if in 2019 he had used a naive strategy, i.e. for each investment included in the portfolio he allocated the same capital. The results of the naive strategy were marked with "n".

Four-element portfolios were used in the study. These always consisted of three investments in companies from a given stock exchange in the Balkan region (traditional investments) and one investment in gold (alternative investment). The investment in gold was chosen because this investment is considered a haven, as described in more detail in the works (Baur and McDermott, 2010; Ciner, Gurdgiev, and Lucey, 2013; Hood and Malik, 2013). Data for investment in gold was obtained from the website http://www.lbma.org.uk/. For each of the analyzed stock exchanges (presented in Table 3), the twenty largest listed companies (according to capitalization) were selected, for which all possible combinations of four-element portfolios were tested. As a result, for each stock exchange, for each length of estimation window, 1140 investment portfolios were determined and the results of these were averaged. These averaged results were then subjected to further analysis. Considering all possible lengths of estimation windows and all surveyed stock

exchanges, over 4 million investment portfolios with maximum efficiency (based on the Sharpe ratio) were determined.

Table 3. *Analyzed stock exchanges and companies*

NO	Country	Stock exchange and source of data on company listings	Analyzed companies
1	Bosnia and Herzegovina	http://www.sase.ba [SSE]	BSNL, SRPV, BHTS, BORB, DBJP, DCNS, ENIS, ENPS, FDSS, IKBZ, JPEM, JPES, PBJT, RMUB, RSTT, SOLT, SOSO, STVK, TCMK, ZGPS
2	Bosnia and Herzegovina	http://www.blberza.com [BLSE]	TLKM-R-A, HEDR-R-A, HETR-R-A, NOVB-R-E, HELV-R-A, BVRU-R-A, RITE-R-A, ELDO-R-A, EKBL-R-A, RTEU-R-A, RFUM-R-A, KRPT-R-A, BOKS-R-A, MIRA-R-A, EKHC-R-A, VITA-R-A, HPKD-R-A, ZERS-R-A, CIST-R-A, VDBL-R-A
3	Croatia	https://zse.hr [ZSE]	ARNT, ATPL, KOEI, PODR, RIVP, ZABA, DLKV, ERNT, ATGR, ADPL, ADRS2, MAIS, OPTE, DDJH, HT, KRAS, VART, IGH, ADRS, INGR
4	Montenegro	http://mnse.me/ [MNSE]	EPCG, JGPK, PREN, TECG, HIBP, PLAP, NKBA, LUBA, BUDR, KOGE, ULRI, ZETP, LUKO, INSM, MARB, TITI, MIGF, IZBR, PRIT, OTRU
5	North Macedonia	https://www.mse.mk [MSE]	ALK, BOO, FER, GRN, KMB, MAK, MPT, STI, REP, SKP, SBT, VVT, TEL, MER, PPI, RZL, TNB, OKT, USJ, OIL
6	Serbia	https://www.belex.rs [BSE]	NIIS, KMBN, AERO, FITO, MTLC, TGAS, ALFA, ENHL, JESV, IMPL, DINNPB, INSJ, TIGR, GFOM, GMON, PPVA, STOTN, SVRL, UTSI, VITL
7	Slovenia	http://www.ljse.si/ [LSE]	IEKG, KRKG, LKPG, MELR, PETG, POSR, TLSG, ZVTG, CETG, DATG, DPRG, GHUG, KSFR, MKOG, MTSG, NALN, SKDR, ST1R, UKIG, VHDR

Source: *Own study.*

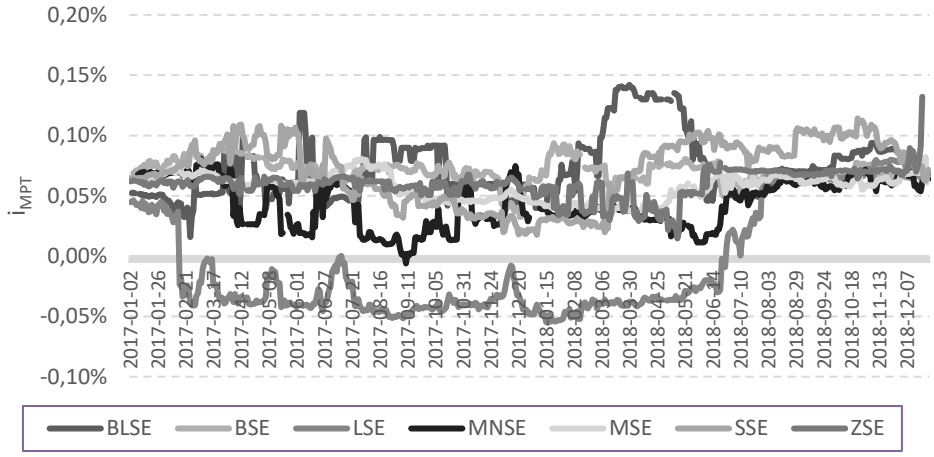
Table 3 shows the countries of the Balkan region for which the analysis was conducted. It lists the website addresses used to download data on the companies whose listings were used as the basis for the study and provides an abbreviation for each stock exchange and abbreviations of companies whose quotations were used in the investment portfolios.

After determining all possible combinations of investment portfolios for each stock exchange and for all lengths of estimation window, the obtained results for rate of return, risk, efficiency, and maximum cumulative loss for each length of estimation window were averaged. The obtained results were then subjected to correlation analysis, which was then used to verify the initial research hypothesis.

5. Research Results – Optimal Investment Portfolio Structures

The figures below show how the average values of the four analyzed investment portfolio characteristics – the rate of return, risk measured by standard deviation, efficiency, and maximum cumulative loss – changed. The results presented in the charts illustrate how the values of these characteristics changed for all seven examined stock exchanges. Importantly, the values that were obtained in the evaluation window (data from 2019) are presented. These were based on the weights established in the various estimation windows according to the procedure in Figure 1. The dates of the first day of the estimation window appear on the "x" axis. In this way, it can also be assessed whether the length of the estimation window in any way affects the results obtained in the evaluation window. The presented values are the average values for all combinations that were obtained during the construction of investment portfolios.

Figure 2. *Rate of return in the evaluation window depending on the day on which the estimation window began*



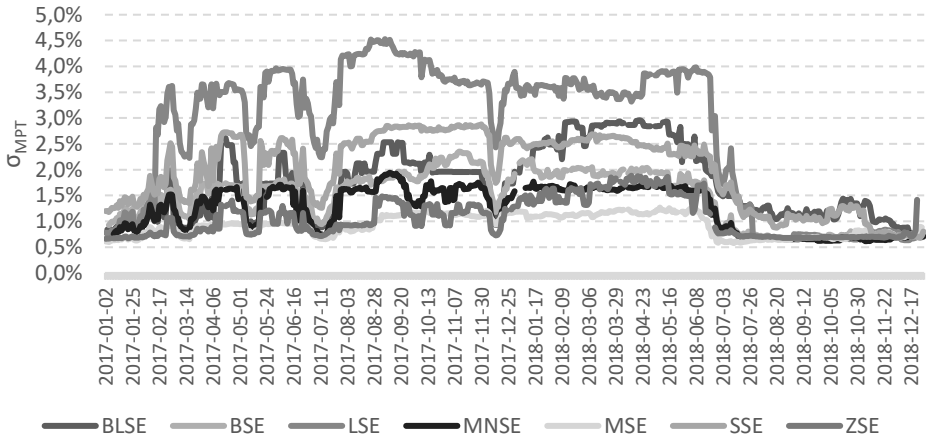
Source: *Own study.*

Figure 2 shows that there are no clear connections for the examined stock exchanges for the rate of return. This is particularly evident for BLSE and MNSE, when an increase in rate of return on BLSE as the estimation window length shortens is accompanied by a decrease in the rate of return on MNSE. A similar relationship occurs between LSE and MSE when the beginning of the estimation window was established in May 2018. Interestingly, only LSE significantly differs from the other analyzed capital markets, as negative interest rates were recorded for this market in most cases.

The next figure illustrates the average risk for the examined stock exchanges depending on the length of the estimation window. In contrast to the rate of return, stronger links between the examined stock exchanges can be seen in this case. The exchanges get low and high values in the same places. For all stock exchanges, for

example, the value of risk decreases for estimation windows beginning in July 2017 or December 2017. In addition, the lowest risk values for the examined stock exchanges are for shorter lengths of the estimation window when the beginning of the estimation window is in July 2018. The case of LSE is interesting again, as it is the market with the average highest risk, and as shown in the previous chart, this exchange had the lowest rate of return.

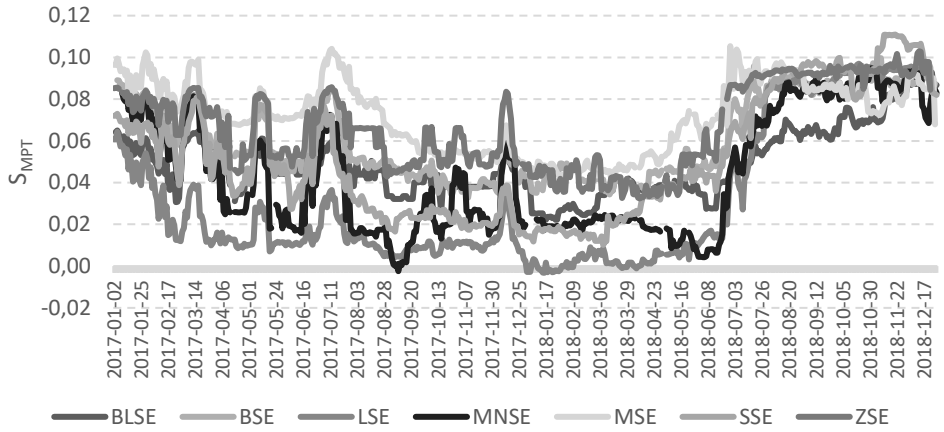
Figure 3. *Risk in the evaluation window depending on the day on which the estimation window began*



Source: *Own study.*

Figure 4 presents the results for efficiency. Analysis of this chart also suggests a strong connection between the results obtained for each of the examined stock exchanges. This is due to the fact that investment efficiency is the result of the quotient of the rate of return and risk, and although analysis did not show a strong relationship between the examined stock exchanges in terms of the rate of return, there was a strong relationship in the case of risk. This translates into an increase in the correlation between the examined stock exchanges in terms of efficiency. The connection between the results obtained for risk and efficiency is also evidenced by the fact that high efficiency was obtained when the beginning of the estimation window was in July 2018, when, as previously shown, low values for risk were obtained.

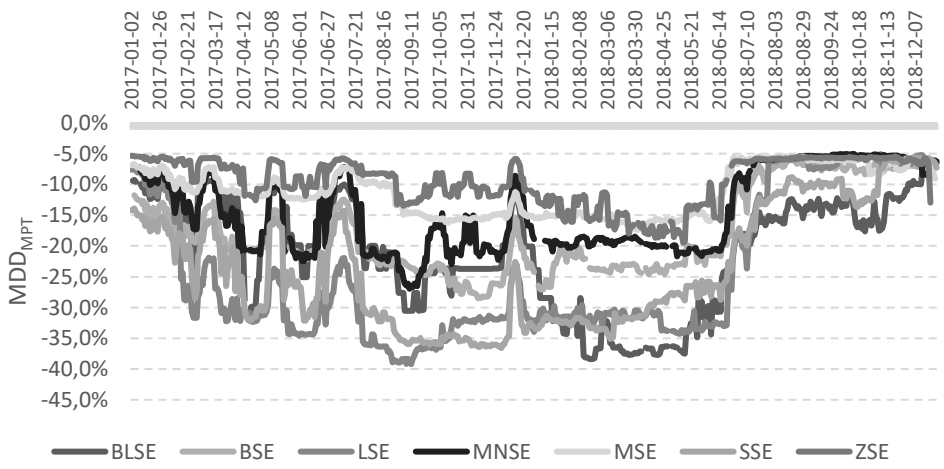
Figure 4. *Efficiency in the evaluation window depending on the day on which the estimation window began*



Source: *Own study.*

Figure 5 shows the value of maximum cumulative loss. It indicates a clear link between the examined stock exchanges in terms of this investment portfolio characteristic. Interestingly, this figure also shows that the lowest values for this measure were obtained when the length of the estimation window was short and covered the last six months, i.e. the period from July 2018 to December 2018.

Figure 5. *Maximum cumulative loss in the evaluation window depending on the day on which the estimation window began*



Source: *Own study.*

Aside from the figure for rate of return, all figures above clearly indicate a relationship between the examined stock exchanges. However, the figures do not unambiguously demonstrate the strength of this relationship or its direction. For this purpose, a

correlation analysis was performed. The results of this are presented in the table below.

Table 4 presents the results of the correlation analysis for all analysed portfolio characteristics for the examined stock exchanges. For the rate of return obtained for different lengths of the estimation window, there is no clear direction of connection for any of the examined stock exchanges. There are values of correlation coefficients lower than zero and higher than zero. For BLSE, in most cases, negative correlation coefficient values were obtained, which means that a decrease in the rate of return in this stock exchange was accompanied by an increase in the rate of return in other examined stock exchanges. This was different for SSE, where only positive values of correlation coefficients were recorded. This means that an increase in the rate of return on this stock exchange was accompanied by increases in the rate of return on the other analyzed stock exchanges. The obtained values of the correlation coefficients testify to the moderate strength of this relationship.

Table 4. *Values of correlation coefficients for the examined portfolio characteristics*

Measure	Stock exchange	BLSE	BSE	LSE	MNSE	MSE	SSE	ZSE
ip	BLSE	1.00	-0.01	**-0.11**	**-0.38**	**-0.42**	0.04	**-0.46**
	BSE	-0.01	1.00	**-0.27**	**-0.15**	0.06	**0.13**	**-0.20**
	LSE	**-0.11**	**-0.27**	1.00	**0.67**	**0.44**	**0.55**	**0.59**
	MNSE	**-0.38**	**-0.15**	**0.67**	1.00	**0.37**	**0.32**	**0.43**
	MSE	**-0.42**	0.06	**0.44**	**0.37**	1.00	**0.52**	**0.59**
	SSE	0.04	**0.13**	**0.55**	**0.32**	**0.52**	1.00	**0.35**
	ZSE	**-0.46**	**-0.20**	**0.59**	**0.43**	**0.59**	**0.35**	1.00
σp	BLSE	1.00	**0.78**	**0.72**	**0.83**	**0.83**	**0.81**	**0.93**
	BSE	**0.78**	1.00	**0.91**	**0.95**	**0.89**	**0.96**	**0.78**
	LSE	**0.72**	**0.91**	1.00	**0.93**	**0.80**	**0.93**	**0.70**
	MNSE	**0.83**	**0.95**	**0.93**	1.00	**0.86**	**0.95**	**0.82**
	MSE	**0.83**	**0.89**	**0.80**	**0.86**	1.00	**0.86**	**0.86**
	SSE	**0.81**	**0.96**	**0.93**	**0.95**	**0.86**	1.00	**0.76**
	ZSE	**0.93**	**0.78**	**0.70**	**0.82**	**0.86**	**0.76**	1.00
Sp	BLSE	1.00	**0.86**	**0.87**	**0.86**	**0.69**	**0.89**	**0.85**
	BSE	**0.86**	1.00	**0.91**	**0.92**	**0.84**	**0.95**	**0.92**
	LSE	**0.87**	**0.91**	1.00	**0.90**	**0.67**	**0.92**	**0.88**
	MNSE	**0.86**	**0.92**	**0.90**	1.00	**0.72**	**0.90**	**0.90**
	MSE	**0.69**	**0.84**	**0.67**	**0.72**	1.00	**0.78**	**0.84**
	SSE	**0.89**	**0.95**	**0.92**	**0.90**	**0.78**	1.00	**0.90**
	ZSE	**0.85**	**0.92**	**0.88**	**0.90**	**0.84**	**0.90**	1.00
MDDp	BLSE	1.00	**0.70**	**0.65**	**0.75**	**0.81**	**0.74**	**0.93**
	BSE	**0.70**	1.00	**0.92**	**0.92**	**0.92**	**0.96**	**0.73**
	LSE	**0.65**	**0.92**	1.00	**0.92**	**0.83**	**0.92**	**0.67**

MNSE	**0.75**	**0.92**	**0.92**	1.00	**0.85**	**0.92**	**0.77**
MSE	**0.81**	**0.92**	**0.83**	**0.85**	1.00	**0.89**	**0.85**
SSE	**0.74**	**0.96**	**0.92**	**0.92**	**0.89**	1.00	**0.72**
ZSE	**0.93**	**0.73**	**0.67**	**0.77**	**0.85**	**0.72**	1.00

Note: *The results in bold are statistically significant for p = 0.05.*
Source: *Own study.*

A different situation was observed for the three remaining analyzed portfolio characteristics. For risk measured by standard deviation, efficiency, and maximum cumulative loss, the calculated correlation coefficient values are close to one. This demonstrates a strong relationship between the examined stock exchanges and the changes taking place in the same direction. This means that if the value of risk increased in one stock exchange, it was accompanied by an increase in the value of risk on another stock exchange, while if the risk in a given stock market decreased, it was followed by a decrease in risk in other stock exchanges. Similar relationships were also observed for efficiency and maximum cumulative loss.

Such results indicate a strong connection between the examined stock exchanges in terms of risk, efficiency, and maximum cumulative loss. Therefore, if investors on the analyzed stock exchanges use the identical number of observations from the past to determine portfolio weights, then the characteristics of their investment portfolio will change in the same direction if the length of the estimation window changes. If an investor wants to limit risk or maximum cumulated loss or strive to maximize efficiency, then he/she should choose to invest in companies outside the analyzed region, as the results in this paper indicate that using portfolio theory with different lengths of estimation window gives results that are strongly correlated. The situation is different in the case of the rate of return as no such strong links were found, and additionally, negative correlations were observed.

The next step compared whether using Markowitz's portfolio theory for various lengths of the estimation window produces better investment results than using a naive strategy. The comparisons were based on results obtained in 2019 for a naive strategy. In the naive strategy, the investment portfolio was structured so that the share of each investment in the portfolio was the same: 25% for four-element portfolios. Table 5 presents the average values of the portfolio characteristics studied for the naive strategy. These are average values because the data contain values for all possible combinations of four-element portfolios.

Table 5. *Average values of the tested portfolio characteristics for the analyzed stock exchanges using a naive strategy*

Stock Exchange	i_n	σ_n	S_n	MDD_n
BLSE	0.127%	1.55%	0.075	-22.4%
BSE	0.055%	1.03%	0.052	-12.0%
LSE	0.005%	1.80%	0.019	-19.6%
MNSE	0.010%	0.89%	0.006	-11.7%

MSE	0.049%	0.74%	0.078	-8.3%
SSE	0.041%	1.31%	0.032	-17.1%
ZSE	0.060%	1.05%	0.059	-10.6%

Source: *Own study.*

Based on the data presented in Table 5, it can be concluded that LSE and MNSE are the least profitable for a naive strategy, while BLSE was the most profitable. This stock exchange was also one of the riskier ones, as only LSE was characterized by higher risk. Importantly, LSE, despite its average high risk, was also characterized by a low average rate of return. In terms of maximum cumulative loss, similar relationships were observed as for risk measured by standard deviation. Table 6 summarizes the structure of percentage shares for the portfolio characteristics studied, broken down by the strategy used.

Table 6. *Assessment of the application of a naive strategy and Markowitz's portfolio theory for the portfolio characteristics studied – all lengths of estimation window considered*

Measure	Stock E. / Strategy	BLSE	BSE	LSE	MNSE	MSE	SSE	ZSE
ip	Naive better	92.6%	4.2%	69.4%	2.8%	28.7%	20.0%	46.1%
	MPT better	7.4%	95.8%	30.6%	97.2%	71.3%	80.0%	53.9%
σp	Naive better	52.5%	71.9%	71.1%	67.7%	71.7%	75.0%	45.5%
	MPT better	47.5%	28.1%	28.9%	32.3%	28.3%	25.0%	54.5%
Sp	Naive better	93.0%	46.5%	58.9%	3.3%	57.3%	34.7%	45.3%
	MPT better	7.0%	53.5%	41.1%	96.7%	42.7%	65.3%	54.7%
MDDp	Naive better	41.3%	74.5%	70.3%	60.0%	66.6%	69.2%	35.6%
	MPT better	58.7%	25.5%	29.7%	40.0%	33.4%	30.8%	64.4%

Source: *Own study.*

It cannot be clearly stated whether the use of portfolio theory obtains better results than using a naive strategy for all analyzed portfolio characteristics if all lengths of the estimation window are considered. In the case of rate of return for five of the seven stock exchanges analyzed, Markowitz's portfolio theory gave better results than a naive strategy. The opposite situation occurred for BLSE, for which for virtually all lengths of estimation windows (92.6%), a naive strategy turned out to be more profitable in terms of rate of return. Unexpected results were obtained in investment risk. Here, the application of portfolio theory gave worse results (higher risk) than the use of a naive strategy except in the case of BLSE, where neither a naive strategy nor portfolio theory was confirmed as better. This may result from the investment objective adopted, which was to maximize efficiency. This kind of objective may have a negative impact on the value of risk.

For the efficiency of investment portfolios, it turned out that only four (BSE, MNSE, SSE, ZSE) out of seven stock exchanges obtained better results from using portfolio theory rather than a naive strategy. For these four stock exchanges, it was found that regardless of the length of the estimation window, in more than half of the cases, efficiency from using portfolio theory was higher than from using a naive strategy. Negative effects of portfolio theory were also observed for maximum cumulative loss.

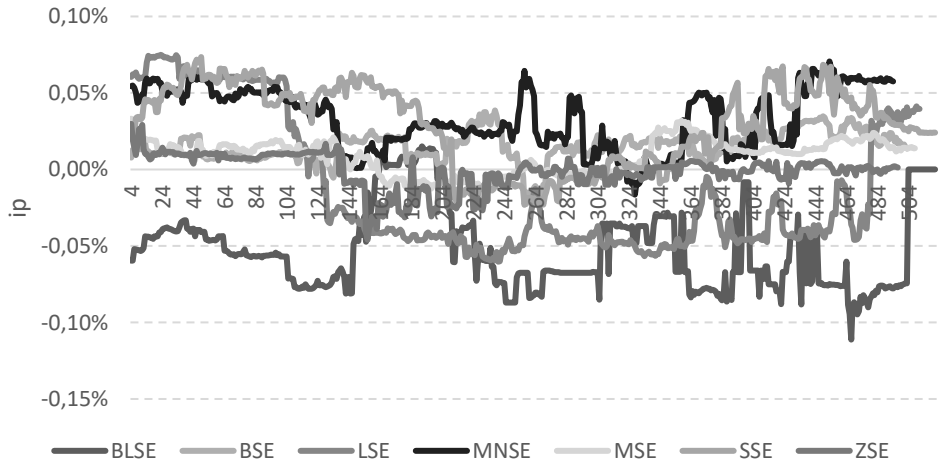
For this portfolio characteristic, the application of portfolio theory gave worse results, i.e. a higher maximum cumulative loss, than a naive strategy for the five of the analyzed stock exchanges. The presented results therefore do not demonstrate unequivocally whether the use of portfolio theory gives better or worse results than the use of naive strategy, which of course can be associated with the different lengths of estimation windows.

To indicate how many past observations should be included in the estimation window to determine the optimal investment portfolio weights, in other words, to determine the optimal length of the estimation window, four graphs have been prepared below. Each of the charts presents one of the four portfolio characteristics studied, for each stock exchange, but in such a way that the value obtained using portfolio theory was subtracted from the value of the same characteristic obtained using a naive strategy. The results of this difference were marked for each characteristic with "p". For example, rate of return is written as follows:

$$i_p = i_{MPT} - i_n$$

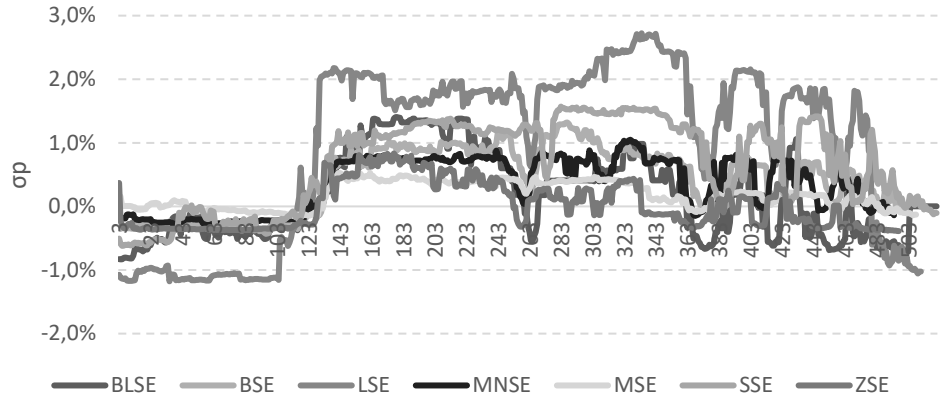
For rate of return, efficiency, and maximum cumulative loss, if the difference was greater than zero, then Markowitz's portfolio theory was more profitable, and if the difference was negative, then the naive strategy was more profitable. For risk measured by standard deviation, a smaller value of difference meant that using portfolio theory was better.

Figure 6. *Difference between the value of the rate of return obtained for portfolio theory and a naive strategy for different lengths of the estimation window*



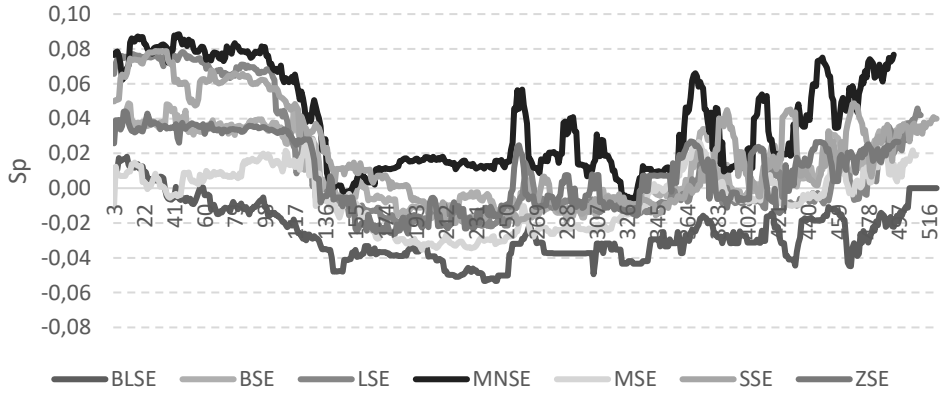
Source: *Own study.*

Figure 7. *Difference between the value of risk obtained for portfolio theory and a naive strategy for different lengths of the estimation window*



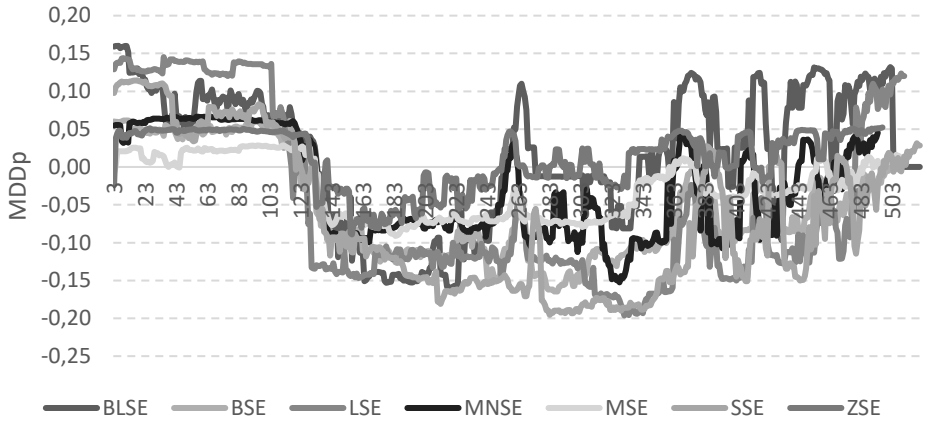
Source: *Own study.*

Figure 8. *Difference between the value of efficiency obtained for portfolio theory and a naive strategy for different lengths of the estimation window*



Source: *Own study.*

Figure 9. *Difference between the value of the maximum cumulative loss obtained for portfolio theory and a naive strategy for different lengths of the estimation window*



Source: *Own study.*

Analysis of the graphs above suggests that for short lengths of the estimation window, better results were obtained using portfolio theory than a naive strategy. The best results were obtained with an estimation window length of up to nearly 120 observations. Using just this length of estimation window, whose starting date was 01/07/2018, the four analyzed portfolio characteristics were again compared for portfolio theory and a naive strategy.

Table 7. *Assessment of the application of a naive strategy and Markowitz's portfolio theory for the studied portfolio characteristics using an estimation window of 120 observations*

Measure	Stock E. / Strategy	BLSE	BSE	LSE	MNSE	MSE	SSE	ZSE
ip	Naive better	100.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%
	MPT better	0.0%	100.0%	99.2%	100.0%	100.0%	100.0%	100.0%
σp	Naive better	0.8%	0.0%	5.0%	0.0%	25.8%	3.3%	0.8%
	MPT better	99.2%	100.0%	95.0%	100.0%	74.2%	96.7%	99.2%
Sp	Naive better	70.8%	0.0%	0.0%	0.0%	10.8%	0.0%	0.0%
	MPT better	29.2%	100.0%	100.0%	100.0%	89.2%	100.0%	100.0%
MDDp	Naive better	0.0%	0.0%	3.3%	0.0%	2.5%	0.8%	0.8%
	MPT better	100.0%	100.0%	96.7%	100.0%	97.5%	99.2%	99.2%

Source: *Own study.*

Based on the data from Table 7, it can be concluded that narrowing the estimation window to a maximum of 120 past observations means, for virtually every analyzed portfolio characteristic and for almost all stock exchanges examined, that applying Markowitz's portfolio theory leads to better results than using a naive strategy. The exception here is BLSE, for which both the rate of return and efficiency were better when using a naive strategy. An explanation for this phenomenon may be that the smallest amount of transactions was concluded on this stock exchange. It was the least

liquid stock exchange, as the prices of shares on it changed the least frequently in relation to the other analyzed stock exchanges.

6. Conclusions

The analysis described in this paper has shown that a change in the length of the estimation window has an identical effect on the results obtained by investment portfolios from the Balkan region for investment portfolio risk, efficiency, and maximum cumulative loss. This was not confirmed for the rate of return on the investment portfolio. Therefore, considering the results obtained, the research hypothesis adopted at the outset can be considered as correct for three of the four portfolio characteristics examined, which means there is a strong connection between the studied markets. An investor from one of the Balkan countries using an investment strategy based on portfolio theory would not be able to gain a competitive advantage over another investor from this region if he built a portfolio based on the same number of observations from the past, and it would therefore be advisable to diversify more widely, extending beyond the Balkan region.

In the next step of this paper, it was shown that the number of past observations that should be taken into account when constructing the investment portfolio should not exceed 120 observations, which corresponds to daily data of nearly six months. An investor from the Balkan region should, therefore, construct an investment portfolio based on historical data from the previous six months. Longer estimation periods are not recommended, as the results obtained for the studied portfolio characteristics were worse for the portfolio theory strategy than a naive strategy. A certain exception here is BLSE, for which this regularity was not clearly confirmed, possibly due to the low liquidity of this market.

Further research directions should check if the above conclusions are true for other evaluation windows and for portfolios with a different number of investments. A separate study should also be carried out for portfolios with minimal risk.

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