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INTERNATIONAL PORTFOLIO DIVERSIFICATION BENEFITS: AN EMPIRICAL INVESTIGATION OF THE 28 EUROPEAN STOCK MARKETS DURING THE PERIOD 2014–2024

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Abstract

This study investigates the benefits of international diversification in the stock markets of the 28 European countries (the EU and the UK) over two five-year periods: a stable period from 2014 to 2019 and a turbulent period from 2019 to 2024. The analysis draws on the Markowitz mean-variance, Sharpe reward-to-variability, and naive diversification models, based on which different investment strategies were developed and implemented. We find that actively managed portfolios perform significantly better than naively diversified portfolios. The analyzed markets exhibit positive short-term associations, with an average correlation coefficient of 0.29 in the first period and 0.46 in the second period. However, these markets do not show long-term cointegration.

Recent crises have reduced diversification benefits, yet significant opportunities for diversification remain. Diversification benefits are almost halved in the second period: average single-market standard deviation can be reduced by 60.5% with investments in 20-indices portfolios in the stable period, and only by 33.7% with the same portfolio size in the turbulent period.

Keywords: *International Diversification, Systematic Risk, Crisis, Covid-19 Pandemic, EU and UK Stock markets, Sharpe Ratio, Markowitz Portfolio Theory, Naive Diversification, Investment Strategies*

JEL Classification: *G11, G15*

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1. Introduction

Investors prefer to hold portfolios of securities because of a risk-reducing effect called risk diversification. The concept of risk diversification is fundamental in finance. Rational investors share the same goal of spreading all diversifiable risks and achieving the best possible risk-return ratio given their level of risk aversion when they choose to invest in securities. Most of the world's stock markets tend to move together in the same direction, implying positive correlation. The increasing association between developed and emerging markets has limited opportunities for international diversification (Srivastava 2007; Kizys and Pierdzioch 2008). Additionally, there is evidence that crises tend to increase association between markets and reduce diversification opportunities (Samitas et al. 2021).

Financial markets play an increasingly important role in financing the economy. For firms, cross-border ownership means access to a larger pool of investors and potentially more stable sources of financing. Conversely, through international investment, portfolio investors seek more diversified portfolios to hedge country-specific risks and take advantage of the development potential of different economies around the world. This study aims to determine whether international investments in the 28 European stock markets (the EU and the UK) offer better portfolio performance and higher diversification opportunities than investments in standalone stock markets in two distinct five-year periods. For the majority of the observed period, the UK was a member of the EU, so we included the UK in our analysis.

The bank-oriented European system needs to be strengthened by further developing and integrating capital markets. Enhanced integration of capital markets in the EU can help mitigate shocks in different parts of the euro area and enhance the resilience of the entire euro area. Financial integration, in general, benefits from the harmonization of financial market data standards (European Central Bank 2016). Conversely, the Capital Market Union represents the EU's policy response to the sovereign debt crisis from 2010–2013 and other negative trends resulting from the 2007–2008 financial crisis (Quaglia, Howarth, and Liebe 2016). The European investment fund industry plays a crucial role in facilitating cross-border integration within the EU. Additionally, investment and pension funds have been the fastest-growing types of non-bank intermediaries in the euro area in recent years (European Central Bank 2020). Investment funds enable investors to diversify their investments across countries and achieve better portfolio diversification than holding assets directly, thereby enhancing private financial risk-sharing in the EU.

The aim of our research is to analyse the performance and diversification potential of international portfolio management in the context of the EU and the UK, assuming that the analysed national stock market indices can be obtained through an index replication strategy. The topic of diversification potential becomes even more significant when considering the growing positive association among stock markets, especially during crises. We analyse and compare the results of different asset allocation methods, represented by the mean-variance optimization method, Sharpe ratio maximization, and naive diversification. Based on almost 10 years of historical data from 28 European national stock market indices, we aim to answer the question about the extent of international diversification benefits in the analysed markets, in two periods.

In our analysis, we utilize data from 28 stock market indices spanning two five-year periods: from September 2014 to August 2019 and from February 2019 to January 2024. The first sample excludes the potential impact of the Global Financial Crisis of 2007–2008 and the sovereign debt crisis (2010–2013), representing a relatively stable market period. In contrast, the second period encompasses turbulence caused by the Covid-19 recession (2020–2022) and the Russian invasion of Ukraine (2022–present).

Our primary methodology is based on Markowitz's (1952) portfolio mean-variance optimization method and Sharpe's (1966) investment performance measure, which assesses the reward-to-variability ratio. These methods form the basis for our sophisticated active investment strategy, alongside the naive diversification approach or the method of equal weights.

The main contribution of our research lies in the design, implementation, and performance measurement of an active investment strategy that proves superior to a simple naive diversification method in the analysed markets and periods. We create and compare the performance of randomly formed international portfolios of different sizes in three different scenarios and in two five-year periods. While the analysed European markets demonstrate short-term integration, there is no evidence of long-term cointegration. Additionally, our results show that an increase in the size of actively managed international portfolios leads to significantly better performance. Actively managed portfolios statistically outperform equally weighted portfolios, while the performance of the active investment strategy could be enhanced by short selling. However, diversification benefits are significantly lowered in the unstable period from 2019 to 2024, and crises do reduce risk diversification possibilities.

The paper commences with a theoretical background and literature review on risk diversification, followed by the methodology, data, and analysis and results sections. The discussion and conclusion sections underscore the practical implications and contribution of the study, including limitations and directions for further research.

2. Theoretical background with literature review

Risk diversification and financial market integration have been studied extensively over the last several decades, especially during stock market crises such as the October 1987 crash, the global financial crisis of 2007–2008 and the current turmoil of the Covid-19 pandemic. International market integration can be defined as assets with similar levels of risk producing similar expected returns, or national stock market indices moving together over the long term, even though there may be short-term divergence. This integration reduces the opportunities for risk diversification among international investors. Understanding these relationships is fundamental to modern portfolio theory, which advocates cross-border diversification of assets when stock returns are not perfectly correlated. There are several methodological approaches to evaluating financial integration and diversification opportunities. The most important and commonly used approaches include Markowitz's modern portfolio theory model, correlation analysis, as well as the Johansen cointegration test and Granger causality test.

The mean-variance optimization framework is most effective for analysing the risk-return trade-off and maximizing diversification benefits (Kim et al. 2021). Efficient mean-variance diversification involves combining securities with low correlation or inverse returns. Markowitz (1952) introduced the efficient mean-variance portfolio, which aims to minimize the variance for a given expected return or maximize the expected return for a given variance. Portfolio decisions are based on the standard deviation of assets and the correlation between returns. To benefit from diversification, investors avoid perfectly positively correlated assets; the lower the correlation, the greater the diversification effect. Although Markowitz's concept is primarily theoretical and its success depends on the assumptions of the model, which are often not fulfilled, numerous portfolio strategies have been developed that are based precisely on the mean-variance model due to their simplicity and comprehensibility (Hoe, Hafizah, and Zaidi 2010).

Fletcher and Marshall (2005) examined the advantages of international diversification for UK investors on the basis of the mean-variance strategy and Sharpe performance measures. They demonstrated significant diversification benefits compared to a domestic mean-variance strategy, but also showed that the degree of risk aversion and international confidence affect the extent of these benefits. Similarly, Chiou, Lee, and Chang (2009) conducted a comprehensive analysis of the benefits of international diversification over time and showed that despite the increasing integration of financial markets, international diversification continues to be beneficial. In their out-of-sample analysis, they showed that the Markowitz model reduces risk, although it does not necessarily increase mean-variance efficiency.

The Markowitz model has been criticized not only for its unrealistic assumptions, but also for its use of standard deviation as a symmetric measure of risk. In this context, the concept of downside risk measures or risk measures using quintile measures is gaining popularity. For example, Hunjra et al. (2020) compare the mean variance, the semi-variance, the mean absolute deviation, and the CVaR as risk measures and show that the CVaR provides the best results in the scenarios examined. Sikalo, Arnaut-Berilo, and Delalic (2023) problematize the concept of comparing different models due to the fact that each model is dominant in its own risk space. Based on a multi-criteria analysis, they show that the minmax model dominates, but also gives naive diversification an advantage over maximizing the Sharpe ratio in the mean-variance space.

Despite the development of risk diversification models, investors still use very simple rules for their asset allocation, so-called naive diversification. Naive diversification means equally weighted portfolios, i.e. $1/n, i = \overline{1,n}$. Its main advantage is that it is very easy to implement. Taljaard and Mar´e (2021) found that equally weighted portfolios perform better than capital-weighted portfolios. DeMiguel, Garlappi, and Uppal (2009) shows that optimal diversification only outperforms naive diversification when unsystematic risks are high. In contrast, Platanakis, Sutcliffe, and Ye (2021) found only minimal differences between naive diversification and optimal diversification. Their study highlights the two stages of the investment process where mean variance analysis proves superior in asset allocation, while simple diversification outperforms mean variance in stock selection.

A study by Alexeev and Tapon (2012) found that holding a relatively small number of stocks can help investors reduce extreme risk, with specific thresholds identified for each of the five developed economies studied. The research findings suggest that regardless of the risk measurement method used, developed financial markets generally require a larger number of stocks for a well-diversified portfolio than emerging markets. For European countries, De Keyzer, De Schaepmeester, and Inghelbrecht (2014) found that investors generally need around 14 shares for PIIGS countries and slightly more for better performing countries, noting that the required number of shares decreases in times of crisis. Regarding the required number of stocks for a well-diversified portfolio, Zaimovic, Omanovic, and Arnaut-Berilo (2021) in their systematic literature review highlighted several important points: (1) today's portfolios require more stocks than in the past, (2) fewer stocks are needed in emerging markets than in developed markets, and (3) higher stock correlations with the market reduce the required number of stocks for individual investors.

Correlation analysis is a widely used method for measuring associations that is known for its simplicity and ease of interpretation. Studies such as those by Goetzmann, Li, and Rouwenhorst (2005) and Quinn and Voth (2008) utilize the average correlation coefficients between pairs of countries to summarize market movements. Pan, Liu, and Roth (2010) find strong correlations within European markets, with the weakest correlation between Europe and Japan, while the correlation between Europe and the US remains almost the same. They emphasize the importance of investment horizons and warn against short-term perspectives for effective diversification. Kizys and Pierdzioch (2008) show that correlations between major markets have increased after the 1990s, reducing diversification effects, and Samitas et al. (2021) point out that the Covid-19 pandemic has increased market correlations, reducing diversification opportunities. Emerging markets such as the BRICS countries offer diversification opportunities due to their relatively low correlation (Liu, Hammoudeh, and Thompson 2013; Syriopoulos 2007). You and Daigler (2010) show different diversification benefits over time, while Forbes and Rigobon (2002) question correlation's adequacy in measuring market integration, and Pukthuanthong and Roll (2009) illustrate that two markets can be perfectly integrated but imperfectly correlated. In contrast, a study by Billio et al. (2017) examines various measures of market integration, with all measures showing similar long-term patterns. It is shown that standard correlation analysis explains fluctuations in diversification benefits as well or better than more complex measures, and the results are robust. The results also confirm that increasing financial integration leads to decreasing benefits from international portfolio diversification.

Granger and Johansen's cointegration methods can be found in numerous studies. Marimuthu (2010) analyzed the long-term and short-term relationships between composite indices of five countries (Malaysia, India, China, USA and United Kingdom) over a decade (1997–2007). The results indicate a long-term relationship between the regional stock markets that can only be decoupled in the short term. Lupu and Horobet (2009) documented rapid market reactions to new information in eight European countries in the period 2003 – 2007. Nedunchezhian and Sakthia (2019) analyzed the movements of the major global stock markets (New York Stock Exchange, NASDAQ, Japan Exchange Group, Shanghai Stock Exchange and European Stock Exchange based on market capitalization) from 2009 to 2018. They found no long-term co-integration between the selected stock markets. Cheng, Jahan-Parvar, and Rothman (2010) and Nardo, Ossola, and Papanagiotou (2021) suggest that regional market integration limits diversification opportunities, especially after the financial crisis. Meric, Ratner, and Meric (2008) found that diversification benefits vary depending on market conditions. Coudert and Gex (2006) suggest that financial crises typically coincide with periods of increased risk aversion.

Due to the increasing integration of markets, in this study we investigate the diversification opportunities between 28 European stock markets and the performance of active investment strategy compared to naively diversified portfolios. Our study is based on Markowitz's efficient diversification methodology (1952, 1991), Sharpe's reward to variability ratio (1966), Sharpe's random diversification (1964, 1970), and the naive diversification approach.

3. Methodology

In our study, we adopted the methodology of Markowitz (1952) to analyse diversification opportunities in 28 European stock markets. Efficient portfolios lie between the minimum variance portfolio and the maximum expected return (mean return) portfolio, regardless of the number of securities analysed. The expected return (1) and the portfolio variance (2) are determined by the classic Markowitz portfolio model

$$\bar{R}_P = \sum_{i=1}^{n} \bar{R}_i \, x_i \tag{1}$$

$$\sigma_p{}^2 = \sum_{j=1}^{n} \sum_{i=1}^{n} x_j \, x_i Cov(R_{i,}R_j) \tag{2}$$

with portfolio investments constraints

$$\sum_{i=1}^{n} x_i = 1 \tag{3}$$

and, if short selling is not allowed we add additional constraints

$$x_i \geq 0, \qquad i = \overline{1,n} \tag{4}$$

where, $\overline{R_i}$ represent expected return of assets, *i,n* is the number of different assets, and x_i share of total investment in assets *i*.

To evaluate the performance of different mean-variance portfolios, we use the reward to variability ratio. This ratio was developed by Sharpe (1966) and measures the average return above the risk-free rate per unit of standard deviation or total risk. When we subtract the risk-free rate from the expected return, investors can better isolate the risk premium associated with risk-exposed assets. The model can be summarized as follows:

$$Max\ Sharpe\ ratio\ = \frac{\bar{R}_p - r_f}{\sigma_p} \tag{5}$$

subject to constraints (1), (2) and (3). In case when short selling is not allowed, additional non-negativity constraints (4) was added.

When the risk-free rate is set equal to zero in objective function (5) we obtain the adopted Sharpe ratio, which should be maximized. This measure represents also the inverse coefficient of variation. A portfolio with the maximized adopted Sharpe ratio is the portfolio with the highest expected return per unit standard deviation. If short selling is not allowed, the sum of all investment weights should equal 1 (100%). If short selling is allowed, the weights can be negative.

Naive diversification means that investors invest the same amount of money in all *n* assets in their portfolios:

$$x_i = \frac{1}{n}, \qquad i\ =\ \overline{1,n} \tag{6}$$

Naive diversification does not aim to reduce risk and does not rely on past or historical data; it focuses on investing in a large number of assets with equal weights.

To test the integration of the European markets, we use Pearson correlation tests to estimate short-term integration and Johansen cointegration tests (Johansen 1988) for long-term integration. The simplest form of the test can be expressed by equation (7), where ΔY_t represents the differenced stationary data series, Γ_i the matrices of short-term correction coefficients, p the number of lags, ε_t the residual in the current period and Π the matrix of cointegration coefficients to measure the long-run relationships between the time series.

$$\Delta Y_t = \Pi Y_{t-p} + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \cdots + \Gamma_{p-1} \Delta Y_{t-p+1} + \varepsilon_t \tag{7}$$

This equation models the dynamics of the cointegrating relationship between time series, taking into account the short-term correction between them. The rank of the matrix Π determines the number of cointegrating vectors and can be between 0 and the number of variables minus one. The Johansen cointegration test can be performed with two statistical tests: the trace statistic and the maximum eigenvalue statistic.

4. Data

To investigate diversification opportunities and asset behaviour in 28 European stock markets, we identified and analysed random mean-variance efficient portfolios and random equal-weighted portfolios constructed from stock market indices, i.e. based on complex and simple asset allocation approaches. The input data for our mean-variance analysis are the weekly values of 28 stock market indices, which provide a good measure of the performance of national markets. They were observed over two five-year periods, from September 2014 to August 2019, and February 2019 to January 2024, totalling 260 weeks in each sample and resulting in approximately 14,000 input data. These two periods are overlapping for 7 months in 2019. Larger markets such as United Kingdom[1], Germany and France are represented by broader stock market indices, while smaller stock markets such as Malta, Slovenia and Luxembourg are represented by narrower indices due to their market size. The MSCI Europe Index, as one of the best representatives of the European market, was used as a benchmark index in the analysis. It includes 439 stocks and covers 85% of the free float-adjusted market capitalization of the 15 developed markets in Europe[2]. The input data is obtained from the official websites of the 28 European national stock exchanges and from the website Yahoo Finance.

Since the risk-free rates are country-level statistics, while our analysis covers 28 stock markets, we adopted the Sharpe ratio by setting the risk-free rate equal to zero in model (5), i.e. we calculated the inverse coefficient of variation ratio, as a measure of portfolio performance. This measure indicates how much the mean return changes relative to the standard deviation. It therefore measures relative variability and allows us to measure risk-adjusted returns. Our analysis is conducted with full (nominal) returns, not excess returns. Country-specific risk, which is included in the country risk premium, is not subject of our analysis. Our analysis is not about predicting returns, but about comparing portfolio performance. Therefore, the inverse coefficient of variation, i.e. the adopted Sharpe ratio, is used as an appropriate measure of portfolio performance (further mostly

Table 1. Descriptive statistics of indices returns and unit root test results

Country (Index)	Period 2014 to 2019				Period 2019 to 2024			
	Mean	Standard Deviation	Adopted Sharpe ratio[1]	Dickey-Fuller test for first difference	Mean	Standard Deviation	Adopted Sharpe ratio[1]	Dickey-Fuller test for first difference
Austria (ATX)	0.001087	0.023516	0.046215	-16.25 ***	0.001188	0.034456	0.034491	-13.25 ***
Belgium (BFX)	0.000611	0.020642	0.029591	-16.39 ***	0.000603	0.029556	0.020388	-15.63 ***
Bulgaria (SOFIX)	0.000164	0.013502	0.012168	-14.39 ***	0.001344	0.018290	0.073479	-12.05 ***
Croatia (CROBEX)	0.000136	0.011957	0.011414	-13.79 ***	0.001799	0.018896	0.095209	-12.74 ***
Cyprus (CYFT)	-0.000912	0.019975	-0.045648	-16.36 ***	0.003511	0.026286	0.133573	-12.93 ***
Czech Rep. (PX)	0.000297	0.017039	0.017437	-15.47 ***	0.001575	0.024361	0.064661	-13.75 ***
Denmark (OMXC20)	0.001543	0.022810	0.067632	-15.94 ***	0.004034	0.027085	0.148926	-17.59 ***
Estonia (OMXTGI)	0.001928	0.012052	0.159946	-14.49 ***	0.001660	0.021221	0.078206	-14.04 ***
Finland (OMXH25)	0.001201	0.022188	0.054124	-18.24 ***	0.000787	0.028241	0.027874	-15.56 ***
France (CAC 40)	0.001033	0.022931	0.045043	-16.92 ***	0.002087	0.029610	0.070485	-16.08 ***
Germany (HDAX)	0.001365	0.023304	0.058556	-16.93 ***	0.001981	0.029477	0.067201	-15.61 ***
Greece (ATHEX)	0.024048	0.462322	0.052016	-18.83 ***	0.003241	0.036762	0.088157	-14.19 ***
Hungary (BUX)	0.003129	0.019959	0.156762	-16.69 ***	0.002363	0.029575	0.079895	-15.47 ***
Ireland (ISEQ 20)	0.000946	0.021417	0.044177	-16.09 ***	0.002265	0.032774	0.069123	-16.83 ***
Italy (FTSE MIB)	0.000334	0.026316	0.012679	-15.35 ***	0.002311	0.032029	0.072162	-14.77 ***
Latvia (OMXRGI)	0.003534	0.020279	0.174262	-16.91 ***	0.001495	0.021523	0.069455	-16.52 ***
Lithuania(OMXVGI)	0.001658	0.011919	0.139076	-18.41 ***	0.001663	0.015875	0.104753	-13.03 ***
Luxembourg (LUTX)	-0.000543	0.028698	-0.018911	-18.14 ***	0.000978	0.038503	0.025414	-16.84 ***
Malta (MSE)	0.001415	0.009086	0.155722	-14.69 ***	-0.000525	0.015987	-0.032843	-13.58 ***
Netherlands (AEX)	0.001316	0.021463	0.061333	-16.06 ***	0.002077	0.026853	0.077341	-15.81 ***
Poland (WIG 30)	-0.000174	0.021477	-0.008121	-17.05 ***	0.000885	0.033565	0.026379	-14.75 ***
Portugal (PSI 20)	-0.000538	0.023907	-0.022491	-16.09 ***	0.001146	0.026234	0.043684	-14.76 ***
Romania (BET)	0.001254	0.022203	0.056477	-17.08 ***	0.003124	0.025077	0.124582	-16.94 ***
Slovakia (SAX)	0.002188	0.021632	0.101136	-22.15 ***	-0.000123	0.018982	-0.006495	-17.34 ***
Slovenia (SBITOP)	0.000323	0.013671	0.023615	-15.82 ***	0.002054	0.022365	0.091834	-13.47 ***
Spain (IBEX 35)	-0.000603	0.024550	-0.024542	-16.45 ***	0.000957	0.030175	0.031709	-15.07 ***
Sweden (OMX 30)	0.000727	0.021776	0.033394	-17.11 ***	0.002069	0.027391	0.075531	-16.19 ***
UK (FTSE 100)	0.000361	0.018366	0.019665	-16.67 ***	0.000580	0.023982	0.024175	-16.31 ***
EU (MSCI EUROPE)	-0.000157	0.019293	-0.008130	-16.55 ***	0.001411	0.029959	0.047102	-16.31 ***

***significant compared with 1% Critical value -3.459

[1] Risk-free rate assumed to be equal to zero.

referred just as Sharpe ratio for simplicity). Table 1 showcases descriptive statistics for the returns of selected stock indices for both periods.

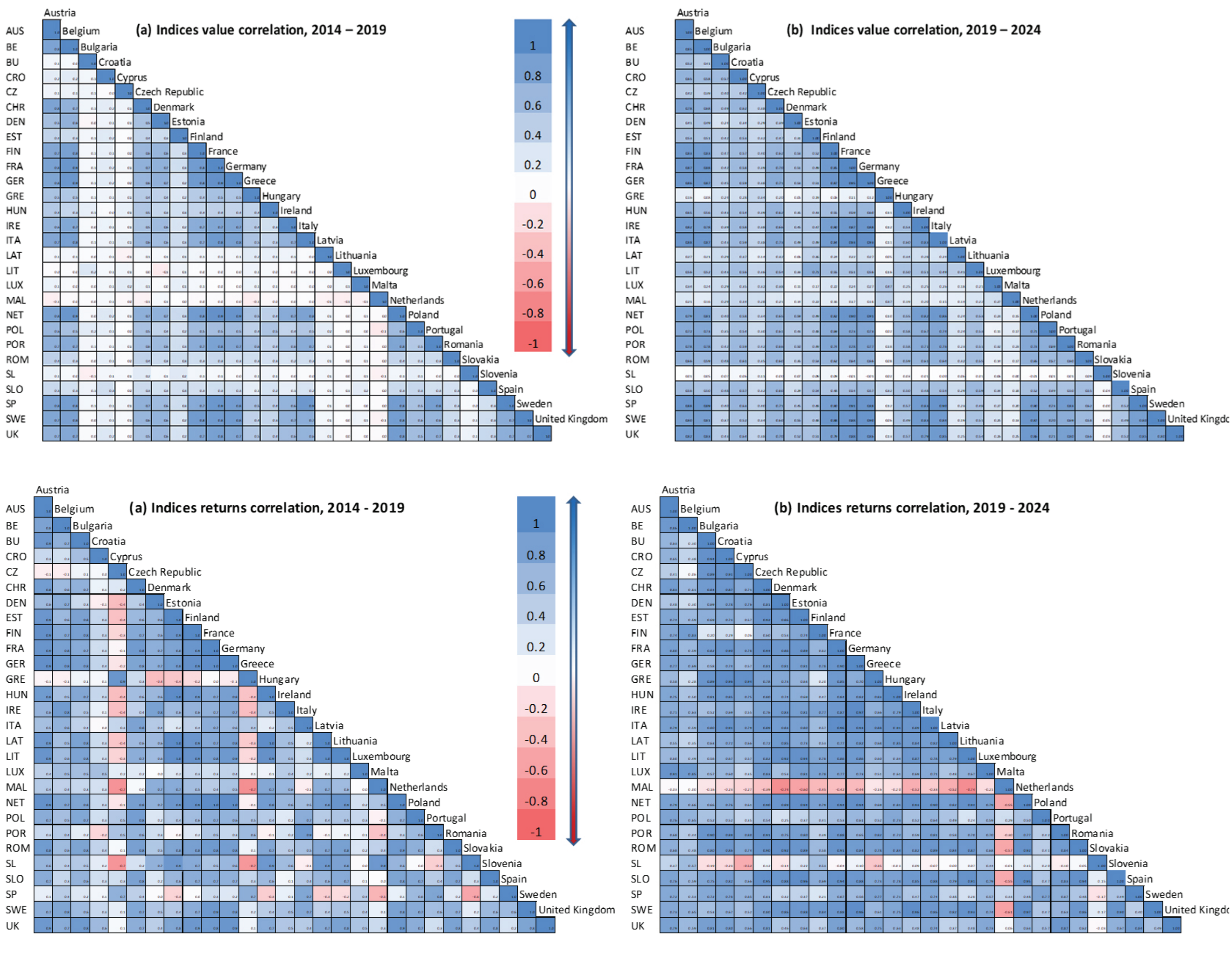
The ADF test, utilized as a unit root test, assessed the stationarity of indices returns. The findings suggest that all indices values are integrated of order one, I(1), thereby implying that the first differences of the index value display stationarity.

5. Analysis and results

To analyse the impact of international diversification on portfolio performance within the analysed European stock markets, we formed unique 200 international portfolios consisting of varying numbers of randomly selected stock indices, along with one portfolio comprising of 28 indices, across three different scenarios, and for two periods. In total approximately 1,200 portfolios of different sizes have been created, comprising from one to 28 assets each. A random selection of subsets, consisting of 5, 10, 15 or 20 indices from a set of 28 observed indices, was made using a random number generator in Excel (pseudo-random numbers). Each index was assigned a randomly generated value. The 5, 10, 15 or 20 smallest random numbers were then selected and the corresponding indices were included in the mean-variance portfolio optimization model. The scenarios are three portfolio creation approaches, i.e. without short selling (Scenario 1), with short selling (Scenario 2), and with a simple, naive diversification with equal weights (Scenario 3). We aimed to assess whether greater international diversification contributes to improved portfolio performance by analysing randomly created index portfolios of different sizes in these scenarios across two distinct periods. The variance-covariance matrix serves as the foundation for crafting an optimal portfolio in Scenario 1 and Scenario 2. Utilizing this matrix we computed each portfolio's mean, variance, and Sharpe ratio. The contribution of each index within the portfolio was adjusted to maximize the Sharpe ratio.

The importance of diversification potential increases notably with the ongoing integration of the EU market. According to economic theory, diversification is possible when markets are not fully integrated, distinguishing between short-term and long-term integration. We wanted to find out whether the diversification opportunities are consistent with theory and whether the observed markets are integrated. Given that many authors use price (value) or return correlation as a measure of short-term integration (Goetzmann, Li, and Rouwenhorst 2005, Quinn and Voth 2008, Pan, Liu, and Roth 2010, Billio et al. 2017) and aware of the criticism of this way of measuring integration (Forbes and Rigobon 2002, Bekaert, Hodrick, and Zhang 2009, Pukthuanthong

Figure 1. Pearson's correlation matrix for indices values and returns in both periods



and Roll 2009), we report the values of the correlation matrix in both periods, Figure 1, for both indices values and indices returns. It can be seen that the blue colour predominates, indicating the unidirectional movement of most indices. When we compare the correlation matrices of the two periods, we find that the right hand matrices associated with the period of market turbulence have many more blue cells indicating a positive relationship with higher correlation coefficients, which is consistent with the previous findings (Kizys and Pierdzioch 2008, Tai 2018, Samitas et al. 2021). Additionally, the average coefficient of correlation among 28 national stock market indices is 0.29 during the period 2014-2019, and it increases to 0.46 during the period 2019-2024. Indeed, stock markets do correlate more in crises, indicating increased short-term association.

The time series under observation exhibit integration of order I(1). The presence of long-term cointegration in both time periods was assessed using the Johansen cointegration test, Table 2. Due to the number of variables involved, we only report the value of the trace statistic for the Johansen test. Since Johansen tests are sensitive to the choice of lag length, we selected the appropriate lag length based on the final prediction error (FPE), the Akaike information criteria, the Schwarz criteria and the Hannah-Quin criteria, which are listed in Table 2.

Based on the findings, we deduce the absence of any cointegration equations in either period, indicating a lack of long-term integration among the observed financial markets in Europe. Although European markets do show short-term integration, the long-term cointegration is not evident.

To examine the performance and diversification possibilities of the observed markets, we create 50 randomly generated portfolios consisting of 5, 10, 15, and 20 indices, and one portfolio comprising of 28 indices, based on mean-variance and naive diversification approach. The average Sharpe ratio for all three scenarios and all portfolio sizes in both time periods has been calculated. We analyse obtained ratios (1) within each scenario and (2) between different scenarios.

Table 2. Optimal Lag-Lengths and Johansen Cointegration test

Period 2014 to 2019						
Lag	**LL**	**LR**	**FPE**	**AIC**	HQIC	SBIC
0	-34427.4		7.2e+86	268.104	268.238	268.436
1	-28482.4	11890	5.2e+68*	226.322*	229.654*	234.608*
2	-28050.3	864.23	1.8e+69	227.442	233.973	243.682
3	-27591.1	918.27	5.8e+69	228.351	238.081	252.546
4	-271707	968.23*	2.1e+70	229.066	241.995	261.215
Johansen Cointegration test						
H0: No cointegration vector		H1: At least one cointegration vector			Trace statistics:1901.6519*[3]	
Period 2019 to 2024						
Lag	**LL**	**LR**	**FPE**	**AIC**	HQIC	SBIC
0	-35886.1		6.1e+91	279.456	279.589	279.787
1	-30268.8	11235	5.7e+74*	240.224*	243.556*	248.51*
2	-29738.9	1059.8	9.0e+74	240.583	247.144	256.823
3	-29246	985.83	2.3e+75	241.229	25.959	265.424
4	-28750	991.96*	7.3e+75	241.852	254.781	274.001
Johansen Cointegration test						
H0: No cointegration vector		H1: At least one cointegration vector			Trace statistics: 1892.8942*	

* Null hypothesis cannot be rejected.

Figure 2 represents the resulting Sharpe ratios, and it is evident that increasing the portfolio size leads to a better performance in terms of Sharpe ratio for both composite investment strategies, Scenario 1 and Scenario 2. Sharpe ratio values are lower in the second period in both scenarios. The second period is a period of turbulence in the economy and in the stock markets accompanied by high variability, so the risk-return ratio is lower. These results are in line with previous results from Danielsson, Valenzuela, and Zer (2018). Finally, average Sharpe ratios are obviously higher in Scenario 1 and 2, compared to Scenario 3.

Statistically significant differences in the Sharpe ratio between portfolios of different sizes across all three scenarios, considering both size and time, are presented in Table 3. Choice of tests used depended on the normality of returns tested by Shapiro-Wilk test.

Results from Table 3 show statistically significant increase in the Sharpe ratio at 1% level in all cases of actively managed mean-variance efficient portfolios, Scenario 1 and Scenario 2, in both periods. Significance of Sharpe ratio increase with respect to size is not so consistent in Scenario 3, and it is not even evident in the second period, except in one case. With naive diversification, the diversification effect is exhausted with 5 assets, and further increase of number of assets does not have a significant impact.

The mean-variance efficient portfolios from Scenario 2 are the best-performing portfolios for all sizes, followed by the mean-variance efficient portfolios from Scenario 1. In contrast, the simply managed portfolios from Scenario 3 have the worst performance, as shown in Table 4. Active portfolio management based on the Markowitz model of mean-variance efficient diversification, combined with the maximization of the Sharpe ratio, is clearly beneficial and can be further enhanced by short selling.

We have plotted the portfolios created to maximize the Sharpe ratio in Scenario 1 and Scenario 2, alongside the European national stock market indices and the MSCI Europe Index for both periods, as shown in Figure 3. As the size of the portfolio increases, the portfolios move upwards and to the left, indicating higher efficiency, consistent with our analysis. It is interesting to note that the randomly generated mean-variance efficient portfolios of different sizes form the familiar cloud of possible portfolios described by modern portfolio theory (Markowitz 1952). Figure 3 demonstrates that both the 15-indices and 20-indices portfolios offer a better risk-return trade-off compared to all national indices and the MSCI Europe Index. In the second period, the portfolio cloud shifts to the right for Scenario 1 and even further to the right for Scenario 2 with a higher upper bound, indicating a significant increase in risk along with the potential for substantially higher returns.

Figure 2. Average Sharpe ratio for mean-variance optimal portfolio (without and with short selling allowed) and equally-weighted portfolio

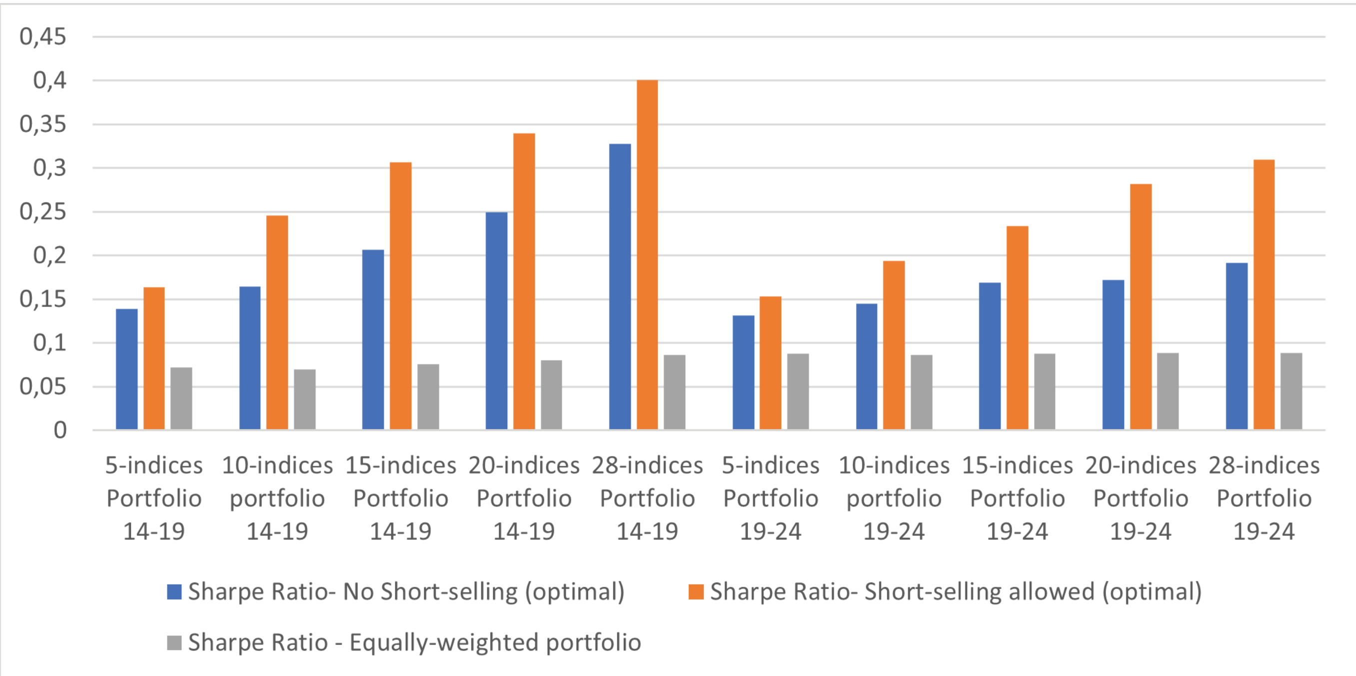


Table 3. Statistical tests for Sharpe ratio value distribution and differences within each scenario

	Scenario 1: No Short selling			Scenario 2: Short Selling allowed			Scenario 3: Naive diversification		
2014 - 2019	mean	z	Prob >z	mean	z	Prob >z	mean	z	Prob >z
One index	0.048434	2.040	0.021	0.048434	2.040	0.021	0.048434	2.040	0.021
Portfolio 5	0.140813	1.715	0.043	0.164064	2.129	0.017	0.071969	3.110	0.001
Portfolio 10	0.204709	0.427	0.335	0.245932	2.405	0.000	0.070108	3.671	0.000
Portfolio 15	0.254165	-0.206	0.581	0.306697	0.236	0.407	0.075809	2.605	0.005
Portfolio 20	0.282122	0.727	0.234	0.339623	1.787	0.037	0.080088	-1.073	0.858
H0: There is no difference between portfolios	Kruskal-Wallis	Chi2 =180.48,df=4 Prob =0.0001***		Kruskal-Wallis	Chi2 = 154.31, df=4 Prob =0.0001		Kruskal-Wallis	Chi2 =43.152, df=4 Prob =0.0001	
	Post Hoc Mann-Whitney 1 vs 5: z= -6.042, p=0.000*** 5 vs 10: z=5.846, p=0.000*** 10 vs 15: z= -6.542, p=0.000*** 15 vs 20: z= -4.605, p=0.000***			Post Hoc Mann-Whitney 1 vs 5: z= -5.523, p=0.000*** 5 vs 10: z=4.712; p=0.000*** 10 vs 15: z= -4.978, p=0.000*** 15 vs 20: z= -3.775, p=0.000***			Post Hoc Mann-Whitney 1 vs 5: z=-2.37, p=0.017** 5 vs 10: z=1.655; p=0.098* 10 vs 15: z=-3.185, p=0.001*** 15 vs 20: z=-2.902, p=0.003***		
	Scenario 1: No Short selling			Scenario 2: Short Selling allowed			Scenario 3: Naive diversification		
2019 - 2024	mean	z	Prob >z	mean	z	Prob >z	mean	z	Prob >z
One index	0.026727	-0.804	0.78932	0.0267272	-0.804	0.78932	0.026727	-0.804	0.78932
Portfolio 5	0.120718	0.036	0.48565	0.141360	-0.568	0.71501	0.087815	-0.249	0.59844
Portfolio 10	0.145342	0.706	0.24008	0.193573	-0.786	0.78421	0.086616	0.479	0.31594
Portfolio 15	0.165471	2.214	0.01341	0.270567	1.537	0.06210	0.088073	-0.916	0.82008
Portfolio 20	0.172482	2.607	0.00457	0.306697	1.295	0.09767	0.088596	0.026	0.48977
H0: There is no difference between portfolios	Kruskal-Wallis	Chi2 =79.59 p = 0.000		ANOVA	F(4, 222) = 525.60 p = 0.000		ANOVA	F(4, 224) = 112.88 p = 0.000	
	Post Hoc Mann-Whitney 1 vs 5: z=-7.35, p=0.000*** 5 vs 10: z=4.29; p=0.000*** 10 vs 15: z=-4.00, p=0.000*** 15vs 20: z=-1.71, p=0.007***			Post Hoc Bonferoni 1 vs 5: p=0.000*** 5 vs 10: p=0.000*** 10 vs 15: p=0.000*** 15 vs 20: p=0.000***			Post Hoc Bonferoni 1 vs 5: p=0.000*** 5 vs 10: p=1.000 10 vs 15: p=1.000 15 vs 20: p=1.000		

*** Indicates significance at the 1% level; ** Indicates significance at the 5% level; * Indicates significance at the 10% level.

Figure 3. Efficiency and risk-return trade-off analysis: created portfolios vs. national stock market indices in mean-variance space

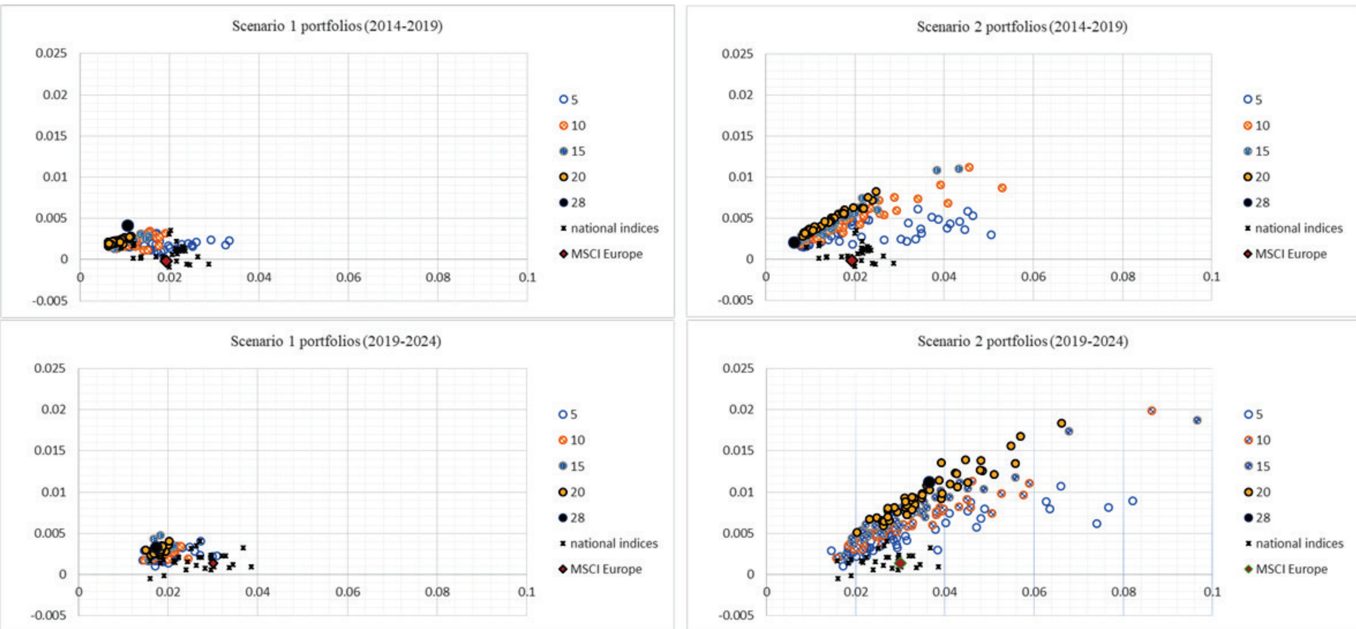


Table 4. Statistical tests for Sharpe ratio value differences between scenarios

2014 - 2019	**Scenario 3: Naive diversification**	**Scenario 1: No Short selling**	**Scenario 2: Short Selling allowed**
5 indices	Mean = 0.0719687	Mean = 0.140813	Mean = 0.164064
Equality of means	Scenario 3 vs. Scenario 1 t = -5.8888; df=85.06; p = 0.000***		Scenario 1 vs. Scenario 2 t = -1.7338; df=98; p = 0.086*
10 indices	Mean = 0.0701077	Mean = 0.2047091	Mean = 0.2459324
Equality of means	Scenario 3 vs. Scenario 1 t = -17.9114; df=62.38; p = 0.000***		Scenario 1 vs. Scenario 2 t = -4.5207; df=98; p = 0.000***
15 indices	Mean = 0.075809	Mean = 0.2541647	Mean = 0.3066974
Equality of means	Scenario 3 vs. Scenario 1 t = -32.0052; df=59.44; p = 0.000***		Scenario 1 vs. Scenario 2 t = -7.3715; df=98; p = 0.000****
20 indices	Mean = 0.0800881	Mean = 0.2821223	Mean = 0.3396231
Equality of means	Scenario 3 vs. Scenario 1 t = -45.0717; df=52.62; p = 0.000***		Scenario 1 vs. Scenario 2 t = -10.6689; df=98; p = 0.000***
2019- 2024	**Scenario 3: Naive diversification**	**Scenario 1: No Short selling**	**Scenario 2: Short Selling allowed**
5 indices	Mean = 0.075809	Mean = 0.1207176	Mean = 0.1413599
Equality of means	Scenario 3 vs. Scenario 1 t = -5.8584; df=90.46; p = 0.000***		Scenario 1 vs. Scenario 2 t = -3.2046; df=96; p = 0.002**
10 indices	Mean = 0.075809	Mean = 0.1453416	Mean = 0.1935716
Equality of means	Scenario 3 vs. Scenario 1 t = -14.7960; df=78.96; p = 0.000***		Scenario 1 vs. Scenario 2 t = -9.5863; df=98; p = 0.000***
15 indices	Mean = 0.075809	Mean = 0.1654707	Mean = 0.2355147
Equality of means	Scenario 3 vs. Scenario 1 t = -25.6434; df=74.11; p = 0.000***		Scenario 1 vs. Scenario 2 t = -16.6991; df=98; p = 0.000***
20 indices	Mean = 0.075809	Mean = 0.1724821	Mean = 0.2705666
Equality of means	Scenario 3 vs. Scenario 1 t = -31.3326; df=65.50; p = 0.000***		Scenario 1 vs. Scenario 2 t = -23.3283; df=98; p = 0.000***

*** Indicates significance at the 1% level; ** Indicates significance at the 5% level; * Indicates significance at the 10% level.

In Scenario 1, many indices underperformed and were not included in the calculated mean-variance portfolios due to the superior performance of other indices. However, in Scenario 2, where negative asset holdings are also possible, the performance of portfolios of all sizes improves significantly. The efficient portfolios expand and move upward. The primary advantage of Scenario 2 portfolios lies in the potential for higher returns rather than simply lower standard deviation compared to Scenario 1. Undoubtedly, larger portfolios contribute to a better risk-return trade-off.

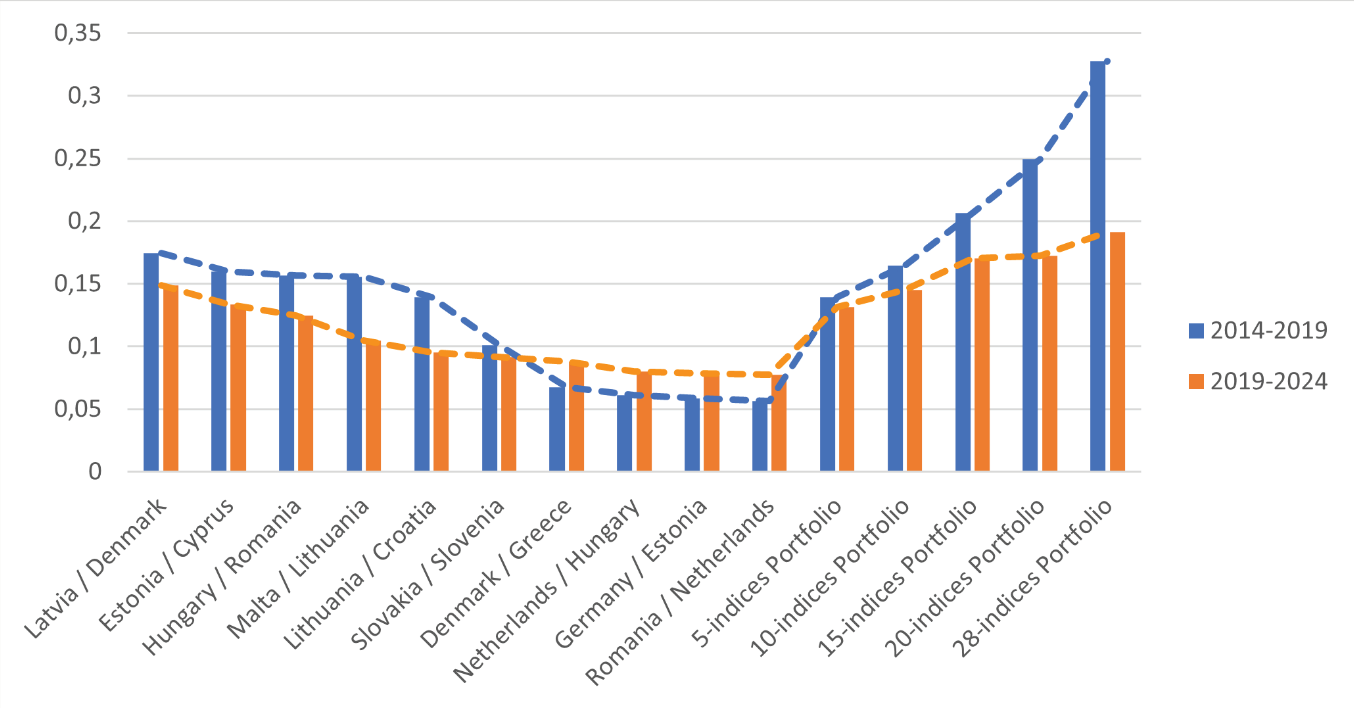
We conducted a comparative analysis between the comprehensive portfolio, comprising all 28 indices, and the benchmark, MSCI Europe Index, to gain insights into broader market performance. Remarkably, the MSCI Europe Index, which exhibited a negative Sharpe ratio, was consistently outperformed by all six 28-index portfolios, as shown in Table 5. Moreover, the standard deviation of portfolios in Scenarios 1 and 2 is notably lower compared to that of the benchmark MSCI Europe Index in the first period. Interestingly, the equally weighted 28-indices portfolio demonstrated nearly identical standard deviation to the MSCI Europe Index. However, during the second period, the standard deviation of the MSCI Europe Index increased significantly, indicating higher risk compared to both the Scenario 1 and Scenario 3 portfolios. Additionally, the mean return of the MSCI Europe Index also increased compared to the first period, but not sufficiently, as the MSCI Europe Index once again performed the worst in terms of the Sharpe ratio.

Next, we compared the performance of single-index and efficient mean-variance portfolios of different sizes from Scenario 1 to demonstrate the

Table 5. 28-indices portfolio and MSCI Europe Index

	2014-2019			2019-2024		
	St. dev.	Return	SR	St. dev.	Return	SR
Scenario 1	0.010566	0.004232	0.40053	0.01723	0.003297	0.191352293
Scenario 2	0.006349	0.002079	0.32745314	0.036428	0.011294	0.310036236
Scenario 3	0.019773	0.000157	0.00794012	0.018936	0.001683	0.088878327
MSCI Europe	0.019293	-0.000157	-0.00813767	0.029959	0.001411	0.0470977

Figure 4. Comparison of the Sharpe ratio of investments at the national and international levels



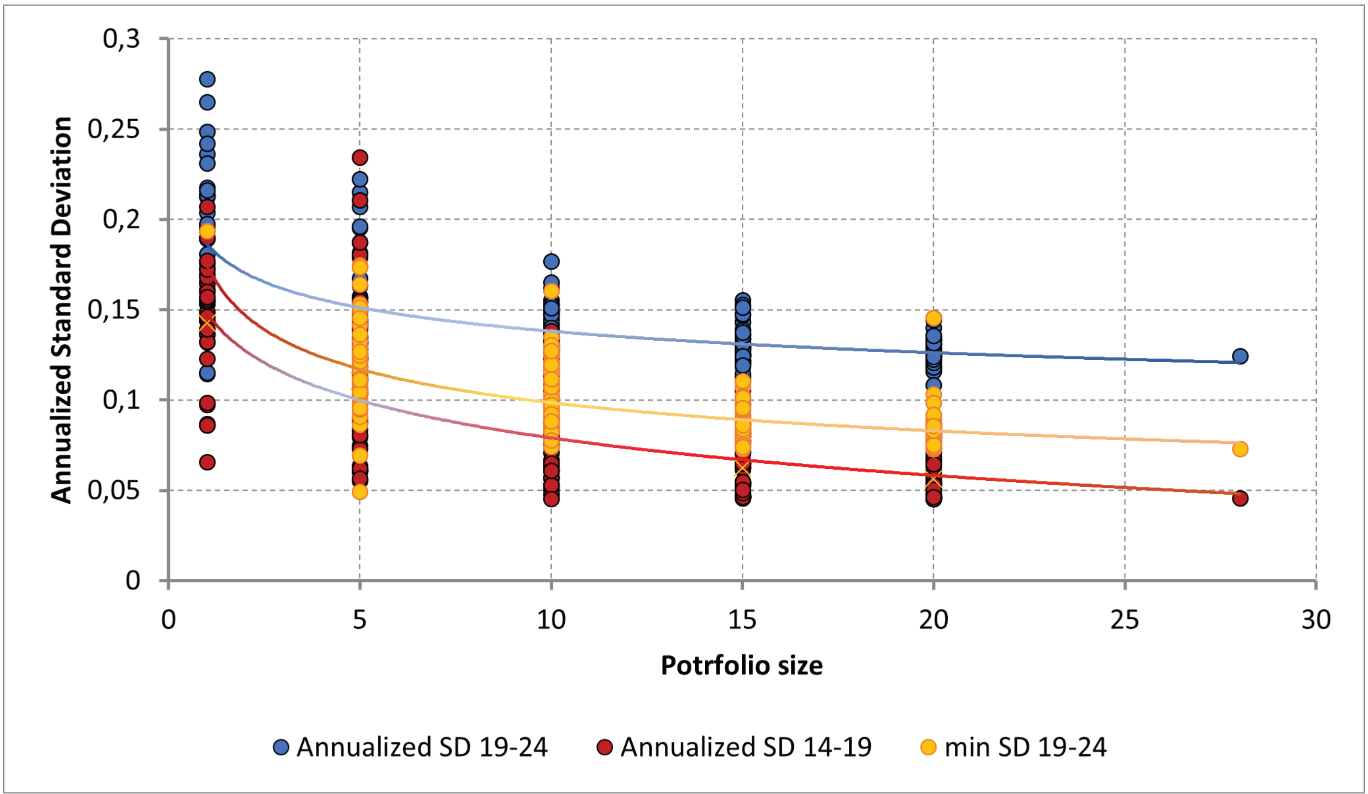
positive effect of international investments compared to the national level investments. Figure 4 includes only the top 10 individual indices ranked by the Sharpe ratio. Accordingly, the average Sharpe ratio value of a 10-indices portfolio outperforms the individual stock market indices, with the exception of Latvia. We find that investments in a 15-indices portfolio outperform all investments at the national level. Nevertheless, even the average 5-indices portfolio can be sufficient in most cases, with only 4 national indices outperforming a portfolio of this size (Latvia, Estonia, Hungary, and Malta).

Once again, we return to the fundamental concept of diversification, where a sufficiently large portfolio (even 10 or 15 indices in the case of the analysed 28 stock markets) consistently leads to improved performance. In the second period, this contribution remains evident and 15-assets portfolio outperforms the leading index (Denmark). Furthermore, in the second period, the increase in the Sharpe ratio as a measure of portfolio performance has diminished, indicating that the contribution from diversification is reduced during this period, as suggested by the entire analysis.

Our final analysis of the risk reduction opportunities in 28 European stock markets involves examining the impact of increasing portfolio size on the annualized standard deviation (SD) of portfolios in Scenario 1, where short selling is not allowed. This analysis considers two aspects: (1) maximized Sharpe ratio and (2) minimized standard deviation, from mean-variance model.

While an average stock has a standard deviation of about 35% (Brigham and Daves, 2012), the average standard deviation of the single European national stock market indices (excluding Greece as outlier)[4] was

Figure 5. Diversification effects in the European stock markets, Scenario 1 - short selling not allowed, during the periods 2014–2019 and 2019–2024



14.2% in the first observed period and 19.2% in the second period (the first dataset from the left in Figure 5). With an increase in portfolio size, formed based on the Sharpe ration maximization, the reduction in standard deviation is as follows:

- 5-indices portfolios: reduced SD to 11.1%, or for 22.3% (14.4%, or for 25.2% in the second period),
- 10-indices portfolios: reduced SD to 8.3%, or for 42% (13.7%, or for 28.7% in the second period),
- 15-indices portfolios: reduced SD to 6.2%, or for 56.3% (13%, or for 32.2% in the second period),
- 20-indices portfolios: reduced SD to 5.6%, or for 60.5% (12.7%, or for 33.7% in the second period),
- 28-indices portfolios: reduced SD to 4.6%, or for 67.9% (12.4% or for 35.3% in the second period).

Moreover, Figure 5 showcases the lower limit for the standard deviation reduction during the period 2019 – 2024, calculated based on the minimum standard deviation values by the mean-variance model. The yellow line, min SD 19-24, represents the lowest possible risk level of the analysed stock markets during the second period, with the following distinct average values displayed in Figure 5 (from left to right): 19.2%, 11.8%, 10.4%, 8.7%, 8.4%, and 7.3%. A substantial rise in risk within the same markets across these two distinct periods is evident. The annualized SD 14-19 line is still below the min SD 19-24, indicating that portfolios formed based on Sharpe ratio maximization criteria during the first period have lower risk not only than equivalent portfolios from the second period but also than portfolios that minimize standard deviation by the mean-variance model from the second period.

Diversification effects are evident in both periods, as we have demonstrated that increasing the number of indices in a portfolio significantly reduces risk. However, risk measured by standard deviation is higher, and diversification opportunities are substantially reduced in the second period (almost to the half, i.e. 67.9% vs. 35.3% for 28-asset portfolios).

6. Discussion

Our study shows positive short-term correlations among 28 European stock markets, which is consistent with the previous research of Pan, Liu, and Roth (2010). The analysis reveals that the average correlation in these markets increased by 57.8%, from 0.29 to 0.46, between the stable period of 2014–2019 and the period characterized by the COVID-19 recession and Russian aggression in Ukraine, 2019–2024, resulting in fewer diversification possibilities. Similarly, Samitas et al. (2021) found increased market correlations and reduced diversification during the COVID-19 pandemic. We found no evidence of long-term relationships between the analysed markets, as measured by Johansen's cointegration equations, in either period, in line to previous research (Nedunchezhian and Sakthia 2019). In addition, our analysis supports previous findings regarding the role of correlation analysis in explaining fluctuations in diversification benefits (Billio et al. 2017). Increased correlation between the analysed indices leads to reduced diversification, and correlation coefficients effectively explain diversification possibilities. Thus, the analysed European stock markets are positively associated in the short run but are not integrated in the long run.

As expected from Markowitz (1952) and Sharpe theory (1964, 1970), we find that larger portfolios dominate smaller portfolios. We find that portfolio performance, measured by the adopted Sharpe ratio (inverse coefficient of variation), increases significantly with portfolio size for both active investment strategies based on the mean-variance method (both without and with short selling). On the other hand, the diversification benefits are limited in the case of naive diversification, and they are exhausted with only 5 assets during the turbulent period of 2019–2024, so further increases in portfolio size do not significantly improve portfolio performance. Our contribution is the finding that increasing portfolio size based on naive diversification has a very limited effect on portfolio performance, i.e., the reward-to-variability ratio, in turbulent times. The adopted Sharpe ratio does not change significantly.

In terms of the reward-to-variability ratio, the best-performing portfolios across all sizes are the mean-variance efficient portfolios with short-selling (Scenario 2), mainly due to their higher returns rather than lower risk, followed by the mean-variance efficient portfolios without short selling (Scenario 1). Simply managed portfolios, i.e., equally weighted portfolios (Scenario 3), have the worst performance among all three investment strategies. In contrast to our findings, DeMiguel, Garlappi, and Uppal (2009) suggests that optimal diversification outperforms naive diversification only when unsystematic risks are high, while Platanakis, Sutcliffe, and Ye (2021) find only minimal differences between optimal and naive diversification.

With the increase in portfolio size of actively managed portfolios, the Sharpe ratio does increase, even in the turbulent period. However, the Sharpe ratio increases at lower rates during crises compared to stable periods, confirming reduced diversification opportunities during the period 2019-2024. This finding aligns with previous research by Chiou, Lee, and Chang (2009), who found benefits of international diversification despite the increasing integration of financial markets. You and Daigler (2010) also found different diversification benefits over time, while Meric, Ratner, and Meric (2008) suggest that diversification benefits very depending on market conditions.

The average annualized standard deviation of the single European national stock market indices has increased from 14.2% in the period 2014–2019 to 19.2% in the period 2019–2024. These levels of standard deviation can be seen as proxies for average market or systematic risk of a well-diversified portfolios in the analysed countries and observed periods, what is a practical implication of our study. If an average stock has a standard deviation of 35% (Brigham and Daves 2012), our findings based on stable period data show that, on average, 59.4% of that risk was diversifiable or unsystematic risk, while 40.6% accounted for un-diversifiable or systematic risk. These diversification benefits are somewhat better than results from financial theory, where portfolio expansion reduced an average single-stock standard deviation of 35% to about 20%, representing a 42.9% reduction in risk (Brigham and Daves 2012). However our somewhat better results might be accounted to active investment strategies based on mean-variance model and the adopted Sharpe ratio maximization. In the second period, the volatility of stock returns increased, as did the level of systematic risk. Still further risk reduction is possible through international diversification.

Increasing portfolio size by spreading investments across other markets, where portfolios are formed based on Sharpe ratio maximization criteria, enables additional reduction in portfolio standard deviation. In the first period, international 20-indices portfolios diversify 60.5% of the average systematic risk in analysed markets, whereas in the second period, they diversify only 33.7% of the systematic risk. Turbulent times, such as those from 2019–2024, significantly reduce risk diversification possibilities, almost halving them compared to the stable period of 2014–2019.

In the second period, the standard deviation could be lowered to 7.3% with a minimum standard deviation portfolio generated from all 28 indices based on the mean-variance model. However, this portfolio would require investments in six country indices with belonging weights (e.g. Exchange Traded Funds): Bulgarian SOFIX (8.3%), Denmark's OMXC20 (3.8%), Latvian OMXRGI (8.3%), Lithuanian OMXVGI (22.7%), Malta's MSE (30.1%), and Slovakia's SAX (26.8%).

7. Conclusion

Our analysis has demonstrated the existence of a diversification effect in the 27 EU and the UK stock markets, albeit less pronounced in turbulent market conditions. While we did not detect a pattern of long-term relationships, nor did the Johansen test indicate the presence of long-term relationships between the markets in both periods observed, short-term correlations showed a greater association during unstable market periods, which is directly related to the smaller diversification effect measured. Additionally, the comparative analysis of the different time periods revealed higher risk during turbulent periods, with even the lowest possible risk, measured by the standard deviation of the portfolio, in the second period being significantly higher than the risk that could be achieved under relatively stable market conditions.

The main contribution of this study lies in the design, implementation, and performance measurement of the complex investment strategy, which was found to be superior to the basic investment strategy of portfolio equal weighting, in the analysed markets and periods. In times of crises and recession, the same number of assets in a portfolio results in fewer diversification effects. Additionally, increasing the portfolio size reduces portfolio risk more slowly than during stable periods. Hereby, we contribute to the discussion on the number of assets needed to diversify risk in an international context.

Our results support the idea of international investment within the 28 European countries. Risk can be reduced below the level of national systematic risk, which is the fundamental concept of the international diversification process. We can conclude that the stock markets of the 28 European countries are not fully integrated; assets with the same risk do not offer the same expected returns, and there are significant diversification opportunities in the markets analysed. Diversification opportunities are greater when short selling is allowed and lower in turbulent times.

This study has several limitations. We utilized national stock indices as proxies for national stock portfolios, but other criteria could be employed to construct portfolios, and different investment strategies could be used to explore diversification benefits further. We measured portfolio performance using the adopted Sharpe ratio or inverse coefficient of variation; however, including the risk-free rate in the analysis and employing other measures of portfolio performance, such as the Treynor ratio and Jensen alpha, could provide additional insights. Standard deviation served as a measure of portfolio risk, but other measures like semi-variance, the mean absolute deviation, or CVaR could also be considered. We did not consider the costs associated with investing, such as transaction costs and management fees, particularly important when implementing active investment strategies. Further research could focus on addressing the limitations identified in this study.

Investors can select investment strategies and tailor their investments based on the findings of this study, aligning them with their investment goals and their level of risk aversion. Our results have implications beyond investors, portfolio managers and mutual fund managers; they are also relevant for policymakers in the EU and the UK. By measuring the potential for diversification between the analysed stock markets in two distinct periods, one of which was characterized by the Covid-19 recession and Russian aggression in Ukraine, our findings offer valuable insights into market integration and dynamics, and risk management strategies.

Endnotes

1 In the observed period from 2014 till 2019 the UK was a EU member state. The UK left the EU on 31st January 2020. We kept the UK in our sample in both analysed periods.

2 15 Developed Markets countries in Europe covered by MSCI Europe include 12 leading EU countries, the UK, Norway and Switzerland.

3 Although our data set includes 28 variables, the used software packages do not provide critical values for the trace statistics for more than 12 variables. Results indicate the rank size with an asterisk (*), which means that the null hypothesis cannot be rejected.

4 The national index of Greece was excluded from the dataset presented in first column of Figure 5 as outlier, with extreme value of the annualised standard deviation of 333%. However, it was included in all other datasets presented in Figure 5.

References

Alexeev, V. and Tapon, F. 2012. Equity portfolio diversification: how many stocks are enough? Evidence from five developed markets. FIRN Research Paper (November 2012).

Bekaert, G., Hodrick, R. J., and Zhang, X. 2009. International stock return comovements. The Journal of Finance 64 (6): 2591-2626.

Billio, M., Donadelli, M., Paradiso, A., and Riedel, M. 2017. Which market integration measure? Journal of Banking & Finance 76: 150-174.

Cheng, A. R., Jahan-Parvar, M. R., and Rothman, P. 2010. An empirical investigation of stock market behavior in the Middle East and North Africa. Journal of Empirical Finance 17 (3): 413-427.

Chiou, W. J. P., Lee, A. C., and Chang, C. C. A. 2009. Do investors still benefit from international diversification with investment constraints? The Quarterly Review of Economics and Finance 49 (2): 448-483.

Coudert, V. and Gex, M. 2006. Can risk aversion indicators anticipate financial crises? Financial Stability Review 9: 67-87.

Danielsson, J., Valenzuela, M., and Zer, I. 2018. Learning from history: Volatility and financial crises. The Review of Financial Studies 31 (7): 2774-2805.

De Keyzer, O., De Schaepmeester, M., and Inghelbrecht, K. 2014. How many stocks does an investor need to diversify within Europe? (Doctoral dissertation, University of Ghent).

DeMiguel, V., Garlappi, L., and Uppal, R. 2009. Optimal versus naive diversification: How inefficient is the 1/N portfolio strategy? The Review of Financial Studies 22 (5): 1915-1953.

European Central Bank. 2016. Financial Integration in Europe. https://www.ecb.europa.eu/pub/pdf/other/financialintegrationineurope201604.en.pdf (accessed March 8, 2020).

European Central Bank. 2020. Financial Integration and Structure in the Euro area. https://www.ecb.europa.eu/pub/fie/html/ecb.fie202003~197074785e.en.html#toc1 (accessed March 5, 2020).

Fletcher, J. and Marshall, A. 2005. An empirical examination of the benefits of international diversification. Journal of International Financial Markets, Institutions and Money 15 (5): 455-468.

Forbes, K. J. and Rigobon, R. 2002. No contagion, only interdependence: measuring stock market comovements. The Journal of Finance 57 (5): 2223-2261.

Goetzmann, W. N., Li, L., and Rouwenhorst, K. G. 2001. Long-term global market correlations. NBER Working Paper Series, Working Paper 8612 (November 2001): 1-52

Hoe, L. W., Hafizah, J. S., and Zaidi, I. 2010. An empirical comparison of different risk measures in portfolio optimization. Business and Economic Horizons 1 (1): 39-45.

Hunjra, A. I., Alawi, S. M., Colombage, S., Sahito, U., and Hanif, M. 2020. Portfolio construction by using different risk models: A comparison among diverse economic scenarios. Risks 8 (4): 126.

Johansen, S. 1988. Statistical analysis of cointegrated vectors. Journal of Economic Dynamics and Control 12: 231-254.

Kim, J. H., Lee, Y., Kim, W. C., and Fabozzi, F. J. 2021. Mean–variance optimization for asset allocation. The Journal of Portfolio Management 47 (5): 24-40.

Kizys, R. and Pierdzioch, C. 2009. Changes in the international comovement of stock returns and asymmetric macroeconomic shocks. Journal of International Financial Markets, Institutions & Money 19 (2): 289-305.

Liu, T., Hammoudeh, S., and Thompson, M. A. 2013. A momentum threshold model of stock prices and country risk ratings: Evidence from BRICS countries. Journal of International Financial Markets, Institutions and Money 27: 99-112.

Lupu, R. and Horobet, A. 2009. Are capital markets integrated? A test of information transmission within the European Union. Romanian Journal of Economic Forecasting 6 (2): 64-80.

Marimuthu, M. 2010. The co-movements of the regional stock markets and some implications on risk diversification. IUP Journal of Applied Economics 9 (2): 61-80.

Markowitz, H. 1952. Portfolio selection. The Journal of Finance 7 (1): 77-91.

Markowitz, H. 1991. Foundations of portfolio theory. The Journal of Finance 46 (2): 469-477.

Meric, I., Ratner, M., and Meric, G. 2008. Co-movements of sector index returns in the world's major stock markets in bull and bear markets: Portfolio diversification implications. International Review of Financial Analysis 17(1): 156-177.

MSCI.com. 2019. MSCI Developed Market Indexes. https://www.msci.com/developed-markets (accessed February 2020 and February 2024).

Nardo, M., Ossola, E., and Papanagiotou, E. 2022. Financial integration in the EU28 equity markets: Measures and drivers. Journal of Financial Markets 57: 100633.

Nedunchezhian, V. R. and Sakthia, P. 2019. Stock market integration with respect to selected stock exchanges of the world. ITHAS The Journal of Indian Management 9 (2): 31-40.

Pan, M. S., Liu, Y. A., and Roth, H. J. 2001. Term structure of return correlations and international diversification: evidence from European stock markets. The European Journal of Finance 7 (2): 144-164.

Platanakis, E., Sutcliffe, C., and Ye, X. 2021. Horses for courses: Mean-variance for asset allocation and 1/N for stock selection. European Journal of Operational Research 288 (1): 302-317.

Pukthuanthong, K. and Roll, R. 2009. Global market integration: An alternative measure and its application. Journal of Financial Economics 94 (2): 214-232.

Quaglia, L., Howarth, D., and Liebe, M. 2016. The political economy of European Capital Markets Union. Journal of Common Market Studies 54: 185-203.

Quinn, D. P. and Voth, H. J. 2008. A century of global equity market correlations. American Economic Review 98 (2): 535-540.

Samitas, A., Papathanasiou, S., Koutsokostas, D., and Kampouris, E. 2022. Volatility spillovers between fine wine and major global markets during COVID-19: A portfolio hedging strategy for investors. International Review of Economics & Finance 78: 629-642.

Sharpe, W. F. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk. The Journal of Finance 19 (3): 425-442.

Sharpe, W. F. 1966. Mutual fund performance. Journal of Business 39 (1): 119–138.

Sharpe, W. F. 1970. Portfolio theory and capital markets. McGraw-Hill College.

Sikalo, M., Arnaut-Berilo, A., and Delalic, A. 2023. A combined AHP-PROMETHEE approach for portfolio performance comparison. International Journal of Financial Studies 11 (1): 46.

Srivastava, A. 2007. Cointegration of Asian markets with US markets: International diversification perspectives. Global Business Review 8: 251-265.

Syriopoulos, T. 2007. International portfolio diversification to Central European stock markets. Applied Financial Economics 14 (17): 1253-1269.

Tai, C. S. 2018. International diversification during financial crises. Managerial Finance 44 (12): 1434-1445.

Taljaard, B. H. and Mare, E. 2021. Why has the equal weight portfolio underperformed and what can we do about it. Quantitative Finance 21 (11): 1855-1868.

You, L. and Daigler, R. T. 2010. Is international diversification really beneficial? Journal of Banking & Finance 34 (1): 163-173.

Zaimovic, A., Omanovic, A., and Arnaut-Berilo, A. 2021. How many stocks are sufficient for equity portfolio diversification? A review of the literature. Journal of Risk and Financial Management 14 (11): 551.