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## Article

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Journal of Risk and Financial Management

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*Suggested Citation:* Zaimovic, Azra; Omanovic, Adna; Arnaut-Berilo, Almira (2021) : How many stocks are sufficient for equity portfolio diversification? A review of the literature, Journal of Risk and Financial Management, ISSN 1911-8074, MDPI, Basel, Vol. 14, Iss. 11, pp. 1-30, <https://doi.org/10.3390/jrfm14110551>

This Version is available at:

<https://hdl.handle.net/10419/258654>

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Review

# How Many Stocks Are Sufficient for Equity Portfolio Diversification? A Review of the Literature

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**Abstract:** Using extensive and comprehensive databases to select a subset of research papers, we aim to critically analyze previous empirical studies to identify certain patterns in determining the optimal number of stocks in well-diversified portfolios in different markets, and to compare how the optimal number of stocks has changed over different periods and how it has been affected by market turmoil such as the Global Financial Crisis (GFC) and the current COVID-19 pandemic. The main methods used are bibliometric analysis and systematic literature review. Evaluating the number of assets which lead to optimal diversification is not an easy task as it is impacted by a huge number of different factors: the way systematic risk is measured, the investment universe (size, asset classes and features of the asset classes), the investor's characteristics, the change over time of the asset features, the model adopted to measure diversification (i.e., equally weighted versus optimal allocation), the frequency of the data that is being used, together with the time horizon, conditions in the market that the study refers to, etc. Our paper provides additional support for the fact that (1) a generalized optimal number of stocks that constitute a well-diversified portfolio does not exist for whichever market, period or investor. Recent studies further suggest that (2) the size of a well-diversified portfolio is larger today than in the past, (3) this number is lower in emerging markets compared to developed financial markets, (4) the higher the stock correlations with the market, the lower the number of stocks required for a well-diversified portfolio for individual investors, and (5) machine learning methods could potentially improve the investment decision process. Our results could be helpful to private and institutional investors in constructing and managing their portfolios and provide a framework for future research.

**Keywords:** portfolio size; diversification; asset allocation; stocks; systematic risk; unsystematic risk



**Citation:** Zaimovic, Azra, Adna Omanovic, and Almira Arnaut-Berilo. 2021. How Many Stocks Are Sufficient for Equity Portfolio Diversification? A Review of the Literature. *Journal of Risk and Financial Management* 14: 551. <https://doi.org/10.3390/jrfm14110551>

Academic Editor: Abderrahim Taamouti

Received: 18 October 2021

Accepted: 12 November 2021

Published: 15 November 2021

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## 1. Introduction

Volatility and uncertainty are just some of the features that characterize modern economies, so we can conclude that risk has become an integral part of business life. Investing in a large number of stocks reduces the unsystematic (idiosyncratic) risk, i.e., the risk specific to a given company, and consequently reduces the volatility of the portfolio. Studies have shown that these two components of overall risk are not completely independent dimensions (Lubatkin and Chatterjee 1994) and that idiosyncratic risk is the largest contributor to total volatility (Miralles-Marcelo et al. 2012). However, even with a very large number of securities in the portfolio, it is not possible to completely avoid overall risk. There will always remain that part of the overall risk that relates to systematic risk factors, which can only be further diversified through international diversification. Since the sources of risk are independent and the investment is diversified in a large number of securities, the exposure to any source of risk is small due to the law of large numbers.

Numerous studies have shown that the traditional rule of thumb of 8–10 stocks established by the pioneering study of Evans and Archer (1968) is indeed sufficient to achieve optimal diversification effects, but on the other hand numerous works, especially

recently, have challenged this fact by showing that 30–50 stocks are required for maximum diversification effect (Benjelloun 2010; Chong and Phillips 2013; Alexeev and Tapon 2014; Bradfield and Munro 2017; Oyenubi 2019; Kurtti 2020; Raju and Agarwalla 2021) or even 100 stocks or more (Statman 2002; Domian et al. 2007; Diyarbakırlıoğlu and Satman 2013).

This paper aims to contribute to knowledge through a bibliometric analysis and a systematic and critical literature review of the main developments in equity risk diversification over the period from 1968 to 2021 with a special focus on the last decade. A clear synthesis of the existing studies on equity risk diversification would help to answer the research question on the required number of stocks in a well-diversified portfolio. The main objective of this study is to critically analyze the existing empirical research to identify certain patterns in determining the optimal number of stocks in different markets and to compare how the optimal number of stocks has changed over different periods and how it has been affected by market turmoil such as the Global Financial Crisis (GFC) and the current COVID-19 pandemic.

The contribution of our study is twofold. Firstly, we contribute to the portfolio diversification literature by analyzing the bibliometric data and providing a detailed presentation of the current number of relevant articles, creating the bibliographic network, identifying the roots of the field, the most influential authors, etc. Secondly, the scientific contribution of this study is in a systematic literature review of the relevant papers on portfolio diversification in three directions: (1) the number of stocks required for risk diversification, (2) portfolio size across different markets, and (3) impact of crises on risk diversification.

Our systematic analysis of the research on diversification of equity risk shows that unsystematic risk has increased over the past thirty years relative to the overall variability of the stock market. In addition, correlations between stock returns have decreased and larger portfolios are needed to diversify unsystematic risk. Although there is still no consensus on the optimal number of stocks, recent studies suggest that a well-diversified portfolio is larger today, also because of lower trading costs. The same portfolio size recommendation may not provide the same level of diversification for many investors. This decision could be influenced by the frequency of the data, the risk measure used, the local market, the confidence level, the correlation structure, diversification benefits measurement metrics, the chosen investment opportunity set, the investor's preference for risk reduction, etc.

Although few studies consider emerging markets, it is shown that the number of stocks required to achieve optimal diversification benefits is much lower in emerging markets compared to developed financial markets. It is also shown that emerging markets are used as an effective hedge precisely because of their low correlations with developed markets. However, the integration of global markets has increased as a result of a greater tendency towards liberalization, which could increase the possibility of higher correlations and consequently reduce the benefits of international diversification. This could also be one of the reasons for the growing number of stocks required to build a well-diversified portfolio.

This paper is organized as follows: Section 2 explains the data and methodology. Section 3 presents three main aspects of equity risk diversification, namely the number of stocks required for risk diversification, the optimal portfolio size in different capital markets, and the impact of crises on risk diversification. Section 4 provides a discussion, followed by a conclusion.

## 2. Data and Methods

The main databases we use for this literature review are Web of Science, Science Direct and Google Scholar, comprehensive databases covering the social sciences and humanities. We selected a subset of financial research to answer the main research question: “How many stocks are sufficient to diversify a stock portfolio”? Our risk diversification analysis is twofold: (1) bibliometric analysis performed on the dataset retrieved from the Web of Science database and (2) a systematic literature review for which the dataset was extended with relevant scientific papers from the Science Direct and Google Scholar databases. BibExcel, Pajek and VOSviewer software packages were used for the bibliographic and

bibliometric analysis. Qualitative content analysis was conducted to obtain an answer to the main research question.

Our goal is to critically analyze previous empirical research on the optimal number of stocks for risk diversification in different markets and compare how this has changed over different periods. We searched the Web of Science database for the following keywords: risk, portfolio diversification, asset allocation, systematic, unsystematic, stock\*. For the purpose of bibliographic analysis, we downloaded 206 papers from the Web of Science database. We excluded papers focusing mainly on cryptocurrencies, real estate, commodities, REITs, futures and options, and similar. The Web of Science core collection database includes documents published from the year 1994 onwards. In the next step we filtered the retrieved papers according to the following main criteria: the research topic is aligned or at least partially related to the topic of our study, namely the number of stocks required for risk diversification and the impact of financial turmoil on risk diversification. Research papers that coherently present their findings and implications in terms of risk diversification, degree of market integration, and international market movements are considered. After reviewing each paper, 115 publications were selected as the final sample for bibliometric analysis, while 91 were excluded from the data pool.

To identify the characteristics of the research database on risk diversification, we review a large amount of data focusing on empirical evidence and research findings by adopting a systematic approach to our analysis. We use a systematic literature review to identify, evaluate, and interpret available research evidence retrieved from the Web of Science, Science Direct and Google Scholar databases with the goal of answering research questions about portfolio sizing required for risk diversification in equity portfolios. In addition to 115 articles already selected from the Web of Science database, we downloaded another 117 articles from Science Direct and Google Scholar. Science Direct database was searched by the previously mentioned keywords, while Google Scholar database was searched according to keywords how many stocks (securities), (optimal) number of stocks, how much diversification and (optimal) portfolio size. Through individual analysis of collected documents, we selected another 36 documents relevant to our research topic. The remaining 83 documents were excluded.

The characteristics of our final sample for the systematic literature review are presented in Figure 1. After reviewing 324 documents, our final dataset consists of 150 documents: 145 scientific journal articles, three theses and dissertations, one working paper and one report (discussion paper). Our dataset includes early research on the topic of interest dating from 1952, while 72% of our dataset was published in the last 10 years, from 2011 onwards.

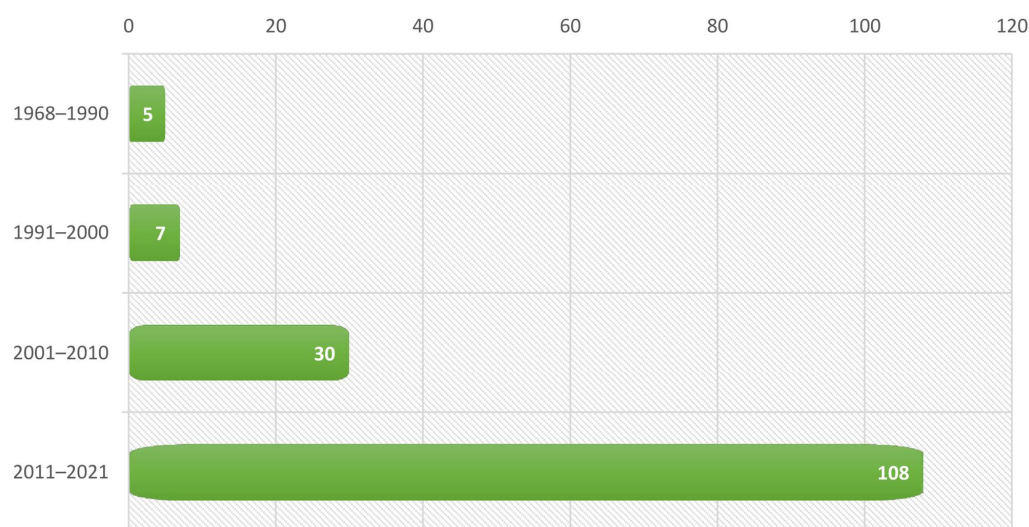


Figure 1. Number of studies for the systematic literature review—a timeline.

### 3. Results of Bibliometric Analysis

In the last decade bibliometric analysis has been used widely for analyzing content of citations within scientific material and to investigate the area of interest more closely (Kreso et al. 2020). We use bibliographic analysis to consider the research areas, keywords, citation and co-citation networks, extract the most influential papers and authors, and identify the roots of the field. Based on the co-citation analysis of our dataset shown in Figure 2. we can see that the chronological development of risk and return theories starts in 1952 with the formulation of the Modern Portfolio Theory by Markowitz (1952). In the specific research area of risk diversification the most important authors besides Markowitz (1952) are Statman (1987), Evans and Archer (1968) and Campbell et al. (2001). We note that the first relevant research focusing on the portfolio size was published by Evans and Archer (1968).

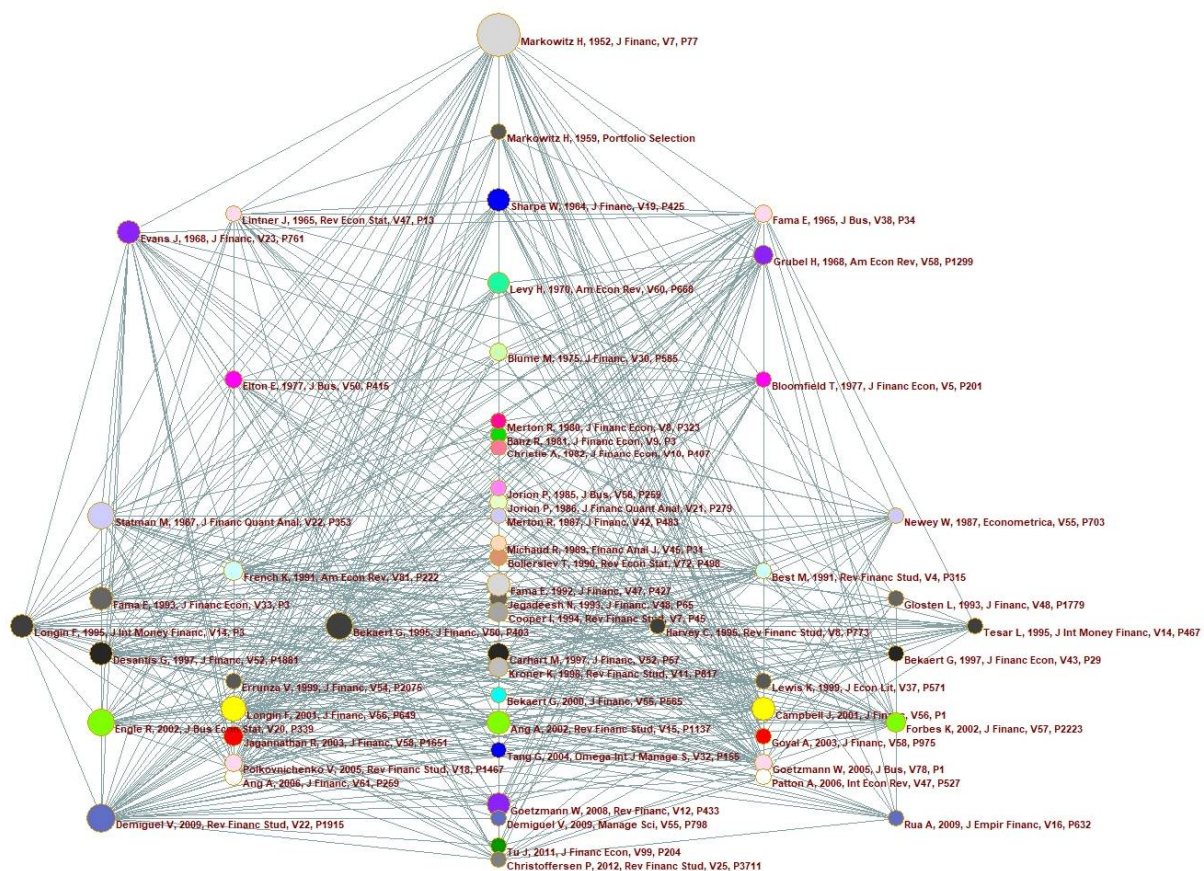
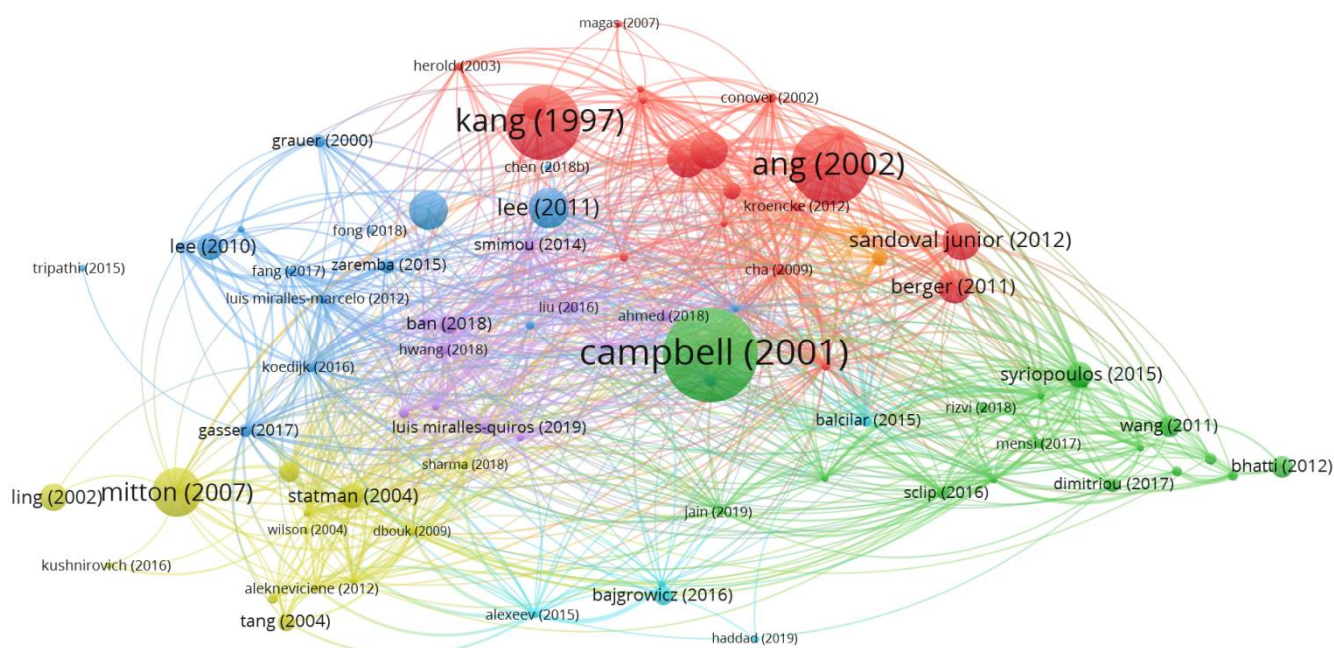


Figure 2. Co-citation analysis—chronological overview.

The authors’ citation network and citation frequency can be found in Figure 3. Nodes or items are objects of interest, i.e., in our image, nodes represent researchers. A link or a connection between any pair of items is a relationship between two items. The strength of each link is a positive numerical value and represents the strength of the bibliographic linkage. VOSviewer does not display the strength of the link. The size of a node indicates the importance of the link; the larger the node, the more significant the work. Different colors represent different clusters. Based on the bibliographic linkage analysis, we find that the most influential authors from 1994 are Campbell et al. (2001) with 912 citations, Ang and Bekaert (2002) with 630 citations, and Kang and Stulz (1997) with 566 citations.



**Figure 3.** Most influential authors organized in clusters.

Furthermore, our bibliographic linkage and co-authorship analysis shows that most cited documents come from the U.S., followed by South Korea, England, France, and Australia. The most cited authors are from the U.S., South Korea and England. The co-occurrence analysis of keywords shows that the keywords with highest occurrence are diversification, asset allocation, systematic risk and portfolio diversification.

The most cited journals are Review of Financial Studies with 1035 citations of three articles, Journal of Finance with 912 citations of one article and Journal of Financial Economics with 895 citations of 5 articles, followed by Journal of Portfolio Management with 155 citations, and Academy of Management Journal with 149 citations.

#### 4. Risk Diversification Thematic Review

##### 4.1. Measuring Risk Diversification

In recent years the academic world has witnessed a surge in interest in the concept of optimal portfolio diversification. Portfolio risk consists of systematic risk and unsystematic risk, which can be reduced through diversification. As the number of stocks in the portfolio approaches the number of stocks in the market, total portfolio risk approaches the market risk, which ultimately represents the systematic risk. Optimal portfolio diversification could be achieved up to the point where all unsystematic risk has been eliminated (Alexeev and Tapon 2012), i.e., where the overall portfolio risk is equal to the systematic risk. There are different approaches of measuring portfolio risk along with their own advantages and disadvantages. There has been some disagreement with regard to the optimal risk measure. The majority of the studies have been using standard deviation as a widely accepted risk measure. Standard deviation has been widely addressed in the earlier studies (Evans and Archer 1968; Solnik 1974; Statman 1987; Beck et al. 1996) but continued to gain much attention in recent studies too (Brands and Gallagher 2005; Benjelloun 2010). One of the major drawbacks to adopting standard deviation as a risk measure is the fact that it could often result in misleading and inaccurate conclusions.

A well-known criticism of standard deviation is the fact that it could result in incorrect estimates of the likelihood of extreme events if the returns are not normally distributed (Wander and D'Vari 2003). It is extremely sensitive to outliers and extreme values. Further, standard deviation equally treats positive and negative deviations from the average return. On the other side, much work on the potential of expected shortfall (ES) together with a terminal wealth standard deviation (TWS) (O'Neal 1997; Brands and Gallagher 2005;

Benjelloun 2010) as an extreme risk measure has been carried out to examine the impact of financial crisis on the optimal number of stocks in the portfolio (Alexeev and Tapon 2012). One of the major advantages of the downside risk measures is the fact that they consider asymmetries in the returns, especially during periods of market turmoil. Expected shortfall provides consistent downside risk measure which enables investors to take into account black swan events such as the GFC or COVID-19 pandemic. Generally, ES could be perceived as an expected value of the losses exceeding VaR (Alexeev and Tapon 2012). When considering terminal wealth standard deviation (TWSD), it is important to emphasize that this risk measure is independent of the data frequency that is being used, but at the same time it accounts for the length of the investment period (Alexeev and Tapon 2012). One of the main advantages of this risk measure is the fact that it considers the variability across portfolios for a given investment horizon (Benjelloun 2010) and it ultimately increases with the length of the investment horizon (O'Neal 1997). In addition, it exhibits similar diversification properties to time-series variance (Brands and Gallagher 2005). Further, very little is known about Value-at-Risk (VaR), the median absolute deviation for risk, mean absolute deviation (MAD) (Fielitz 1974; Alexeev and Tapon 2012), or even unsystematic risk ratio (URR) (Sharma and Vipul 2018) as a risk measure. Mean absolute deviation (MAD) uses absolute deviation instead of variance as the portfolio risk measure, whereas the URR provides the measure of diversification relative to its variance. It has been stated that the URR could serve as a statistically significant predictor of future risk-adjusted performance (Sharma and Vipul 2018). Taken as a whole, portfolio constructions created by different risk measures vary quite significantly from one risk measure to another.

#### 4.2. Number of Stocks Required for Risk Diversification

In selecting and critically analyzing the papers, we focused on three issues: (1) the number of stocks needed to reduce unsystematic risk, (2) how this number differs across capital markets, and (3) the impact of crises on the optimal number of stocks in the portfolio. To answer research questions about the minimum number of stocks in a well-diversified portfolio, we conducted a chronological review of 37 studies on this problem, which are presented in Table 1 for the period from 1968 to 2021. In addition to the chronological overview, the research focus of each study is also provided, as well as the period observed, the market they referred to, the methods they used during the research, the main results of the work, and finally the number of securities they consider necessary to minimize the unsystematic risk.

Most of the studies dealing with the necessary number of stocks to diversify the unsystematic risk were mainly conducted in the U.S. market (Evans and Archer 1968; Fielitz 1974; Statman 1987; Beck et al. 1996; O'Neal 1997; Barber and Odean 2000; Statman 2002; Domian et al. 2007; Benjelloun 2010; Diyarbakırlıoğlu and Satman 2013; Alexeev and Tapon 2014; Zhou 2014; Oyenubi 2019; Kurtti 2020), while few have attempted to investigate this issue in other (underdeveloped) markets (Gupta and Khoon 2001; Brands and Gallagher 2005; Irala and Patil 2007; Alekneviene et al. 2012; Stotz and Lu 2014; Ahuja 2015; Bradfield and Munro 2017; Murthy 2018; Raju and Agarwalla 2021). Based on the results, most studies in the past have used the variance or standard deviation of returns as a metric to assess risk reduction (Evans and Archer 1968; Solnik 1974; Statman 1987; Beck et al. 1996), and this has continued to be the authors' first choice in recent years (Brands and Gallagher 2005; Benjelloun 2010). On the other hand, several studies have also used terminal wealth standard deviation (TMSD) in their analysis (O'Neal 1997; Brands and Gallagher 2005; Benjelloun 2010), but also mean absolute deviation (MAD) (Fielitz 1974; Alexeev and Tapon 2012) or even unsystematic risk ratio (URR) (Sharma and Vipul 2018).

**Table 1.** Chronological overview of articles about the needed number of stocks for risk diversification.

Author(s) and Year	Research Focus	Market(s) and the Observed Period	Method(s)	Research Findings	Number of Stocks or Other Information
Evans and Archer (1968)	To study the rate at which return fluctuations decrease for randomly selected portfolios as a function of the number of securities in the portfolio.	U.S. 1958–1967	Equally Weighted Portfolio, Standard Deviation	The results also cast doubt on whether it is economically justified to increase portfolio size beyond 10 or more securities and suggest that both analysts and private investors need to incorporate some form of marginal analysis into their portfolio selection model.	8–10 stocks
Fielitz (1974)	Analyze how much to invest in each security to ensure that the return on the investment is not significantly affected by commission charges.	U.S. 1964–1968	Mean Absolute Deviation (MAD), Equally Weighted Portfolio	Direct investment in a randomly diversified portfolio of common stocks is preferable because the return on the random stock portfolio is, on average, higher than that achievable with mutual funds.	8 stocks
Solnik (1974)	To show that substantial risk reduction benefits can be achieved by portfolio diversification into foreign securities as well as domestic common stocks.	U.S., UK, Germany, France, Switzerland, Italy, Belgium and Netherland 1966–1971	Standard Deviation	Foreign capital markets differ significantly from the U.S. market. Because European investors often find that their domestic markets do not offer the variety of investment opportunities that Americans enjoy, international diversification is relatively more attractive to them.	10–15 stocks
Statman (1987)	To show that no fewer than 30 stocks are required for a well-diversified portfolio and to compare this result with the levels of diversification observed in studies of individual investors' portfolios.	U.S. 1979–1984	Standard Deviation	The benefits of diversification for stock portfolios are exhausted when the number of stocks reaches 10 or 15.	30 for borrowing investors and 40 for the lending investors
Beck et al. (1996)	To investigate the development of alternative methods that reduce the impact of repeated replications on test results.	U.S. 1982–1991	Variance, Correlations, Kruskal-Wallis test, Chi-square test	Researchers studying the issue of portfolio size and portfolio variance may be misled by replication-sensitive tests.	14–20 securities
O'Neal (1997)	To examine the impact of holding various numbers of mutual funds on the expected variability of investors' terminal wealth.	U.S. 1976–1994	Standard Deviation, Semi-variance, Terminal Wealth Standard Deviation	Two out of three downside risk measures are also substantially reduced by including multiple funds in a portfolio.	16–18 FoF
Gupta and Khoon (2001)	To investigate the size of a well-diversified portfolio in Malaysia and determine the size of the diversified portfolio for each of the lending and borrowing investors.	Malaysia 1988–1997	Standard Deviation, T-test	A portfolio of 30 securities results in a well-diversified portfolio for borrowing investors, and one of 50 securities for lending investors.	27 securities



Table 1. Cont.

Author(s) and Year	Research Focus	Market(s) and the Observed Period	Method(s)	Research Findings	Number of Stocks or Other Information
Barber and Odean (2000)	To analyze the performance of a randomly selected sample of 166 investment clubs.	U.S. 1991–1997	CAPM, Jensen’s Alpha, Fama–French Three-Factor Model	The average club invested in high beta common stocks, small-cap growth stocks, and turned over 65% of its portfolio annually; 60% of clubs underperformed the index.	7–8 stocks
Statman (2002)	To analyze the optimal number of stocks needed to achieve maximum diversification effects and compare the benefits and costs of diversification using mean-variance and behavioral portfolio theory.	U.S. 1926–2001	Mean-variance Portfolio Theory, Behavioral Portfolio Theory	The behavior of investors is better described with behavioral portfolio theory; the benefits and costs of diversification under the rules of mean-variance portfolio theory are different from those under the rules of behavioral portfolio theory.	More than 120 stocks
Tang (2004)	To analytically examine the efficiency of naive diversification from an educational point of view.	International 1991–2002	Variance	Given an infinite population of stocks, a portfolio size of 20 is required to eliminate 95% of the diversifiable risk on average; adding 80 stocks is required to eliminate an additional 4% of the diversifiable risk on average.	20 stocks
Statman (2004)	To investigate whether the number of stocks required to reduce unsystematic risk has changed over time.	U.S. 1926–2001	Standard Deviation, Mean-variance Portfolio Theory, Behavioral Portfolio Theory	The diversification puzzle can be solved within the framework of behavioral portfolio theory.	More than 300 stocks
Brands and Gallagher (2005)	Attention to FoF portfolio configuration for Australian investors, examining FoF performance and risk characteristics within traditional asset classes.	Australia 1989–1999	Standard Deviation, Terminal Wealth Standard Deviation, Sharpe Ratio, Skewness, Kurtosis	As the number of funds in an FoF portfolio increases, performance improves in a mean-variance setting; adding funds to the FoF structure leads to deterioration in FoF portfolio skewness and kurtosis.	6 FoF
Shawky and Smith (2005)	Investigate the relationship between the risk-adjusted return and the number of stocks.	U.S. 1992–2000	Correlation, Ordinary Least Squares Regression (OLS)	Changes in the number of stocks are closely related to the number of new investments and redemptions, but not to changes in fund size due to market returns.	40–120 stocks
Domian et al. (2007)	To compare results of random diversification with portfolios diversified by industry group.	U.S. 1985–2004	Shortfall Risk, Ending Wealth, F-test, Industry Diversification	For small portfolios, a small reduction in risk can be achieved by diversifying across industries, but a larger reduction is achieved by simply increasing the number of stocks.	More than 100 stocks
Irala and Patil (2007)	To analyze the optimal number of stocks required to achieve maximum diversification effect in the Indian market.	India 1999–2005	Standard Deviation	A very high degree of diversification is possible in India; a portfolio size of 10–15 stocks is considered appropriate as the risk reduction is marginal thereafter.	10–15 stocks

Table 1. Cont.

Author(s) and Year	Research Focus	Market(s) and the Observed Period	Method(s)	Research Findings	Number of Stocks or Other Information
<a href="#">Dbouk and Kryzanowski (2009)</a>	Evaluate diversification benefits and optimal bond portfolio sizes (PS) for investment opportunity (IO) sets differentiated by issuer type, credit ratings, and term-to-maturity.	U.S. 1985–1997	Correlations, Skewness, Kurtosis	Minimum PSs vary not only by issuer type, term-to-maturity, and bond rating but also by the metric used to measure the marginal benefits of further diversification.	25–40 bonds
<a href="#">Kryzanowski and Singh (2010)</a>	To find out whether minimum portfolio sizes should be prescribed to achieve sufficiently well-diversified equity portfolios.	Canada 1975–2003	Correlations, Mean Derived Dispersion, Mean Realized Dispersion, Normalized Portfolio Variance, Skewness, Kurtosis	Minimum sizes for a fixed investment opportunity set differ both within and across categories of metrics used to measure diversification benefits.	Depends upon different factors
<a href="#">Benjelloun (2010)</a>	Examine the reduction in time series risk, as measured by the standard deviation of the time series, and cross-sectional risk, as measured by the standard deviation of terminal wealth.	U.S. 1980–2000	Equally Weighted and Market Weighted Portfolios, Standard Deviation, Terminal Wealth Standard Deviation	Regardless of how risk is measured or how a portfolio is constructed, a randomly selected portfolio of about 40 to 50 stocks can be considered well diversified.	40–50 stocks
<a href="#">Ahuja (2015)</a>	Analyze whether the theory of risk reduction through portfolio diversification applies to the Karachi Stock Exchange.	Pakistan 2007–2009	Standard Deviation	The theory of portfolio diversification applies to Karachi Stock Exchange: a 52.25% reduction in risk was achieved.	10 stocks
<a href="#">Aleksnevičienė et al. (2012)</a>	Evaluate the diversification opportunities when portfolios consist of differentially weighted stocks and compare the diversification effect of naive and differentially weighted stock portfolios.	Lithuania 2009–2010	Standard Deviation, HHI index	A greater diversification effect is obtained in naive portfolios.	22 stocks for equally-weighted portfolios and 25 stocks for differently-weighted portfolios
<a href="#">Alexeev and Tapon (2012)</a>	Estimating confidence bands around two central measures to provide portfolio size recommendations that achieve the most diversification benefits 90% of the time, rather than on average.	U.S., UK, Japan, Canada and Australia 1975–2011	Standard Deviation, Terminal Wealth Standard Deviation, MAD, ES, LMP, Skewness, Kurtosis	The correlation structures in the five markets change in times of financial market crisis, and these changes differ in times of market-wide crises and industry-specific meltdowns.	Influenced by different factors
<a href="#">Diyarbakırlıoğlu and Satman (2013)</a>	Analyze whether the MDI might prove a useful tool for practitioners seeking to improve portfolio diversification within a smaller and therefore more manageable subset of assets.	U.S. 2006–2011	Portfolio Diversification Index (PDI), Maximum Diversification Index (MDI)	The MDI can be efficiently implemented to narrow down a large set of investable assets by eliminating those issues that do not improve the diversification characteristics of the underlying portfolio pool.	90–99 stocks

Table 1. Cont.

Author(s) and Year	Research Focus	Market(s) and the Observed Period	Method(s)	Research Findings	Number of Stocks or Other Information
Chong and Phillips (2013)	Study the effect of the number of holdings in a portfolio on the properties of the portfolio.	U.S. 2003–2010	Standard Deviation, Downside Risk, Sharpe Ratio, Beta, Correlations	Massive portfolios are not necessary to achieve diversified portfolios.	31 stocks on average
Zhou (2014)	Analyze the specific relationship between portfolio size and risk reduction.	U.S. 2008–2013	Standard Deviation, Regression, T-test, F-test	There is a strong relationship between portfolio size and risk, and this relationship could be captured by a decreasing asymptotic function. The results of the analysis using modern stock data are consistent with the result of the analysis using securities data from the 1950s and 1960s.	10 stocks
Alexeev and Tapon (2014)	Determine the number of stocks in a portfolio required to minimize diversifiable risk for Canadian institutional investors using various risk measures, including those that take into account black swan events.	Canada 1975–2011	Heavy-Tailed Risk, Expected Shortfall, Time Series Standard Deviation, Terminal Wealth Standard Deviation	The recommended number of stocks is influenced by market conditions as well as the average correlations between stocks in the Canadian market.	More than 50 stocks
Stotz and Lu (2014)	To determine the optimal number of stocks that an active fund manager should hold in a portfolio of stocks in Asia and a portfolio of stocks in the domestic Chinese stock market.	China, India, Korea, Taiwan, Hong-Kong, Malaysia, Singapore, Thailand, Indonesia, Philippines 2003–2013	Standard Deviation, Risk-Adjusted Return Measure	Adding additional stocks put more downward pressure on returns than in Asia, and market risk in China was almost twice as high as in Asia.	10 (Asia) and 8 stocks (China)
Alexeev and Dungey (2015)	To analyze how the use of higher frequency data affects the recommendations for the number of shares required to reduce risk to a given level.	U.S. 2003–2011	Unconditional Correlation, Standard Deviation	Investors may not need to hold as large portfolios as lower frequency risk measures suggest, especially during financial crises. During the crisis, the correlation between the best-performing stocks increased more than that between the worst-performing stocks.	7 (10) stocks
De Keyzer and De Schaepmeester (2014)	Analysis of the impact of the GFC on the optimal number of stocks, and of whether this number differs between better-performing countries and PIIGS or between different sectors.	Europe 2000–2014	Standard Deviation	For five better-performing countries, the optimal required number of stocks in a portfolio was higher than for the PIIGS countries; the number of stocks is significantly affected by the financial crisis.	Depends on the observed period, sector, as well as on the economic development of the country itself
Kisaka et al. (2015)	Investigating the optimal portfolio size for an investor at Nairobi Securities Exchange.	Kenya 2009–2013	Mean-variance Optimization Model, Standard Deviation	Portfolio risk decreased as the number of securities in the portfolio increased, but beyond the optimal portfolio size, risk began to increase again.	18–22 stocks

**Table 1.** *Cont.*

Author(s) and Year	Research Focus	Market(s) and the Observed Period	Method(s)	Research Findings	Number of Stocks or Other Information
Bradfield and Munro (2017)	To analyze the number of stocks that should be held in concentrated markets in South Africa.	South Africa 2002–2014	Standard Deviation, 4 Different Weighting Schemes	Equally-weighted portfolios require far fewer stocks for effective risk reduction because of the concentrated stock environment in South Africa.	15–19 for equally-weighted portfolios and 33–60 for SWIX-weighting scheme
Oyenubi (2019)	To explain why the optimal number of stocks in a portfolio is hard to find, the relationship between portfolio diversification and concentration studied using a genetic algorithm.	U.S. 2005–2013	Portfolio Diversification Index (PDI), HHI index, Variance	For a given universe, there is a set of Pareto-optimal portfolios with a different number of stocks that simultaneously maximizes diversification and minimizes concentration.	30–40 stocks
Habibah et al. (2018)	Determine the number of stocks required to form a well-diversified portfolio in Pakistan, as each investor has limited funds to invest in securities.	Pakistan 2009–2015	Variance, Correlation, Kurtosis, Skewness	The data are normally distributed and the average return on most securities is positive.	20 stocks
Murthy (2018)	The study focuses on finding an optimal portfolio using Sharpe’s single index model.	India 2012–2016	Sharpe Single Index Model, Beta, Variance	Only two stocks, namely Vedanta and Tata Steel, are included in the Optimal Portfolio constructed in this study, suggesting a maximum investment of 86% in Vedanta and 14 % in Tata Steel.	14 stocks
Norsiman et al. (2019)	Two different bases are used to determine the significant number of stocks required for well-diversified portfolio risk.	Malaysia 2010–2014	Standard Deviation, Covariance, Correlation	Data frequency affects the number of stocks in a portfolio required to achieve optimal diversification.	45 stocks (daily basis) 35 stocks (weekly basis)
Alexeev et al. (2019)	Evaluate the impact of extreme market shifts on equity portfolios and analyze the difference between negative and positive responses to market jumps with implications for portfolio risk management.	U.S. 2003–2017	Beta, Regression (OLS)	The number of holdings required to stabilize portfolio sensitivity to negative jumps is higher than for positive jumps, and the asymmetry is more pronounced for more extreme events.	35 (if the asymmetry is ignored) or 54 stocks
Kurtti (2020)	To examine the factors that determine diversification effects in a real continuous time, as opposed to a thoroughly studied theoretical single period timespan.	U.S. 1973–2018	Risk Premium Ratio, Gross Compound Excess Wealth Ratio, Shannon Limit, Kelly Criterion, Sharpe Ratio, Variance	These factors are the number of stocks in the benchmark, the Sharpe ratio and variance of the benchmark, the idiosyncratic variance of an average stock, the investment proportion, and time.	20, 40, or 200 stocks for a short-term risk-neutral investor

Table 1. Cont.

Author(s) and Year	Research Focus	Market(s) and the Observed Period	Method(s)	Research Findings	Number of Stocks or Other Information
Haensly (2020)	Investigate different approaches for dividing total portfolio risk into a diversifiable and a non-diversifiable component.	U.S.2007–2016	Naive Diversification, Portfolio Risk Decomposition, OLS, Variance	Simulation analysis shows that diversifiable risk cannot be easily diversified away. Regardless of the model used, the dispersion of the cross-sectional distributions of diversifiable risk is not negligible for portfolio sizes up to and including 300 stocks.	300 stocks
Lee et al. (2020)	To investigate whether it is theoretically possible to construct fully risk-diversified portfolios, even for small numbers of not-so-wealthy individuals.	U.S., UK, Germany, France, Canada and Japan 2008–2019	Mean-variance Optimization model	Constructing fully risk-diversified portfolios requires more money when the required rate of return is lower; diversification is most expensive in the United Kingdom.	\$10,000–\$100,000
Raju and Agarwalla (2021)	To examine how many stocks make up a well-diversified portfolio of Indian stocks and to propose a practical heuristic that investors can use to evaluate the number of stocks in their portfolios.	India 2014–2020	Standard Deviation	The actual number of stocks would depend on the investor's preferences in terms of risk-reduction preferences, the desired confidence level to meet his objectives, and the weighting scheme used for portfolio construction.	40–50 stocks

One of the problems with much of the literature regarding optimal portfolio diversification are different opinions on what is considered effective diversification. [Kisaka et al. \(2015\)](#) state that investors could generally create a well-diversified portfolio with a 95.26% reduction in diversifiable risk, while [Alexeev and Dungey \(2015\)](#) emphasize that an equally weighted portfolio of 7 (10) stocks would be sufficient for an average investor who wants to diversify away 85% (90%) of the risk. On the other hand, [Tang \(2004\)](#) highlights that a portfolio of 20 stocks is required to eliminate 95% of the unsystematic risk on average, while investors could eliminate an additional 4% of the unsystematic risk with an additional 80 stocks. Moreover, [Alekneviene et al. \(2012\)](#) find that 97% of the unsystematic risk can be eliminated with 22 stocks in the portfolio when differentially weighted portfolios are created, while [Stotz and Lu \(2014\)](#) highlight that in China 67% of unsystematic risk can be eliminated with investments in only 10 stocks. For [Kryzanowski and Singh \(2010\)](#), 90% of diversifiable risk could be eliminated by investing in 20–25 stocks. Ultimately, it is revealed that the optimal number of stocks in the portfolio also depends on the investor's attitude towards risk, with more conservative investors preferring a 99% risk reduction, while more aggressive investors seeking higher returns at the cost of higher risk may be comfortable with a 90% risk reduction. As [Alexeev and Tapon \(2014\)](#) noted, when comparing the dynamics of portfolio holdings over several years, the recommended number of stocks in a well-diversified portfolio is determined by the average correlations between stocks as well as the conditions in the markets—whether they are distressed or quiescent. According to [Raju and Agarwalla \(2021\)](#), the optimal number of stocks also depends on the investor's preferences for risk reduction and target confidence level, as well as the weighting structure used in portfolio construction. These results were expected, as investors tend to behave differently depending on the situation they face. Most of the time, their behaviors are dynamic, strongly influenced by economic, cultural and social factors ([Kushnirovich 2016](#)) and not always rational. Consequently, their attitudes, preferences, beliefs, and biases are constantly changing along with economic fundamentals ([Arjoon and Bhatnagar 2017](#)). Further, optimal asset allocation together with the investment performance is also influenced by the location of an investor ([Flavin and Wickens 2006](#)). It is evident that housing assets make up a large proportion of the household portfolio and that this moderately increases as income increases ([Lu et al. 2020](#)). It is found that an individual investor's portfolio consists of stocks whose volatilities are in line with their risk aversion ([Dorn and Huberman 2010](#)). Further, [Baker et al. \(2018\)](#) emphasize that new investors hold undiversified portfolios and consequently they fail to beat more experienced investors. Unsystematic risk of the portfolio is also related to gender, where male investors tend to have higher unsystematic risk in their portfolios compared to female investors, as well as with age, where it is found that older investors tend to have more diversified portfolios compared to younger ones. [Yilmaz and Dube \(2014\)](#) have found that portfolio performance depends upon the asset class, as well as the thresholds and constraints which investors are faced with. Constraints could lead to significant risk reduction, but at the cost of smaller returns ([Grauer and Shen 2000](#)). As socially responsible investing has become significant in recent years, investors strive also to include these stocks in their portfolios. In order to maximize the social impacts of their investments, investors are confronted with a significant reduction in expected returns ([Gasser et al. 2017](#)). The number of stocks required varies widely depending on the measurement criteria used ([Chong and Phillips 2013](#)). Furthermore, [Chong and Phillips \(2013\)](#) have shown that the optimal number of stocks varies across 18 performance measures. For comparison, if we consider the year 1987 when a significant stock market crash occurred, an investor with a portfolio of 10 stocks and standard deviation as a risk measure would bear 25% of the idiosyncratic risk ([Alexeev and Tapon 2014](#)). On the other hand, with the same 10-stock portfolio and taking expected shortfall as a risk measure, this investor would be exposed to 28% of idiosyncratic risk in the event of a black swan.

The traditional “rule of thumb” that applies in the financial market and refers to the complete reduction of diversifiable risk with only 8–10 stocks in the portfolio has been presented in many studies after the pioneering work of [Evans and Archer \(1968\)](#)

(Fielitz 1974; Solnik 1974; Zhou 2014; Alexeev and Dungey 2015), but surprisingly, after researchers considered a longer time period (Domian et al. 2007; Benjelloun 2010; Alexeev and Tapon 2014; Kurtti 2020), the number of stocks necessary to reduce the diversifiable risk to the lowest possible level has increased. Moreover, Statman (1987) concluded that borrowing investors should hold at least 30 stocks to create a well-diversified stock portfolio, or at least 40 stocks if we do not consider leverage, and after updating his previous study he showed that an investor would need at least 300 stocks in his portfolio for the marginal benefit to exceed the marginal cost of diversification.

As Campbell et al. (2001) note in their study, and as has also been noted by other researchers, unsystematic risk has certainly increased over the past thirty years in the United States relative to the overall variability of the stock market, while on the other hand, correlations among stocks in the financial market have declined correspondingly. This underscores the need for larger portfolios with more stocks to minimize diversifiable risk. It has also been found that companies could decrease idiosyncratic risk by compensating CEOs with inside debts (Lee et al. 2021). As mentioned earlier, while there is still no consensus on the optimal number of stocks, recent research suggests that the size of a well-diversified portfolio is larger today, mainly due to lower trading costs, as also noted by Kryzanowski and Singh (2010). According to Alexeev and Tapon (2012), investors with a larger portfolio are more likely to underperform the benchmark after fees. Based on the results of the previous studies, it is possible to eliminate a large percentage of diversifiable risk with a small portfolio and consequently the need for larger portfolios, mostly created and held by equity funds, is not justified. Studies have shown that tail fatness (TF) is not eliminated by portfolio diversification, which may be one of the reasons why investors with diversified portfolios face high losses during market downturns (Eom et al. 2021).

It is interesting to note that the optimal number of stocks can also be affected by the frequency of the data used. Alexeev and Dungey (2015) have shown that using low-frequency data can lead to an “exaggerated number of stocks in a portfolio”. They also emphasize that this difference is exacerbated during times of financial market crises. Just for comparison, early studies based on (semi-)annual and quarterly data have shown that 8 to 16 stocks are sufficient for optimal diversification (Evans and Archer 1968; Fielitz 1974; Zhou 2014). Some have used monthly data (Statman 1987; Beck et al. 1996; Gupta and Khoon 2001; Statman 2002; Tang 2004; Brands and Gallagher 2005; Irala and Patil 2007; Dbouk and Kryzanowski 2009; Benjelloun 2010; Kryzanowski and Singh 2010; Stotz and Lu 2014; Kisaka et al. 2015; Haensly 2020; Raju and Agarwalla 2021), but also weak data (Solnik 1974; Bradfield and Munro 2017; Oyenubi 2019; Lee et al. 2020) or even daily data (Domian et al. 2007; Alekneviene et al. 2012; Alexeev and Tapon 2012; Chong and Phillips 2013; Ahuja 2015). As Alexeev and Dungey (2015) further point out, high-frequency data undeniably improves risk assessment and brings significant benefits to decision-making. They also note that when higher frequency data is considered, the number of stocks required to achieve the desired risk reduction decreases. They have shown that the difference in unsystematic risk estimated with data of different frequencies was minimal during calm periods, but quite pronounced during periods of high volatility. When lower frequency data were used, especially during periods of financial distress, the estimates of diversifiable risk were found to be exaggerated. Given that risk measures incorporating higher frequency data outperform those based on lower frequency data, we can conclude that, especially during a financial crisis, it is not necessary to hold large portfolios as suggested by the lower frequency risk measures. It is also evident that price movements of financial instruments are influenced by fundamental factors such as interest rates, economic growth, currencies, etc. If investors could identify these factors, then portfolio construction based on them could provide diversification benefits (Koedijk et al. 2016). Far from diversification with equities, it is also evident that corporate bonds offer significant risk reduction, especially during periods of financial turmoil. These benefits are even more significant when international diversification is taken into account (Liu 2016). Studies have shown that corporate bonds could provide significant diversification and hedging benefits

(Wu and Liang 2011). It is also evident that correlations between U.S. stocks and bonds have experienced dramatic decrease recently (Dopfel 2003). Further, as socially responsible investment has become more significant in recent years, investors are required to contribute with their investment decisions and to take into account social, environmental, as well as ethical dimensions of the securities they invest in. Studies have shown that investors could benefit by investing in the companies which pay close attention to SDG (Sustainable Development Goals) (Azmi et al. 2019; Miralles-Quirós et al. 2019). At the same time, they could also achieve diversification effects through an inclusion of LPE (Listed private equity) in their portfolio which consists of bonds and stocks (Aigner et al. 2012).

Aboura and Chevallier (2017) have shown that, by constructing an aggregate stock index composed of the most influential stocks in the S&P 500, investors can reduce the associated transaction costs while having a sufficient number of stocks to diversify. Studies also emphasize the importance of portfolio diversification and hedging strategies not only for individual investors but also for mutual fund managers to avoid international financial contagion (Fong et al. 2018). It is interesting to note that funds with less liquid stocks in their portfolio tend to be more diversified. They proved to be bigger and cheaper, and they also trade more (Pástor et al. 2020). This is another breakthrough in the field of active portfolio management. When considering socially responsible investment funds, it is found that screening intensity, as an important part of an investment strategy, has no effect on idiosyncratic risk (Lee et al. 2010). An interesting thing to point out is the fact that mutual-fund managers tend to rebalance their portfolios during periods of political uncertainty pointing to companies with higher financial reporting quality (Chen et al. 2018).

#### 4.3. Optimal Portfolio Size across Different Capital Markets

Most previous studies on diversification effects and portfolio size have focused primarily on developed markets, and relatively few studies have considered emerging markets (Gupta and Khoon 2001; Brands and Gallagher 2005; Irala and Patil 2007; Kryzanowski and Singh 2010; Aleknevičienė et al. 2012; Stotz and Lu 2014; Ahuja 2015; Tripathi and Bhandari 2015; Bradfield and Munro 2017; Fang et al. 2017; Ahmed et al. 2018; Habibah et al. 2018; Norsiman et al. 2019; Raju and Agarwalla 2021). It is obvious that there are a whole range of factors that distinguish emerging from developed markets, such as size, liquidity or regulation (Kiyamaz and Simsek 2017). With the development of globalization and the integration of global stock indices, the importance of emerging markets as a research area is steadily increasing. Researchers face several obstacles related to these markets, starting from political and economic instability, low diversification opportunities, and higher unemployment rates. All these obstacles affect the normal functioning of capital markets and make it more difficult to understand them. However, researchers need to overcome these obstacles to understand all the forces behind stock returns in emerging markets.

From the results of previous studies presented in Table 1, we can conclude that the number of stocks required to achieve optimal diversification benefits is much smaller in emerging markets compared to developed financial markets (Gupta and Khoon 2001; Irala and Patil 2007; Stotz and Lu 2014; Ahuja 2015; Kisaka et al. 2015; Bradfield and Munro 2017; Habibah et al. 2018). When stock markets are as large as the U.S. financial market, one of the problems investors face is selecting appropriate stocks for the portfolio. On the other hand, it is much easier for investors in emerging markets to achieve an optimal level of diversification and perform in line with the market index.

It is interesting to note that international investors consider emerging markets as an effective hedge precisely because of their low correlations with developed markets (Bai et al. 2021). Moreover, the return volatility of emerging markets has proved to be much higher. In addition, stock returns in these markets deviate significantly from the normal distribution (Bekaert et al. 1998). Bekaert et al. (1998) further argue that market-to-book ratios and liquidity, among other factors, can lead to return reversals following price declines. Greater market openness could also lead to greater overreaction, suggesting that international



investors could increase the volatility of stock returns in emerging markets. It turns out that large price declines are more common in emerging markets and that downside risks are significantly greater compared to developed markets.

When comparing five developed equity markets to trace the dynamics of diversification benefits in these markets, [Alexeev and Tapon \(2012\)](#) pointed out that portfolios that seek to diversify extreme losses are larger than those that use standard deviation as a measure of risk. As indicated by the research findings, the number of stocks that make up a well-diversified portfolio is larger in developed financial markets than in emerging markets, regardless of the risk measure used in the analysis. On the other hand, [Basu and Huang-Jones \(2015\)](#) argue that investors' attempt to invest in diversified emerging market equity funds to earn extra return is likely to prove ineffective. It appears that equity funds that focus on single emerging markets perform better in terms of diversification benefits than equity funds that diversify across numerous emerging markets.

Studies have shown that there are differences in the optimal number of stocks even between European countries. [De Keyzer and De Schaepmeester \(2014\)](#) concluded that investors need 14 stocks for PIIGS countries (Portugal, Italy, Ireland, Greece, and Spain), while this number was slightly higher for better performing countries (Denmark, France, Germany, Sweden, and United Kingdom) with 16 stocks. As mentioned earlier, stocks with a higher correlation tend to move in the same direction, which reduces diversification opportunities. It also showed that the average standard deviation is higher when comparing PIIGS countries with better-performing countries, which can be explained by the higher debt, unstable politics with high levels of corruption, or higher unemployment rates in these countries. In addition, it has been shown that the stock returns of a firm are more related to the returns of firms in its neighborhood than to those of firms far away ([Li and Zhao 2016](#)). They have also shown that the same state or industry, the same stock price and size, and the investor's local preference further strengthen the return co-movements. Looking at Islamic stock markets, both [Rizvi and Arshad \(2018\)](#) and [Haroon et al. \(2021\)](#) found that both Islamic and conventional indices follow a similar pattern over time. They further argue that the lower systematic risk of Islamic stocks could potentially provide diversification opportunities. Furthermore, [Haroon et al. \(2021\)](#) argue that the lower idiosyncratic risk of Islamic indices could potentially provide diversification benefits. In addition, [Hadhri \(2021\)](#) argues that negative changes in oil prices could cause a significant increase in Islamic stocks prices. This aggressive reaction caused by the negative oil price movements had a stronger impact compared to the positive. On the other hand, [Wilson \(2004\)](#) argues that domestic risk-sharing opportunities have led to slower growth. When investors include bonds in their portfolios, they should consider that collateral significantly reduces both systematic and unsystematic risk. Systematic risk in covered bonds has been shown to be lower than systematic risk in senior bonds ([Helberg and Lindset 2020](#)).

In emerging markets, such as the South African, investors need 33 stocks (90% reduction in diversifiable risk) or even 60 stocks (95% reduction in diversifiable risk) to achieve the desired level of diversifiable risk reduction ([Bradfield and Munro 2017](#)). On the other hand, [Lee et al. \(2020\)](#), looking at investments in the US, UK, German, French, Canadian, and Japanese markets, found that it is possible to create a well-diversified portfolio with a significantly smaller amount of investment than the average amount invested in stocks in the U.S. financial market (less than \$10,000). In analyzing the Asian financial market, [Stotz and Lu \(2014\)](#) also found that adding additional stocks in China puts more pressure on returns compared to Asia. In addition, China was found to have higher overall market risk as well as much higher correlations between stocks compared to Asia as a whole. In analyzing the integration of the Chinese stock market with the global market, [Li \(2013\)](#) argues that there is a wide range of opportunities for international portfolio diversification in China. Furthermore, [Nguyen and Elisabeta \(2016\)](#) found that the degree of financial integration of stock markets in China and Indonesia, Malaysia, Philippines, and Thailand was moderate before and after the crisis and high during the crisis. Moreover, they showed that the cross-sector investment strategy outperformed the cross-country investment strategy

when diversification benefits were considered. On the other hand, observing the Indian financial market, [Tripathi and Bhandari \(2015\)](#) argue that stocks of socially responsible companies tend to have lower relative risk although they have higher systematic risk. It is interesting to note that, during the crisis period, a portfolio consisting of stocks of socially responsible companies had significantly higher returns in the Indian stock market. On the other hand, [Pizzutilo \(2017\)](#) argues that investors could diversify away a significant portion of volatility by not restricting investment to socially responsible companies.

The question is whether these differences are due to the different methodological approaches used in the studies or whether they are the result of market trends. As mentioned earlier, previous studies have concluded that the minimum number of stocks required to create a well-diversified portfolio depends on the risk measure used, the local market, the confidence level that allows for a 90% reduction in idiosyncratic risk, the volatile correlation structure between stock returns during periods of financial turmoil, and the differences in the correlation structure during periods of financial crises and crashes that are specific to certain industries ([Alexeev and Tapon 2012](#)). In addition, research has shown that there are differences between the diversification effects of naive and differentially weighted portfolios, which are higher when they consist of a smaller number of stocks. The larger the portfolio, the smaller was the difference between diversification effects ([Alekneviene et al. 2012](#)). As [Branger et al. \(2019\)](#) note, there is a trade-off in using the 1/N strategy where losses from parameter uncertainty are minimized, but on the other hand the benefits of optimizing portfolio weights are sacrificed. When investors focus on a smaller portfolio, they can reduce management and transaction costs. Further, portfolios containing small number of stocks turned out to outperform mean-variance diversification, also having less exposure to tail risk ([Hwang et al. 2018](#)). Considering the fact that the investment process consists of two stages, asset allocation and stock selection, mean-variance turned out to be superior to naive diversification considering asset allocation, whereas naive diversification outperformed the mean-variance during the stock selection phase ([Platanakis et al. 2021](#)). Further, [Levy and Levy \(2021\)](#) have shown that constant asset allocation outperformed diversification over time. Portfolio risk is composed of variance, skewness, and kurtosis. Therefore, it is important to consider the other two components of portfolio risk in addition to variance. The traditional method of using either variance or standard deviation as the sole measure of portfolio risk is incomplete. It is shown that the skewness and kurtosis of a skewed and fat-tailed portfolio decrease as the number of risky assets in the portfolio is increased. It is also shown that skewness risk is the most difficult to diversify among the three components of portfolio risk ([Kim et al. 2018](#)). Further, studies have shown that under-diversified portfolios tend to have higher average skewness compared to diversified, which ultimately increases the possibility of high payoffs ([Mitton and Vorkink 2007](#)). Many approaches in the literature have been proposed considering asset allocation problem. All of them strive to achieve the goal of maximizing the return while minimizing the portfolio risk. The past decade has seen a renewed importance of machine learning when considering portfolio optimization. Machine learning has been in focus in recent years due to its ability to overcome all the obstacles which investors are faced with during the investment decision process. In this context, [Ban et al. \(2016\)](#) have presented a performance-based regularization (PBR), as a promising prototype for controlling uncertainty. [Duarte and De Castro \(2020\)](#) seek to address this problem by focusing on the partitional clustering algorithms. Their study calls into a question traditional methods of portfolio optimization. They emphasize the fact that wrong estimation of future returns could lead to an insufficiently diversified portfolio. A major source of uncertainty is found in the traditional optimization methods that require inverse calculation of the covariance matrix, which could potentially be vulnerable to errors. Besides partitional clustering, the Hierarchical risk parity (HRP) presented by [Jain and Jain \(2019\)](#) also strives to overcome one of the major concerns which is related with the invertibility of covariance matrix. It is crucial to note that HRP outperformed other allocation methods in minimizing the portfolio risk. Machine learning methods could significantly improve investment decision process by creating a

well-diversified portfolio with less extreme weights which is aligned with investors' profile and attitude toward risk (Warken and Hille 2018).

In analyzing the benefits of international diversification, Gilmore and McManus (2002) concluded that the Hungarian, Czech, and Polish stock markets are not integrated with the U.S. stock market, either individually or as a group. Therefore, these relatively low correlations between emerging markets and the U.S. market could be considered as appropriate indicators of the benefits of international diversification for both short-term and long-term U.S. investors. Consequently, U.S. investors could benefit from diversification into Central European equity markets. Besides U.S. investors, Chinese investors could also significantly reduce investment risk if they diversify their portfolios internationally (Tang et al. 2020). In addition, Ahmed et al. (2018) showed that investors could benefit from selecting stocks from non-integrated sectors in their portfolios. Also, the empirical results of Chiou (2008) suggest that local investors in underdeveloped countries in East Asia and Latin America might benefit more from regional diversification than from global diversification. Even though the international market has become increasingly integrated over the past two decades (Anas et al. 2020), leading to a decline in diversification benefits, investors have concluded that this finding still holds.

Studies have shown that foreign investors tend to build portfolios with a dominant holding of manufacturing stocks, stocks of large companies, companies with good accounting performance and companies with low leverage and unsystematic risk. Consequently, foreign investors' portfolios tend to be much more volatile compared to domestic investors' portfolios (Kang and Stulz 1997). When considering international diversification, it is found that liquidity risk, along with market risk, is an important component of the investment portfolio decision (Lee 2011). The authors further highlight that the U.S. market emerged as a driver of global liquidity risk. In analyzing international real estate returns, Ling and Naranjo (2002) found evidence of a strong global factor suggesting that real estate securities could potentially provide international diversification benefits. It is evident that international diversification performs better than a U.S. mixed-asset portfolio. In addition, Kroencke and Schindler (2012) found that adding international real estate to an already internationally diversified equity portfolio resulted in a significant diversification benefit. It is evident that international diversification provides an important hedging opportunity in stock markets (Topaloglou et al. 2002; Fugazza et al. 2011). Nevertheless, U.S. investors still hold significantly less foreign stocks compared to the optimal number according to the portfolio theory (Herold and Maurer 2003). Investors should also consider credit risk when investing internationally, as credit risk has been found to be one of the causes of declining international diversification benefits (Martin-Bujack et al. 2018).

The results of principal component analysis from the study of Berger et al. (2011) show a low degree of integration between frontier markets. They showed that over time, frontier markets showed no evidence of increasing levels of integration compared to developed and emerging markets, which consequently indicates international diversification advantages. In addition, Ngene et al. (2018) emphasize a low or negative correlation between the U.S. and each frontier market. Further, Sharma and Vipul (2018) emphasize that frontier and emerging markets provide a higher level of diversification possibilities for investors compared to developed markets. Studies have shown that U.S. investors could benefit by adding stocks from emerging markets to their solely domestic portfolios (Susmel 2001), as well as by adding them to a portfolio of developed market equities (Conover et al. 2002). Cha and Jithendranathan (2009) state that, in order to achieve significant diversification benefits, investors have to invest at least 20% in emerging markets. Consequently, constraining investments only to domestic stocks could result in higher portfolio risk, as well as lower portfolio returns. This is clearly evident when institutional investors, like pension funds, are taken into account (Angelidis and Tessaromatis 2010). Hadhri and Ftiti (2019) have found higher Skewness factors (SKF) in regional emerging markets compared to developed, global and U.S. markets. They have also shown that emerging markets could outperform developed ones and consequently serve as an alternative for international

investors. Besides international diversification, investors should also take into account commodities when constructing their portfolios (Batten et al. 2015). Their time-varying integration with local stock markets together with a downfall during periods of crisis further deepens the problem that investors could face.

#### 4.4. Impact of Crises on Risk Diversification

As we have seen from major financial and economic turmoil such as the Global Financial Crisis or the Covid-19 crisis that hit the global economy, all these shocks have led to huge losses, increased volatility in global financial markets, large capital outflows, and enormous pressure on most countries, especially developing countries. All these factors have further amplified both the duration and the severity of the recession itself. Although the greatest impact has been felt in the financial markets most affected by the crisis, the crisis is spreading to the rest of the world market and has implications for the whole world. When financial crises occur, global financial markets can face large losses and high volatility, ultimately leading to an extremely sharp decline in the value of market indices, but also a widening of the credit spread on corporate and government bonds.

Numerous studies examining the spillover of volatility between markets as well as the changing correlation structure between world markets and the increasing trend of the correlation coefficient during periods of high volatility have been published since 1987 (Sandoval and Franca 2012). It is crucial for investors to understand, analyze and estimate co-movements together with a global and regional risk factors between different asset classes and to incorporate them into the decision making process (Sclip et al. 2016; Babalos and Stavroyiannis 2017; Halunga and Savva 2019). Decisions based on the short run correlations could steer investors in the wrong direction which emphasizes the importance of considering the time horizon during the investment process (Babalos and Stavroyiannis 2017; Conlon et al. 2018). It is also essential to consider tail dependence as an important part of financial risk management and the investment decision process (Bhatti and Nguyen 2012). Milcheva and Zhu (2018) and Mensi et al. (2017) have found that spillover risk significantly increases during a period of GFC. Further, significant volatility and return spillovers together with asymmetric dependences are recognized between the U.S. and BRICS (Brazil, Russia, India, China, South Africa) stock markets (Syriopoulos et al. 2015), between the U.S. and major Asian markets (Rajwani and Kumar 2016) during the GFC, as well as between Chinese and markets in Japan and the Pacific (Wang et al. 2011). When comparing Europe with BRIC sectoral indices Ahmed et al. (2018) state that Europe's sectoral indices could act as a crises transmitters to BRIC sectoral indices. In addition, studies have shown a significant increase in the dependence between oil prices and Asia-Pacific stock returns after the GFC (Zhu et al. 2014). Tai (2018) has found that international diversification benefits exhibit volatile movement during periods of financial crises, but in the end, it is evident that investors should take into account average gains from international diversification over a longer time period. One of the reasons why investors tend to neglect benefits from international diversification could be due to foreign risk and political instability (Smimou 2014). Besides barriers to international investments, another reason for home bias could also be significantly higher transaction costs (Guidolin and Timmermann 2008), as well as the changing correlation structure of global markets together with a growing currency risk (Magas 2007). The interesting thing to point out is the fact that oil-rich GCC (Gulf Cooperation Council) countries turned out to be separate from global markets through a set of limitations which ultimately gives them an opportunity to act as a safe haven for investors during periods of high market volatility (Balcilar et al. 2015). In addition, Alqahtani et al. (2020) state that there are a significant diversification benefits when creating a portfolio which consists of U.S. and GCC bank stocks. Previous studies have shown that markets tend to behave similarly during periods of high volatility which consequently results in lower international diversification benefits (Conover et al. 2002; Sclip et al. 2016; Mokni and Mansouri 2017). Ang and Bekaert (2002) state that there is an increase in correlations between international equity markets during a bear market period. Horvath and Poldauf

(2012) also find that the correlation between stock returns increased over the 2008–2010 period, suggesting that the crises were a shock that affected all countries. In addition, [Batten et al. \(2017\)](#) found that the Asian stock market moved synchronously with oil prices during the post-GFC period. This is also evident from the results of [Dimitriou et al. \(2017\)](#), where it is found that the Canadian dollar and the British pound were highly influenced by the U.S. dollar during the period of the GFC. Further, creating a portfolio with various currencies could potentially provide investors with diversification benefits because they are less subject to systematic risk. In addition, it is shown that diversification benefits vary across time and frequencies when selecting Bitcoin or Islamic equity in a portfolio. It turned out that Bitcoin could provide hedging benefits for investors and consequently they could use it as a diversifier ([Mensi et al. 2020](#)). Also, when considering positive co-movements of pairwise exchange rates, [Meng and Huang \(2019\)](#) have found that they could increase the portfolio risk which could consequently result in lower diversification possibilities. On the other hand, [Bajgrowicz et al. \(2016\)](#) find that jumps in stocks are considered rare events where not all stocks are affected by a jump at the same time, suggesting that investors can still diversify jump risk. [Chen et al. \(2018\)](#) emphasize the importance of differentiating between idiosyncratic and systematic co-jumps, where idiosyncratic jumps turned out to have significant impact on portfolio weights when emerging markets are taken into account.

Looking only at the Greek market, [Dimitrios and Vasileios \(2015\)](#) have shown that there were more correlated stocks in 2007 than in 2012. Moreover, they have shown that the market turmoil had a small impact on the common fluctuation of many stocks, but on the other hand a large impact on the creation of a community of stocks that constitute a particular sector. It is interesting to note that there was a very small number of negatively correlated stocks in the Greek market during this period. These results support previous claims that markets tend to behave similarly during the crisis as they follow the “herd rule”. It is also important to note that a small number of strong investors in emerging markets have a large impact on the common fluctuations of many stock prices ([Dimitrios and Vasileios 2015](#)). Financial crises generally emphasize the role of emerging markets as return boosters, as well as risk diversifiers ([Balçilar et al. 2015](#)).

The majority of the studies have focused primarily on risk and income as the main criteria in the investment decision process neglecting many other important criteria at the same time ([Rahiminezhad Galankashi et al. 2020](#)). As [Diyarbakırlıoğlu and Satman \(2013\)](#) point out, correlations are an essential part of investment decisions as they provide important information about diversification potential. On the other side, [Lubatkin and Chatterjee \(1994\)](#) have come to the conclusion that investors should include stocks of related companies in their portfolios in order to minimize the risk, whereas unrelated companies are shown to have a high level of risk suggesting that diversification benefits could be reduced.

[Alexeev and Dungey \(2015\)](#), observing the crisis period in the U.S. financial markets, concluded that when comparing the worst and best-performing stocks, the correlation between the best-performing stocks increased more. [Zaremba \(2018\)](#) emphasizes the importance of the relationship between the country composite risk and expected returns. He has shown that an equally weighted portfolio focused on hazardous countries surpassed one focused on safe countries.

During financial crises, the number of stocks required by an average investor to achieve a 90% reduction in idiosyncratic risk, using standard deviation as a measure of risk, decreases. However, if we look at institutional investors, we find that the number of stocks required to achieve the same level of diversification is larger. [Alexeev and Tapon \(2014\)](#) in their study emphasize that when stocks have higher correlations with the market, a smaller number of stocks is required for a well-diversified portfolio. They also emphasize that, when comparing periods with larger and smaller portfolio recommendations, market volatility and correlations are lower in periods where large portfolios are recommended. Moreover, [Alexeev et al. \(2019\)](#) showed that there is a difference in recommended portfolio size during more extreme bounces, with the number of portfolio holdings during extreme

market downturns being twice as high as the number of holdings during positive market shifts. As they point out, the asymmetry was found to be more pronounced during events that occur during periods of high market volatility. It is evident from the recent studies which focus on mutual fund performance that the benefits of diversification tend to increase during high market volatility periods (such as GFC) resulting in a higher number of stock needed to create a well-diversified portfolio (Hu et al. 2014; Delpini et al. 2019). In addition, Corzo et al. (2020) emphasize the importance of common risk factor during periods of financial crisis, where it was evident that common risk factor reduces diversification possibilities when correlations among assets tend to rise.

When analyzing whether volatility during the financial crisis affected the required number of stocks in a well-diversified portfolio, De Keyzer and De Schaepmeester (2014) observed three different periods: before the crisis (2004–2006), during the crisis (2007–2009), and after the crisis (2010–2012). They showed that in the pre-financial crisis period, most diversification benefits are obtained with a portfolio of 16 to 20 stocks. During the financial crisis, the optimal number of stocks decreased to an interval of 6–9 stocks, while in the post-crisis period, a large part of the diversification benefits is achieved with a portfolio of 12–14 stocks. As also shown in previous studies, due to the recession in the crisis period, high volatility was found in the markets, which is directly associated with strong correlations between markets. Idiosyncratic risk was the biggest component of overall risk during the period of GFC (Fazil and İpek 2013).

Considering the recent market turmoil caused by the emergence and spread of the COVID-19 pandemic, Raju and Agarwalla (2021) find that the average correlations between and among stocks and with an equally weighted market portfolio soared in June 2020, indicating an extremely strong impact of the COVID-19 pandemic on financial markets. Moreover, a significant increase in the transmission effects of US, Austrian and Finnish firms was observed during COVID-19 (Rehman et al. 2021). Consequently, the presence of these peaks could lead to a significant reduction in diversification benefits. However, investors need to consider the correlations between stocks, as well as with the market portfolio. Rehman et al. (2021) showed that there is a high degree of dependence between U.S. metals and mining stocks compared to European companies where such dependence was not present. Their results suggest that U.S. metals and mining stocks do not provide optimal diversification benefits for investors during quiet times. In times of crisis, on the other hand, U.S. metals and mining stocks could offer diversification benefits, but only in combination with their European counterparts in the portfolio. Studies have shown that neglecting extreme events during the process of portfolio construction could result in the inability of fund managers to reduce the portfolio risk through diversification (Bergmann et al. 2018). Higher frequency of occurrence and extremely strong intensity of crises in recent decades have created a demand for the development of suitable methods of clustering in order to distinguish investment alternatives. A new method of clustering presented by Haddad (2019) could help investors when faced with investment decisions, especially during periods of high volatility when stocks tend to become more similar.

## 5. Discussion

Through these detailed analyzes, we highlight the distinctive features of equity risk diversification in different capital markets. Our study contributes to the literature in several ways. To date, no study has solved all the obstacles that researchers face, nor has it offered the optimal number of stocks that will be, as such, a well-established rule in the global financial market. Evaluating the number of assets leading to optimal diversification is not an easy task as it is impacted by a huge number of elements: the way systematic risk is measured; the investment universe (size, asset classes, features of the asset classes); the investor's characteristics; the change over time of asset features; the model adopted to measure diversification (i.e., equally weighted versus an optimal allocation); the frequency of the data that is being used together with the time horizon; conditions in the market that study refers to, etc. Our paper provides additional support for the fact that a generalized

optimal number of stocks that constitute a well-diversified portfolio does not exist for whatever market, period or investor. Moreover, there is not enough evidence on the complexity of this issue in emerging markets. As mentioned above, it is extremely important to understand the issue we have outlined from the perspective of emerging markets, to define the difference with developed markets and conduct a deeper analysis in order to significantly improve the performance of financial markets in emerging markets and provide greater opportunities for investors. Key problems with much of the literature regarding emerging markets are political and economic instability, low diversification opportunities, and higher unemployment rates. All of these obstacles disable normal functioning of capital markets making them more difficult to understand. Investors may need to use different methods when investing in emerging markets compared to developed ones. Without information, investors in these markets may be tempted to invest in a large number of stocks, which may be too expensive due to increased maintenance and transaction costs, or to invest in very few stocks and consequently miss out on the benefits of diversification. Future research needs to pay additional attention to analysis of the diversification benefits of emerging markets, as this topic is understudied in the existing literature.

Despite the fact that an optimal number of stocks that constitute a well-diversified portfolio does not exist for whatever market, period nor investor, our study provides compelling evidence that there was a significant increase in the optimal number of stocks that constitute a well-diversified portfolio over time. We believe that the reason for this lies in the reduction of trading costs. A number of studies have found that unsystematic risk has increased over the past 30 years in the U.S. relative to the overall variability of the stock market which underscores the need for larger portfolios in order to minimize diversifiable risk. However, the question that arises is: are massive portfolio sizes really necessary to achieve maximum diversification effects? Our study provides compelling evidence for redundancy of large portfolios. Previous studies further strengthen the fact that it is possible to eliminate a large percentage of diversifiable risk with simultaneous reduction in transaction costs.

It is also well known that researchers generally use random stock selection or equally weighted portfolios in constructing their portfolios. In practice, however, investors generally behave quite differently. There are a variety of factors that can affect their asset allocation and weighting decisions during the investment process. Consequently, each component of the portfolio with its weighting will determine the reduction in diversifiable risk. On the other hand, many optimization-based portfolios are not able to beat the traditional equally weighted portfolios due to parameter uncertainty. The past decade has seen a renewed importance in machine learning when considering portfolio optimization. Machine learning has been in focus in recent years due to its ability to overcome all the obstacles investors are faced with during the investment decision process. Traditional optimization methods suffer from a number of pitfalls such as the requirement for calculation of the inverse covariance matrix, which could potentially be vulnerable to errors. It is crucial to note that wrong estimation of future returns could result in an insufficiently diversified portfolio. This is also an important issue for future research.

Market conditions have undoubtedly changed and will continue to change over time. The occurrence of spikes or jumps in correlation structures during times of market turmoil has a huge impact on the number of stocks that make up a well-diversified portfolio. This could lead to an increase in portfolio variance and ultimately reduce the benefits of diversification for investors. Moreover, ignoring the asymmetry of returns could lead to under-diversification of the portfolio and consequently increase the vulnerability to unexpected extreme negative market changes (Alexeev et al. 2019). Hedging against these extreme events could be difficult for investors unless their portfolios are large enough to bear such risk. Future studies should target the behavior of stock returns during unpredictable periods between extreme lows and highs.

The research analyzed also shows that the same portfolio size recommendation does not provide the same level of diversification for many investors. Although based on a

chronological overview, we can identify an upward trend in the number of securities required to maximize the reduction of unsystematic risk, the results obtained depending on a wide range of different factors.

If we observe financial markets in recent years, we can see that many things have changed. Business cycles have become much shorter, new financial innovations are emerging every day, globalization has reached extreme levels, and all of this ultimately has a significant impact on overall economic development. Today, investors have many opportunities to acquire diversified portfolios at low cost, which was unattainable at the time when the first seminal study on this topic was published (Evans and Archer 1968). Idiosyncratic risk in the U.S., as well as the number of stocks in the portfolio required to minimize unsystematic risk, has increased substantially since then. Previous studies have also shown that financial markets tend to follow the same movement path during periods of high volatility. This is evidenced by an increase in correlations between stock returns during periods of market turmoil, suggesting that the crisis represents a global shock with rapidly growing spillover effects.

In considering the benefits of international diversification, investors must also consider the costs of international investment. On the one hand, international investing may well offer greater opportunities when constructing a portfolio, but problems such as diversification, security analysis, and asset allocation remain. On the other hand, investors face obstacles in international investing that they do not face in the domestic market, such as currency and political risks, restrictions on capital flows between countries, and different laws that apply to different countries.

Our study has several limitations. First, we used the Science Direct and Google Scholar databases based on their availability. Second, the thematic review of risk diversification could be partially subjective, as we analyzed the dataset based on the established keywords and objectives of our research. There is a potential bias in our methodology where the results and implications are reshaped by selective empirical evidence. In addition, the optimal number of stocks in a well-diversified portfolio depends on many factors already mentioned, such as the degree of risk aversion, the perceived definition of risk and the measure of risk, and the portfolio management technique, i.e., the weighting structure used in portfolio construction, which makes it difficult to generalize the conclusions.

Research interest in the topic of diversifying equity risk has increased following the financial and economic turmoil. This topic is a fertile field for further research, especially since the Covid-19 crisis, an exogenous shock that triggered the largest economic crisis in modern history. From the analysis of previous pandemics, we know that the consequences of a pandemic are long-term. Financial markets around the world responded with a sharp decline with the Covid-19 outbreak and a fairly rapid rebound to pre-crisis levels, resulting in a “V-shaped” movement in indices (e.g., S&P 500), as opposed to the “U-shaped” movement during the GFC. Increased volatility and potentially more integrated capital markets during the turmoil have negative implications for diversification opportunities. The impact of the Covid-19 crisis on the number of stocks in well-diversified portfolios should be further investigated. Further research is also warranted to examine whether an expansionary monetary policy with historically low interest rates in developed countries, which has boosted the economy and capital markets and, in particular, helped growth stocks, which include most technology companies, to achieve higher price multiples, has had a significant impact on the number of stocks in well-diversified portfolios.

## 6. Conclusions

This paper systematically analyses the diversification of equity risk using a dataset of 150 publications over the period 1952 to 2021. The framework used in this article to review research on the optimal number of stocks that make up a well-diversified portfolio shows the depth and complexity of the topic itself, as well as the many related connections. Based on the extensive review of the optimal portfolio diversification we can identify several directions for future research. First, after a thorough analysis of all the studies,



it can be concluded that an optimal number of stocks that constitute a well-diversified portfolio does not exist for whatever market, period nor investor. This work has proved that evaluating the number of assets which lead to optimal diversification is not an easy task as it is impacted by a huge number of different factors: the way systematic risk is measured; the investment universe (size, asset classes, features of the asset classes); the investor's characteristics; the change over time of the assets features; the model adopted to measure diversification (i.e., equally weighted versus an optimal allocation); the frequency of the data that is being used together with the time horizon; conditions in the market that the study refers to. One of the problems with much literature regarding optimal portfolio diversification is the range of opinion on what is considered effective diversification. More recent evidence highlights that the size of a well-diversified portfolio is larger today compared to the past studies, which could mainly be caused by lower transaction costs. This study further reveals that there was a significant increase in the optimal number of stocks that constitute a well-diversified portfolio after considering a longer time period. Another important finding of this study reveals that unsystematic risk has significantly increased over the last thirty years in the U.S. compared to the overall variability of the stock market, which underscores the need for larger portfolios to reduce diversifiable risk as much as possible.

As mentioned earlier, the same portfolio size recommendation may not provide the same level of diversification for many investors. This decision could be influenced by the frequency of the data, the risk measure used, the local market, the confidence level, the correlation structure, the measures of diversification benefit, the chosen investment opportunity set, the investor's preference for risk mitigation, etc.

A recent review of the literature on this topic emphasizes an increasing importance of emerging markets as a research field. Key problems with much of the literature regarding emerging markets are political and economic instability, low diversification opportunities, and higher unemployment rates. All of these obstacles hinder the normal functioning of capital markets and make them difficult to understand, and it is shown that the number of stocks required for optimal diversification is much lower in emerging markets compared to developed financial markets. The reason for this lies in the fact that investors in large financial markets (such as U.S.) struggle with selecting appropriate stocks for the portfolio. As expected, return volatility together with stock price volatility in emerging markets turned out to be much higher, which is accompanied by negative correlations with developed markets. This underlines the importance of emerging markets as risk diversifiers and return boosters in the context of optimal portfolio diversification.

Numerous studies have shown that an investor can achieve an even greater reduction in overall risk by diversifying his portfolio internationally. Macroeconomic movements in different economies are not perfectly correlated, which ultimately allows investors to further reduce systematic risk through international diversification. This is the reason why investors have become more active in foreign financial markets. However, global markets are more integrated as a result of a greater tendency towards liberalization, which could potentially increase the possibility of higher correlations and consequently reduce the benefits of international diversification. This could also be one of the reasons for the increasing trend in the number of stocks required for a well-diversified portfolio.

Considering the fact that the past decade has seen a renewed importance in machine learning methods when considering portfolio optimization, due to its ability to overcome all the obstacles investors are faced with when using traditional optimization methods, we believe that our study will be helpful for future research in solving the difficulty of optimal portfolio diversification with machine learning methods.

Numerous studies emphasize the importance of spillover effect between markets and an increasing trend in the correlation coefficients during periods of high volatility. Contrary to expectations, there is no compliant opinion on how the optimal number of stocks that constitute a well-diversified portfolio reacts to the financial turmoil. [Alexeev and Tapon \(2014\)](#) together with [De Keyzer and De Schaepmeester \(2014\)](#) suggest that individual

investors will need smaller number of stocks for a well-diversified portfolio with higher correlations with the market. On the other side, when considering institutional investors, the number of stocks required to achieve the same level of diversification was higher (Alexeev and Tapon 2014). This finding was further strengthened with the results from Hu et al. (2014) and Delpini et al. (2019), who considered mutual fund performance, and underlined the fact that the benefits of diversification tend to increase during high market volatility periods (such as GFC) resulting in a higher number of stocks needed to create a well-diversified portfolio. This could be explained by the fact that institutional investors are striving to ensure that their portfolios will be well diversified under a diversity of market conditions. Unfortunately, there is still considerable uncertainty with regard to portfolio size and diversification benefits during crisis periods. A recent review of the literature that covers the period of GFC has questioned the effectiveness of portfolio diversification during financial turmoil.

Further research is warranted to examine the impact of the Covid-19 crisis, as well as expansionary monetary policy and extremely low interest rates, on the number of stocks in well-diversified portfolios. Particular attention should be paid to the study of emerging and underdeveloped capital markets in the context of diversification benefits and opportunities.

**Author Contributions:** Conceptualization, A.Z., A.O. and A.A.-B.; methodology, A.Z., A.O. and A.A.-B.; formal analysis, A.Z., A.O. and A.A.-B.; investigation, A.Z., A.O. and A.A.-B.; resources, A.Z., A.O. and A.A.-B.; data curation, A.Z., A.O. and A.A.-B.; writing—original draft preparation, A.Z., A.O. and A.A.-B.; writing—review and editing, A.Z.; visualization, A.Z. and A.O.; supervision, A.Z. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The dataset used in this study can be available upon request.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

- Aboura, Sofiane, and Julien Chevallier. 2017. A new weighting-scheme for equity indexes. *International Review of Financial Analysis* 54: 159–75. [\[CrossRef\]](#)
- Ahmed, Awais, Rizwan Ali, Abdullsh Ejaz, and Ishfaq Ahmad. 2018. Sectoral integration and investment diversification opportunities: Evidence from Colombo Stock Exchange. *Entrepreneurship and Sustainability Issues* 5: 514–27. [\[CrossRef\]](#)
- Ahuja, Aakash. 2015. Portfolio Diversification in the Karachi Stock Exchange. *Pakistan Journal of Engineering, Technology & Science* 1: 37–44. [\[CrossRef\]](#)
- Aigner, Philipp, Georg Beyschlag, Tim Friederich, Markus Kalepky, and Rudi Zagst. 2012. Modeling and managing portfolios including listed private equity. *Computers & Operations Research* 39: 753–64. [\[CrossRef\]](#)
- Aleknevičienė, Vilija, Egle Aleknevičiūtė, and Rasa Rinkevičienė. 2012. Portfolio Size and Diversification Effect in Lithuanian Stock Exchange Market. *Engineering Economics* 23: 338–47. [\[CrossRef\]](#)
- Alexeev, Vitali, and Mardi Dungey. 2015. Equity portfolio diversification with high frequency data. *Quantitative Finance* 15: 1205–15. [\[CrossRef\]](#)
- Alexeev, Vitali, and Francis Tapon. 2012. Equity Portfolio Diversification: How Many Stocks are Enough? Evidence from Five Developed Markets. *SSRN Electronic Journal*. [\[CrossRef\]](#)
- Alexeev, Vitali, and Francis Tapon. 2014. *How Many Stocks Are Enough for Diversifying Canadian Institutional Portfolios?* Hobart: University of Tasmania.
- Alexeev, Vitali, Giovanni Urga, and Wenying Yao. 2019. Asymmetric jump beta estimation with implications for portfolio risk management. *International Review of Economics & Finance* 62: 20–40. [\[CrossRef\]](#)
- Alqahtani, Faisal, Nader Trabelsi, Nahla Samargandi, and Syed Jawad Hussain Shahzad. 2020. Tail Dependence and Risk Spillover from the US to GCC Banking Sectors. *Mathematics* 8: 2055. [\[CrossRef\]](#)
- Anas, Muhammad, Ghulam Mujtaba, Sadaf Nayyar, and Saira Ashfaq. 2020. Time-Frequency Based Dynamics of Decoupling or Integration between Islamic and Conventional Equity Markets. *Journal of Risk and Financial Management* 13: 156. [\[CrossRef\]](#)
- Ang, Andrew, and Geert Bekaert. 2002. International Asset Allocation With Regime Shifts. *The Review of Financial Studies* 15: 1137–87. [\[CrossRef\]](#)

- Angelidis, Timotheos, and Nikolaos Tassaromatis. 2010. The efficiency of Greek public pension fund portfolios. *Journal of Banking & Finance* 34: 2158–67. [[CrossRef](#)]
- Arjoon, Vaalmikki, and Chandra Shekhar Bhatnagar. 2017. Dynamic herding analysis in a frontier market. *Research in International Business and Finance* 42: 496–508. [[CrossRef](#)]
- Azmi, Wajahat, Adam Ng, Ginanjar Dewandaru, and Ruslan Nagayev. 2019. Doing well while doing good: The case of Islamic and sustainability equity investing. *Borsa Istanbul Review* 19: 207–18. [[CrossRef](#)]
- Babalos, Vassilios, and Stavros Stavroyiannis. 2017. Modelling correlation dynamics of EMU sovereign debt markets during the recent turmoil. *Research in International Business and Finance* 42: 1021–29. [[CrossRef](#)]
- Bai, Min, Yafeng Qin, and Huiping Zhang. 2021. Stock price crashes in emerging markets. *International Review of Economics & Finance* 72: 466–82. [[CrossRef](#)]
- Bajgrowicz, Pierre, Olivier Scaillet, and Adrien Treccani. 2016. Jumps in High-Frequency Data: Spurious Detections, Dynamics, and News. *Management Science* 62: 2198–217. [[CrossRef](#)]
- Baker, Kent, Adri De Ridder, and Annalien De Vries. 2018. Stockholdings of first-time and more experienced investors. *Review of Behavioral Finance* 10: 146–62. [[CrossRef](#)]
- Balçilar, Mehmet, Rıza Demirer, and Shawkat Hammoudeh. 2015. Regional and global spillovers and diversification opportunities in the GCC equity sectors. *Emerging Markets Review* 24: 160–87. [[CrossRef](#)]
- Ban, Gah-Yi, Noureddine El Karoui, and Andrew E. B. Lim. 2016. Machine Learning and Portfolio Optimization. *Management Science* 64: 1136–54. [[CrossRef](#)]
- Barber, Brad M., and Terrance Odean. 2000. Too Many Cooks Spoil the Profits: Investment Club Performance. *Financial Analysts Journal* 56: 17–25. [[CrossRef](#)]
- Basu, Anup K., and Jason Huang-Jones. 2015. The performance of diversified emerging market equity funds. *Journal of International Financial Markets, Institutions and Money* 35: 116–31. [[CrossRef](#)]
- Batten, Jonathan A., Peter G. Szilagyi, and Niklas F. Wagner. 2015. Should emerging market investors buy commodities? *Applied Economics* 47: 4228–46. [[CrossRef](#)]
- Batten, Jonathan A., Harald Kinateder, Peter G. Szilagyi, and Niklas F. Wagner. 2017. Can stock market investors hedge energy risk? Evidence from Asia. *Energy Economics* 66: 559–70. [[CrossRef](#)]
- Beck, Kristine L., Sieven B. Perfect, and Pamela P. Peterson. 1996. The Role of Alternative Methodology on the Relation Between Portfolio Size and Diversification. *The Financial Review* 31: 381–406. [[CrossRef](#)]
- Bekaert, Gert, Claude B. Erb, Campbell R. Harvey, and Tadas E. Viskanta. 1998. Distributional characteristics of emerging market returns and asset allocation. *The Journal of Portfolio Management* 24: 102–16. [[CrossRef](#)]
- Benjelloun, Hicham. 2010. Evans and Archer—Forty years later. *Investment Management and Financial Innovations* 7: 8.
- Berger, Dave, Kuntara Pukthuanthong, and J. Jimmy Yang. 2011. International diversification with frontier markets. *Journal of Financial Economics* 101: 227–42. [[CrossRef](#)]
- Bergmann, Daniel Reed, Jose Roberto Ferreira Savoia, Claudio Felisoni de Angelo, Eduardo Augusto do Rosário Contani, and Fabiana Lopes da Silva. 2018. Portfolio management with tail dependence. *Applied Economics* 50: 5510–20. [[CrossRef](#)]
- Bhatti, M. Ishaq, and Cuong C. Nguyen. 2012. Diversification evidence from international equity markets using extreme values and stochastic copulas. *Journal of International Financial Markets, Institutions and Money* 22: 622–46. [[CrossRef](#)]
- Bradfield, David, and Brian Munro. 2017. The number of stocks required for effective portfolio diversification: The South African case. *South African Journal of Accounting Research* 31: 44–59. [[CrossRef](#)]
- Brands, Simone, and David R. Gallagher. 2005. Portfolio selection, diversification and fund-of-funds: A note. *Accounting & Finance* 45: 185–97. [[CrossRef](#)]
- Branger, Nicole, Katarína Lučivjanská, and Alex Weissensteiner. 2019. Optimal granularity for portfolio choice. *Journal of Empirical Finance* 50: 125–46. [[CrossRef](#)]
- Campbell, John Y., Martin Lettau, Burton G. Malkiel, and Yexiao Xu. 2001. Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk. *The Journal of Finance* 56: 1–43. [[CrossRef](#)]
- Cha, Heung-Joo, and Thadavillil Jithendranathan. 2009. Time-varying correlations and optimal allocation in emerging market equities for the US investors. *International Journal of Finance & Economics* 14: 172–87. [[CrossRef](#)]
- Chen, Feng, Ole-Kristian Hope, Qingyuan Li, and Xin Wang. 2018. Flight to Quality in International Markets: Investors' Demand for Financial Reporting Quality during Political Uncertainty Events. *Contemporary Accounting Research* 35: 117–55. [[CrossRef](#)]
- Chen, Ke, Luiz Vitiello, Stuart Hyde, and Ser-Huang Poon. 2018. The reality of stock market jumps diversification. *Journal of International Money and Finance* 86: 171–88. [[CrossRef](#)]
- Chiou, Wan-Jiun Paul. 2008. Who benefits more from international diversification? *Journal of International Financial Markets, Institutions and Money* 18: 466–82. [[CrossRef](#)]
- Chong, James, and G. Michael Phillips. 2013. Portfolio Size Revisited. *The Journal of Wealth Management* 15: 49–60. [[CrossRef](#)]
- Conlon, Thomas, John Cotter, and Ramazan Gençay. 2018. Long-run wavelet-based correlation for financial time series. *European Journal of Operational Research* 271: 676–96. [[CrossRef](#)]
- Conover, C. Mitchell, Gerald R. Jensen, and Robert R. Johnson. 2002. Emerging Markets: When Are They Worth It? *Financial Analysts Journal* 58: 86–95. [[CrossRef](#)]

- Corzo, Teresa, Laura Lazcano, Javier Márquez, Laura Gismera, and Sara Lumbreras. 2020. A common risk factor in global credit and equity markets: An exploratory analysis of the subprime and the sovereign-debt crises. *Heliyon* 6: e03980. [\[CrossRef\]](#) [\[PubMed\]](#)
- Dbouk, Wassim, and Lawrence Kryzanowski. 2009. Diversification benefits for bond portfolios. *The European Journal of Finance* 15: 533–53. [\[CrossRef\]](#)
- De Keyzer, Olivier, and Michiel De Schaepmeester. 2014. How Many Stocks Does an Investor Need to Diversify within Europe? Master's thesis, University of Ghent, Ghent, Belgium.
- Delpini, Danilo, Stefano Battiston, Guido Caldarelli, and Massimo Riccaboni. 2019. Systemic risk from investment similarities. *PLoS ONE* 14: e0217141. [\[CrossRef\]](#) [\[PubMed\]](#)
- Dimitrios, Kydros, and Oumbailis Vasileios. 2015. A Network Analysis of the Greek Stock Market. *Procedia Economics and Finance* 33: 340–49. [\[CrossRef\]](#)
- Dimitriou, Dimitrios, Dimitris Kenourgios, and Theodore Simos. 2017. Financial crises, exchange rate linkages and uncovered interest parity: Evidence from G7 markets. *Economic Modelling* 66: 112–20. [\[CrossRef\]](#)
- Diyarbakırlıoğlu, Erkin, and Mehmet H. Satman. 2013. The Maximum Diversification Index. *Journal of Asset Management* 14: 400–9. [\[CrossRef\]](#)
- Domian, Dale L., David A. Louton, and Marie D. Racine. 2007. Diversification in Portfolios of Individual Stocks: 100 Stocks Are Not Enough. *Financial Review* 42: 557–70. [\[CrossRef\]](#)
- Dopfel, Frederick E. 2003. Asset Allocation in a Lower Stock-Bond Correlation Environment. *The Journal of Portfolio Management* 30: 25–38. [\[CrossRef\]](#)
- Dorn, Daniel, and Gur Huberman. 2010. Preferred risk habitat of individual investors. *Journal of Financial Economics* 97: 155–73. [\[CrossRef\]](#)
- Duarte, Flávio Gabriel, and Leandro Nunes De Castro. 2020. A Framework to Perform Asset Allocation Based on Partitional Clustering. *IEEE Access* 8: 110775–88. [\[CrossRef\]](#)
- Eom, Cheoljun, Taisei Kaizoji, Giacomo Livan, and Enrico Scalas. 2021. Limitations of portfolio diversification through fat tails of the return Distributions: Some empirical evidence. *The North American Journal of Economics and Finance* 56: 101358. [\[CrossRef\]](#)
- Evans, John L., and Stephen H. Archer. 1968. Diversification and the Reduction of Dispersion: An Empirical Analysis. *The Journal of Finance* 23: 761–67. [\[CrossRef\]](#)
- Fang, Kuangnan, Ji Wu, and Cuong Nguyen. 2017. The Risk-Return Trade-Off in a Liberalized Emerging Stock Market: Evidence from Vietnam. *Emerging Markets Finance and Trade* 53: 746–63. [\[CrossRef\]](#)
- Fazil, Gökgöz, and Altıntaş İpek. 2013. Does Idiosyncratic Volatility Matter in the Emerging Markets? Istanbul Stock Exchange Evidence. *Economic Research-Ekonomika Istraživanja* 26: 133–50. [\[CrossRef\]](#)
- Fielitz, Bruce D. 1974. Indirect versus Direct Diversification. *Financial Management* 3: 54–62. [\[CrossRef\]](#)
- Flavin, Thomas J., and Michael R. Wickens. 2006. Optimal International Asset Allocation with Time-Varying Risk. *Scottish Journal of Political Economy* 53: 543–64. [\[CrossRef\]](#)
- Fong, Tom Pak Wing, Angela Kin Wan Sze, and Edmund Ho Cheung Ho. 2018. Determinants of equity mutual fund flows—Evidence from the fund flow dynamics between Hong Kong and global markets. *Journal of International Financial Markets, Institutions and Money* 57: 231–47. [\[CrossRef\]](#)
- Fugazza, Carolina, Maela Giofré, and Giovanna Nicodano. 2011. International diversification and industry-related labor income risk. *International Review of Economics & Finance* 20: 764–83. [\[CrossRef\]](#)
- Gasser, Stephan M., Margarethe Rammerstorfer, and Karl Weinmayer. 2017. Markowitz revisited: Social portfolio engineering. *European Journal of Operational Research* 258: 1181–90. [\[CrossRef\]](#)
- Gilmore, Claire G., and Ginette M. McManus. 2002. International portfolio diversification: US and Central European equity markets. *Emerging Markets Review* 3: 69–83. [\[CrossRef\]](#)
- Grauer, Robert R., and Frederick C. Shen. 2000. Do constraints improve portfolio performance? *Journal of Banking & Finance* 24: 1253–74. [\[CrossRef\]](#)
- Guidolin, Massimo, and Allan Timmermann. 2008. International asset allocation under regime switching, skew, and kurtosis preferences. *The Review of Financial Studies* 21: 889–935. [\[CrossRef\]](#)
- Gupta, G. S., and Ch'ng Huck Khoo. 2001. How many securities make a diversified portfolio: KLSE stocks? *Asian Academy of Management Journal* 6: 63–79.
- Habibah, Ume, Ranjeeta Sadhwani, and Pervaiz Memon. 2018. Selecting Optimal Portfolio in Pakistan. *Sukkur IBA Journal of Economics and Finance* 2: 68–77. [\[CrossRef\]](#)
- Haddad, Michel Ferreira Cardia. 2019. Sphere-sphere intersection for investment portfolio diversification—A new data-driven cluster analysis. *MethodsX* 6: 1261–78. [\[CrossRef\]](#)
- Hadhri, Sinda. 2021. The nexus, downside risk and asset allocation between oil and Islamic stock markets: A cross-country analysis. *Energy Economics* 101: 105448. [\[CrossRef\]](#)
- Hadhri, Sinda, and Zied Ftiti. 2019. Asset allocation and investment opportunities in emerging stock markets: Evidence from return asymmetry-based analysis. *Journal of International Money and Finance* 93: 187–200. [\[CrossRef\]](#)
- Haensly, Paul J. 2020. Risk decomposition, estimation error, and naïve diversification. *The North American Journal of Economics and Finance* 52: 101146. [\[CrossRef\]](#)

- Halunga, Andreea G., and Christos S. Savva. 2019. Neglecting structural breaks when estimating and valuing dynamic correlations for asset allocation. *Econometric Reviews* 38: 660–78. [[CrossRef](#)]
- Haroon, Omair, Mohsin Ali, Abdullah Khan, Mudeer A. Khattak, and Syed Aun R. Rizvi. 2021. Financial Market Risks during the COVID-19 Pandemic. *Emerging Markets Finance and Trade* 57: 2407–14. [[CrossRef](#)]
- Helberg, Stig, and Snorre Lindset. 2020. Collateral affects return risk: Evidence from the euro bond market. *Financial Markets and Portfolio Management* 34: 99–128. [[CrossRef](#)]
- Herold, Ulf, and Raimond Maurer. 2003. Bayesian Asset Allocation and U.S. Domestic Bias. *Financial Analysts Journal* 59: 54–65. [[CrossRef](#)]
- Horvath, Roman, and Petr Poldauf. 2012. International Stock Market Comovements: What Happened during the Financial Crisis? *Global Economy Journal* 12: 1850252. [[CrossRef](#)]
- Hu, Jin-Li, Tzu-Pu Chang, and Ray Yeutien Chou. 2014. Market conditions and the effect of diversification on mutual fund performance: Should funds be more concentrative under crisis? *Journal of Productivity Analysis* 41: 141–51. [[CrossRef](#)]
- Hwang, Inchang, Simon Xu, and Francis In. 2018. Naive versus optimal diversification: Tail risk and performance. *European Journal of Operational Research* 265: 372–88. [[CrossRef](#)]
- Irala, Lokanandha Reddy, and Prakash Patil. 2007. Portfolio Size and Diversification. *SCMS Journal of Indian Management* 4: 6.
- Jain, Prayut, and Shashi Jain. 2019. Can Machine Learning-Based Portfolios Outperform Traditional Risk-Based Portfolios? The Need to Account for Covariance Misspecification. *Risks* 7: 74. [[CrossRef](#)]
- Kang, Jun-Koo, and Rene M. Stulz. 1997. Why is there a home bias? An analysis of foreign portfolio equity ownership in Japan. *Journal of Financial Economics* 46: 3–28. [[CrossRef](#)]
- Kim, Woohwan, Young Min Kim, Tae-Hwan Kim, and Seungbeom Bang. 2018. Multi-dimensional portfolio risk and its diversification: A note. *Global Finance Journal* 35: 147–56. [[CrossRef](#)]
- Kisaka, Sifunjo E., Joseph Aloise Mbithi, and Hilary Kitur. 2015. Determining the Optimal Portfolio Size on the Nairobi Securities Exchange. *Research Journal of Finance and Accounting* 6: 215.
- Kiyamaz, Halil, and Koray Simsek. 2017. The performance of US-based emerging market mutual funds. *Journal of Capital Markets Studies* 1: 58–73. [[CrossRef](#)]
- Koedijk, Kees G., Alfred M. H. Slager, and Philip A. Stork. 2016. Investing in Systematic Factor Premiums: Investing in Systematic Factor Premiums. *European Financial Management* 22: 193–234. [[CrossRef](#)]
- Kreso, Inda, Amra Kapo, and Lejla Turulja. 2020. Data mining privacy preserving: Research agenda. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery* 1: 1–29. [[CrossRef](#)]
- Kroencke, Tim A., and Felix Schindler. 2012. International diversification with securitized real estate and the veiling glare from currency risk. *Journal of International Money and Finance* 31: 1851–66. [[CrossRef](#)]
- Kryzanowski, Lawrence, and Shishir Singh. 2010. Should Minimum Portfolio Sizes Be Prescribed for Achieving Sufficiently Well-Diversified Equity Portfolios? *SSRN Electronic Journal* 7: 1–37.
- Kurtti, Markku. 2020. How Many Stocks Make a Diversified Portfolio in a Continuous-time World? Master's thesis, University of Oulu, Oulu, Finland.
- Kushnirovich, Nonna. 2016. Immigrant investors in financial markets: Modes of financial behavior. *Journal of Business Economics and Management* 17: 992–1006. [[CrossRef](#)]
- Lee, Kuan-Hui. 2011. The world price of liquidity risk. *Journal of Financial Economics* 99: 136–61. [[CrossRef](#)]
- Lee, Darren D., Jacquelyn E. Humphrey, Karen L. Benson, and Jason Y. K. Ahn. 2010. Socially responsible investment fund performance: The impact of screening intensity. *Accounting & Finance* 50: 351–70. [[CrossRef](#)]
- Lee, Yongjae, Woo Chang Kim, and Jang Ho Kim. 2020. Achieving Portfolio Diversification for Individuals with Low Financial Sustainability. *Sustainability* 12: 7073. [[CrossRef](#)]
- Lee, Cheng-Few, Chengru Hu, and Maggie Foley. 2021. Differential risk effect of inside debt, CEO compensation diversification, and firm investment. *Review of Quantitative Finance and Accounting* 56: 505–43. [[CrossRef](#)]
- Levy, Haim, and Moshe Levy. 2021. The cost of diversification over time, and a simple way to improve target-date funds. *Journal of Banking & Finance* 122: 105995. [[CrossRef](#)]
- Li, Hong. 2013. Integration versus segmentation in China's stock market: An analysis of time-varying beta risks. *Journal of International Financial Markets, Institutions and Money* 25: 88–105. [[CrossRef](#)]
- Li, Mingsheng, and Xin Zhao. 2016. Neighborhood effect on stock price comovement. *The North American Journal of Economics and Finance* 35: 1–22. [[CrossRef](#)]
- Ling, David C., and Andy Naranjo. 2002. Commercial Real Estate Return Performance: A Cross-Country Analysis. *The Journal of Real Estate Finance and Economics* 24: 119–42. [[CrossRef](#)]
- Liu, Edith X. 2016. Portfolio Diversification and International Corporate Bonds. *Journal of Financial and Quantitative Analysis* 51: 959–83. [[CrossRef](#)]
- Lu, Xiaomeng, Jiaojiao Guo, and Li Gan. 2020. International comparison of household asset allocation: Micro-evidence from cross-country comparisons. *Emerging Markets Review* 43: 100691. [[CrossRef](#)]
- Lubatkin, Michael, and Sayan Chatterjee. 1994. Extending Modern Portfolio Theory into the Domain of Corporate Diversification: Does it Apply? *Academy of Management Journal* 37: 109–36. [[CrossRef](#)]

- Magas, I. 2007. The changing benefits of global equity investing: Developed and emerging markets, 1997–2007. *Acta Oeconomica* 57: 343–62. [\[CrossRef\]](#)
- Markowitz, Harry. 1952. Portfolio Selection. *The Journal of Finance* 7: 77–91. [\[CrossRef\]](#)
- Martin-Bujack, Karin, Teresa Santamaría, and Isabel Figuerola-Ferretti. 2018. International diversification and global credit risk: A methodology for portfolio building 1. *UCJC Business and Society Review* 15: 92–136. [\[CrossRef\]](#)
- Meng, Xiangcai, and Chia-Hsing Huang. 2019. The time-frequency co-movement of Asian effective exchange rates: A wavelet approach with daily data. *The North American Journal of Economics and Finance* 48: 131–48. [\[CrossRef\]](#)
- Mensi, Walid, Shawkat Hammoudeh, Ahmet Sensoy, and Seong-Min Yoon. 2017. Analysing dynamic linkages and hedging strategies between Islamic and conventional sector equity indexes. *Applied Economics* 49: 2456–79. [\[CrossRef\]](#)
- Mensi, Walid, Mobeen Ur Rehman, Debasish Maitra, Khamis Hamed Al-Yahyaee, and Ahmet Sensoy. 2020. Does bitcoin co-move and share risk with Sukuk and world and regional Islamic stock markets? Evidence using a time-frequency approach. *Research in International Business and Finance* 53: 101230. [\[CrossRef\]](#)
- Milcheva, Stanimira, and Bing Zhu. 2018. Asset pricing, spatial linkages and contagion in real estate stocks. *Journal of Property Research* 35: 271–95. [\[CrossRef\]](#)
- Miralles-Marcelo, José Luis, María del Mar Miralles-Quirós, and José Luis Miralles-Quirós. 2012. Asset pricing with idiosyncratic risk: The Spanish case. *International Review of Economics & Finance* 21: 261–71. [\[CrossRef\]](#)
- Miralles-Quirós, José Luis, María Mar Miralles-Quirós, and José Manuel Nogueira. 2019. Diversification benefits of using exchange-traded funds in compliance to the sustainable development goals. *Business Strategy and the Environment* 28: 244–55. [\[CrossRef\]](#)
- Mitton, Todd, and Keith Vorkink. 2007. Equilibrium Underdiversification and the Preference for Skewness. *The Review of Financial Studies* 20: 1255–88. [\[CrossRef\]](#)
- Mokni, Khaled, and Faysal Mansouri. 2017. Conditional dependence between international stock markets: A long memory GARCH-copula model approach. *Journal of Multinational Financial Management* 42–43: 116–31. [\[CrossRef\]](#)
- Murthy, Jogalapuram. 2018. The construction of optimal portfolio using sharpe's single index model-an empirical study on nifty metal index. *JIMS8M: The Journal of Indian Management & Strategy* 23: 4. [\[CrossRef\]](#)
- Ngene, Geoffrey, Jordin A. Post, and Ann N. Mungai. 2018. Volatility and shock interactions and risk management implications: Evidence from the U.S. and frontier markets. *Emerging Markets Review* 37: 181–98. [\[CrossRef\]](#)
- Nguyen, Tung Dao, and Pana Elisabeta. 2016. Financial integration and diversification benefits: China and ASEAN4 countries. *Managerial Finance* 42: 496–514. [\[CrossRef\]](#)
- Norsiman, Nadia, Noor Yakob, and Carl Mcgowan. 2019. The Effect of Portfolio Diversification for the Bursa Malaysia. *Accounting and Finance Research* 8: 76. [\[CrossRef\]](#)
- O'Neal, Edward S. 1997. How Many Mutual Funds Constitute a Diversified Mutual Fund Portfolio? *Financial Analysts Journal* 53: 37–46. [\[CrossRef\]](#)
- Oyenubi, Adeola. 2019. Diversification Measures and the Optimal Number of Stocks in a Portfolio: An Information Theoretic Explanation. *Computational Economics* 54: 1443–71. [\[CrossRef\]](#)
- Pástor, Ľuboš, Robert F. Stambaugh, and Lucian A. Taylor. 2020. Fund tradeoffs. *Journal of Financial Economics* 138: 614–34. [\[CrossRef\]](#)
- Pizzutilo, Fabio. 2017. Measuring the under-diversification of socially responsible investments. *Applied Economics Letters* 24: 1005–18. [\[CrossRef\]](#)
- Platanakis, Emmanouil, Charles Sutcliffe, and Xiaoxia Ye. 2021. Horses for courses: Mean-variance for asset allocation and 1/N for stock selection. *European Journal of Operational Research* 288: 302–17. [\[CrossRef\]](#)
- Rahiminezhad Galankashi, Masoud, Farimah Mokhtab Rafiei, and Maryam Ghezalbash. 2020. Portfolio selection: A fuzzy-ANP approach. *Financial Innovation* 6: 17. [\[CrossRef\]](#)
- Raju, Rajan, and Sobhesh Kumar Agarwalla. 2021. Equity Portfolio Diversification: How Many Stocks Are Enough? Evidence from India. *SSRN Electronic Journal*. [\[CrossRef\]](#)
- Rajwani, Shegorika, and Dilip Kumar. 2016. Asymmetric Dynamic Conditional Correlation Approach to Financial Contagion: A Study of Asian Markets. *Global Business Review* 17: 1339–56. [\[CrossRef\]](#)
- Rehman, Mobeen Ur, Syed Jawad Hussain Shahzad, Nasir Ahmad, and Xuan Vinh Vo. 2021. Dependence among metals and mining companies of the US and Europe during normal and crises periods. *Resources Policy* 73: 102199. [\[CrossRef\]](#)
- Rizvi, Syed Aun R., and Shaista Arshad. 2018. Understanding time-varying systematic risks in Islamic and conventional sectoral indices. *Economic Modelling* 70: 561–70. [\[CrossRef\]](#)
- Sandoval, Leonidas, and Italo De Paula Franca. 2012. Correlation of financial markets in times of crisis. *Physica A: Statistical Mechanics and Its Applications* 391: 187–208. [\[CrossRef\]](#)
- Sclip, Alex, Alberto Dreassi, Stefano Miani, and Andrea Paltrinieri. 2016. Dynamic correlations and volatility linkages between stocks and sukuk: Evidence from international markets. *Review of Financial Economics* 31: 34–44. [\[CrossRef\]](#)
- Sharma, Prateek, and Vipul. 2018. Improving portfolio diversification: Identifying the right baskets for putting your eggs. *Managerial and Decision Economics* 39: 698–711. [\[CrossRef\]](#)
- Shawky, Hany A., and David M. Smith. 2005. Optimal Number of Stock Holdings in Mutual Fund Portfolios Based on Market Performance. *Financial Review* 40: 481–95. [\[CrossRef\]](#)
- Smimou, Kamal. 2014. International portfolio choice and political instability risk: A multi-objective approach. *European Journal of Operational Research* 234: 546–60. [\[CrossRef\]](#)

- Solnik, Bruno H. 1974. Why Not Diversify Internationally Rather Than Domestically? *Financial Analysts Journal* 30: 48–54. [[CrossRef](#)]
- Statman, Meir. 1987. How Many Stocks Make a Diversified Portfolio? *Journal of Financial and Quantitative Analysis* 22: 353–63. [[CrossRef](#)]
- Statman, Meir. 2002. *How Much Diversification Is Enough?* Working Paper. Santa Clara: Leavey School of Business, Santa Clara University. [[CrossRef](#)]
- Statman, Meir. 2004. The Diversification Puzzle. *Financial Analysts Journal* 60: 44–53. [[CrossRef](#)]
- Stotz, Andrew, and Wei Lu. 2014. Eight Stocks are Enough in China. *SSRN Electronic Journal*. [[CrossRef](#)]
- Susmel, Raul. 2001. Extreme observations and diversification in Latin American emerging equity markets. *Journal of International Money and Finance* 20: 971–86. [[CrossRef](#)]
- Syriopoulos, Theodore, Beljid Makram, and Adel Boubaker. 2015. Stock market volatility spillovers and portfolio hedging: BRICS and the financial crisis. *International Review of Financial Analysis* 39: 7–18. [[CrossRef](#)]
- Tai, Chu-Sheng. 2018. International diversification during financial crises. *Managerial Finance* 44: 1434–45. [[CrossRef](#)]
- Tang, Gordon Y. N. 2004. How efficient is naive portfolio diversification? an educational note. *Omega* 32: 155–60. [[CrossRef](#)]
- Tang, Xuan, Xing Gao, Qiuping Zhou, and Jian Ma. 2020. The BSS-FM Estimation of International Assets Allocation for China Mainland Investors. *Emerging Markets Finance and Trade* 56: 1224–36. [[CrossRef](#)]
- Topaloglou, Nikolas, Hercules Vladimirou, and Stavros A. Zenios. 2002. CVaR models with selective hedging for international asset allocation. *Journal of Banking & Finance* 26: 1535–61. [[CrossRef](#)]
- Tripathi, Vanita, and Varun Bhandari. 2015. Socially responsible stocks: A boon for investors in India. *Journal of Advances in Management Research* 12: 209–25. [[CrossRef](#)]
- Wander, Brett H., and Ron D'Vari. 2003. The Limitations of Standard Deviation as a Measure of Bond Portfolio Risk. *The Journal of Wealth Management* 6: 35–38. [[CrossRef](#)]
- Wang, Kehluh, Yi-Hsuan Chen, and Szu-Wei Huang. 2011. The dynamic dependence between the Chinese market and other international stock markets: A time-varying copula approach. *International Review of Economics & Finance* 20: 654–64. [[CrossRef](#)]
- Warren, Peter, and Christian Hille. 2018. A risk-based approach to construct multi asset portfolio solutions. *The Journal of Investment Strategies* 7: 33–51. [[CrossRef](#)]
- Wilson, Bonnie. 2004. Diversification of risk and growth. *Macroeconomic Dynamics* 8: 335–61. [[CrossRef](#)]
- Wu, Chih-Chiang, and Shin-Shun Liang. 2011. The economic value of range-based covariance between stock and bond returns with dynamic copulas. *Journal of Empirical Finance* 18: 711–27. [[CrossRef](#)]
- Yilmaz, Tolgahan, and Sema Dube. 2014. Asset allocation and stock selection: Evidence from static and dynamic strategies in Turkish markets. *Iktisat Isletme ve Finans* 29: 73–94. [[CrossRef](#)]
- Zaremba, Adam. 2018. Country Risk and Expected Returns Across Global Equity Markets. *Czech Journal of Economics and Finance* 68: 374–98. [[CrossRef](#)]
- Zhou, Yuan. 2014. Number of Stocks in Portfolio and Risk Reduction. Master's thesis, University of California, Los Angeles, CA, USA.
- Zhu, Hui-Ming, Rong Li, and Sufang Li. 2014. Modelling dynamic dependence between crude oil prices and Asia-Pacific stock market returns. *International Review of Economics & Finance* 29: 208–23. [[CrossRef](#)]