



Degree Program in Economics & Business
Major in Finance

Course of Capital Markets

**Portfolio Diversification Under Market Stress:
Evaluating Its Effectiveness During Financial Crises**

Prof. Paolo Vitale

Supervisor

Prof. Giovanni Rillo

Co-Supervisor

Maria Eugenia Furnari

Candidate

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ABSTRACT

This thesis explores the effectiveness of portfolio diversification under market stress, with a focus on the COVID-19 financial crisis. While Modern Portfolio Theory asserts that diversification reduces risk by combining uncorrelated assets, empirical evidence suggests that correlations between assets tend to converge during crises, diminishing the protective benefits of diversification when they are most needed.

The study analyzes asset behavior across three different periods: pre-COVID (2019), during COVID (2020), and post-COVID (2021). Using a portfolio composed of eight large-cap NASDAQ stocks, the study highlights how traditional diversification failed during the crisis. Risk-adjusted return metrics, Monte Carlo simulations, and correlation heatmaps contributed to the analysis. The results indicate that the portfolio, although it appeared diversified, became systemically fragile under stress due to high sectoral concentration and elevated correlation among assets.

The study evaluated gold as an alternative asset. It analyzes its correlation with both individual stocks and the overall portfolio. The results indicate that gold keeps a low and often negative correlation during all three periods. In addition, it improved the portfolio's Sharpe Ratio when included among the assets.

These findings show that diversification is not just about holding more assets, but about choosing the right ones, especially those that are uncorrelated and withstand stress. This thesis adds to the ongoing discussion around whether traditional diversification works when markets are in trouble and offers useful ideas for building portfolios that can better handle crises.

Chapter 1: Introduction – Rethinking diversification

1.1 Background and Context

1.1.1 The need to assess diversification effectiveness during extreme market conditions

Diversification has always been a pillar of Modern Portfolio Theory, giving investors a strategy to mitigate risk through an allocation of investments across various assets. The essential work of Harry Markowitz introduced the concept of the efficient frontier¹. This emphasized the theory that a diversified portfolio, for a given level of risk, could achieve optimal returns. However, in our history, many financial crises and shocks have challenged the efficiency of diversification.

Empirical studies have proven that during a financial crisis, the correlation factor among assets tends to increase². These findings have led to the questioning of the traditional investment strategies. This was evident during crises such as the COVID-19 shock. This crisis presented unique challenges caused by a rapid decline in markets and an unexpected high volatility.

1.2 Research Gap and Guiding Questions

The theory behind the diversification strategy has always been well-known. Nonetheless, the efficiency of this strategy in a real-world setting under major market stress has not been explored as much. Many studies focus on the long-term benefits derived from diversifying portfolios. However, they often overlook how the correlation between assets evolves during financial turmoil, breaking down in the short term if a crisis hits.

This thesis seeks to reduce this gap by exploring the following research questions:

¹ (Behan 2024)

² (Schwebach, Olienyk e Zumwalt 2002)

- How do asset correlations behave across different market regimes, specifically before, during and after the COVID-19 crisis?
- To what extent does increased correlation during crises impact the effectiveness of portfolio diversification?

1.3 Objectives of the Study

The primary objective of this study is to evaluate the performance of diversification strategies across different market regimes, with a focus on the COVID-19 crisis. The study aims to assess the reliability of diversification to mitigate risk by analyzing asset correlations and portfolio returns before, during, and after the crisis.

Specific objectives include:

- Analyzing changes in asset correlations across the three distinct market environments.
- Assessing the impact of increased correlations on portfolio volatility and returns.
- Applying Monte Carlo simulations to model portfolio performance under stressful market conditions, thus evaluating the resilience of diversification strategies.

1.4 Methodology Overview and Thesis Structure

To achieve the mentioned objectives, the study employs a quantitative research methodology combined with empirical data analysis. It incorporates statistical analyses and simulation techniques. In addition, it investigates historical asset behavior and stress-testing portfolio outcomes under crisis conditions.

1.4.1 Data sources - Historical Asset Returns and Crisis Timeline

The study utilizes historical daily returns data from a selection of large capitalization NASDAQ stocks. The analysis covers three distinct periods: pre-COVID (2019), during COVID (2020) and post-COVID (2021).

1.4.2 Analytical Approach – Correlation Matrices, Risk Metrics and Monte Carlo Simulations

The study employs three main analytical techniques. First, correlation analysis is used to examine pairwise asset correlations and identify how these relationships change across different market regimes. Next, we perform a volatility assessment. This phase is conducted by analyzing daily return fluctuations to evaluate how increased correlations affect overall portfolio risk. Finally, Monte Carlo simulations are implemented to model portfolio performance under a hypothetical scenario. It allows for a deeper evaluation of how effective diversification strategies remain during periods of market stress.

1.5 Contribution of the Study

This thesis focuses on whether diversification helps manage risk during major market crises like COVID-19. By analyzing real data from that period, it shows how different assets moved together and how portfolios performed. The simulations and statistical tools employed helped me better understand how portfolios might react in extreme situations, giving useful insights for building stronger investment strategies.

Chapter 2: Literature Review on Portfolio Diversification

2.1 Theoretical Foundations of Diversification

2.1.1 Modern Portfolio Theory (MPT) – Harry Markowitz's Efficient Frontier

Before the introduction of the Modern Portfolio Theory (MPT) by the Nobel Prize winner Harry Markowitz, it was believed that to construct an attractive portfolio, investors had to select the securities with the best individual profit opportunities and then add these together in a portfolio. However, Markowitz showed that the opposite technique was more efficient. Investors should select portfolio compositions based on their overall risk and reward characteristics.

Markowitz questioned the initially employed technique because selecting securities individually often led to higher risk. The enormous pool of securities had the risk of containing many of them having the same characteristics leading to returns being strongly correlated. This means that the portfolio would lack diversification.

Markowitz's key contribution was to formalize the principles of diversification and highlight how a portfolio's total volatility—used as a measure of risk—is derived from the covariance matrix of its asset returns. His work provided asset managers with a structured approach to analyzing various security combinations and identifying those that offer the best possible returns for a given level of risk.

Given the theory, there are a series of possible portfolio combinations that balance risk and reward. Markowitz's key contribution was to formalize the principles of diversification using a quantitative framework. The expected return of a portfolio is computed as the weighted sum of the expected returns of its individual assets:

$$E(r_p) = w_D E(r_D) + w_E E(r_E)$$

where w_i represents the weights of each asset, and $E(r_i)$ is the expected return of asset i . The risk of a portfolio, represented by its variance, is given by

$$\sigma_p^2 = w_D^2 \sigma_D^2 + w_E^2 \sigma_E^2 + 2w_D w_E \text{Cov}(r_D, r_E)$$

In this context, σ_{ij} represents the covariance between assets i and j . This equation illustrates that portfolio risk is not only a function of individual asset risks but is also influenced by how assets interact through their correlations.

One of the fundamental ideas of MPT is that diversification helps reduce unsystematic risk: the risk that can be eliminated through diversification, also called firm-specific risk or diversifiable risk. This benefit helps investors construct more stable portfolios that are less exposed to volatility.

Given this theory, there exist multiple portfolio combinations that balance risk and reward. The best combinations that yield the highest returns for each level of risk are positioned along what Markowitz defined as the Efficient Frontier³. This consists of portfolios that have the maximum expected return for a given level of risk or, alternatively, the lowest possible risk for a given return.

When a risk-free asset, is introduced, the Capital Market Line (CML) emerges, representing the optimal mix of risk-free assets and the market portfolio, composed only of risky assets⁴. The CML is used to determine the most efficient way to allocate capital between the risk-free and risky assets, and by doing this, improving the portfolio's risk-return tradeoff.

³ (Bodie Z., Kane A. e Marcus A.J. 2018)

⁴ (Bodie Z., Kane A. e Marcus A.J. 2018)

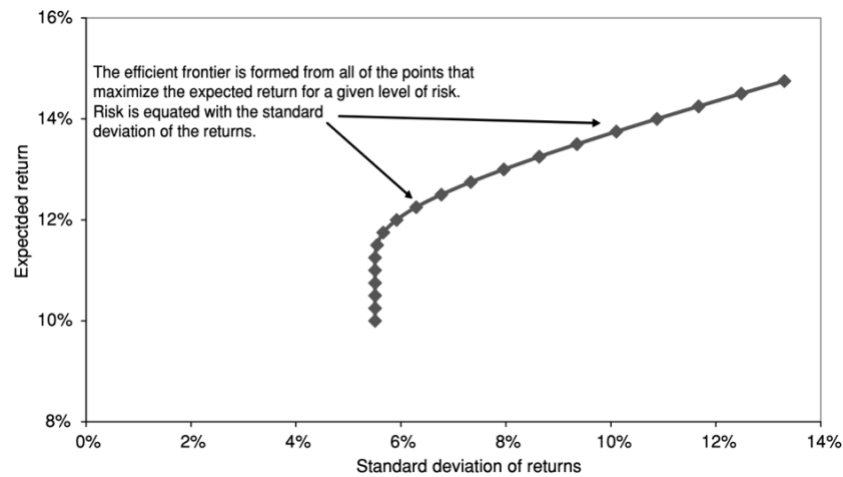


Figure 1: Portfolio Theory - The Efficient Frontier.

Figure 1⁵ illustrates the Efficient frontier. The principal idea behind the frontier set of risky portfolios is that, for any risk level, we are interested only in that portfolio with the highest expected return. Alternatively, the frontier is the set of portfolios that minimizes the variance for any target expected return⁶: these portfolios are deemed as optimal.

2.1.2 Risk vs. return trade-off: the optimal reward for a given level of risk.

William Sharpe, a prestigious economist, first introduced the now so-called, Sharpe Ratio as a reward-to-volatility measure that is commonly used to assess the performance of investment managers⁷. It quantifies a portfolio's excess return per unit of risk. It is calculated using the following formula:

⁵ (Corcoran 2007)

⁶ (Corcoran 2007)

⁷ (Longin e Solnik 2001)

$$S_A = \frac{E(r_A) - r_f}{\sigma_A}$$

where r_f represents the risk-free rate, $E(r_A)$ the expected return of asset A and, σ_A represents the Standard Deviation of asset A's return.

A higher Sharpe Ratio indicates that the investor is getting better returns for the amount of risk he is taking. This ratio provides investors with a tool that helps them choose portfolios that earn more without fewer ups and downs. Diversification plays a crucial role in managing this trade-off: it reduces the portfolio risk without necessarily diminishing the expected return.

Later, we will conclude that according to Markowitz, the optimal risky portfolio is the one that maximizes the Sharpe Ratio⁸.

Maximizing the Sharpe Ratio is a key objective when constructing a portfolio. However, the effective use of diversification during this process depends heavily on the relationship between the assets inside the portfolio. Correlation is for example, an essential factor that influences diversification. Understanding how assets move is key to figuring out whether diversification helps reduce risk and improve portfolio performance.

2.2 Empirical Findings on Diversification

2.2.1 Historical research on diversification effectiveness

Diversification has always been at the center of investment strategies since its introduction by Harry Markowitz. The main claim of Modern Portfolio Theory is that investors can have optimal

⁸ (Bodie Z., Kane A. e Marcus A.J. 2018)

returns for a given level of risk if they hold a diversified portfolio. Many empirical studies have supported this theory by demonstrating that diversification across assets coming from different classes can reduce the overall portfolio volatility. That said, diversification's benefits are not consistent over time. In the last years, financial markets started becoming very interconnected, and the effect has been shown by a convergence in asset correlations. This phenomenon happens especially in developed economies, leading investors to reconsider the effectiveness of diversification in modern markets.

Research has also highlighted the importance of diversification not only at the portfolio level but also at the corporate level. To increase long-term profitability and reduce risk, firms often diversify their business. However, studies proved that corporate diversification could have benefits but also negative effects. During periods of economic downturns, it can provide some stability, but it can also lead to inefficiency if it is not well managed⁹. This perspective highlights how important is to evaluate diversification strategies to each specific situation, whether it is for an individual investor or a global company.

2.2.2 Studies on correlation behaviors in normal vs. crisis periods

To understand whether diversification truly works when needed, it is important to look at how asset correlation behaves in calm periods versus in crisis ones.

Under normal market conditions, asset correlations tend to remain low – this allows diversification to effectively reduce risk and enhance returns. On the other hand, empirical research finds that during financial crises, correlations between assets that are usually not correlated, tends to increase leading to a significant reduction of the protection generated by diversification. This type of phenomenon is called “diversification breakdown”. It was especially observed during the 2008 Global Financial Crisis and the COVID-19 market crash¹⁰. As a reaction to these types of financial

⁹ (Guerras-Martín, et al. 2020)

¹⁰ (Guerras-Martín, et al. 2020)

turmoil, investors tend to invest their capital in safer assets like U.S. Treasury bonds, gold, and the U.S. dollar. This shift causes correlation to increase between riskier assets, and consequently it amplifies even more market stress.

Referring to the concept of corporate diversification, it was also examined how firms modify their diversification strategies during economic downturns. The framework we commented earlier shows how companies adapt their diversification choices when market conditions change ¹¹.

2.3 The role of correlations

2.3.1 How correlations behave during crisis

Correlation is a statistical measure that describes the degree to which two variables move in relation to each other. In finance, with values ranging from -1, meaning perfect negative correlation, to +1, indicating perfect positive correlation. A correlation of 0 indicates no linear relationship between the variables¹².

When a pair of assets is perfectly correlated, it means that they are both moving in the same direction. When the pair is uncorrelated, there is no consistent relationship in how those assets move. Finally, when two assets are negatively correlated, they move in opposite directions, providing an ideal scenario for an investor seeking portfolio diversification.

Assets with low or negative correlations contribute to risk reduction by ensuring that negative price movements in one of them are offset by stable or positive movements in the other. This is a key aspect of effective portfolio diversification and the management of the portfolio's risk.

Under normal market conditions, correlations between assets tend to remain relatively stable, supporting the idea of diversification as a risk reduction strategy. However, during financial crises,

¹¹ (Guerras-Martín, et al. 2020)

¹² (Bodie Z., Kane A. e Marcus A.J. 2018)

correlations among different asset classes tend to increase. As a result, diversification becomes less effective because assets that were expected to offset each other's risk may all lose value at the same time, increasing the overall risk of the portfolio.

Correlation is computed using the following formula:

$$\rho_{X,Y} = \frac{Cov(X,Y)}{\sigma_X \sigma_Y}$$

Where **Cov(X,Y)** represents the covariance between the two assets, indicating how they move together, while σ_x and σ_y denote the standard deviations of X and Y, respectively. Standard deviation is a statistical measure that quantifies the amount of variation or dispersion in a set of values. A low standard deviation indicates that the data points tend to be close to the mean, whereas a high standard deviation signifies that the data are spread out over a wider range of values¹³. By dividing the covariance by the product of the assets' standard deviations results in the correlation coefficient.

Following the theoretical and empirical foundation, the next section will comment on how correlation behaves in different market environments. This will be especially highlighted during crisis periods to assess diversification results in times of financial stress.

2.3.2 Implications of Correlation behavior on Diversification

Diversification strategies are heavily impacted when correlation among assets increases because of financial crises. Diversification is based on the principle that combining assets with low or negative correlations can reduce overall portfolio risk. This happens because the simultaneous movement of assets can lead to losses in the portfolio that are way larger than the expected ones.

¹³ (Pearson K. 1894)

It highlights how important it is to consider the changes in correlation when managing risk and building a portfolio.

Investors may need to explore alternative diversification approaches, such as incorporating assets that are less likely to become correlated during crises or employing strategies that hedge against systemic risks¹⁴. Understanding the behavior of correlations under different market conditions is crucial for developing resilient investment portfolios that can resist financial turmoil.

2.4 Gaps in the Literature and the Rationale for Reassessing Diversification

2.4.1 Where existing studies fall short

Despite Modern Portfolio Theory's prominence in finance, it has many limitations that have been criticized. Especially when it is applied in real-world settings and in stress scenarios such as financial crises.

Modern Portfolio Theory assumes investors make decision based mainly on risk and return factors. However, it has been proven that even educated and professional investors are influenced by factors such as behavioral ones. One of the key findings was that investors frequently deviate from optimal diversification strategies, because of psychological factors such as the neglect of correlation and overconfidence¹⁵.

Markowitz's theory depends strongly on the assumption of stable correlation between assets in a portfolio. Experimental studies showed that investors, even when they were told that assets were highly correlated, still chose to diversify their portfolios¹⁶. This suggests that people believe that spreading their investments between multiple assets is always beneficial, regardless of their

¹⁴ (Sandoval e De Paula Franca 2012)

¹⁵ (Gubaydullina e Spiwoks 2009)

¹⁶ (Gubaydullina e Spiwoks 2009)

underlying relationship. So, investors would keep using the same strategy even if it would not provide an actual reduction in risk. These findings clearly reveal a gap between theoretical models and their practical application.

In addition, research shows that investors use too often historical data to predict future market conditions. By relying on this strategy, they ignore important information about assets, such as correlation. Moreover, they tend to make decisions based on historical data that is not relevant¹⁷. This behavior leads to non-optimal choices and questions the validity of Modern Portfolio Theory in real investor behavior.

Another critical gap in traditional diversification theory arises from its disregard for portfolio similarity and the network present in financial systems. “The Network of U.S. Mutual Fund Investments: Diversification, Similarity and Fragility throughout the Global Financial Crisis” paper uses the “Network theory” to analyze U.S. mutual fund portfolios during the Global Financial crises. It highlights that while individual portfolios became more diversified during periods of financial distress, similarities between these portfolios caused an increase in systematic risk¹⁸.

This study demonstrates how the concentration of shared assets in many diversified portfolios leads to a more fragile financial system. In addition, it increases the transmission of financial shocks between these assets. This challenges the main idea behind Modern Portfolio Theory that diversification reduces systematic risk independently.

The paper shows that funds held a high number of assets, aiming to increase diversification. Nonetheless, the similarity in their diversification strategies meant that a negative shock on one of those assets, held by many funds, could still propagate through the whole network of assets,

¹⁷ (Gubaydullina e Spiwoks 2009)

¹⁸ (Delpini, et al. 2018)

causing systematic losses¹⁹. This study questions the notion of diversification, indicating that portfolio affinity and the similarity between strategies should be considered when diversifying.

2.4.2 How this thesis aims to contribute new insights

This thesis aims to challenge the traditional theories on portfolio diversification by evaluating how portfolios behave before and after a financial crisis. It seeks to analyze the reasons why diversification often results in the opposite effect, failing to mitigate the losses, and identify the factors that are often overlooked when diversifying a portfolio.

The research aims to expand the Modern Portfolio Theory by integrating other variables that reflect the current complex financial system. By analyzing portfolio behavior across different times, this study will assess whether the assumptions behind classical diversification models still hold true in today's volatile market environment.

To accomplish this, the research employs stress-testing methods, such as the Monte Carlo simulations, and correlation analysis across different time frames and portfolio compositions. This approach ensures that conclusions are not only based on historical data but also on a wider range of factors and scenarios that could impact diversification.

2.5 Understanding Financial Crises and Their Impact on Markets

2.5.1 Defining a Financial Crisis

A financial crisis occurs when financial markets stop functioning efficiently, often triggered by a sudden drop in asset prices, a severe contraction in liquidity, and the potential failure of major

¹⁹ (Delpini, et al. 2018)

financial institutions. Such events disrupt the allocation of capital and undermine confidence in the financial system. While volatility is inherent to markets, a crisis is distinguished by the scale and systemic nature of its impact²⁰. The International Monetary Fund (IMF) further emphasizes that financial crises typically involve sharp asset price declines, bank runs, and disruptions to credit availability²¹.

2.5.2 Characteristics and Types of Crises

Various types of financial crises can be distinguished, for example, currency crises, banking crises, and sovereign debt crises. In this study, we are going to focus on a market crash crisis: the COVID-19 market crash.

Market crashes involve a rapid and steep decline in asset prices in a very short period. These are often driven by panic selling, speculation or external shocks and events. Although market crashes do not always turn into financial crises, they can inflict significant losses on investors and disrupt capital markets. The initial shock of the COVID-19 pandemic in 2020 is a prime example.

2.6 COVID-19 Market Crash and its Effects on Portfolios

The COVID-19 pandemic in 2020 led to an extensive financial market downturn. The virus rapidly spread globally so governments tried to reduce its propagation by implementing lockdowns. This led them to halt economic activities, resulting in an increasing uncertainty. Naturally, financial markets reacted with panic in response to this unexpected global crisis.

Research indicates that the crash was not solely a consequence of the pandemic. The U.S. stock market possessed underlying systemic vulnerabilities that increased the negative effects of such

²⁰ (Rogoff K. S. e Reinhart C. M. 2009)

²¹ (International Monetary Fund 1998)

downturn. The pandemic functioned as a trigger, exposing and amplifying these pre-existing instabilities. These instabilities included high asset valuations, heavy reliance on leveraged instruments and a fragile financial network structure²².

The COVID-19 crash is distinguished not only by how fast it spread but also by its simultaneous impact across many asset classes. Previous crises originated because of imbalances in the structures of the financial system. On the other hand, the pandemic represented a health shock that had immediate and global implications. Thus, its effects on investments were, therefore, unusually complex and widespread.

2.6.1 The COVID-19 Market Crash (2020)

In February and March 2020, global equity markets experienced a rapid and severe decline. The S&P 500, for example, fell by approximately 30% in a short period, between February and March 2020²³. This marked the fastest bear market in U.S. history. The same happened in the European and Asian markets.

From a portfolio management perspective, the COVID-19 crash highlighted again critical vulnerabilities in the traditional diversification strategies. Even the portfolios diversified across asset classes, sectors, and geographies experienced giant and simultaneous losses. Correlations between assets increased, compromising the assumption that diversification would protect against downside risk.

Investors reacted with panic and started looking for liquidity. This was done by often shifting toward cash or very safe assets. Central banks responded rapidly, with measures including interest rate cuts, quantitative easing, and direct market support. These actions helped stabilize markets

²² (Longin e Solnik 2001)

²³ (Longin e Solnik 2001)

and helped reach a subsequent recovery. Nonetheless, the initial impact of the crash revealed the fragility of even well-diversified portfolios under extreme systemic stress.

The COVID-19 market crash serves as a contemporary case study on the limitations of traditional portfolio theory under crisis conditions. It reinforces the importance of stress-testing, scenario analysis, and dynamic correlation modeling in risk management. Moreover, it emphasizes the necessity of recognizing and addressing systemic vulnerabilities within financial markets to increase resilience against future shocks.

2.6.2 How Financial Crises Affect Asset Correlations: Empirical Evidence on Correlation Shifts.

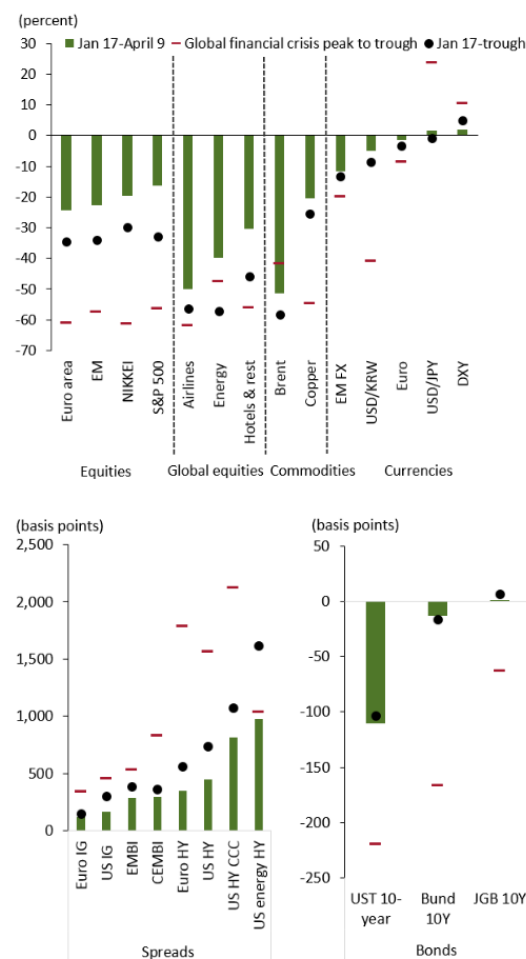
The COVID-19 pandemic serves as a pivotal case study in understanding how asset correlations can behave under extreme financial stress. The International Monetary Fund (IMF) highlighted in its “Global Financial Stability Report” that the initial reaction to the pandemic induced a “dash for

cash” dynamic, leading to severe and rapid increases in asset correlations globally²⁴. As illustrated in the figures *Asset prices plummet*²⁵, prices of assets—including equities, commodities, and high-yield bonds—collapsed sharply, corresponding with intensified financial stress across global markets.

This figure directly illustrates the empirical phenomenon of correlation convergence during systemic crises. The widespread and simultaneous drop in asset prices, spanning global equities, commodities, and credit markets, suggests that the traditional benefits of diversification, based on low correlations, resulted ineffective. Even assets typically seen as uncorrelated or protective, such as high-yield bonds and commodities, moved in the same direction. This pattern of behavior aligns with prior academic research showing that during periods of market stress, correlations rise sharply, undermining portfolio resilience²⁶. Therefore, the chart not only visualizes the scale of the COVID-19 market shock but also validates the core argument of this research: that diversification often fails precisely when investors depend on it most.

Asset prices plummet

Prices of risk assets, such as equities, commodities, and high-yield bonds, have fallen sharply.



Sources: Bloomberg Finance L.P. and IMF staff calculations.
 Note: EM = emerging markets, FX = foreign currency, KRW = Korean won, JPY = Japanese yen, DX = dollar index, IG = investment grade, HY = high yield, EMBI = JP Morgan Emerging Market Bond Index, CEMBI = JP Morgan Corporate Emerging Market Bond Index, UST = US Treasury notes or bond, JGB = Japanese Government Bond.

²⁴ (Longin e Solnik 2001)

²⁵ (International Monetary Fund 1998)

²⁶ (Longin e Solnik 2001)

Numerous studies confirm that asset correlations are not stable and tend to rise significantly during financial crises. In the “Extreme correlation and international equity markets” paper by Longin and Solnik empirical evidence shows that equity market correlations increase during downturns, undermining diversification benefits²⁷. Increased volatility during crises can cause measured correlations to rise, suggesting caution in interpreting these shifts as contagion. Taken together, these studies support the following central claim: portfolio diversification is less effective in crisis periods precisely because correlation structures become unstable.

²⁷ (Longin e Solnik 2001)

Chapter 3: Data and Methodology

3.1 Data Collection

3.1.1 Selection of a portfolio

In this research, the NASDAQ portfolio has been selected for analysis during the period of the COVID-19 market crash. The NASDAQ (National Association of Securities Dealers Automated Quotations) is a fully electronic stock exchange, widely recognized for listing many of the world's leading technology and innovation-driven companies. When opened in 1971, it was the first stock exchange to operate without a physical trading floor. Instead, it uses a computerized system to connect buyers and sellers²⁸. Today, it stands as one of the largest stock exchanges globally. The exchange plays a central role in global financial markets.

3.1.2 Presentation of the portfolio's composition

For this analysis, I chose to focus on a selection of companies within the NASDAQ portfolio that have significant market capitalization and influence. The selected companies are Apple (AAPL), Microsoft (MSFT), Amazon (AMZN), Alphabet (GOOGL), NVIDIA (NVDA), Tesla (TSLA), Meta Platforms (META), and Adobe (ADBE). These firms are often referred to as part of the “Magnificent Seven” or “Mega-cap Tech”. They have been the primary drivers of the United States' equity market performance in recent years. According to a Goldman Sachs report, without the contribution of these few large-cap technology firms, the S&P 500 would have delivered flat or even negative returns across multiple periods²⁹. Their inclusion in this study reflects not only their dominance in terms of market capitalization but also a realistic portrayal of modern portfolio dynamics, where a small category of companies significantly shapes index-level outcomes.

²⁸ (Bodie Z., Kane A. e Marcus A.J. 2018)

²⁹ (Goldman Sachs 2024)



Figure 2: S&P 500 P/E Multiple - Top 10 vs. Other 490.

This dynamic is further illustrated by Figure 2, which represents the price-to-earning (P/E) ratios of the top 10 stock in the S&P 500 versus the remaining 490³⁰. The chart highlights their outsized influence on the index compared to the rest of the stocks. This observation strengthens the reason behind choosing these stocks in the portfolio analysis. Their dominance shows both the performance and the risk profile of diversified portfolios. In addition, the high valuation of these stocks increases its exposure during downturns, and this reinforces the need to assess diversification breakdown in portfolio concentrated around such stocks.

4.4.3 Time periods covered (historical crises, normal periods, recovery phases– e.g., COVID-19)

³⁰ (Goldman Sachs 2024)

I selected three distinct time periods—pre COVID-19, during COVID-19, and post COVID-19—to reflect distinct phases of market conditions, each relevant for analyzing the behavior of portfolio diversification under different levels of stress.

- Pre COVID-19 (Jan 1st, 2019 – Dec 31st, 2019): A period that represents a stable market environment, useful as a baseline for comparison.
- During COVID-19 (Jan 1st, 2020 – Dec 31st, 2020): It captures the period of extreme market volatility and uncertainty triggered by the global pandemic.
- Post COVID-19 (Jan 1st, 2021 – Dec 31st, 2021): A time that reflects the early recovery phase, marked by adaptation to new economic conditions and partial normalization of markets.

Analyzing these three periods allows for a clearer understanding of how portfolio correlations—and thus the benefits of diversification—evolve across normal, crisis, and recovery phases.

3.2 Analytical Framework

To assess whether portfolio diversification effectively reduces risk during times of crisis, this thesis adopts a dual analytical framework. It includes correlation analysis and risk-adjusted return metrics. This framework enables us to make an evaluation of asset relationships and performance outcomes across three distinct market conditions—normal, crisis, and recovery periods. The approach reflects insights from both classical portfolio theory and contemporary empirical studies on systemic fragility and investor behavior.

I downloaded the daily returns of these companies from the online platform Investing.com, covering the period from January 1st, 2019, to December 31st, 2021. I then assembled all the data into an Excel spreadsheet and divided it into the three distinct time periods for analysis. Next, I computed the correlation of daily returns between each stock for each period and generated three

heatmaps—one for each time frame. As a final step, I used AI tools to get a visually better version of the heatmaps, which helps better identify periods of high or low correlation among the selected stocks.

3.2.1 Correlation analysis: Asset correlations in normal vs. crisis periods

The first step of this analysis investigates changes in pairwise correlations among NASDAQ stock returns over 2019 (pre-COVID), 2020 (COVID crisis), and 2021 (recovery). The goal of this framework is to determine whether diversification still protects portfolios during periods of financial stress or if its benefits disappear when asset correlations rise.

Empirical studies show that asset correlations often increase during periods of financial stress. As it is argued in “The Network of U.S. Mutual Fund Investments”: if mutual funds diversify in similar ways, systematic risk can increase leading to high exposures and a fragile protection³¹. Even when individual portfolios seem well diversified, the hidden connections between their assets can cause problems to spread quickly, making the whole system more fragile³².

Later in the thesis, visual correlation heatmaps will be used to analyze how asset relationships change over time, offering an intuitive and data-driven way to assess the stability of diversification.

3.2.2 Risk-adjusted return analysis: Sharpe ratio, Sortino ratio, maximum drawdown

Correlation analysis explores the relationship between asset movements, but it does not directly reflect portfolio outcomes. To address this, the second step of the analytical framework evaluates risk-adjusted return metrics—namely the Sharpe Ratio, Sortino Ratio, and Maximum Drawdown.

³¹ (Delpini, et al. 2018)

³² (Libiao Bai 2021)

This was made to assess how the portfolio balances return and risk across distinct market conditions.

- Sharpe Ratio – It measures excess return per unit of total volatility.
- Sortino Ratio – A refinement of the Sharpe Ratio, it focuses only on downside deviation—i.e., returns that fall below zero—making it particularly suitable for stress-testing during crisis periods.
- Maximum Drawdown (MDD) – It quantifies the largest observed loss from peak to trough in the value of the portfolio, offering a practical view of extreme risk exposure.

These indicators were calculated for the pre-crisis, crisis, and recovery periods to test whether diversification meaningfully mitigates downside risk.

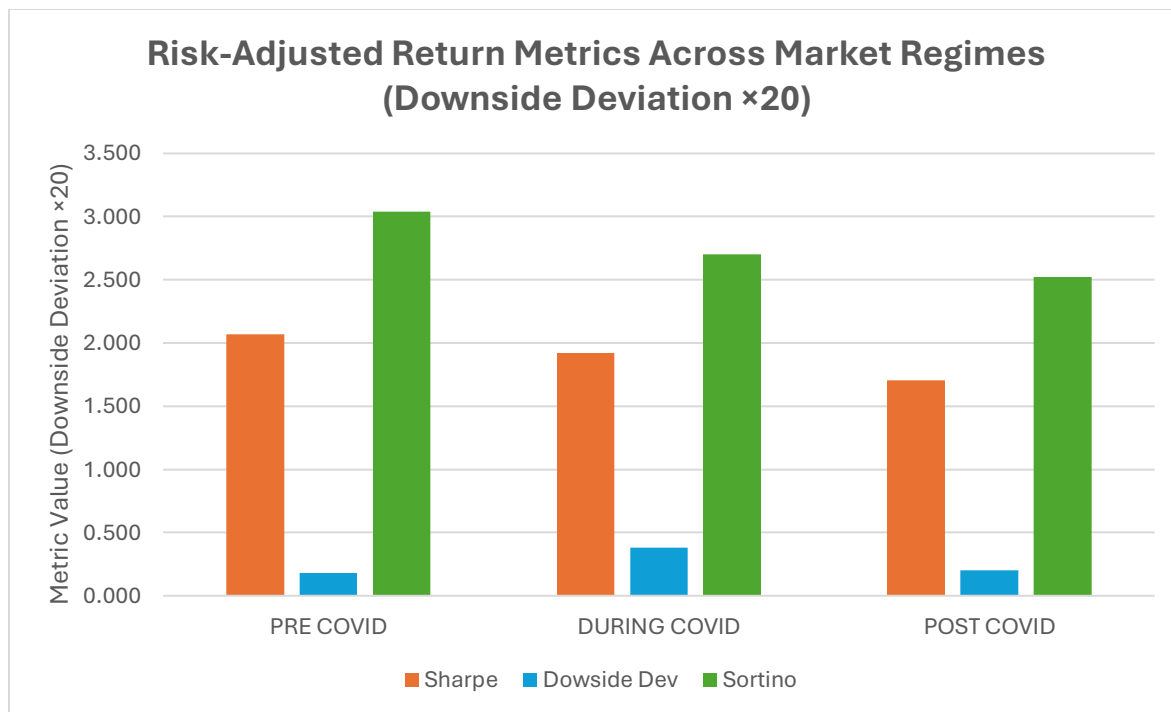


Figure 3: Risk-Adjusted Return Metrics Across Market Regimes (Downside Deviation ×20). This chart compares Sharpe Ratio, Sortino Ratio, and scaled Downside Deviation across pre-COVID, COVID, and post-COVID periods.

At first glance, the Sharpe and Sortino ratios appear relatively stable across market regimes suggesting that the portfolio maintained a consistent level of efficiency. However, this interpretation may be misleading. The portfolio selected consists entirely of large-cap technology stocks. These assets pertain to the same sector and so are concentrated and historically prone to increased correlation during periods of market stress. Thus, the attractive risk-adjusted returns probably have more to do with the tech sector's strong performance than with real diversification.

Interestingly, downside deviation increased during the COVID period, as it can be observed because of the spike in the blue bar. It indicates a rise in negative returns during the market shock. Yet the Sortino Ratio only declined slightly, implying that returns still compensated for the added downside risk. This reinforces the idea that traditional risk-adjusted metrics, especially when returns are strong, can hide concentration risk. This gives a false sense of security regarding portfolio resilience.

This observation raises critical questions about the effectiveness of diversification in portfolios. While Modern Portfolio Theory encourages diversification based on return covariances, it relies on assumptions of stable correlations and risk reduction through asset variety³³. However, as the portfolio risk literature highlights, structural similarity among assets can lead to systemic fragility. This can happen especially during crises, when correlations tend to spike, and diversification can effectively break down³⁴.

To examine this further, Chapter 5 will analyze the correlation structure of the portfolio's constituents across the same three periods. This will clarify whether the portfolio's resilience was due to genuine diversification or merely the result of favorable, but fragile, sector dynamics.

3.3 Stress Testing and Scenario Analysis

³³ (Corcoran 2007)

³⁴ (Delpini, et al. 2018)

3.3.1 Simulating a Financial Crisis: Stress-Testing the NASDAQ Portfolio

To assess the resilience of the NASDAQ portfolio during the COVID-19 financial crisis, I conducted a Monte Carlo simulation.

Using historical data and making probability assumptions has helped model many possible outcomes by simulating various scenarios. For portfolio and risk management, the simulations I conducted allowed me to assess potential upcoming losses. Furthermore, it made clearer the distribution of portfolio returns during a period of financial stress.

The main goal was to replicate the market performance during the 2020 COVID-19 crisis. I employed the volatility and returns of that period to simulate the market dynamics of that crisis.

The simulations were conducted under the assumption of normally distributed returns for each asset within the NASDAQ portfolio. For each simulation, 252 trading days' returns were generated using the NORM.INV (RAND (), mean, std_dev) function in Excel. The portfolio return was calculated as the weighted average of individual asset returns. Later, I repeated the process 30 times to obtain a distribution of possible outcomes. This methodology provided a simplified but efficient framework for evaluating portfolio performance under crisis.

3.3.2 Monte Carlo simulations to Explore Tail Risk and Correlation Breakdown

This section presents the results of a Monte Carlo simulation conducted to assess the potential risk of the NASDAQ portfolio during market stress.

After computing the daily mean and standard deviation of returns of the eight stocks selected, I used this data to define normal distributions. Using Excel's NORM.INV (RAND (), mean, std_dev) function I randomly generated 252 daily returns for the period of 2020. Consequently, I calculated the daily returns of each stock by assuming the portfolio was equally weighted. These

returns were finally compounded over time to generate the final value of the portfolio at the end of the year.

As mentioned earlier, this procedure was then repeated 30 times to simulate various possible outcomes during the COVID-19 financial crisis. I then combined the results in a histogram (Figure 4), to better visualize the distribution of the final values of the portfolio after one year based on the Monte Carlo simulations. As it can be observed, the majority of the values are situated approximately in the range of 155 and 251. And the most frequent results are between 203 and 251, with 11 simulations. That said, only two simulations are higher than 300.

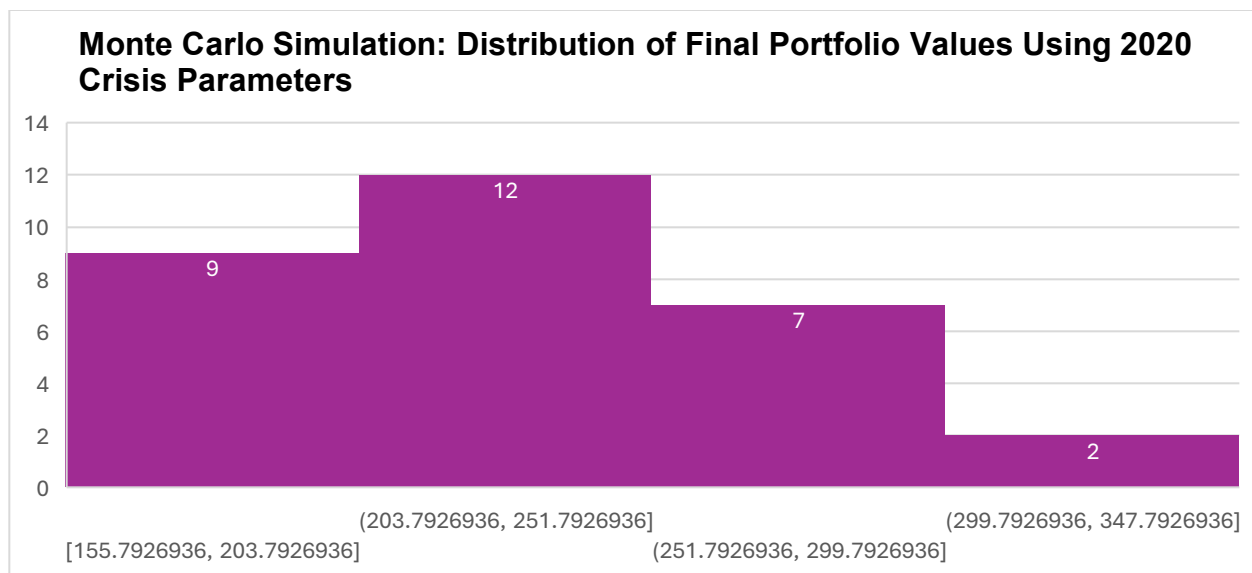


Figure 4: Monte Carlo Simulation - Distribution of Final Portfolio Values Under 2020 Crisis Parameters. This histogram shows the simulated end-of-year portfolio values across 30 randomized paths using 2020 mean and volatility data.

The average final portfolio value is approximately 228.62³⁵. However, the presence of 12 simulations ending below 251 and a 5th percentile value of 170.06 highlights meaningful downside

³⁵ Calculations were performed using Excel functions. See Appendix A for details on the formulas used in the simulation.

exposure²². Even under diversified portfolio strategy, these results demonstrate the potential losses during market stress and emphasizes the importance of stress testing investment strategies other than traditional risk measures.

While this simulation adopts a simplified model by assuming constant volatility and normal return distributions, it still reveals valuable insights. It highlights the fact that diversification can protect investors only to a certain extent during times of market stress. This is shown especially when assets are exposed to the same type of systematic shock. In the next section the implications and conclusions of these results will be further explored, together with a correlation analysis across the selected stocks.

Chapter 4 – Correlation Analysis Across Market Regimes

4.1 Methodological Framework for Correlation Analysis Across Market Regimes

4.1.1 Data processing and Computation of Pairwise Correlations.

The final portfolio includes Apple (AAPL), Microsoft (MSFT), Amazon (AMZN), Alphabet (GOOGL), NVIDIA (NVDA), Tesla (TSLA), Meta Platforms (META), and Adobe (ADBE). These firms represent a significant portion of the index and reflect the core of the technology sector.

Daily return data for each of these stocks was downloaded³⁶, covering the period from January 1st, 2019, to December 31st, 2021. The dataset was divided into three distinct market phases: pre-COVID (2019), COVID crisis (2020), and post-COVID recovery (2021). The return series were exported to Excel. And finally, pairwise correlation matrices were calculated separately for each period.

To make the analysis easier, correlation matrices were converted into heatmaps, allowing for a clear visual representation of the relationships between assets. These heatmaps helped identify shifts in correlation intensity across different regimes. Finally, the visuals were refined using artificial intelligence tools to improve clarity.

4.1.2 Temporal Segmentation and Heatmap Choice.

To better understand how correlations between assets change under different market conditions, the analysis was divided into three separate time periods: before the COVID-19 crisis (2019), during the height of the crisis (2020), and the recovery phase that followed (2021). This approach

³⁶ (Investing.com s.d.)

allowed us to observe how relationships between stocks shifted from stable times to periods of extreme stress and then into a more normalized market environment.

Using these time frames, we generated heatmaps based on the correlation matrices. Heatmaps offer a clear and intuitive way to spot patterns. In times of crisis, for example, correlations often rise sharply, and these changes are much easier to detect visually through heatmaps.

This method allowed for a more direct comparison of asset behavior across each period and helped reveal whether the protective effect of diversification held up when it was needed most.

4.2 Visual and Statistical Interpretation of Heatmaps

4.2.1 Pre-COVID (2019): characterized by low and stable correlations.

The correlation heatmap for 2019 reflects a relatively low and stable level of correlation among the portfolio's assets. Most pairwise correlations fall within the 0.40 to 0.60 range, suggesting a moderate degree of diversification. This indicates that, during this pre-crisis period, the selected NASDAQ stocks were not strongly moving in tandem, allowing for more effective risk dispersion.

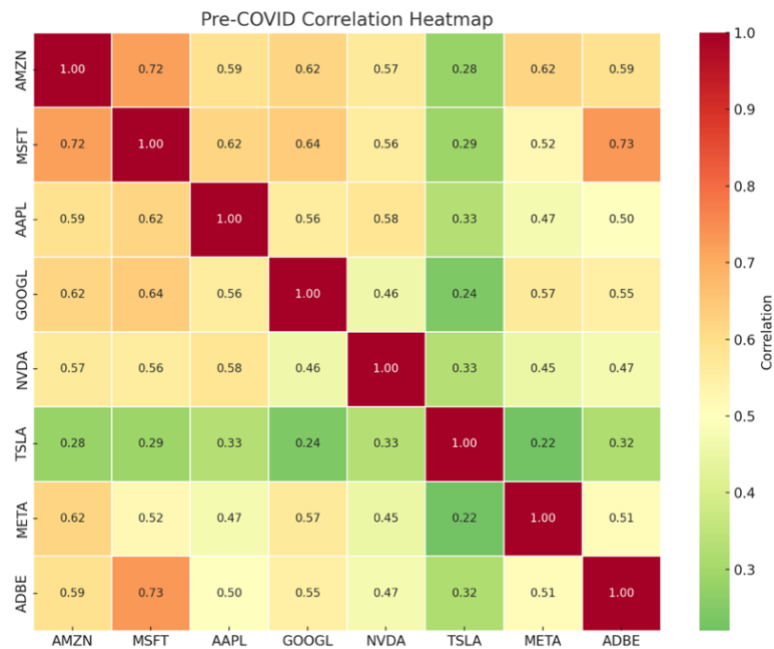


Figure 5: NASDAQ Portfolio Correlation Heatmap (Pre-COVID, 2019). This heatmap shows the pairwise correlation of daily returns among the eight NASDAQ stocks in 2019.

One notable observation is Tesla (TSLA), which stands out as the least correlated asset across the board. Its correlation with companies like Google (0.24) and Meta (0.22) is particularly low, highlighting TSLA's distinct behavior within the group at the time. On the other hand, the strongest relationship is observed between Microsoft (MSFT) and Adobe (ADBE), with a correlation of 0.73. However, this appears to be an outlier rather than a reflection of broader interdependence in the portfolio.

Overall, this period is characterized by relatively independent asset movements, reinforcing the idea that diversification was functioning as expected under normal market conditions. It serves as a baseline against which the shifts observed during the crisis will later be compared.

4.2.2 During the COVID crisis (2020): Market by convergence and elevated correlations.

The correlation heatmap for 2020 reveals a marked shift in asset relationships compared to the pre-COVID period. Correlation values rose significantly, with most pairs falling in the 0.70 to 0.87

range. This sharp convergence is especially visible among the portfolio's largest technology stocks, suggesting that investor behavior during the crisis became more synchronized.

Some of the highest correlation values include MSFT–ADBE at 0.87 and GOOGL–META at 0.80, both notably higher than the corresponding figures from the previous year. Even TSLA, typically characterized by more volatile and independent price action, shows elevated correlations, such as 0.52 with NVDA.

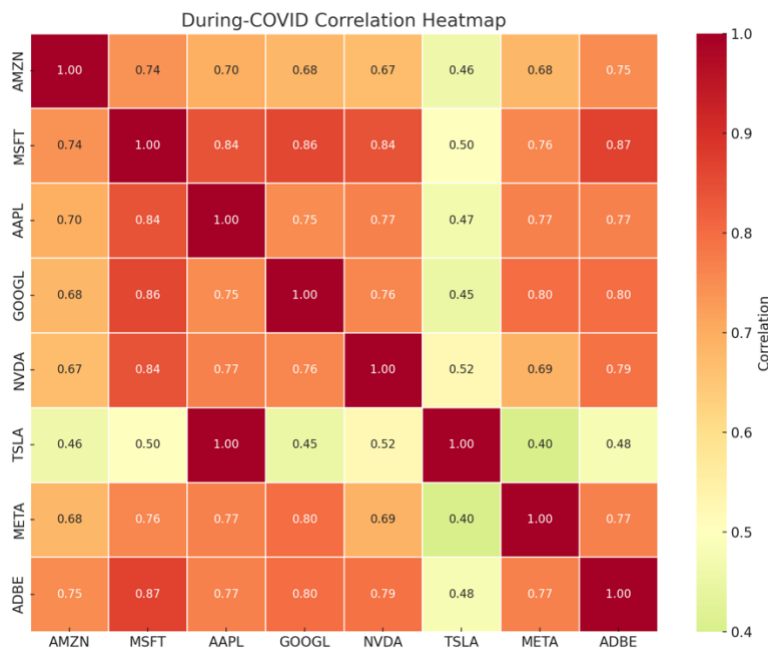


Figure 6: NASDAQ Portfolio Correlation Heatmap (During COVID, 2020). This heatmap shows the pairwise correlation of daily returns among the eight NASDAQ stocks in 2020.

This pattern points to a breakdown in diversification benefits. As fear and uncertainty spread across markets in 2020, individual company fundamentals became less relevant, and systemic risk began to dominate. Assets that would otherwise behave differently started moving in tandem, reducing the effectiveness of traditional portfolio construction methods.

In short, the COVID crisis triggered a collective reaction among investors, amplifying correlations and undermining the independence of returns. This period represents the clearest example of

diversification collapse, where the protective qualities of asset mix faded just when they were needed most.

4.2.3 Post-COVID (2021): Observed partial persistence of elevated correlation levels.

The correlation landscape in 2021 suggests a partial return to pre-crisis behavior, though some elevated relationships persist. Compared to the peak correlation levels seen during the COVID crash in 2020, the post-COVID period shows a noticeable decline. However, correlations generally remain higher than in 2019, indicating that the effects of the crisis did not fully dissipate.

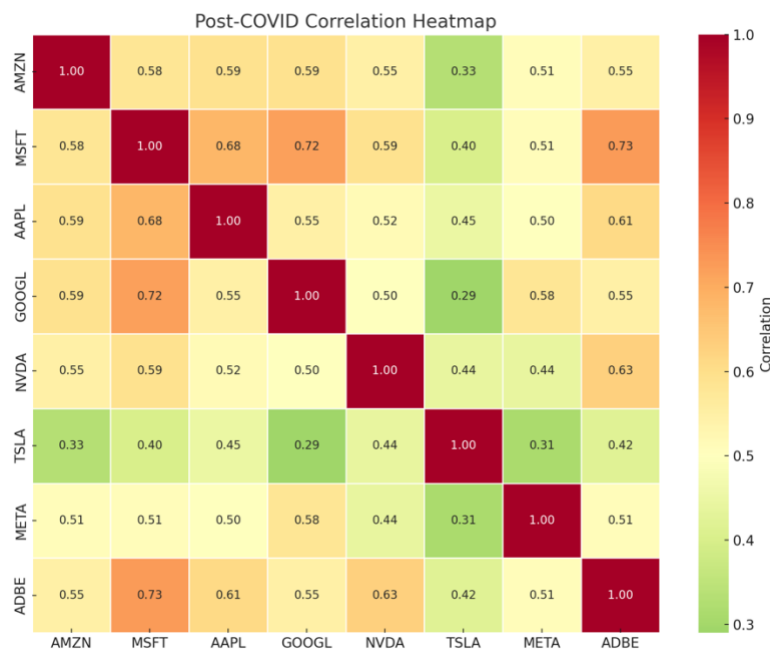


Figure 7: NASDAQ Portfolio Correlation Heatmap (Post-COVID, 2021). This heatmap shows the pairwise correlation of daily returns among the eight NASDAQ stocks in 2021.

Some strong relationships continue—most notably, MSFT–ADBE at 0.73 and GOOGL–AMZN at 0.59—suggesting that certain big tech stocks remained tightly connected in their price movements. On the other end, TSLA once again emerges as the most idiosyncratic stock in the

portfolio, with correlations ranging from 0.29 to 0.44 with other companies, similar to its pre-COVID profile.

Overall, the data indicates a market in recovery, where diversification benefits are gradually returning but not yet fully restored. The heatmap reflects a hybrid state: while investor behavior appears more differentiated than during the crisis, some structural shifts in asset co-movement remain. This highlights the importance of monitoring how market stress can leave lasting effects on correlation dynamics, even beyond the acute phase of a financial shock.

4.3 Evidence of Diversification Breakdown During Crisis

4.3.1 Correlation spikes across assets during 2020.

The COVID-19 market shock in 2020 caused asset prices to move together more than usual. As shown in the 2020 heatmap, stocks that typically behaved differently started to have a higher correlation. This sudden alignment undercut the portfolio's ability to stay diversified, making it more exposed to market-wide risk.

In 2020, many of the portfolio's key stocks, like Microsoft, Adobe, and Google, were moving together with correlations over 0.80. Even Tesla, which usually follows its own path, became more tightly linked to the rest of the group. This phenomenon happens during moments of extreme uncertainty.

All of this points to the same conclusion: when markets are stressed, the benefits of diversification can quickly disappear. Assets that normally help balance each other out start moving in the same direction, which means portfolios become more vulnerable just when investors are counting on them to provide protection.

4.3.2 Visualization of Daily Return Volatility Under Varying Market Conditions.

To further understand the implications of increased asset correlations, it is essential to examine the portfolio's daily return volatility across different market regimes. The following charts depict the daily returns during the pre-COVID (2019), during COVID (2020), and post-COVID (2021) periods, providing a visual representation of the portfolio's behavior under varying market conditions.

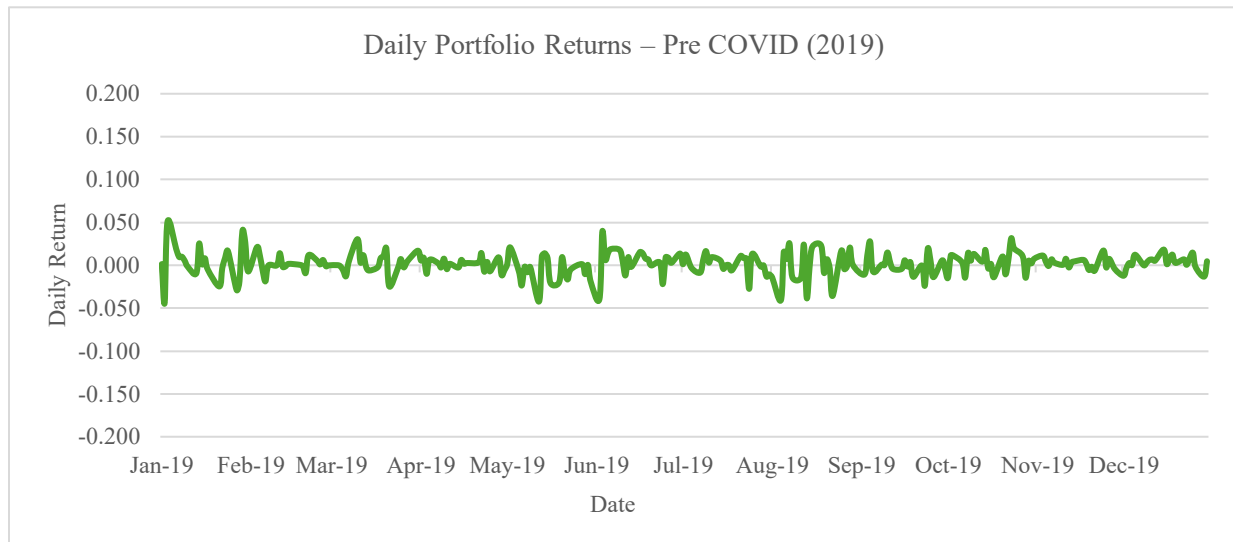


Figure 8: Daily Portfolio Returns Before Covid crisis (2019).

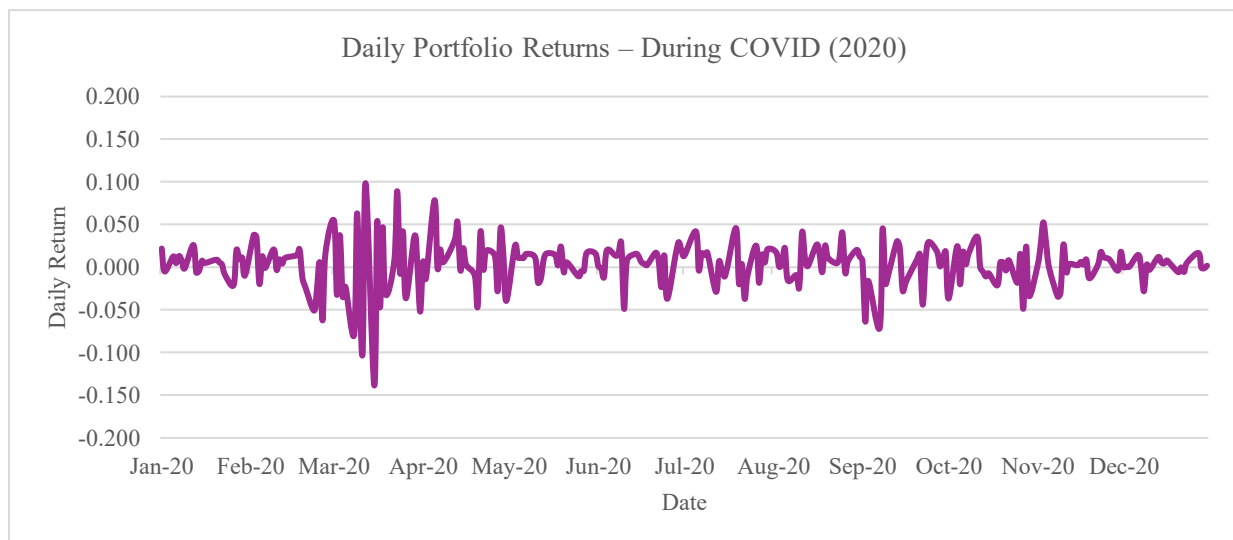


Figure 9: Daily Portfolio Returns During Covid crisis (2020).

Notably, the During COVID chart shows heightened volatility, reflecting the market's reaction to global events. In contrast, the pre- and post-COVID periods show stable return patterns, though there are subtle differences that may indicate lasting impacts of the pandemic on market dynamics.

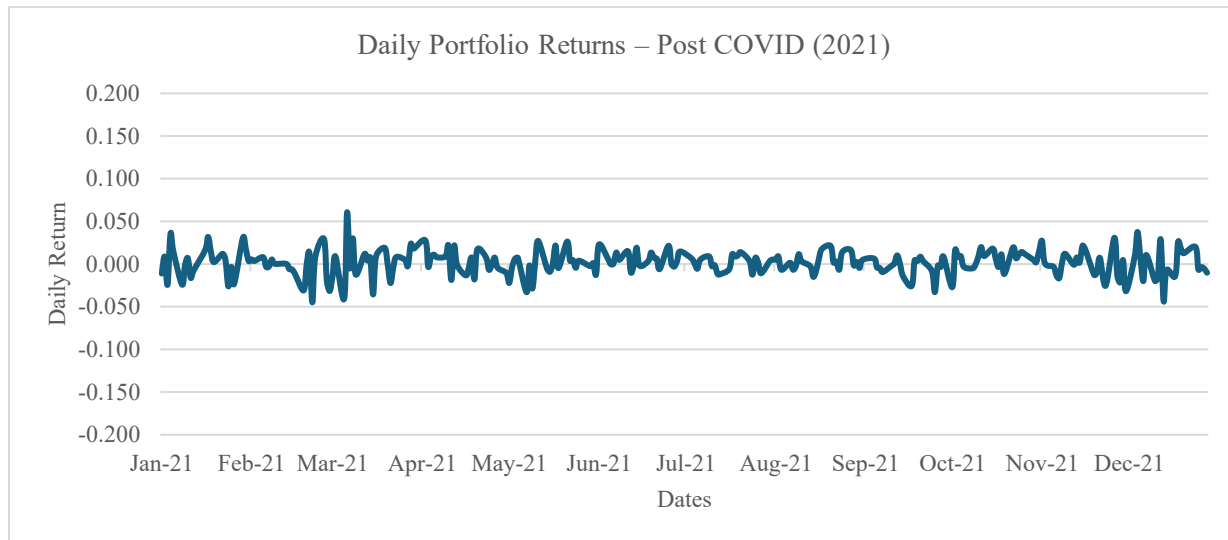


Figure 10: Daily Portfolio Returns After Covid crisis (2021).

These observations highlight the importance of stress testing and risk assessment methodologies, such as Monte Carlo simulations, to evaluate portfolio resilience under extreme market scenarios. By simulating a wide range of possible outcomes, these models can provide insights into potential risks and inform more robust investment strategies.

4.3.3 Assessing the Impact of Elevated Correlations on Portfolio Downside Risk via Monte Carlo Simulations.

The Monte Carlo simulations conducted earlier in the thesis offer a practical confirmation of the problem discussed. Despite using an equally weighted portfolio of eight leading NASDAQ stocks, the simulated outcomes under crisis conditions revealed significant negative effects. In fact, 12 out

of 30 simulations ended below a final value of 209, and the 5th percentile value dropped to around 162, well below the initial baseline of 100.

These results reinforce what we saw in the correlation analysis. As correlations rose during 2020, the portfolio lost one of its key defenses: the ability for losses in some assets to be offset by gains in others. Instead, most holdings moved in the same direction, increasing losses. In other words, the portfolio became systemically fragile, even though, on the surface, it appeared diversified.

When taken together, the correlation heatmaps and simulation results lead us to conclude that diversification does not always work when markets are under stress. It is crucial for investors to understand when and why diversification fails.

4.5 Evaluating Gold as a Diversification Asset

Following the observed correlation spikes among the selected equities I decided to assess whether nonequity assets can contribute positively to a more stable diversification, especially during market stress. Gold has historically been considered a safe-haven asset³⁷. It has frequently been included in portfolios to take advantage of its potential to hedge against volatility and systematic shocks.

This section evaluates first gold's correlation with individual portfolio components and then gold's correlation with the overall portfolio across the previously selected market regimes – pre-COVID, during COVID and post-COVID. This analysis tries to determine whether gold stayed an uncorrelated asset and whether its inclusion could contribute to the construction of a more resilient portfolio.

³⁷ (Ashworth 2024)

4.5.1 Low Correlation Between Gold and Portfolio Constituents: Potential for Risk Dispersion

To evaluate the capacity of gold to be a diversification tool, I downloaded Gold's daily returns from Investing.com and computed the correlation coefficient between gold returns and the portfolio's components returns from January 1st, 2019, till December 31st 2021³⁸.

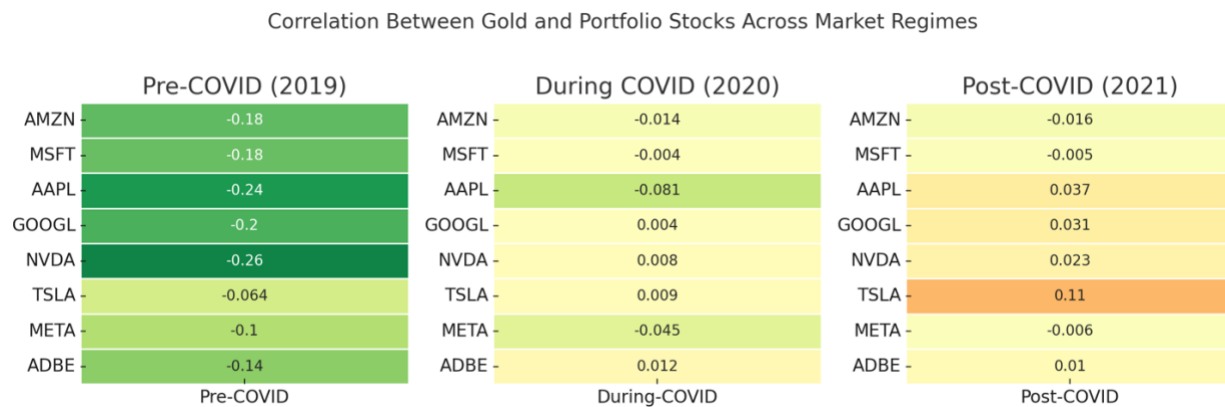


Figure 11: Correlation Between Gold and Portfolio Stocks Across Market Regimes. This figure displays the correlation coefficient between gold and each individual stock in the portfolio during the pre-COVID (2019), during COVID (2020), and post-COVID (2021) periods.

As shown in Figure 11, gold maintained a consistently low correlation or even a negative one across the three market regimes. The values ranged from -0.27 (NVDA), the lowest value in 2019, to 0.0037 (AAPL) the higher value in 2021. This behavior clearly aligns with gold's reputation as a safe-haven asset.

During the COVID-19 crisis in 2020, gold's correlation with the portfolio's stocks increased slightly but remained close to zero for most assets (e.g., MSFT: -0.004; AAPL: -0.081; TSLA: 0.009). Post-COVID, correlations began to decline again (e.g., AMZN: -0.016; NVDA: 0.023), though not to the strongly negative levels observed before the crisis.

³⁸ (Investing.com s.d.)

This minimum shift can suggest that while gold has a diversification power that might decrease slightly during market downturns, it still remains significantly less correlated with equities. This highlights gold's advantage for risk dispersion.

4.5.2 Correlation Between Gold and the Overall Portfolio: Toward an Optimal Asset Mix

To assess gold's contribution to overall portfolio efficiency, I calculated the correlation between the portfolio's daily returns and gold's daily returns across the three periods. This, compared to the previous analysis, which focused on gold's correlation with individual assets, assesses gold's correlation with the whole portfolio. By examining the relationship at the portfolio level, the goal was to evaluate gold's ability to increase overall diversification. And by doing this, contribute to a more optimal asset mix.

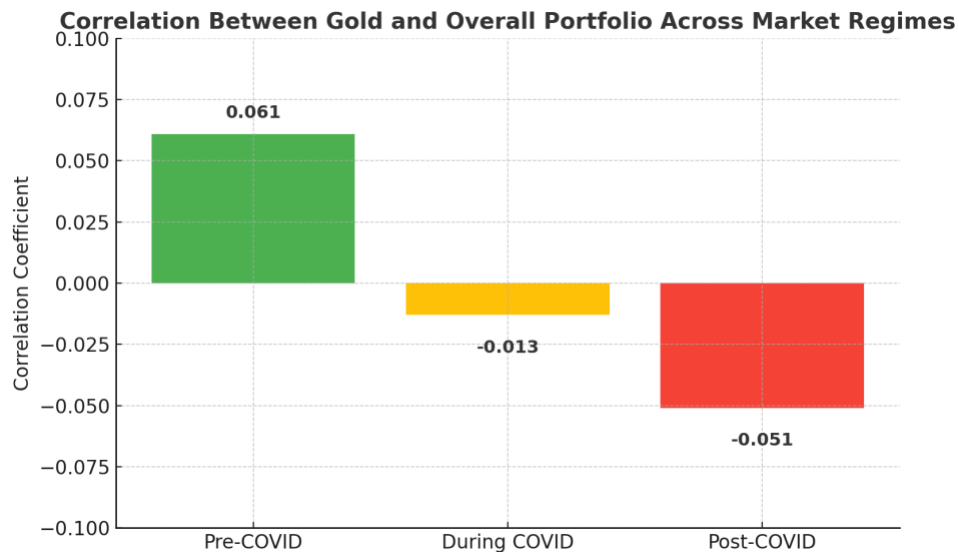


Figure 12: Correlation Between Gold and the Overall Portfolio Across Market Regimes. This chart displays the correlation coefficient between gold and the overall portfolio return during pre-COVID (2019), COVID (2020), and post-COVID periods.

As observed in Figure 12, the results show that the correlation was slightly positive before the crisis (0.061). Then it turned negative during COVID (−0.013) and finally remained negative in

the post-COVID phase (-0.051). These shifts suggest that gold remained independent from equity even during financial turmoil. This highlights its potential role in improving portfolio resilience and moving closer to the efficient frontier.

To explore this potential further, I conducted an allocation test to evaluate how gold affects overall portfolio efficiency. In the first place I tested a simple allocation of 90% equities and 10% gold. This conservative allocation reduced annual volatility from 30.7% to 27.9% and improved the Sharpe Ratio significantly—from 0.11 to 1.83—despite having a lower overall return.

I then used Excel's Solver tool to find the optimal weight of gold that maximizes the Sharpe Ratio. This resulted in an allocation of approximately 41.1% gold and 58.9% equities and a Sharpe Ratio of 1.90, the highest across all tested configurations.

To further assess gold's impact on portfolio efficiency, I compared three different allocation strategies. The pure equity portfolio is based on the original one used for the previous analysis, as are the correlation heatmaps and the Monte Carlo simulations. The second is the fixed-weight portfolio, which simulates a conservative diversification strategy. And finally, the optimal portfolio that maximizes the Sharpe Ratio.

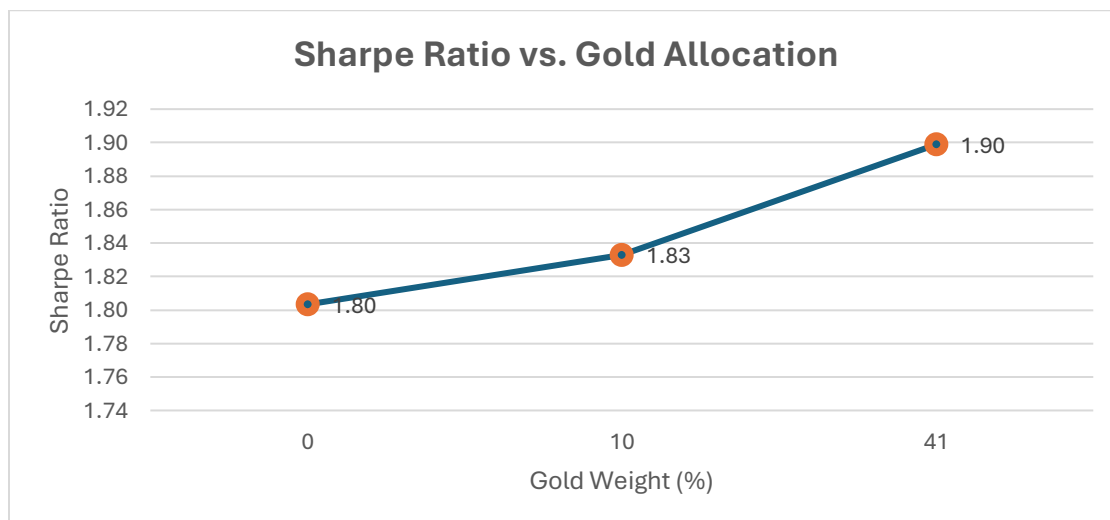


Figure 13: Sharpe Ratio vs. Gold Allocation. The chart illustrates how risk-adjusted performance (measured by Sharpe Ratio) improves as the gold weight increases.

To visualize and compare the performance of these strategies, I created two figures. Figure 13 presents a line chart plotting the different Sharpe ratios based on the three gold weights. The chart highlights that risk-adjusted performance improves as more gold is added to the original portfolio. Moreover, figure 14 presents a bar chart comparison of the Sharpe Ratios achieved by each of the three strategies.

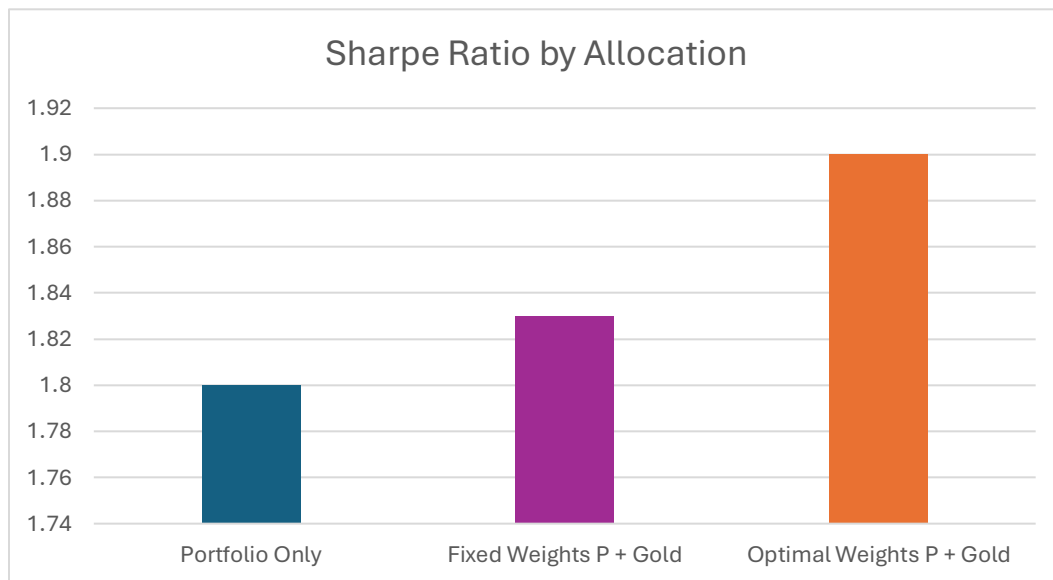


Figure 14: Sharpe Ratio by Portfolio Allocation. This bar chart compares the Sharpe Ratio of three portfolios: equity-only, a fixed-weight mix (90% equities and 10% gold), and the Optimal Portfolio (41.1% gold).

These findings reinforce the central theme of this thesis: that traditional diversification, as defined by the Modern Portfolio Theory, can fail when it is most needed. Observing the original portfolio, composed of eight large-cap technology stocks, the correlation convergence during the market COVID-19 market crisis was evident. Despite appearing diversified, its components moved in the same direction under market stress. This revealed the fragility of sector-based diversification and exposed Modern Portfolio Theory to critics.

By contrast, the comparison that was just illustrated shows that even a low allocation to gold, such as 10%, can meaningfully increase the portfolio's risk-adjusted performance. However, as we saw,

the optimal portfolio, with an allocation of approximately 41% to gold, achieved the highest Sharpe Ratio (1.90). This indicates that this allocation uses risk in the more efficient way. It suggests that diversification is not only about spreading investments across different assets but also about identifying uncorrelated components. Especially components, like gold, that have low correlation during market stress. Gold has the ability to keep its independence from equities across all types of market environments, helping the portfolio move closer to the efficient frontier that the original portfolio failed to reach.

These results validate the need to reassess diversification under real-world crisis conditions. In addition, it also highlights the importance of including adaptive strategies that take into consideration correlation dynamics. The following chapter will discuss the implications of these findings for portfolio management, the limits of theoretical studies and the future strategies for diversification.

Chapter 5: Discussion, Implications and Conclusion

5.1 Interpretation of Findings

5.1.1 Do traditional diversification strategies hold up in crises?

The analysis of the selected NASDAQ tech portfolio led to the conclusion that diversification strategies often fail during financial turmoil. While the tech portfolio appeared well-diversified under normal market conditions, correlation between these assets increased dramatically during the COVID-19 market crash. As a result of this increase in correlation, the protection that traditional diversification offers disappeared.

5.1.2 How does asset correlation shift impact investors?

Changes in asset correlations have a direct impact on investors. The portfolio analyzed in this thesis is composed of assets from the same sector. This was a deliberate choice given that these assets have been the main drivers of the S&P500 growth in the recent years³⁹. However, when correlation rise, especially among assets from the same sector, portfolio volatility increases substantially. This implies that during periods of financial stress losses are amplified, and the investors that relied on historical data may find themselves exposed to an unexpected greater risk.

The heatmaps and Monte Carlo simulations conducted in this thesis illustrate how an initially diversified portfolio can quickly become fragile when the relationships between the assets change. This shows the importance of monitoring correlation dynamics rather than relying only on static diversification strategies.

³⁹ (Goldman Sachs 2024)

5.1.3 Which assets provide true risk protection?

Including gold in the initial portfolio, which contained only tech stocks, demonstrated robust risk protection. Gold maintained a low and even negative correlation with the rest of the portfolio, which was not the case for equities. Including gold in the portfolio significantly increased the Sharpe Ratio, even when its allocation was low. Finally, the optimal allocation included 40% gold.

Other than gold, a strategic inclusion would be selecting non-cyclical or defensive stocks, such as those in utilities sectors. These classes of stocks offer additional protection, since they usually show resilience during economic downturns⁴⁰. This is because they provide essential goods and services that remain in demand regardless of economic conditions. These stocks are present in various sub-industries, such as healthcare and utilities, that provide diversification benefits.

By contrast, cyclical stocks, which include sectors like consumer discretionary and industrials, are more exposed to economic cycles. Even though these stocks might have negative effects under market stress, they might enhance returns during periods of economic expansion. Holding a mix of cyclical and non-cyclical stocks allows investors to balance growth potential with stability. This kind of portfolio can reduce exposure to sudden market swings by spreading risk across sectors that react differently to economic cycles⁴¹.

Gold stands out as an effective safe-haven asset. In addition, including cyclical stocks with a mix of non-cyclical ones can fortify even more the diversification of the portfolio. This strategy ensures both resilience during downturns and growth potential during economic booms.

5.2 Implications for Portfolio Management

⁴⁰ (SmartAsset Team 2024)

⁴¹ (Miles 2024)

5.2.1 Should investors rethink diversification strategies?

The heatmaps revealed that during crises, correlations between assets tend to increase, underscoring the unreliability of traditional diversification strategies that rely on historical correlations. Investors should move away from the static models like Modern Portfolio Theory and adopt more resilient frameworks. These strategies should be based on dynamic approaches that analyze the evolving relationship between the assets that form part of the portfolio. In addition, they should be analyzed under different market conditions, using tools like Monte Carlo simulations to replicate hypothetical extreme stress scenarios.

Sectoral diversification remains essential. Diversifying the portfolio across various sectors is a strategy that can reduce extremely the risk exposure. Adding geographical diversification can strengthens even more diversification benefits. It offers unique advantages in terms of correlation structure and portfolio construction. Notably, country indexes, compared to the industry ones, tend to exhibit significantly lower correlations⁴². This approach is considered especially relevant for real-world portfolio management where diversification is key. However, even well-constructed portfolios can fall short if behavioral factors are overlooked.

Behavioral biases, such as overconfidence and the neglect of correlation, may lead investors to make the wrong investments overestimating diversification⁴³. This highlights the important need for better investor education and tools.

5.2.2 Potential shifts in asset allocation strategies

In today's market environment, investors are rethinking how they build their portfolios. The idea of sticking to a fixed mix of assets, no matter what is happening in the world, does not hold up anymore. One major shift is the inclusion of assets that behave differently under pressure. As

⁴² (Ehling e Brito Ramos 2005)

⁴³ (Barberis 1998)

mentioned earlier, these non-traditional assets can act as a cushion when stocks are falling. More investors are moving away from rigid allocations and adopting dynamic rebalancing strategies. This allows them to adjust their portfolios based on market signals like volatility or macroeconomic trends, rather than letting them fluctuate. Studies have shown that such dynamic rebalancing can improve portfolio performance by responding to changing market conditions⁴⁴.

Finally, the pandemic highlighted a key weakness in many portfolios: too much exposure to a single region or sector, especially U.S. tech. As a result, there is growing interest in global diversification, with investors looking more at emerging markets to spread risk more effectively across different regions⁴⁵. Studies have demonstrated that incorporating emerging markets into portfolios can enhance diversification and potentially improve risk-adjusted returns.

5.3 Limitations of the Study

5.3.1 Data constraints and assumptions

Conducting this research required setting a range of assumptions to simplify the analysis. However, these assumptions may have limited the robustness of the results.

Each financial crisis is unique and has different characteristics that can influence how it affects financial assets. In this thesis, the COVID-19 crisis was selected as the main case study. While this choice allowed for a focused analysis, it also restricted the temporal scope of the research. This led to a potential omission of relevant historical patterns.

Moreover, the dataset was limited to NASDAQ stocks that survived the crisis, potentially excluding companies that failed or were delisted. This introduces survivorship bias, which can influence the perceived benefits of diversification⁴⁶. Additionally in the case of simulations model

⁴⁴ (Jing-Rung Yu 2022)

⁴⁵ (Jing-Rung Yu 2022)

⁴⁶ (Elton, Gruber e Blake 1996)

like the Monte Carlo one, it was assumed that returns were normally distributed, and that volatility was constant. These assumptions oversimplify the crises and do not manage to capture all of the complex dynamics of financial crises⁴⁷.

5.3.2 Challenges in predicting financial crises

Financial crises are often triggered by rare and extreme events, such as the Covid-19 pandemic. These phenomena are highly unpredictable and have nonlinear contagion effects⁴⁸. This makes them difficult to model through the traditional frameworks. Taleb refers to such events as “Black Swans”: unpredictable and extreme events that catch us off guard and whose significance becomes clear only in retrospect⁴⁹. In his famous work *The Black Swan*, he argues that the human tendency to underestimate rare events contributes to systemic fragility.

Moreover, behavioral responses such as panic selling or sudden changes in investor sentiment, together with unpredictable regulatory decisions can amplify the systemic risk. This increase in risk is often difficult to capture with traditional economic models.

Finally, while many diversification models rely on the idea that correlations between assets stay steady, these relationships often break down during times of market stress – making tools that depend on historical data far less reliable⁵⁰.

5.4 Future Research Directions

⁴⁷ (Cont 2001)

⁴⁸ (Reinhart e Rogoff 2009)

⁴⁹ (Taleb 2007)

⁵⁰ (Longin e Solnik 2001)

Considering the findings and limitations of this study, there are several interesting paths that future research could take. These reflect the changing landscape of portfolio management and the ongoing need for smarter tools to improve diversification, especially during times of market stress.

5.4.1 Role of AI in crisis prediction

The emerging role of Artificial Intelligence (AI) and machine learning could be used as a tool to detect early signals of market stress. The ability of AI to process large data sets can capture nonlinear patterns and adjust to new data in real time. In addition, through news and social media, market sentiment can be detected easily⁵¹. Future research could help integrate AI forecast into diversification models or stress testing frameworks.

5.4.2 Impact of geopolitical risks on diversification strategies

Traditional risk models often overlook the impact of political risk factors such as sanction, trade wars, or armed conflicts. These factors can significantly the performance of financial assets, yet they are rarely incorporated into standard diversification frameworks. A clear example is the recent escalation of trade tensions involving the United States of America, which has introduced considerable volatility into global markets. Future studies could explore how well-diversified portfolios perform during periods of geopolitical instability⁵². A suggestion could be to integrate geopolitical risk indices into portfolio construction and stress-testing practices.

5.4.3 Emerging markets and diversification

⁵¹ (López de Prado 2018)

⁵² (Caldara e Iacovello 2022)

Emerging markets often exhibit distinct behaviors during periods of financial stress. Although they tend to be more volatile, their returns are not always closely aligned with those of developed markets⁵³. This lower correlation can enhance diversification, particularly during global downturns when traditional asset classes tend to move in tandem. Future research could examine the role of emerging market assets in building more resilient portfolios, with a focus on understanding both their diversification benefits and the risks associated with limited liquidity, political instability, or governance issues.

⁵³ (Bekaert e Campbell 2000)

Conclusion

This thesis aimed to understand whether diversification truly protects investors during times of financial stress. Focusing on the COVID-19 crisis, the findings show that when markets panic, asset correlations rise sharply – even among stocks that usually move independently. This weakens the main benefit of diversification, making portfolios more fragile when protection is most needed.

By analyzing a tech-heavy NASDAQ portfolio, it became clear that holding many assets is not enough. What matters is how those assets behave under pressure and with respect to each other. The inclusion of gold, which remained largely uncorrelated throughout all periods, improved the portfolio's stability and risk-adjusted returns. This proved that it is fundamental to choose assets that move differently from the rest.

These results challenge the idea that traditional diversification alone is enough. Investors should adopt more flexible strategies - ones that consider how asset relationships shift in real time during crises. While this study focuses on one specific event, its message is broader: to build stronger portfolios, we need to rethink how we define and apply diversification in today's markets.

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Appendix A – Excel Functions

1) Portfolio Returns Calculations

- AVERAGE (range)

Used to compute the average return on assets in the portfolio.

- STDEV.P (range)

Used to compute the standard deviation of daily returns to measure total volatility.

- CORREL (array1, array2)

Assesses the correlation between pairs of asset returns.

2) Risk-Adjusted Metrics

- =AVERAGE (range) / STDEV.P(range)

Used for the computation of the *Sharpe Ratio*.

- AVERAGE (range) / DSTDEV (range)

Used for the computation for the *Sortino Ratio approximation*, using filtered downside deviations.

- =IF (logical_test, value_if_true, "")

Applied to isolate negative returns for Sortino Ratio calculations.

3) Monte Carlo Simulation

- NORM.INV (RAND (), mean, std_dev)

Used to simulate daily returns based on normally distributed values, where mean and std_dev represent the daily historical return average and standard deviation for each stock.

- AVERAGE (range)

Calculated the mean of the final portfolio values across all simulation runs.

- =IF (condition, value_if_true, value_if_false)

Used for applying conditions within simulations, such as limiting drawdowns or controlling paths.

- PERCENTILE.INC (range, 0.05)

Used to compute the 5th percentile value, indicating downside exposure.

- MIN (range) and MAX (range)

Identified the worst possible and best possible simulated outcomes, respectively.

4) Solver Optimization Setup

- *Objective:* Maximize Sharpe Ratio cell
- *Variable cell:* Gold weight cell
- *Constraints:*
 - GoldWeight ≥ 0
 - GoldWeight ≤ 1
 - EquityWeight = 1 – GoldWeight

