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BIBLIOMETRIC ANALYSIS OF PORTFOLIO DIVERSIFICATION FOCUSING ON ALTERNATIVE INVESTMENTS

ABSTRACT: *Portfolio diversification, a key investment management strategy, traditionally involved stocks, bonds, and cash. However, the growing complexity of financial markets has led to increased interest in alternative investments such as hedge funds, private equity, real estate, commodities, and cryptocurrencies due to their low correlations with traditional assets. This study aims to explore the evolving role of alternative investments in portfolio diversification by conducting a bibliometric analysis of 405 articles from the Web of Science database. The analysis provides insights into the most frequently cited articles, journals, co-author teams, individual authors, organisations, and countries. Additionally, it includes sentiment analysis of abstracts, followed by keyword co-occurrence, bibliographic coupling, and co-citation analysis. The findings reveal a marked increase in research activity on alternative investments over the past five years, peaking in 2019. Key themes identified include portfolio optimisation, asset allocation, and the integration of traditional and alternative investments, underscoring the growing significance of alternative assets in modern investment strategies. These findings have implications for both the academic community and practitioners, enhancing the understanding of alternative investments in portfolio diversification and informing future research and investment strategies.*

KEY WORDS: *portfolio diversification, alternative investments, bibliometric analysis, data visualisation and analysis*

JEL CLASSIFICATION: G11, G15, C88, F36

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1. INTRODUCTION

In the realm of finance, portfolio diversification has long been recognised as a fundamental strategy for risk management and performance enhancement. Traditionally, diversification strategies have predominantly focused on a mix of equities, bonds, and other conventional financial instruments. However, the evolving financial landscape has ushered in a growing interest in alternative investments, which include assets such as real estate, private equity, hedge funds, commodities, and digital currencies. These alternative investments are increasingly being considered for their potential to enhance portfolio returns and mitigate risks, prompting a surge in scholarly research dedicated to their role in diversified portfolios (Ang et al., 2009; Baur & Lucey, 2010;).

The traditional approach to portfolio diversification, grounded in modern portfolio theory (MPT) proposed by Markowitz (1952), emphasises the balance of risk and return through the allocation of investments across various asset classes with low correlations. While equities and bonds have historically formed the core components of diversified portfolios, the financial crises and market volatilities of the past few decades have highlighted the limitations of relying solely on these traditional assets (Campbell et al., 2013; Longstaff & Schwartz, 1995). Consequently, investors and researchers have turned their attention to alternative investments, seeking additional avenues for risk mitigation and return enhancement (Fabozzi et al., 2002).

Alternative investments are characterised by their distinct asset classes and investment strategies, which often exhibit low correlations with traditional assets (Kat & Miffre, 2008; Schneeweis et al., 2010). This unique characteristic positions them as valuable components in a diversified portfolio, potentially reducing overall portfolio volatility and enhancing returns (Swensen, 2000). Despite their growing popularity, the academic literature on the integration of alternative investments into diversified portfolios remains fragmented, necessitating a comprehensive analysis to synthesise existing findings and identify research gaps (Amenc & Martellini, 2002).

To the best of our knowledge, no bibliometric analysis has been performed on portfolio diversification with a specific focus on alternative investments. A closely related study is ‘A bibliometric review of portfolio diversification literature’ by

Migliavacca et al. (2023), which focuses on portfolio diversification in general. Our study extends this work by specifically addressing the integration of alternative investments into diversified portfolios. Another related piece of research is Patel et al. (2022), which conducts a bibliometric analysis focused on financial markets integration. However, there is no content overlap between the studies, as market integration is only one of the numerous factors that have influenced portfolio diversification over the last decades.

By providing a targeted analysis of alternative investments, our study offers novel insights that are highly relevant for contemporary portfolio management. The increasing complexity of financial markets and the emergence of new asset classes necessitate an updated understanding of diversification strategies. Our findings can inform educators updating curricula, researchers identifying new areas of inquiry, and practitioners seeking to enhance portfolio performance through the inclusion of alternative assets.

This analysis provides a review of the evolution of portfolio diversification literature over the last fifty years. Bibliometric investigation, firmly established as a scientific approach and integral to research evaluation (Ellegaard & Wallin, 2015), allows for a quantitative and qualitative review of the portfolio diversification literature. By examining the contributions of various types of alternative investments, this analysis aims to deepen the understanding of their impact on portfolio performance and risk management. Considering this, our article addresses several research questions (RQs):

RQ1: What are the influential aspects of this stream of literature in terms of top journals, authors, most studied and least studied countries, influential and trending articles/topics?

RQ2: What are the key research streams in portfolio diversification literature?

RQ3: What are the trends in research on alternative investments in portfolio diversification over the last two decades?

RQ4: What are the main themes and findings in the literature regarding alternative investments and portfolio diversification?

Adopting the guidelines provided by Donthu et al. (2021), Øyna and Alon (2018), and Zott et al. (2011), this study performs bibliometric analysis of portfolio diversification articles published between January 1974 and January 2023 in the Web of Science (WoS) database. This descriptive part of the analysis identifies influential journals, authors, and articles, while the content analysis maps out key research streams and trends within the portfolio diversification literature (Ellegaard & Wallin, 2015).

Our contribution to the extant literature lies in our methodological approach, which uniquely focuses on alternative investments. We adopt a holistic research design that utilises both descriptive analysis and content analysis tools to organise research streams on portfolio diversification that include alternative assets, such as real estate, private equity, hedge funds, commodities, and digital currencies. This comprehensive framework allows us to provide a thorough assessment of portfolio diversification, starting from defining its broad domain and identifying the most influential articles, journals, and research groups specifically in the context of alternative investments. We then map portfolio diversification research avenues, visualising focus areas and trends related to these non-traditional assets and finally propose future research questions that may further expand the extant literature on alternative investments (Goodell & Goutte, 2021; Guesmi et al., 2019).

Thus, this study not only advances academic knowledge by synthesising and structuring the existing literature but also offers practical implications for investment professionals. By highlighting the growing importance of alternative investments in portfolio diversification, we provide insights that can aid in the development of more resilient and optimised investment strategies in today's dynamic financial markets.

The remainder of this paper is organised as follows: Section 2 provides an in-depth description of the methodological approach adopted. Section 3 presents the results of the bibliometric analysis, including descriptive analysis and the analysis of keywords, bibliographic coupling of articles, authors, and countries, as well as co-citation of references. Section 4 discusses the findings, while Section 5 suggests directions for future research. Finally, Section 6 concludes the paper.

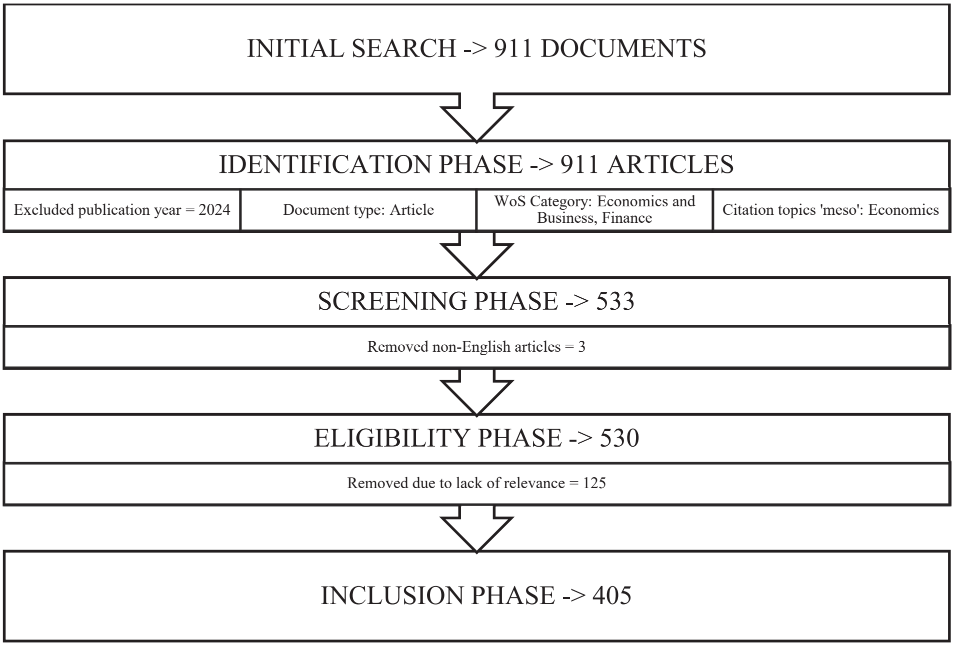
2. METHODOLOGY

A bibliometric review or bibliometric analysis serves as a research approach to examine the evolutionary development of scientific literature over time, shedding light on the intellectual relationships and diversity of knowledge within a field. For this study, we conducted a bibliometric analysis using data downloaded from the WoS database. The metadata was retrieved using a comprehensive search query based on terms such as: alternative assets, alternative investments, asset allocation, Bitcoin, commodities, digital currency, diversification, equity, hedge funds, portfolio, private equity, real estate, REITs, and virtual currency. This initial search produced a total of 911 documents. See the Appendix for details on the search query.

Furthermore, we utilised the PRISMA methodology to sift through the relevant articles. We applied specific filters to the WoS database in the initial identification phase. Initially, we excluded the year 2024 since it was ongoing, leaving us with 886 documents. Subsequently, we focused solely on articles as document types, reducing the count to 758. Further refinement was made by narrowing the categories to Economics and Business as well as Finance,–which reduced the number to 601 articles. To further narrow the selection, we included only those articles classified under the citation topics ‘meso’ for Economics, resulting in 533 articles.

During the screening phase, we focused on articles written in English, a common language in academic research, which resulted in a selection of 530 articles. In the subsequent eligibility phase, we applied rigorous criteria to narrow down the articles, carefully reviewing the abstracts and ensuring that each selected article was relevant to our study. This meticulous process excluded 125 articles, leaving us with a high-quality set of 405 articles for our analysis (Figure 1).

Figure 1: Visualisation of the PRISMA protocol



Source: Authors' compilation

3. RESULTS AND DISCUSSION

Our analysis began with a descriptive examination of the articles, in which we identified the most cited articles and annual publication trends as well as the most cited articles, author groups, individual authors, organisations, and countries. Additionally, we performed a sentiment analysis of the abstracts to gauge the general tone and sentiment expressed in the literature.

After conducting a descriptive analysis, we performed a more advanced bibliometric analysis using VOSViewer software (van Eck & Waltman, 2014). This included keyword co-occurrence analysis to uncover the relationships and common themes within the articles. Additionally, we carried out a bibliographic coupling of articles, authors, and countries to gain insights into the field's intellectual structure and collaboration patterns. Lastly, we conducted a co-citation analysis of references to pinpoint the most influential works and authors in portfolio diversification. This comprehensive approach gave us a profound understanding of the current state and trends in the literature on portfolio diversification and alternative investments.

3.1. Descriptive analysis

Building upon the previous discussion, a detailed examination of the most frequently cited articles (Table 1) reveals several notable trends and focal points within portfolio diversification and alternative investments. One prominent area of interest is the study of home bias, in which investors prefer domestic equities over foreign ones. This is underscored by several highly cited papers, highlighting a significant interest in comprehending investors' inclination towards local investments despite the potential advantages of international diversification. Home bias can potentially hinder optimal portfolio performance by constraining the opportunities for risk mitigation through diversification across global markets.

An important area of focus pertains to the advantages and mechanisms of international diversification. Various highly regarded articles delve into how investors can optimise their portfolios by incorporating international equities, which allows for risk diversification and potential improvement of returns. This topic is essential for individual and institutional investors seeking to offset risks linked to local market declines. The concept of asymmetric correlations, wherein equity correlations fluctuate under different market conditions, is also a significant study area. Understanding these correlations is crucial for portfolio management as it enables investors to foresee and handle risks, especially during market declines when correlations among assets tend to rise, thereby diminishing the benefits of diversification.

The increasing attention towards alternative assets, including hedge funds, commodities, and digital currencies, represents a significant trend. Studies on these assets underscore their potential for enhancing portfolio diversification strategies. For instance, incorporating hedge funds and commodities can provide diversification advantages owing to their minimal correlation with conventional equity markets. Similarly, digital currencies such as Bitcoin are being examined for their ability to hedge against conventional market fluctuations (Table 1).

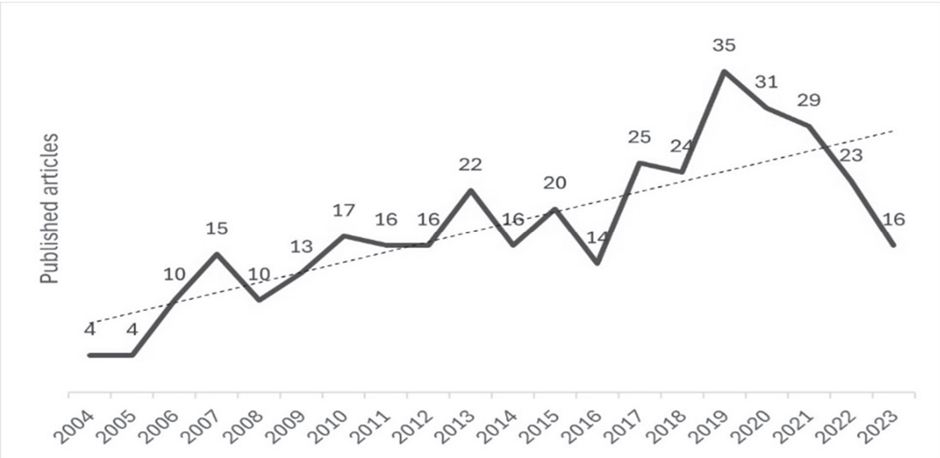
Table 1: The ten most cited articles

Article	Journal	Authors	Year	All databases' citations	WoS Core citations
Home bias at home: Local equity preference in domestic portfolios	The Journal of Finance	Coval, J. D.; Moskowitz, T. J.	1999	1493	1246
Investor diversification and international equity markets	The American Economic Review	French, K. R.; Poterba, J. M.	1991	1225	1056
Asymmetric correlations of equity portfolios	Journal of Financial Economics	Ang, A.; Chen, J.	2002	845	738
Why is there a home bias? An analysis of foreign portfolio equity ownership in Japan	Journal of Financial Economics	Kang, J. K.; Stulz, R. M.	1997	744	662
Risks and portfolio decisions involving hedge funds	The Review of Financial Studies	Agarwal, V.; Naik, N.Y.	2004	587	509
Equity portfolio diversification	Review of Finance	Goetzmann, W. N.; Kumar, A.	2008	566	498
Portfolio diversification with virtual currency: Evidence from Bitcoin	International Review of Financial Analysis	Guesmi, K.; Saadi, S.; Abid, I.; Ftiti, Z.	2019	362	355
Home bias in equity portfolios, inflation hedging, and international capital-market equilibrium	The Review of Financial Studies	Cooper, I.; Kaplanis, E.	1994	334	284
Should investors include commodities in their portfolios after all? New evidence	Journal of Banking & Finance	Daskalaki, C.; Skiadopoulos, G.	2011	234	210
US equity investment in foreign markets: Portfolio rebalancing or return chasing?	The American Economic Review	Bohn, H.; Tesar, L. L.	1996	223	204

Source: WoS database.

In addition, Figure 2 illustrates the annual trends in published articles on portfolio diversification focusing on alternative investments from 2004 to 2023. The data shows a general upward trajectory, indicating growing interest and increased research activity in this area. After a relatively low and stable period from 2004 to 2006, the number of publications began to rise in 2007. Despite some fluctuations, the overall trend continued upwards, peaking at 35 articles in 2019. Although there was a slight decline in subsequent years – with 23 articles in 2022 and preliminary data indicating 16 articles in 2023 – the research output remains significantly higher compared to the early years.

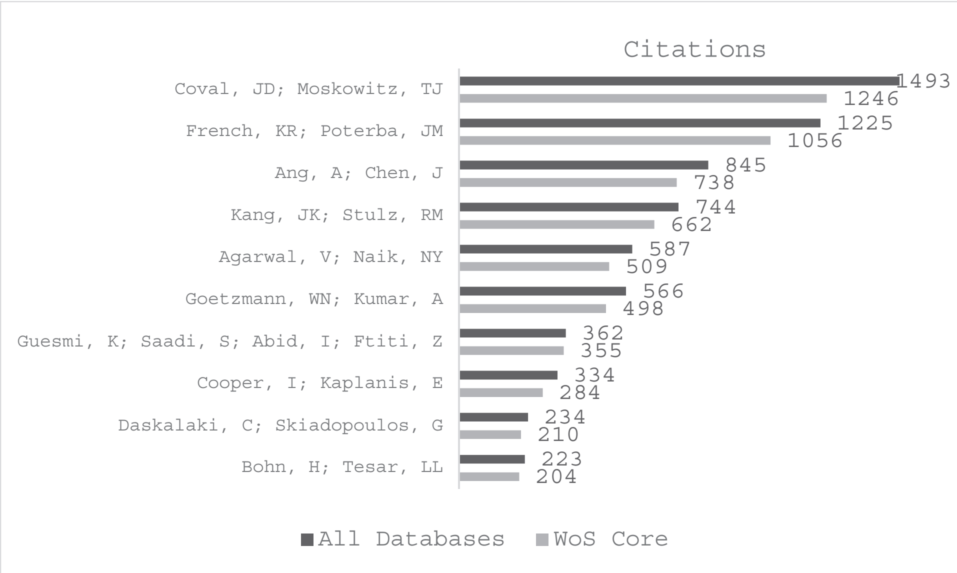
Figure 2: Annual trends of published articles



Source: WoS database.

Furthermore, Figure 3 presents the most cited authors (author groups) in all databases and the WoS database. Collaborative efforts by co-author teams account for 82% of the articles, emphasising the pivotal role of collaboration in producing influential research. This substantial percentage suggests combining diverse expertise and perspectives often leads to more comprehensive and impactful studies. The collaborative approach empowers researchers to tackle complex questions and devise innovative strategies, propelling the field more effectively.

Figure 3: The ten most cited author groups

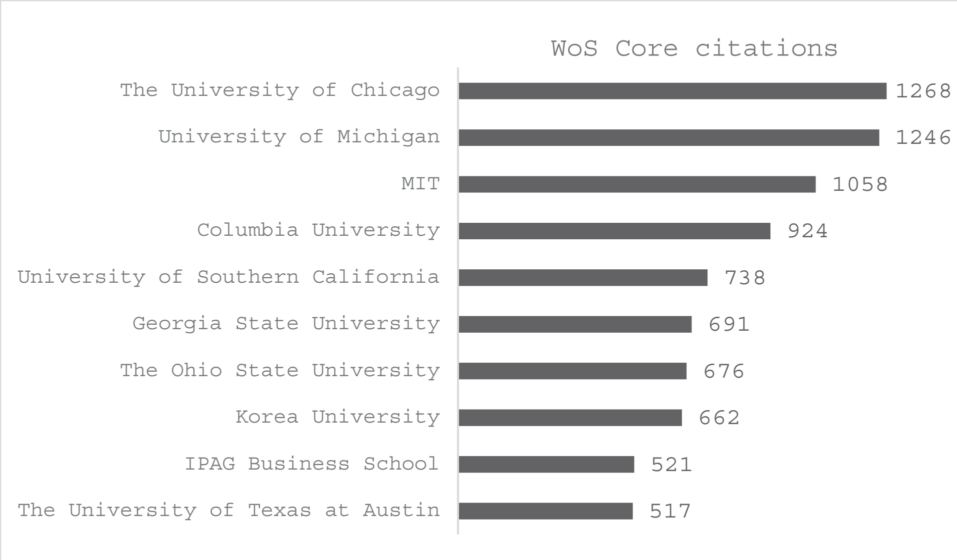


Source: WoS database.

In contrast, only 18% of the articles are authored by individuals. While these individual contributions remain significant, the lower percentage underscores the distinct advantage of teamwork in generating high-quality research. Individual authors often offer foundational insights and innovative ideas, but the scope and impact of their work are frequently amplified through collaborative endeavours.

Moreover, Figures 4 and 5 offer valuable insights into the organisations and countries most frequently cited in portfolio diversification with a focus on alternative investments. Figure 4 displays the top ten most cited organisations based on their WoS Core citations. Esteemed institutions such as the University of Chicago and the University of Michigan lead the list, with 1268 and 1246 citations, respectively. Other notable contributors include MIT, Columbia University, and the University of Southern California. These organisations are lauded for their significant research contributions to portfolio diversification, focusing on alternative investments, underscoring their influential roles in advancing knowledge and shaping the discourse within this field.

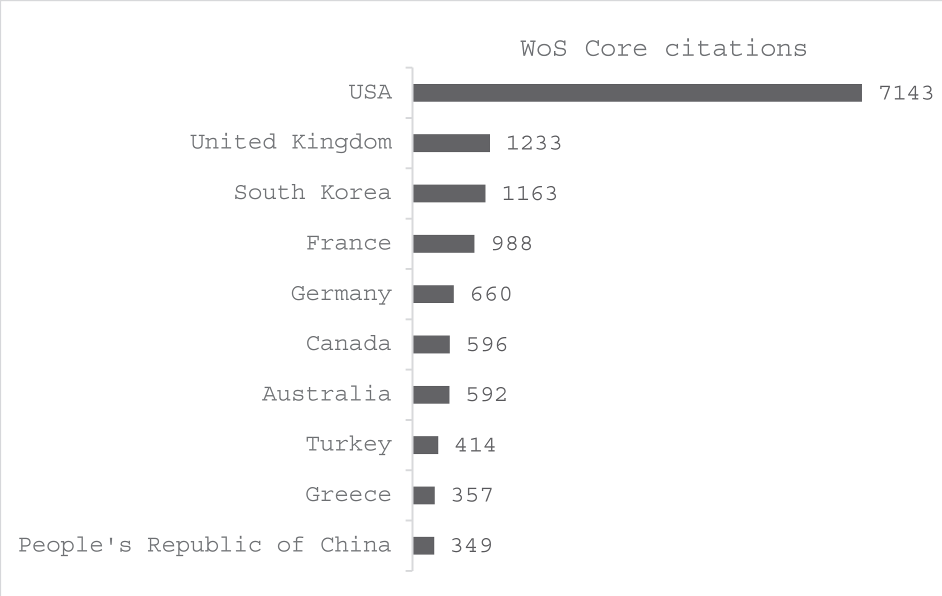
Figure 4: The ten most cited organisations



Source: WoS database.

In Figure 5, the focus shifts to the ten most cited countries, illustrating the global distribution of influential research in portfolio diversification with a focus on alternative investments. The United States leads the list with 7143 citations, firmly establishing its prominence in generating high-impact research. The United Kingdom (UK) and South Korea follow, with 1233 and 1163 citations, respectively, signalling their noteworthy contributions. Countries such as France, Germany, and Canada are also prominently featured, highlighting their active participation in portfolio diversification research. This international diversity underscores the widespread interest and collaboration across different regions in propelling advancements in the field.

Figure 5: The ten most cited countries

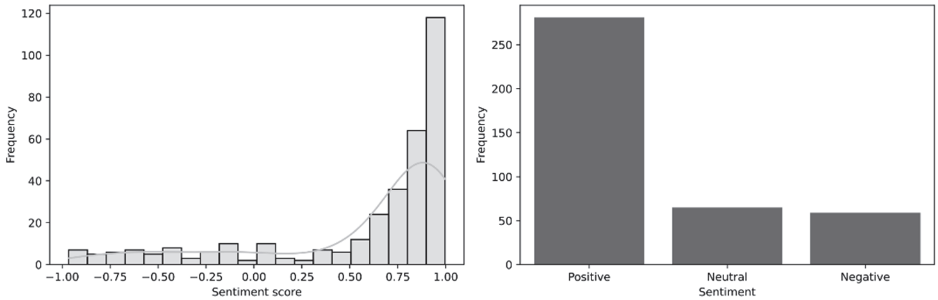


Source: WoS database.

Finally, Figure 6 presents the sentiment analysis of the abstracts, highlighting both the distribution of sentiment scores (ranging from -1.0 to 1.0) and the categorisation into positive, neutral, and negative sentiments. The distribution shows a significant clustering of positive sentiment scores, particularly between 0.75 and 1.0, indicating that the majority of abstracts convey a positive tone. Specifically, approximately 69% of the abstracts are classified as positive, 16% as neutral, and only about 15% as negative.

These findings suggest that the literature on portfolio diversification focusing on alternative investments predominantly reflects optimistic perspectives. This prevalence of positive sentiment may indicate that researchers are reporting favourable outcomes, successful strategies, or the benefits associated with alternative investments in diversification processes. Specifically, the positive sentiment could be attributed to the improved optimisation of portfolio diversification when alternative investments are included. By enhancing risk-adjusted returns and providing diversification benefits due to their lower correlation with traditional assets, alternative investments contribute to more efficient portfolios. This growing confidence in incorporating alternative investments is likely contributing to the optimistic tone observed in the literature.

Figure 6: Abstracts sentiment distribution and categories



Source: WoS database.

3.2. Analysis of keywords co-occurrence, bibliographic coupling and co-citation

The keyword co-occurrence and clustering analysis in portfolio diversification focusing on alternative investments identifies thirteen critical clusters, with 1008 links connecting these items and a total link strength of 1188, each reflecting significant themes and methodologies within the field. They form a network visualisation map, which is presented in Figure 7. The larger circles and labels on the map indicate greater weight, whereas smaller ones represent smaller weight and, in some cases, may not be presented to avoid overlapping and making the map difficult to follow. Based on how closely connected they are and the topic they correspond to, all items are grouped into clusters, which the map highlights in separate colours. Additionally, the items are connected with lines called links. Thus, the shorter the distance and the deeper the lines are, the stronger the relationship between the terms is.

This analysis focuses on the most important clusters to provide a deeper understanding of their contributions to the evolving landscape of portfolio diversification, particularly emphasising alternative investments. From all clusters, the terms that occur the most are (portfolio) diversification and asset allocation (occurrences: 73, links: 107, total link strength: 148); Bitcoin (occurrences: 20, links: 32, total link strength: 47); portfolio optimisation and portfolio choice (occurrences: 29, links: 47, total link strength: 52); and commodities (commodity futures) (occurrences: 23, links: 36, total link strength:

43). These terms highlight the significant focus on both traditional and alternative investments, underscoring the diverse aspects of portfolio diversification. Following these, terms such as hedge funds, real estate, portfolio construction, and volatility further emphasise the variety of investment strategies and asset classes considered in diversification research.

The first cluster, marked in red, is the most prominent with 71 occurrences and focuses on portfolio optimisation, equity markets, and risk models. This cluster is central because it combines advanced optimisation techniques with traditional equity markets and sophisticated financial risk modelling approaches. Portfolio optimisation involves maximising returns while managing risk, a fundamental aspect of modern portfolio theory. Equity markets provide essential opportunities for growth and income, serving as performance benchmarks, while financial risk models offer robust methods for assessing and mitigating potential financial risks, thereby enhancing the diversification and resilience of traditional portfolios.

The blue cluster, with 59 occurrences, highlights asset allocation, portfolio diversification, and volatility spillover. This cluster is crucial because it addresses the core strategies of distributing investments across various asset classes to balance risk and reward. Effective asset allocation considers factors such as investment horizon, risk tolerance, and market conditions to optimise portfolio performance. Portfolio diversification aims to reduce risk by spreading investments across different assets, industries, and geographies, thereby mitigating unsystematic risk. Understanding volatility spillover, or how volatility in one market or asset can impact others, is essential for maintaining portfolio stability and crafting resilient investment strategies.

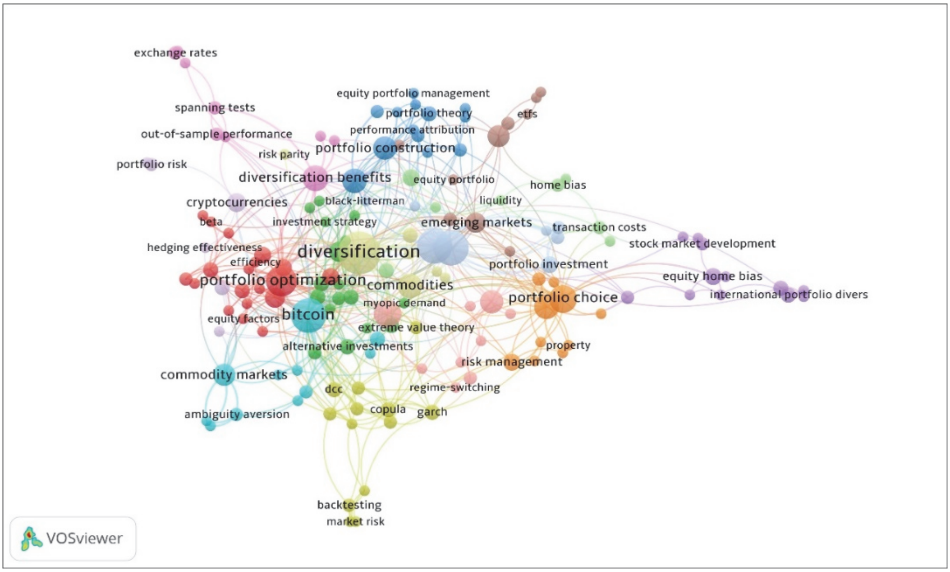
The yellow cluster, with 53 occurrences, focuses on diversification, commodities, and performance evaluation. This cluster emphasises the inclusion of non-traditional assets, such as commodities, in portfolios to provide diversification benefits and hedge against economic uncertainties. Commodities, with their low correlation to traditional stocks and bonds, enhance portfolio diversification and stability. Performance evaluation is critical in this context, as it involves assessing the effectiveness of diversification strategies through metrics such as returns and risk-adjusted returns, ensuring that the portfolio meets its investment objectives.

The green cluster, with 51 occurrences, delves into portfolio management, Islamic equities, and financial crises. This cluster's significance lies in its exploration of effective portfolio management strategies, especially during periods of financial turbulence. Portfolio management encompasses various strategies and practices aimed at achieving investment goals while managing risk. Islamic equities, adhering to Sharia principles, offer ethical investment opportunities and have shown resilience during financial crises. This cluster highlights the importance of understanding how different asset classes perform under stress and how they can be managed to mitigate risks effectively.

Finally, the turquoise cluster, with 50 occurrences, explores Bitcoin, commodity markets, and dynamic conditional correlation. This cluster is notable for its focus on emerging markets and such assets as Bitcoin, which offer unique risk-return profiles. The inclusion of digital currencies and commodities in portfolios represents the evolving nature of asset classes in modern finance. Dynamic conditional correlation models are used to analyse time-varying correlations between asset returns, providing insights into how different assets co-move over time.

Overall, these clusters collectively illustrate the evolving landscape of portfolio diversification research, with a particular focus on alternative investments. The integration of traditional and alternative assets, advanced optimisation techniques, and sophisticated risk management strategies are pivotal for developing robust investment portfolios. By incorporating emerging assets and effectively managing risks, researchers and practitioners can build portfolios capable of navigating diverse market conditions, ultimately contributing to more resilient and optimised investment strategies.

Figure 7: Network visualisation map of keyword co-occurrence



Source: WoS database.

Based on the overlay visualisation map (Figure 8), the focus in the field of portfolio diversification research has shifted over time. Initially, around 2012, the primary focus was on terms such as portfolio choice, portfolio investment, international portfolio diversification, emerging markets, equity home bias, hedge funds, and real estate.

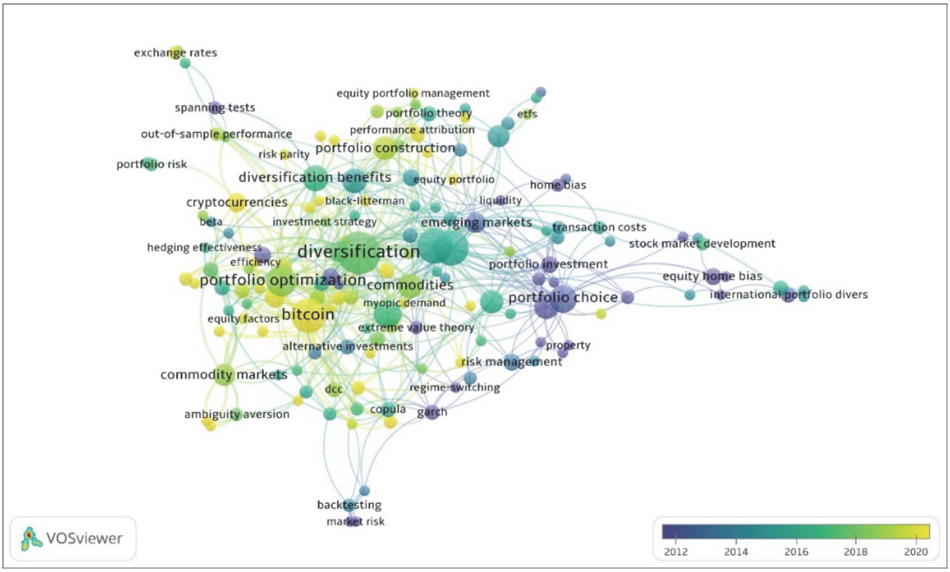
These concepts dominated the research landscape, reflecting a strong focus on optimising returns through established asset classes and mitigating risks associated with global equity markets.

However, more recent research trends, centered around 2020 and beyond, highlight a significant shift towards integrating alternative and innovative assets into diversified portfolios. This is evident from the increased focus on terms like ‘Bitcoin’, ‘cryptocurrencies’, ‘private equity’, and ‘digital assets’, which have gained prominence as investors seek new avenues for returns amid volatile market conditions. Alongside these, there is a growing interest in the role of ‘commodities’ and ‘commodity markets’, driven by their potential to act as hedges against inflation and economic uncertainties.

Further, modern portfolio management now encompasses advanced methodologies, such as 'dynamic conditional correlation' models, which allow for a more sophisticated analysis of time-varying relationships between assets. The focus on 'portfolio optimisation' and 'portfolio construction' remains strong, but it has expanded to include the use of algorithms and data-driven approaches to enhance performance measurement and risk management.

These evolving research trends indicate a critical shift towards embracing alternative investments and leveraging technological advancements for portfolio diversification. Researchers are increasingly exploring the implications of integrating these non-traditional assets, while portfolio managers are looking to optimise their strategies by incorporating such assets as digital currencies, commodities, and Sharia-compliant investments. This diversification is crucial for creating resilient portfolios that can withstand varying market conditions and achieve long-term investment goals.

Figure 8: Overlay visualisation map of keyword co-occurrence



Source: WoS database.

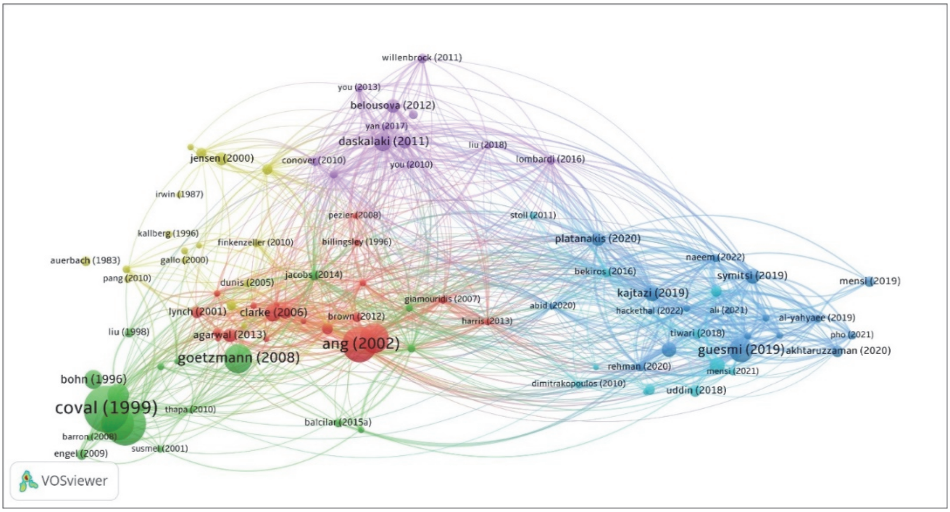
In addition, bibliographic coupling is employed in this study as a method within bibliometric analysis to identify relationships between research articles based on shared references, which helps in mapping the intellectual structure of a research field (Figure 9). This technique involves measuring the similarity between articles by counting the number of references they have in common, creating links between articles that cite the same sources. These links form a network of nodes (articles) and edges (shared references), which can be analysed to identify clusters representing interconnected themes and methodologies. In this study, six critical clusters within the field of portfolio diversification focusing on alternative investments were identified based on the thematic coherence and frequency of shared references among the articles (to enhance readability, only the first author is cited for works with multiple authors).

The first cluster (red) includes key works such as Ang (2002), Agarwal (2004, 2013), Clarke (2006), and Bali (2013), emphasising portfolio optimisation and diversification in equity markets. The second cluster (green) features works by Coval (1999), French (1991), Kang (1997), Goetzmann (2008), Cooper (1994), and Bohn (1996) focusing on portfolio management and equity home bias. The third cluster (blue) explores the integration of emerging assets, such as cryptocurrencies, with influential contributions from Guesmi (2019), Kajtazi (2019), Symitsi (2019), and Platanakis (2020).

Cluster 4 (yellow) emphasises commodities and performance evaluation, highlighted by significant studies from Jensen (2000, 2002), Cheung (2010), and Umar (2017). The fifth cluster (purple) delves into financial integration and international diversification, represented by Daskalaki (2011), Belousova (2012), Bessler (2015), and Willenbrock (2011). Lastly, the sixth cluster (orange) focuses on risk management and the integration of alternative assets, with notable works by Lin (2014), Uddin (2018), Guhathakurta (2020), and Bhatti (2012).

These clusters were identified based on the thematic coherence of the articles, with each cluster representing a distinct area of focus within portfolio diversification. The interconnectedness of research themes in portfolio diversification highlights traditional and alternative assets, advanced optimisation techniques, and sophisticated risk management strategies. This comprehensive and evolving nature of research underscores the importance of integrating diverse assets and effectively managing risks to develop resilient and optimised investment portfolios capable of navigating various market conditions.

Figure 9: Network visualisation map of articles' bibliographic coupling



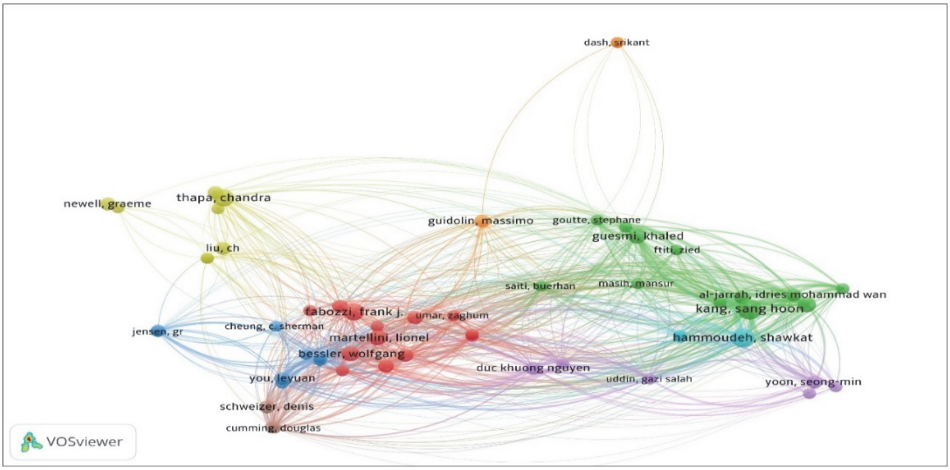
Source: WoS database.

In addition, the bibliographic coupling of authors was analysed to identify key thematic clusters (Figure 10). This analysis identified eight critical clusters also based on the thematic coherence and frequency of shared references among the authors. Cluster one (red) includes prominent authors such as Fabozzi, Platanakis, Bessler, and Sutcliffe. Cluster two (green) comprises notable contributors like Kang, Mensi, and Al-Jarrah. Cluster three (blue) features authors including Cheung, Daskalaki, Skiadopoulos, and You, while cluster four (yellow) includes Thapa, Poshakwale, Liu, Newell, and Ni. Cluster five (purple) features Duc Khuong Nguyen, Sjo, and Yoon, whereas cluster six (turquoise) comprises Hammoudeh, Balcilar, and Demirer. Cluster seven (orange) includes authors such as Guidolin, Dash, and Moran and finally, cluster eight (brown) features Schweizer, Cumming, and Hass.

The clusters identified in red, green, and blue are particularly relevant due to their strong interconnections and the prominence of their authors in the field. This interconnectedness underscores critical facets of contemporary portfolio diversification research, including the integration of diverse asset classes, the application of advanced optimisation techniques, and the implementation of sophisticated risk management strategies.

Moreover, the bibliographic coupling of authors is crucial for generating new ideas, methods, and instruments in the field. By understanding how different researchers are interconnected through their references, it becomes possible to identify emerging trends, foster collaborations, and stimulate innovative approaches in portfolio diversification and alternative investments. This analysis not only maps the current intellectual landscape but also paves the way for future research directions, contributing to the development of more resilient and optimised investment portfolios.

Figure 10: Network visualisation map of authors' bibliographic coupling

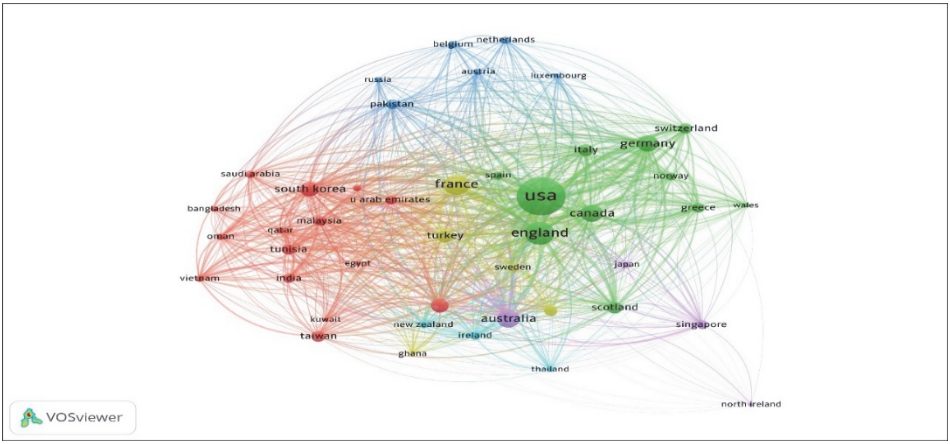


Source: WoS database.

Finally, we analysed the bibliographic coupling of countries, resulting in the identification of six distinct clusters (Figure 11). This analysis reveals how countries are interconnected based on the shared references in their scholarly publications, indicating similarities in research interests and academic focus areas in the field of portfolio diversification with a focus on alternative investments. Cluster one (red), includes South Korea, China, and Tunisia. The bibliographic coupling among these countries suggests that researchers from these nations frequently cite similar literature related to portfolio diversification and alternative investments. While we cannot determine the exact thematic focus without further analysis, the shared references indicate a common interest in specific topics within the field, potentially reflecting collaborative research efforts or parallel academic interests. Cluster two (green), comprising the USA, the UK, Germany, Canada, and Greece, represents countries with strong research output in finance and economics. This suggests a shared engagement with core theories and methodologies that advance the field, reflecting their contributions to leading global financial research. Cluster three (blue), includes Pakistan, Russia, and the Netherlands. The shared references among these countries point to mutual research interests in portfolio diversification strategies. This suggests that, despite differences in their economic contexts, researchers from these nations engage with similar scholarly works, possibly exploring topics such as risk management, investment in alternative assets, or the dynamics of emerging markets. However, precise themes would require further investigation. Cluster four (yellow), features France, Turkey, and Sweden. While the specific themes cannot be ascertained without deeper analysis, this coupling may reflect shared academic interests or collaborations in certain aspects of alternative investments. Cluster five (purple), encompasses Australia, Singapore, Northern Ireland, and Japan. The shared bibliographic links among these countries suggest a collective engagement with specific topics in portfolio diversification and alternative investments. Researchers may be focusing on areas such as the impact of global trade on investment strategies, the integration of alternative assets into portfolios, or regional financial challenges. Cluster six (turquoise), consists of Ireland, New Zealand, and Thailand. It indicates that researchers cite similar references, pointing to shared interests in innovative portfolio diversification strategies. This may reflect a focus on tailoring investment approaches to their specific market conditions or exploring niche areas within alternative investments.

These clusters underscore the global interconnectedness and collaborative nature of research in portfolio diversification. The bibliographic coupling of countries reveals how scholars across different nations build upon shared foundational literature, leading to collective advancements in understanding and implementing alternative investments within diversified portfolios. While the exact thematic focuses within each cluster require deeper exploration, the coupling highlights significant academic linkages and potential areas for future collaborative research.

Figure 11: Network visualisation map of countries' bibliographic coupling



Source: WoS database.

The co-citation network graphs provide a comprehensive visualisation of the intellectual structure and prominent themes within the same field. Reference co-citation analysis is a bibliometric method that examines how frequently pairs of references are cited together in subsequent publications, thereby revealing the relationships and thematic clusters within a body of literature. This analysis helps identify influential works and emerging trends by highlighting the interconnectedness of scholarly contributions.

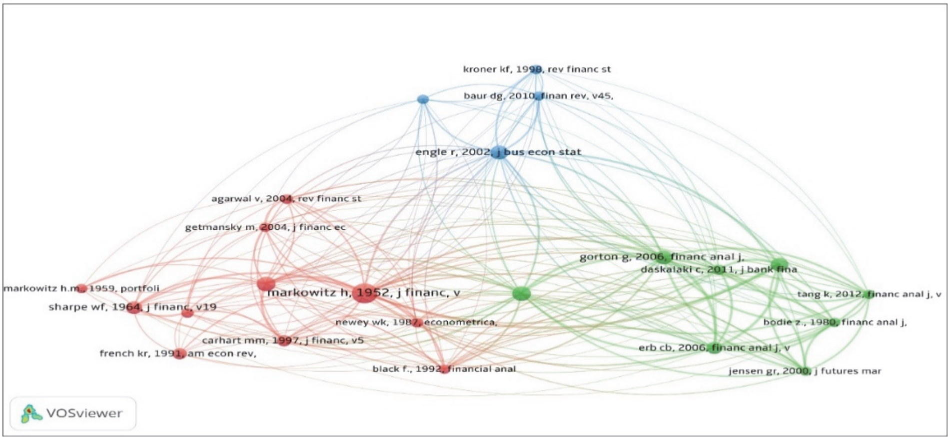
In this analysis, the graph (Figure 12) is divided into distinct clusters, each representing a thematic grouping of highly co-cited references. Cluster one (red), centred around Markowitz's seminal 1952 paper in *The Journal of Finance*, highlights foundational works on portfolio theory, as well as the capital asset pricing model and the efficient market hypothesis, including significant contributions by Sharpe (1964) and Fama and French (1993). These works are critical in the development of modern portfolio theory and asset pricing models.

Cluster two (green), prominently featuring the 2009 publication of DeMiguel et al. in *The Review of Financial Studies*, addresses the challenges of estimation errors in portfolio optimisation models, offering insights into the practical limits of theoretical diversification benefits. Additionally, Gorton and Rouwenhorst's 2006 publication contributes significantly to this cluster, highlighting critical analyses of financial instruments and their market behaviours. Additionally, contributions by Erb and Harvey (2006) and Daskalaki and Skiadopoulos (2011) enrich the cluster's focus on the practical implications and performance of financial instruments, particularly in the context of alternative investments.

Cluster three (blue), with Engle's 2002 work in the *Journal of Business & Economic Statistics*, encapsulates the advancements in econometric models and time-series analysis applied to finance. This cluster features key references, such as Baur and Lucey (2010) and Engle (1982), which have significantly contributed to the understanding of volatility and co-movement in financial markets.

The graph elucidates the interconnectedness of these clusters through co-citation links, demonstrating how foundational theories in finance are built upon and interconnected with empirical research and advanced econometric methods. These works collectively contribute to a nuanced appreciation of the complexities involved in optimising investment portfolios, highlighting both the theoretical advancements and practical challenges inherent in achieving diversification benefits.

Figure 12: Network visualisation map of references co-citation



Source: WoS database.

4. DISCUSSION

The findings from this bibliometric analysis offer a comprehensive overview of the evolving landscape of portfolio diversification, particularly with a focus on alternative investments. The increasing attention towards alternative assets, as highlighted in this study, underscores the growing importance of these assets in modern investment strategies. The results reveal significant trends, key contributors, and thematic shifts that have shaped the research field over the last five decades.

A primary observation is the significant increase in research activity on alternative investments. This surge reflects broader market movements, where both investors and researchers increasingly recognise alternative assets as effective tools for enhancing portfolio resilience and mitigating risks associated with traditional assets, such as equities and bonds. Due to their distinct characteristics, such as low correlation with conventional assets, alternatives present an attractive option for constructing more resilient portfolios.

Sentiment analysis of abstracts points to a predominantly positive outlook on portfolio diversification involving alternative investments. This favourable tone may reflect the successful outcomes of recent studies, validating the efficacy of innovative strategies with alternative assets. Moreover, keyword co-occurrence and clustering analyses reveal an array of approaches, from portfolio optimisation to the inclusion of cryptocurrencies and digital assets, underscoring the field's dynamic nature. Advanced techniques, including dynamic conditional correlation models, factor-based investing, and other sophisticated optimisation tools, are increasingly employed to enhance portfolio construction. This shift signals an evolution from traditional asset management towards more sophisticated, resilient investment solutions.

For practitioners, the growing emphasis on alternative investments suggests that integrating assets such as cryptocurrencies, commodities, private equity, and digital assets can enhance portfolio diversification. Their unique attributes and low correlations with traditional assets offer potential for reduced overall risk and enhanced returns. Advanced optimisation and risk management tools are essential for creating resilient portfolios. As alternative investments become more integral to diversification strategies, their benefits may be even more pronounced over longer investment horizons. Understanding volatility spillovers can help practitioners craft robust strategies that incorporate alternatives for improved stability, especially during market downturns.

For researchers, these insights open avenues for exploring new dimensions of portfolio diversification, potentially leading to novel theories and models. Educators, too, can leverage these findings to enhance curricula, ensuring students are well-prepared for the evolving financial landscape by exposing them to contemporary topics such as digital assets and advanced risk management.

In conclusion, this bibliometric analysis maps out key research streams, influential contributors, and emerging trends in portfolio diversification with a focus on alternative investments. The study bridges academic insights with actionable strategies, offering value to researchers and practitioners alike. The field is poised to evolve further as financial innovations, methodological advancements, and global dynamics drive research, setting the foundation for more robust and effective diversification strategies in the years to come.

5. DIRECTIONS FOR FUTURE RESEARCH

With the growing complexity and dynamism of financial markets, the role of alternative investments in portfolio diversification has become increasingly significant. This section highlights current trends, challenges, and opportunities for future scientific research in this area. The insights gained from this work will inform the development of more resilient and optimised investment portfolios, particularly as alternative assets continue to evolve in response to market demands. Moreover, we focus on the following aspects and emerging trends expected to shape the landscape of portfolio diversification in the upcoming period:

1. Deeper analysis of understudied keywords: While mainstream keywords such as 'commodities' and 'digital currencies' dominate the literature, future research should focus on less-commonly researched terms such as 'infrastructure investments,' 'blockchain technology,' 'impact investments,' 'intellectual property rights,' and 'sustainable investing.' Analysing the interconnectedness of these keywords and their impact on portfolio performance could provide novel insights into diversification strategies.
2. Expansion of data sources: The majority of studies rely heavily on data from such prominent databases as Web of Science and Scopus. Future research could benefit from incorporating a wider range of databases, including Google Scholar, SSRN, and industry-specific repositories. This broader scope

would not only enhance the analysis but also capture more diverse perspectives and methodologies.

3. Impact of big data and artificial intelligence (AI) on portfolio diversification: The advent of big data and AI presents new opportunities for enhancing portfolio management. Future studies should investigate how these technologies can be integrated with traditional and alternative investments to improve predictive analytics, risk assessment, and decision-making processes. Specifically, exploring the role of machine learning algorithms in optimising diversification strategies could yield significant advancements.
4. Development of hybrid investment models: Combining traditional financial models with alternative investment strategies is a promising area for future research. The development and empirical testing of hybrid models that integrate elements of modern portfolio theory, behavioural finance, and machine learning could lead to more effective and resilient portfolio management frameworks.
5. Longitudinal studies on alternative investments: Conducting longitudinal studies to track the performance and risk characteristics of alternative investments over extended periods can provide a deeper understanding of their long-term benefits and drawbacks. This approach can help identify patterns and trends that are not apparent in short-term analyses.

By addressing these areas, future research can significantly contribute to the evolving landscape of portfolio diversification, offering innovative solutions and practical insights that enhance the effectiveness of investment strategies in a rapidly changing financial environment.

6. CONCLUSION

The objective of this study was to conduct a comprehensive bibliometric analysis of existing research on portfolio diversification, specifically focusing on alternative investments. Utilising data from peer-reviewed articles indexed in the Web of Science database, we provided a detailed citation analysis, identified annual publication trends, highlighted top authors, journals, and countries, and synthesised the findings to pinpoint research hotspots and future trends.

Our analysis reveals a significant rise in scholarly attention towards alternative investments as they relate to portfolio diversification, especially within the last five years. A peak in publication activity observed in 2019 reflects a heightened recognition of alternative assets – such as cryptocurrencies, commodities, private equity, and digital assets – within both academic and practitioner domains. This shift underscores the expanding role of alternative assets in building diversified, resilient portfolios in a rapidly transforming financial landscape. The unique characteristics of these assets, particularly their low correlation with traditional investments, highlight their potential to mitigate risk and optimise returns, positioning them as essential components in modern investment strategies.

The journals with the most significant impact in this field include the *Journal of Financial Economics*, *The Journal of Finance*, and *The American Economic Review*, reflecting their critical role in disseminating influential research. The United States emerged as the leading country in terms of both the number of publications and citations, followed by the UK and South Korea, highlighting their substantial contributions to the global discourse on portfolio diversification.

Through keyword co-occurrence analysis, our study identifies core thematic areas, such as portfolio optimisation, asset allocation, and the integration of traditional and alternative investments. These themes reflect shifting priorities in the field, underscoring a progressively nuanced understanding of diversification strategies that leverage alternative assets to enhance investment performance. Additionally, bibliographic coupling and co-citation analyses illuminate the intellectual structure and collaborative networks within the research community, revealing distinct clusters focused on various aspects of portfolio diversification. These clusters offer insights into the diverse methodological approaches and theoretical frameworks driving advancements in the field.

Despite the comprehensive nature of our study, it is important to acknowledge its limitations. The dataset was limited to articles indexed in the Web of Science database, which, although extensive, may exclude relevant studies from other databases such as Scopus, Google Scholar, and SSRN. Future research could benefit from incorporating these additional sources to provide a more holistic view of the literature. Furthermore, while VOSviewer provided valuable insights through network visualisations, other bibliometric tools such as Bibliometrix in R, Gephi, and Leximancer offer alternative analytical perspectives that could complement and enhance these insights in subsequent analyses.

In conclusion, this bibliometric study offers a nuanced understanding of portfolio diversification research, with particular attention to the growing role of alternative investments. By mapping influential works, identifying leading contributors, and elucidating thematic trends, the study establishes a foundation for future research aimed at expanding theoretical frameworks and empirical methods. For scholars, the findings emphasise the value of interdisciplinary and collaborative approaches to examining the complex dimensions of diversification. For practitioners, the insights offer actionable guidance on incorporating alternative investments to construct portfolios that are resilient to market volatility and adaptable to an evolving global financial environment. Ultimately, this study bridges academic insights and practical applications, providing a valuable resource for understanding the contributions of alternative investments to robust and diversified investment strategies.

This research is well-positioned to inform and inspire future studies that may explore the nuances of alternative asset classes, refine diversification models, and assess the implications of advanced analytics, such as machine learning in portfolio construction. As the financial landscape continues to evolve, so too will the frameworks and strategies underpinning effective diversification, driven by innovations in both theoretical and practical domains.

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