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Asset allocation models: evolution and diversity – a systematic literature review

Bolivar Godinho de Oliveira Filho
Academic Department of Management,
Escola Paulista de Política Economia e Negócios,
Universidade Federal de São Paulo, Osasco, Brazil, and
Johan Hendrick Poker Junior
Faculdade de Ciências Aplicadas, Universidade Estadual de Campinas,
Limeira, Brazil

Abstract

Purpose – This study aims to provide a comprehensive overview of asset allocation by conducting a systematic literature review and a bibliometric analysis.
Design/methodology/approach – Employing a Preferred Reporting Items for Systematic Reviews and Meta-Analyses-based methodology allows for rigorous mapping of the academic landscape.
Findings – An analysis of this topic reveals a significant increase in asset allocation research since 2013, driven by a growing focus on advanced modeling and risk metrics. This study identifies distinct research clusters, with topics such as behavioral finance and alternative assets gaining prominence in the literature. Furthermore, the most prolific authors on this topic are Zhang, WG, and Zhou, XY.
Research limitations/implications – This review contributes to a more comprehensive understanding of this field by delineating the evolution and diversity of asset allocation models. The limitations of this study are the potential publication bias (English/Scopus/WoS selection) and the dynamic nature of asset allocation models, especially in the current dynamic environment.
Practical implications – Asset and risk managers must keep up with ongoing innovations to apply their knowledge and create value for investors. The study's findings highlight critical research gaps related to the practical application of advanced models, particularly in the context of environmental, social and governance investing and sustainable portfolio construction.
Social implications – The management of third-party resources impacts society because of the substantial resources and participation in pension plans and investment funds.
Originality/value – By combining a systematic literature review with bibliometric analysis, this study offers a unique and transparent framework for understanding the evolution and diversity of asset allocation models.

Keywords Asset allocation models, Asset management, Portfolio optimization
Paper type Literature review

1. Introduction

Resource managers rely on academic research in asset management. Asset allocation models are essential for informing decisions regarding the selection of assets that comprise investment fund portfolios. Investment funds are a primary means of resource allocation in global financial and capital markets. According to the Investment Company Institute (ICI, 2024), the total global net assets of investment funds reached US$ 68.9 trillion in 2023.

Markowitz (1952) pioneered the field of asset management, inspiring models aimed at maximizing the efficiency of resource allocation, such as the Capital Asset Pricing Model (CAPM) introduced by Sharpe (1964).

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Over time, these models have evolved and become more complex, incorporating diverse scenarios and variables. This led to the development of multifactor models, such as the Fama and French Three-Factor Model (Fama and French, 1993). Furthermore, several other models began incorporating behavioral sciences into their analyses, inspired by the work of Kahneman and Tversky (1979). These models consider the risks and uncertainties in their analyses and highlight the subjectivity inherent in investment decisions, which are not solely predicated on expected returns.

Despite the growing body of scholarly work on specific models, a comprehensive overview of asset allocation remains scarce. This study aims to address this gap by exploring asset allocation through a review of classical seminal articles, followed by a systematic review and bibliometric analysis of the theme of asset allocation. By combining different methods, this study allows for a more robust analysis that enables the identification of trends and gaps in the field.

Other authors have conducted literature reviews on asset allocation, but their work has focused on specific models, such as static and dynamic models (Wachter, 2010), the Markowitz mean-variance model, the Merton dynamic model (Detemple, 2014), robust portfolio selection (Ghahtarani *et al.*, 2022), and higher-order moments (Mandal and Thakur, 2024).

The objective is to analyze the state of the art in the asset allocation literature and identify the main models, as well as their practical and theoretical evolution. To this end, a rigorous selection of articles was carried out using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology to enable the methodological analyses proposed by the paper. After identifying the main articles based on the selection criteria, their abstracts were read to identify the models and trends of the studies.

This research is innovative because it unites different methods to highlight the gaps and trends in the field. This study allows future work to utilize the presented models to make capital allocation more efficient and integrate different models that can address diverse and complex scenarios.

This made it possible to relate the different methods and identify a growing advancement in the theme of asset allocation within Behavioral Finance concepts, demonstrating that investment decisions are subjective, consider uncertainties and risk aversion, and are not always rational decisions based on utility. Furthermore, the evolution of models towards more complex multifactor models that consider this behavioral aspect, making them more realistic and practically applicable, was demonstrated.

This study aimed to address the following research questions:

(1) How have asset allocation models evolved over time?

(2) What gaps exist in the current asset allocation research that future studies can address?

(3) Which sources, articles, and authors are the most influential in this research area?

2. Methodological procedures

For the systematic review, this study used the PRISMA tool for the protocol and flowchart of identification, analysis, and selection of the most relevant articles on asset allocation models. Therefore, the process involved the initial identification of studies on the topic in scientific databases, screening based on the determined criteria, elimination of duplicate articles, reading abstracts, and selection of the most relevant studies based on the established criteria.

The PRISMA methodology serves as a standardized framework that contains the guidelines used for conducting systematic reviews and meta-analyses. It serves as a guide to identify, select, and synthesize the most relevant studies to minimize bias and maximize the quality of the analyses, ensuring clarity and transparency in the search process, inclusion

criteria, and results through clear documentation of this process. Through its transparency, this method ensures the reproducibility of the study and the reliability of the findings and is widely accepted in the scientific community (Page *et al.*, 2020).

A systematic review is a scientific methodology that gathers relevant information from selected studies based on determined criteria, minimizes bias, and provides a comprehensive and reliable view of the literature on the topic (Higgins and Green, 2011). This methodology has been used by recent and well-conceptualized Systematic Literature Reviews (SLRs) in financial markets, such as the SLR on passive investment by Malhotra (2024), corporate governance (Elhabib, 2024), nomination and remuneration committees (Putra and Setiawan, 2024), and short-sale constraints and stock returns (Khan, 2024).

In addition to this systematic review, we conducted a bibliometric analysis of asset allocation using the selected articles. Bibliometric analysis is a technique for analyzing scientific production using metrics such as citations, co-authorship networks, and keyword occurrences. A meta-analysis review allows for the identification of patterns and trends in a study topic. It is also possible to identify gaps in the literature among other uses, potentially complementing systematic reviews (Donthu *et al.*, 2011).

The initial selection of the sample was carried out in stages, starting with a database search, filtering based on criteria, and reading the abstracts to identify asset allocation models. The search was conducted using two different databases, Web of Science (WoS) and Scopus.

Scopus and Web of Science are widely recognized multidisciplinary academic databases that index highly relevant scientific publications and offer tools for bibliometric analysis, such as impact metrics and citations, which are essential for research and evaluation of global scientific production.

In the Scopus database, the search conducted with the keywords "Asset Allocation Model or Portfolio Allocation Model or Portfolio Selection Model" yielded 1,059 results. By selecting only articles, this number was reduced to 779 results; by defining only articles in English, 735 remained. The search was further refined by subject area: mathematics, computer science, economics and finance, business, management decision sciences, engineering, and social sciences. Selection of these subject areas yielded 715 articles.

Next, the search was refined using the following keywords: portfolio selection, portfolio selection models, investments, portfolio optimization, portfolio selection problems, asset allocation, linear programming, fuzzy portfolio selection, efficient frontier, stochastic models, robust optimization, portfolio selection model, portfolio model, optimal portfolios, mean variance model, mean variance, Markowitz, portfolio, mean-variance portfolios, constrained optimization, mean-variance model, portfolio optimization, portfolio choice, multi-period portfolio selection, diversification, project portfolio selection, portfolio management, multi-period portfolio selections, mean-variance, dynamic portfolio selection, multi-objective optimization, mean-variance portfolio selection, efficient portfolio, portfolio investment, portfolio allocation, multiperiod portfolio selections, fuzzy portfolio optimization, portfolio strategies, portfolio management, optimal portfolio selection, constrained portfolios, Black-Litterman, and Black-Litterman models.

A total of 515 articles were identified by selecting the cited keywords. The selection was defined to include only articles in the final stage of publication, leaving 505 articles, which were further refined by articles from journal sources, leaving 503 articles to work on the remaining selection and analysis criteria.

The same search terms were used in the WoS database, which initially yielded 661 studies. After selecting only articles, 479 works remained, of which 478 were in English. The following subject areas were selected, leaving 444 articles to work with in the selection and analysis: operations research management science, economics, computer science artificial intelligence, business finance, mathematics application, mathematics interdisciplinary applications, management, computer science interdisciplinary applications, computer science information systems, engineering multidisciplinary, social sciences mathematical

methods, business, mathematics, multidisciplinary sciences, statistical probability, computer science software engineering, interdisciplinary social sciencesnary.

The total number of the articles selected by WoS and Scopus was 947; however, after removing duplicates, 660 studies remained. The selection criterion for this study was the use of articles published in the most important journals, with an impact factor in the first and second quartiles. The Scimago Journal website was used to rank the journals for impact selection. Thus, when only articles published in the most important journals were selected, 163 articles were selected, of which nine did not have abstracts and were removed from the selection, leaving 154 articles.

A filter was applied based on the number of citations. To select the most important articles, they should have at least one citation per year, except for articles from 2023 to 2024, which, being more recent, were included regardless of the number of citations. There were a total of 19 articles from 2023 to 2024, in addition to 77 articles with at least one citation per year. 58 articles with a citation rate of less than one were excluded, leaving 96 articles for subsequent analyses.

Finally, the abstracts were read, classifying the articles according to their adherence to the topic, with increasing scores, where five were those focused on asset modeling, and a score of four was given to those not necessarily focused on modeling but containing asset allocation models in their articles, and three for those articles that might mention some model, but the article is not about the topic.

The selected articles were those that reached an adherence score of 4 and 5, with the other articles with a score of 3 or less being removed from the selection, removing a total of 15 articles from the selection, leaving 81 articles for carrying out the analyses proposed in this study.

Table 1 reports the review process with a detailed PRISMA 2020 flow diagram that summarizes the rigorous process of selecting articles with the respective criteria and quantities that met these criteria.

3. Literature review of seminal articles

The asset allocation theory was propelled by the seminal work of Markowitz (1952), who created the foundation of Modern Portfolio Theory by formulating a mathematical basis for the

Table 1. PRISMA flow diagram

Steps	Filtration criteria	Excluded	Accepted
Identification	Records identified through keywords and Boolean operators: Asset Allocation Model or Portfolio Allocation Model or Portfolio Selection Model		
	Registers Scopus		1,059
	Registers Web of Science (WoS)		661
Screening	Non-article records or those not published in English	507	1,213
Eligibility	Duplicate removed	287	926
	Filtration on the basis of the subject areas: mathematics, computer science, economics and finance, business, management decision sciences, engineering, and social sciences	254	672
	Excluded for not being journal articles	12	660
	Filter for top journals in the Scimago Journal website, with an impact factor in the first and second quartiles	497	163
	Filter for number of citations criterion at least one citation per year, except for articles from 2023 to 2024	58	105
	Filter for adherence to the theme after reading abstracts	15	90
Included	Articles with no abstracts	9	81

Source(s): Authors' own work

idea of diversification in forming investment portfolios in a way that balances risk and return. He innovated by demonstrating that assets previously evaluated individually should be evaluated collectively, showing that it is possible to construct an investment portfolio that maximizes returns for a given level of risk or a dual problem that minimizes risks for a given level of return. Thus, the concept of diversification was introduced, showing that it is possible to reduce the risk of a portfolio by combining different assets, as well as the concept of the Efficient Frontier, which is the search for the maximum return for a given risk or the minimum risk for a given return, creating an optimal boundary where any investment outside this boundary might not be optimized in terms of either return or risk, with better investments being possible for the same level of return or risk as the chosen one.

This relationship was further deepened in another study by Markowitz (1959), who provided a more robust technical basis for asset allocation. In his work, the author addressed practical scenarios, expanding the mathematical analysis of the efficient frontier and detailing the portfolio optimization process, consolidating the theoretical foundations of efficient diversification.

Sharpe (1964) introduced the Capital Asset Pricing Model (CAPM), an asset pricing model widely used by the market, that measures the relationship between risk and return based on the idea that investors seek to maximize their return for a given level of risk, extend Markowitz's mean-variance concept, and provide a mathematical model for asset pricing in which expected returns are linearly related to market beta, which measures systematic risk. Furthermore, the author introduces a distinction between the concepts of risk: systematic risk, which affects the entire market and cannot be diversified (such as exchange rates and interest rates); and non-systematic risk, which is the specific risk of an asset or company and can be reduced through diversification, as events can be compensated for within a diversified portfolio (examples of this risk include bankruptcy risk or a management change).

Lintner (1965), almost simultaneously with Sharpe, laid the groundwork for CAPM, demonstrating the relationship between expected returns and systematic risk, meaning that the return of an asset should be adjusted for systematic risk, and the risk premium of an asset is proportional to its beta, demonstrating the linear relationship between return and risk. This model can also be applied to company projects and corporate decision-making. Along the same lines, Mossin (1966) contributed to CAPM by establishing a theory of market risk premiums by introducing the concept of a market line, which relates the expected return to the standard deviation of return.

Jensen (1968) contributed to the topic of asset pricing with the introduction of a measure for evaluating the performance of investment portfolios, making it possible to assess investment strategies and fund managers. Jensen's Alpha, as it is called, represents the difference between the actual return of a portfolio and the expected return based on the portfolio's systematic risk (beta). The author demonstrated that in efficient markets, managers rarely manage to deliver returns above the market, and this method is used to evaluate investment strategies and fund managers' abilities.

Black (1972) developed a model that extends the CAPM, considering the constraint that some investors cannot borrow, as the traditional model assumes that all investors can borrow and lend at a risk-free interest rate (which allows for the construction of optimal portfolios). One of the main innovations is the introduction of an equilibrium model without a risk-free asset, proposing that in a market where borrowing is restricted, investors cannot adjust their portfolios to obtain the desired risk exposure. Equilibrium is achieved with risky assets to optimize portfolio returns and risk, without relying on a risk-free asset as a reference point. Thus, it provides a more realistic perspective on market behavior.

Black and Scholes (1973) proposed a widely used and seminal option pricing model that became the basis of the modern derivatives theory. The model establishes a formula for pricing call options based on factors such as the current stock price, strike price, time to expiration, risk-free interest rate, and volatility of the underlying asset. By introducing a mathematical approach, they transformed the option pricing process, which was previously predominantly

subjective. Although it has revolutionized the financial market, one of its limitations is the exclusion of transaction costs, which should be considered for practical adjustments. Nevertheless, this study introduced a tool for the valuation of derivatives and liabilities, bringing greater precision and consistency to the pricing of financial assets.

The Black-Scholes model was expanded by Merton (1973) to a wider range of more flexible conditions, without the need for some assumptions, such as a constant interest rate and the possibility of dividend payments, making it more realistic.

Fama and MacBeth (1973) created a two-stage regression method that has been widely used to estimate risk premiums in asset pricing models.

Ross (1976) introduced Arbitrage Pricing Theory (APT), a more comprehensive and flexible approach than CAPM, which considers multiple factors that influence asset returns and serves as the basis for modern multifactor models. APT incorporates macroeconomic factors that systematically affect returns, such as interest rates, inflation, and economic growth. Unlike CAPM, APT does not depend on a market in equilibrium but is based on the absence of arbitrage opportunities to correct discrepancies in asset pricing, ensuring that prices reflect fair values.

Kahneman and Tversky (1979) represent a milestone in behavioral economics, redefining how we understand decisions under risk and uncertainty, introducing Prospect Theory, and showing that decisions are not guided solely by expected returns. Therefore, human decisions often violate the assumptions of rationality. According to this theory, certain outcomes are preferred over probabilistic outcomes, even when associated with lower returns, with individuals being more inclined. Individuals tend to avoid losses, rather than seek equivalent gains.

Konno and Yamazaki (1991) proposed an alternative model to the traditional model based on the mean-variance approach, employing the mean absolute deviation (MAD) as a measure of risk instead of variance. This model is linear, computationally less complex, more practical, and less sensitive to extreme returns; thus, it is more robust under market conditions with non-normal return distributions, especially useful in emerging markets or in scenarios where covariance data are scarce or unstable under non-normal return distributions, particularly useful in emerging markets or situations with scarce or unstable covariance data.

Fama and French (1993) expanded the CAPM model through by developing a multifactor model (the Fama-French Three-Factor Model) that helps explain variations in stock returns using factors beyond market risk. The model includes market risk, company size, and the relationship between book and market value, which are fundamental factors that affect returns.

Carhart (1997) furthers the study of equity fund performance by adding the momentum factor to the Fama-French Three-Factor model. This factor represents the tendency of assets with good recent performance to continue performing well in the short term. The author found that, in general, the superior performance of funds does not persist in the long term, meaning that superior performance does not guarantee superior performance in the future.

Artzner *et al.* (1999) studied the measurement of financial risk, introducing the concept of a coherent risk measure, defining the four properties that should define a coherent risk measure its four defining properties: monotonicity, subadditivity, positive homogeneity, and translation invariance and challenging the use of VaR (Value at Risk) as a coherent measure, arguing that the metric does not incentivize diversification. The authors propose Expected Shortfall (ES), also called Conditional Value at Risk (CVaR), as an alternative to VaR, which calculates the average of losses exceeding VaR, and offers a more robust measure for scenarios with high volatility or heavy tails.

Rockafeller and Uryasev (2000) introduced a method to efficiently calculate and optimize ES or CVaR, which can be directly applied as a constraint or objective in portfolio optimization problems, facilitating financial decisions based on aversion to extreme losses. The calculation of CVaR considers losses beyond a predefined limit, allowing VaR to be calculated as a by-product of CVaR, making it more applicable to practical scenarios and offering a broader risk assessment.

DeMiguel *et al.* (2009) compared the equally weighted diversification strategy among assets with the optimization strategy, demonstrating that more sophisticated strategies do not always outperform, suggesting that naive diversification can be advantageous when market conditions are unstable, historical data are limited, when there is uncertainty in future returns, or even when the number of assets in the portfolio is high.

Elton *et al.* (2012) contribute to Portfolio Theory and Investment Analysis by deepening Markowitz's modern portfolio theory and CAPM, exploring diversification and portfolio selection to determine the efficient frontier, introducing multifactor models for risk and return analyses, and considering additional factors, such as company size and value.

However, in multifactor models, Fama and French (2015) refined the three-factor model, including two more factors to explain variations in asset returns, adding the profitability factor and the investment rates factor. According to these studies, companies with lower investment rates and higher profitability tend to obtain higher returns.

Hartzmark and Sussman (2019) investigated whether investors prefer sustainable funds by analyzing the impact of ESG ratings on fund inflows and examining the effects of Morningstar's 2016 on net investment flow. They demonstrated investors' preferences for the shares of sustainable companies and showed that transparency and availability of information affect investment decisions. Investors showed willingness to accept lower financial returns to invest in more sustainable stocks.

4. Systematic review and bibliometric analysis

In this section, a Bibliometric Analysis and Systematic Review are presented. Regarding the Bibliometric Analysis, according to the definition by Higgins and Green (2011), the table of the number of journals that published the most on the topic (along with the impact factor of each of these journals), the number of keywords that most frequently appeared in the selected articles, the authors who published the most in the area, and the most cited articles are presented. In terms of the systematic review, the table with the most frequently identified models is presented, as well as the table of the most cited articles, which by definition fall under Bibliometric Analysis but were used to complement the systematic review. Table 2 reports the number of journals that published the most articles in the study area.

Table 2. Journals with the most publications

Journal	Number
Journal of the operational research society	6
North american journal of economics and finance	6
Quantitative finance	6
Computational economics	5
Economic modeling	5
Journal of global optimization	4
Mathematical finance	4
Finance research letters	3
Empirical economics	2
Ima journal of management mathematics	2
International review of financial analysis	2
Journal of Asset Management	2
Journal of Banking and Finance	2
Journal of econometrics	2
Operational research	2
Opsearch	2

Source(s): Authors' own work

It is noticeable that there are a reasonable number of journals with four or more publications and several others with two or three articles on the topic, indicating that the theme is of broad interest to the scientific community, even considering that this selection comprises only 81 articles that met the established criteria. Figure 1 shows the publication years of these articles.

The graph demonstrates a clear trend of increasing research in the field of asset allocation over the years, showing growing academic interest in the field.

An analysis was performed using the VOSviewer tool to identify the co-occurrence of keywords. The 81 articles were compiled into an RIS file, and analysis was performed using keyword co-occurrence and the full counting method. The minimum number of co-occurrences was three, and the number of keywords was 31. Consequently, VOSviewer created five clusters. Figure 2 shows the clusters obtained.

Cluster 1 - Portfolio Selection (eight items): cost, finance, integer programming, loss aversion, optimization, portfolio selection, risk assessment, and robust optimization.

Cluster 2: Stochastic models (eight items): conditional value-at-risk, linear programming, multi-objective optimization, risk parity, scenario tree, stochastic models, stochastic programming, and stochastic systems.

Cluster 3: Investments (seven items): Commerce, dynamic portfolio selection, financial data processing, financial markets, investments, portfolio selection models, and portfolio strategies.

Cluster 4: Portfolio optimization (four items): mean variance, portfolio, portfolio optimization, and value-at-risk.

Cluster 5: Asset Allocation (three items): asset allocation, copula, and risk measures.

The analysis of keyword occurrences using VOSviewer in five clusters indicates that articles published from 2020 onwards highlight keywords related to risk metrics and advanced modeling, such as scenario tree, conditional value-at-risk, robust optimization, and risk parity. Figure 3 shows the keywords map.

The following conceptual map illustrates the objectives and foundations of the main asset allocation model. Other SLRs use conceptual mapping as a synthesis technique, such as Tranfield *et al*. (2003).

The mean-variance model by Markowitz (1952) created the foundation of Modern Portfolio Theory but was limited by prescribing short positions in many assets. Black and

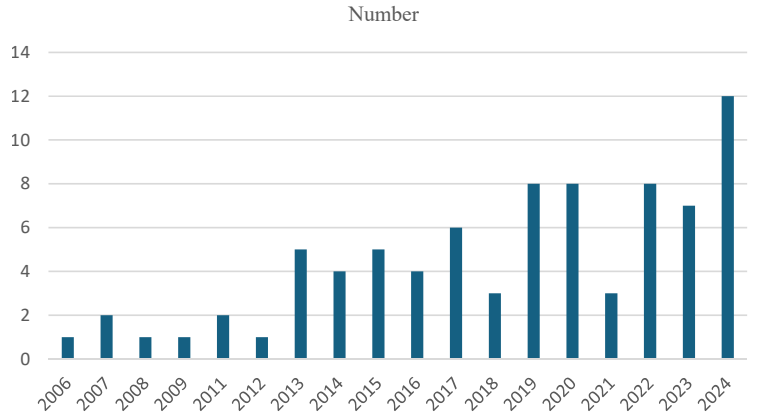

Figure 1. Year of publication of selected articles. Source: Authors' own work

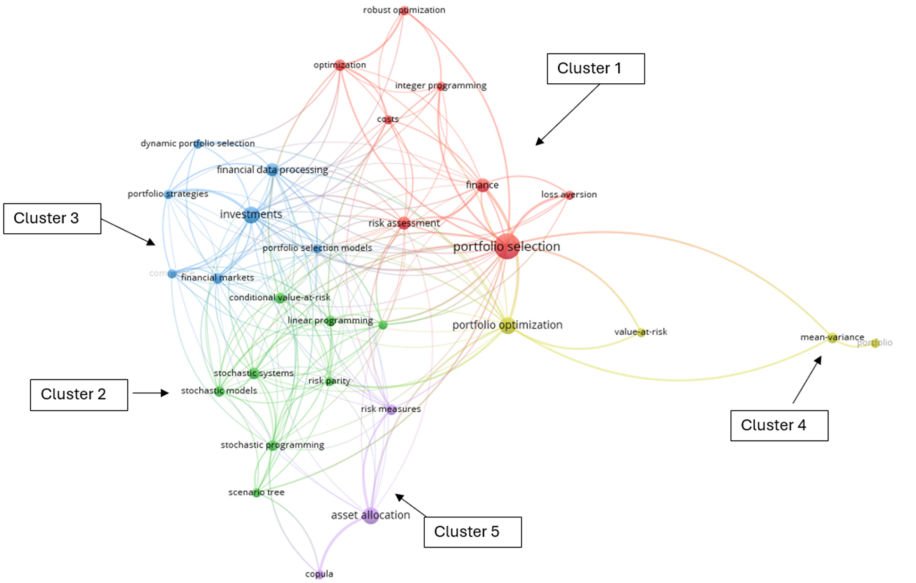

Figure 2. Network visualization. Source: Elaborated by the authors using VOSviewer

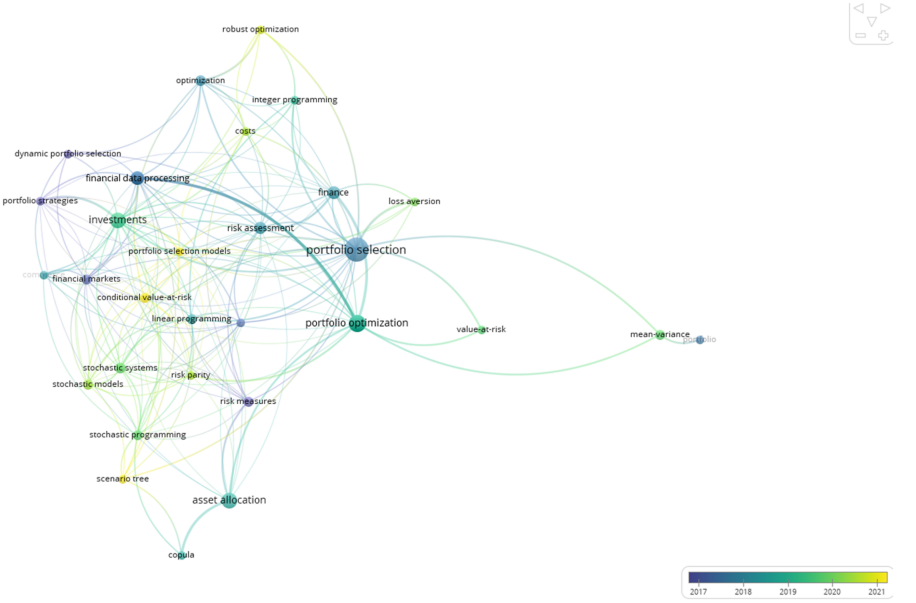

Figure 3. Keywords map. Source: Elaborated by the authors using VOSviewer

Litterman (1992) corrected this by combining the mean-variance model with the CAPM model by Sharpe and Lintner. Stochastic models incorporate the probability theory and scenario analysis, making them more realistic. The Conditional Value-at-Risk (CVaR) focuses on

potential losses in the tails of the distribution, aligning with the behavioral insight of investors' loss aversion. The use of CVaR allows for the integration of traditional models with Prospect Theory by Kahneman and Tversky (1979), giving rise to behavioral models. These models incorporate both investors' and market sentiments, demonstrating their effectiveness in achieving higher investment returns per unit of risk than conventional models. Figure 4 shows the conceptual map.

Table 3 presents the number of keyword occurrences in the articles selected using VOSviewer.

Table 4 shows the authors with the highest number of publications in the study area.

It is noted that there are several authors with more than one publication in the area, showing that it is a field of great interest to the scientific and financial community, with some authors standing out with more publications on the topic, such as Zhang, WG and Zhou, XY, who have four publications among the articles that met the rigorous selection criteria, including one selected work co-authored with Markowitz.

Table 5 presents the number of citations of each selected article.

The number of most-cited articles falls under Bibliometric Analysis; however, the results can help complement the systematic review. The most cited article develops a portfolio selection model based on the Cumulative Prospect Theory by Kahneman and Tversky, which is used in Behavioral Finance. Unlike traditional models based on utility maximization, this model addresses behavioral preferences that reflect loss aversion and distorted perceptions of probabilities, considering psychological aspects in decision-making. In the most cited articles, it is also possible to identify one of the authors as one of the most cited articles in Table 4 (Zhou, XY), who appears again among the most frequently cited articles.

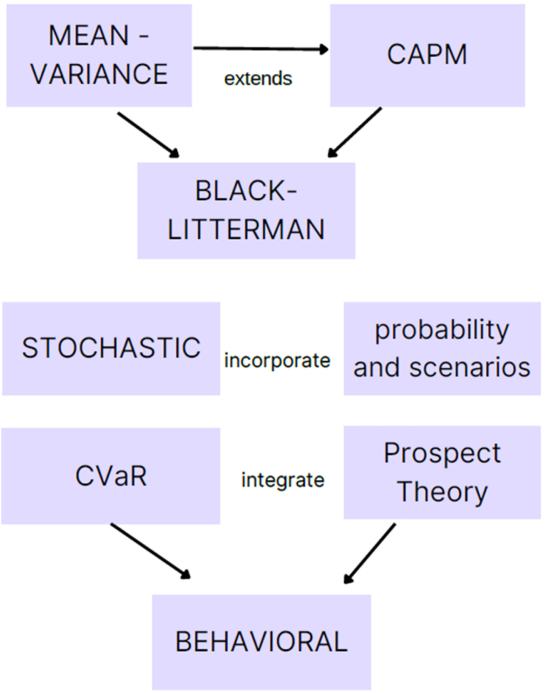

Figure 4. Asset allocation models–conceptual map. Source: Authors' own work

Table 3. Keywords occurences

Keywords	Ocorrences	Total link strength
Portfolio selection	24	13
Investments	10	10
Portfolio optimization	10	9
Finance	6	6
Financial data processing	6	6
Risk assessment	6	6
Optimization	5	5
Stochastic systems	5	5
Asset allocation	9	4
Stochastic programming	4	4
Financial markets	4	4
Linear programming	4	4
Stochastic models	4	4
conditional value-at-risk	4	3
Portfolio strategies	3	3
Risk parity	3	3
Portfolio selection models	3	3
Commerce	3	3
Copula	3	3
Costs	3	3
Integer programming	3	3
Loss aversion	3	3
Mean-variance	4	3
Multiobjective optimization	3	3
Robust optimization	3	3
Scenario tree	3	3
Risk measures	4	2
Value-at-risk	3	2
Dynamic portfolio selection	3	2
Portfolio	3	1
Fuzzy portfolio selection	3	0

Source(s): Authors' own work

The second most-cited work demonstrates that high exchange rate volatility leads investors to prefer low-return, low-volatility domestic assets in the local currency using a traditional Markowitz model for this purpose.

The third most cited also studies individual risk aversion preferences, including the study of subjective characteristics in decision making and understanding how individual risk perceptions shape portfolio composition.

Table 6 presents the Identification of models based on the reading of the selected articles, showing those that were repeated the most frequently.

In the table identifying the models, the occurrence of models for tail risk measures and extreme loss management is noted, as shown by the occurrence of CVaR four times, indicating the loss aversion behavior sought by investors. It is also possible to highlight a combination of approaches from traditional models that use advanced modeling techniques. Furthermore, the double occurrence of other models based on behavioral psychology (such as Prospect Theory) and loss aversion is noted, showing that there is an evolution in portfolio selection that seeks to blend robust mathematical models with more realistic investment behaviors. Table 7 shows risk measures used by the models.

This section has managed to elucidate, in some way, the state of the art of the current literature regarding asset allocation and portfolio selection, carrying out a bibliometric

Table 4. Authors with the most publications

Authors	Number
Zhang, WG	4
Zhou, XY	4
Chen, ZP	3
Jiang, CX	3
Esfahanipour, A	2
Ji, BB	2
Kim, H	2
Kim, WC	2
Li, J	2
Liu, J	2
Seifi, A	2
Wolff D	2
Zhu, SS	2
Bessler W	2
Cesarone F	2
Chen, ZP	2
Jin, HQ	2
Liu, YJ	2
Momen, O	2
Xu, QF	2

Source(s): Authors' own work

Table 5. Most cited articles

Article title	Authors	Year of publication	Number of citations
Behavioral portfolio selection in continuous time	Jin, HQ; Zhou, XY	2008	188
Home bias in global bond and equity markets: The role of real exchange rate volatility	Fidora, M; Fratzscher, M; Thimann, C	2007	169
Cost-sensitive boosted tree for loan evaluation in peer-to-peer lending	Xia, YF; Liu, CZ; Liu, NN	2017	132
Do commodities add value in multi-asset portfolios? An out-of-sample analysis for different investment strategies	Bessler W.; Wolff D	2015	106
Multi-asset portfolio optimization and out-of-sample performance: an evaluation of Black–Litterman, mean-variance, and naïve diversification approaches	Bessler W.; Opfer H.; Wolff D	2017	74
Portfolio selection with monotone mean-variance preferences	Maccheroni, F; Marinacci, M; Rustichini, A; Taboga, M	2009	47
Interval portfolio selection models within the framework of uncertainty theory	Li X.; Qin Z	2014	42
Markov-switching asset allocation: Do profitable strategies exist	Bulla J.; Mergner S.; Bulla I.; Sesboüé A.; Chesneau C	2011	40
Stable distributions in the Black-Litterman approach to asset allocation	Giacometti R.; Bertocchi M.; Rachev S.T.; Fabozzi F.J.	2007	36
Data-driven robust mean-CVaR portfolio selection under distribution ambiguity	Kang, ZL; Li, X; Li, ZF; Zhu, SS	2019	35

Source(s): Authors' own work

Table 6. Identification of models

Model	Number
Conditional Value-at-Risk (CVaR)	4
Mean-Variance	3
Efficient Frontier-Based Model	3
Copula-GARCH Model	3
Minimum-Variance	2
Prospect Theory	2
Dynamic Portfolio Selection Model	2
Parametric Quadratic Programming	2
Risk Parity	2
Chance-Constrained Approach	2
Downside Risk Model	2
Mean-CVaR	2
Behavior-Based Sparse Portfolio Model (BPSM)	2
Black-Litterman Model	2

Source(s): Authors' own work

Table 7. Risk measures used by the models

Risk measures	Models
Mean-Variance, Mean-VaR, Mean-Conditional VaR	Black–Litterman, Mean-variance
Below-mean absolute, semi-deviation	Multi-objective optimization
Variance	Robust portfolio
Variance and higher moments (e.g. skewness, kurtosis)	Multi-period Portfolio Selection with Fuzzy Returns
Volatility	Markov-switching asset allocation
Conditional Value-at-Risk (CVaR)	Risk Parity, Dynamic robust portfolio, robust mean-CVaR portfolio
Drawdown duration (average, maximum, and tail)	Portfolio model for optimizing drawdown duration
Robust version of variance	A robust markowitz mean-variance portfolio selection
Value-at-Risk (VaR)	Nonlinear portfolio selection, mean-VaR portfolio selection model
Semivariance	Mean-semivariance portfolio selection model
Beta	A multiple objective stochastic portfolio selection
S-shaped utility function and probability distortions	Behavioral portfolio selection
Liquidity risk, loss-averse utility, chance constraint	Behavioral portfolio
Spectral risk measure	A robust behavioral portfolio selection

Source(s): Authors' own work

analysis and systematic review for this purpose, which, added to the theoretical framework, can complement each other to conduct a discussion on the studied topic, which will be discussed in the next section.

5. Discussion

A joint analysis of the procedures allowed us to identify interesting trends and gaps that deserve highlighting. The identification of the models in each article showed that 14 of them had a frequency greater than one, with none having a significantly different frequency from the others, but it is possible to perceive some interesting trends.

First, the plurality of approaches to models that attempt to represent the various factors that can influence portfolio selection can be highlighted. However, it also demonstrates a certain lack of standards or consensus in the literature regarding the best way to represent investment decisions, allowing us to identify a gap for future research to explore the integration of the complementary characteristics of existing approaches, combining different models to offer greater effectiveness and applicability.

The table presented with the identification of the models highlights a balance between more traditional models, such as mean-variance, and more complex approaches, such as CVaR. Growth in models that reflect the approach not only of return but also of the importance of dealing with extreme risks was observed. In addition, other models have demonstrated behavioral focuses, such as Prospect Theory and the Behavior-Based Sparse Portfolio Model (BPSM), and more complex mathematical models (Copula-GARCH).

This trend towards advanced models and behavioral approaches can be reinforced by several keywords that appear in the count. For example, with the exception of the most recurrent general words, conditional value-at-risk, Copula, Garch, Mean-Variance, and Risk measures can also be cited, translating and reinforcing other findings regarding subjective perceptions and modeling of uncertainties and risk aversion.

In the analysis of the most cited articles, the same trend observed in the model identification table is noticeable: a growing exploration of behavioral finance in the literature. The article Behavioral portfolio selection in continuous time (Jin and Zhou, 2008) relates behavioral finance to mathematical models of asset allocation, exploring concepts such as loss aversion, distorted perceptions of probability, and behavioral biases in portfolio selection, going against traditional utility optimization models. Meanwhile, the article Subjective measures of risk aversion, fixed costs, and portfolio choice (Kapteyn and Teppa, 2011) explore how behavioral characteristics and fixed costs shape portfolio selection, highlighting that the integration of subjective preferences and practical constraints is essential to arrive at more realistic models, opening space for methodologies that integrate subjective uncertainties and dynamic preferences in the field of asset allocation. Furthermore, the second most-cited article by Fidora *et al.* (2007), Home bias in global bond and equity markets: The role of real exchange rate volatility, provides a theoretical basis for understanding how psychological and structural factors affect investment decisions.

Therefore, the evolution of the literature reflects a search to align mathematical models based on utility maximization with those that reflect the more realistic behavior of investors, seeking to incorporate the concept of loss aversion and decision-making based on psychological or behavioral factors.

Thus, the different methods of analysis complement each other in such a way that, together, they demonstrate the growth of more complex models that can consider more behavioral, psychological, and subjective aspects, thus making them more realistic and open space for the literature to further explore this integration of traditional models with practical aspects in investment decision-making. This gap presents an opportunity for future research to consolidate or integrate the most effective characteristics of these models into a unified structure.

This bibliographic review and meta-analysis offer theoretical and practical contribution by identifying the following research gaps in asset allocation:

(1) Develop optimization models to control the duration of portfolio drawdown, in addition to existing models, to control the magnitude of the drawdown.

(2) Identify evidence showing the superiority of the Black-Litterman model in out-of-sample optimization compared to mean variance, minimum variance, or naive diversified portfolios.

(3) Investigate nonlinear portfolios containing more types of assets, such as bonds, swaps, and derivatives, beyond European options.

(4) Investigate the performance of different copula models, asset allocation horizons, asset classes, and asset return frequencies.

(5) Incorporate exogenous factors into the models to assess their impact on the estimation of mean and variance-covariance.

(6) Investigate the impact of dynamic rebalancing on asset allocation.

(7) Evaluate the performance of the Black-Litterman portfolio for return estimates that are not historical.

These gaps will enable research with practical applications of advanced models, particularly in the context of ESG investing and sustainable portfolio development. Institutional investors and pension funds can benefit from advances in combining different models to gain greater effectiveness and applicability in measuring the performance of various asset classes, controlling the magnitude of losses by mitigating risks, and defining investments compatible with their objectives.

6. Conclusion

This study was motivated by the following research question: How have asset allocation models evolved over time? What are the research gaps? Which articles and authors are the most influential? The analysis reveals a significant increase in asset allocation research since 2013, driven by a growing focus on advanced modeling and risk metrics. It identifies distinct research clusters, with topics such as behavioral finance and alternative assets gaining prominence in the literature. The findings of this study highlight the critical research gaps related to the practical applications of these advanced models. Several authors with more than one publication in the area show that it is a field of great interest to the scientific and financial community, with some authors standing out with more publications on the topic, such as Zhang, WG, and Zhou, XY, who have four publications.

This study conducted a systematic literature review and bibliometric analysis of asset allocation and portfolio selection models, as well as a literature review of the most important seminal articles in the field, with the aim of elucidating the state-of-the-art literature on the subject. The first part of the study presents the main theoretical works in the area, showing its evolution from the pioneering work of Markowitz (1952) on Asset Management to the current, more complex, and comprehensive multifactorial models.

Data selection performed rigorously using the PRISMA tool, which is recognized in the literature and aids in the clarity and rigor of the selection. The initial search was comprehensive, but the criteria used were strict, selecting only articles published in journals in English, with filters that included the impact factor of the publishing journals, citation rate, and adherence criteria to the topic, until it was finally possible to analyze the abstracts of each article in greater depth. This search was conducted in two important databases, WoS and Scopus, and keywords were selected during the filtering process to ensure a focus on the topic of the study. Thus, 81 articles were analyzed individually and in greater depth, identifying the models, thereby allowing the creation of relationships between the data.

Based on this selection of articles, the abstracts, theoretical framework, and identification of the models of each article were read, which constituted a systematic review and complemented the bibliometric analysis conducted in this study. Bibliometric analysis enabled the identification of the main authors in the field, the most frequently appearing keywords, and the main journals that published articles on the topic.

However, trends in the literature were identified based on the most cited articles, combining traditional models with new approaches and advanced modeling such as scenario trees, conditional value-at-risk, copula GARCH, robust optimization, and risk parity. The integration of concepts from behavioral economics, such as momentum-based investing, has also gained attention.

Relating the theoretical framework to the findings of the systematic review promotes the robustness of this dual analysis, which allows for a deeper and more detailed view of the state-of-the-art literature on asset allocation in addition to being an innovative contribution to the field. The identification of several research gaps, which are listed in the Discussion section, can be explored by researchers in future work.

The limitations of this study are that the analysis was conducted considering only articles published in English and that the detailed analysis covered only 81 articles. Although the Elsevier Scopus and Web of Science databases are comprehensive, studies from other databases may have been overlooked. Additionally, the highly dynamic nature of the asset allocation field and continuous innovations mean that the snapshot offered by this review may not capture the most recent developments in the field.

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Corresponding author
Bolivar Godinho de Oliveira Filho can be contacted at: bolivar.godinho@unifesp.br