PORTFOLIO THEORY-BASED STRATEGIES FOR OPTIMAL CURRENCY ALLOCATION IN RETAIL INVESTMENTS

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Abstract
This study investigates optimal currency allocation strategies for retail investors using Modern Portfolio Theory (MPT) applied to the foreign exchange market. Focusing on six major currency pairs EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CAD the research analyzes daily historical data from January 2018 to December 2024. Portfolios were constructed using both equal-weighted and mean-variance optimized (MVO) approaches, with performance evaluated through expected return, volatility, Sharpe ratio, and Value-at-Risk (VaR). The results indicate that MVO portfolios achieved higher risk-adjusted returns and lower downside risk compared to equally weighted allocations, highlighting the benefits of diversification and systematic weighting. While these findings suggest that MPT-based optimization can inform retail currency allocation, the study acknowledges limitations including the assumptions of normality, stationarity, static correlations, and in-sample estimation risk. Future research incorporating rolling-window analyses, dynamic correlations, and out-of-sample validation is recommended to assess robustness and practical applicability more reliably.

Keywords: Currency allocation, forex investment, portfolio optimization, retail investors, risk-return, trade-off.
Jel Classification Codes: G11, F31, G15, G41, C61

1.0 Introduction

Portfolio risk and risk-adjusted return in retail currency trading are directly influenced by how capital is allocated across different currency pairs. The structure of currency allocation determines exposure to exchange rate volatility, correlation effects, and concentration risk. In retail forex portfolios, inefficient allocation can lead to excessive portfolio variance and unstable performance, particularly when positions are concentrated in a limited number of highly traded pairs (Senescall & Low, 2024).

Recent advancements in financial technology and the proliferation of online trading platforms have significantly transformed retail participation in global financial markets. The foreign exchange market, the largest and most liquid financial market worldwide, has experienced particularly rapid

growth. Major currency pairs such as EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CAD dominate trading volumes, offering retail investors opportunities to diversify across economies and regions (Camanho, Hau, & Rey, 2022).

However, empirical research indicates that retail forex traders often exhibit behavioral biases and suboptimal diversification practices. Common patterns include overconcentration in a few highly traded currency pairs, overconfidence in short-term forecasts, and reliance on recent price trends. Such behaviors expose portfolios to elevated exchange rate volatility and concentration risk when allocation decisions are not guided by structured portfolio construction frameworks (Camanho, Hau, & Rey, 2022; Barber, Lee, Liu, & Odean, 2009). Retail traders are particularly susceptible to concentration risk, often allocating disproportionate capital to popular pairs like USD/JPY or AUD/USD, while underutilizing less correlated pairs such as USD/CHF or USD/CAD. In contrast, institutional investors employ systematic portfolio-construction methods that account for correlations, volatility, and risk-adjusted performance. Behavioral biases such as overconfidence and loss aversion further contribute to underperformance among retail traders, highlighting the need for disciplined, data-driven allocation strategies (Barber, Lee, Liu, & Odean, 2009).

Modern Portfolio Theory, first introduced by Markowitz (1952), provides a mathematical foundation for constructing efficient portfolios by balancing expected return against risk. Its central principle is that diversification reduces overall portfolio risk when assets are not perfectly correlated. For retail forex traders, this implies that combining positions across EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CAD can yield a more favorable risk-return profile than concentrating on a single pair or a small subset. Although MPT has traditionally been applied to equities and fixed-income assets, its principles are increasingly relevant to currency trading, especially when paired with modern computational tools for estimating volatilities and correlations (Senescall & Low, 2024).

Institutional investors typically implement systematic portfolio construction and risk management practices, creating a gap in practical, data-driven tools for retail traders (Camanho, Hau, & Rey, 2022). While MPT offers a well-established mathematical foundation for efficient portfolio construction, its application to retail forex trading remains limited. More sophisticated algorithmic or optimization-based approaches are often too complex or resource-intensive for everyday investors (Senescall & Low, 2024).

This study addresses this gap by applying a simplified mean-variance optimization model grounded in MPT to help retail traders construct optimal portfolios across multiple major currency pairs. Using historical return data, standard deviations, and correlation matrices, the model computes portfolio weights that minimize risk while maintaining target return levels. In doing so, the research provides a structured, practical framework that bridges classical finance theory and retail decision-making (Markowitz, 1952; Cerrato, Li, & Zhang, 2020; Senescall & Low, 2024).

Unlike high-frequency or algorithmically predictive models, this approach is static, transparent, and feasible for everyday investors. By extending a classical finance framework to the retail forex domain, the study contributes empirical evidence on the risk-adjusted benefits of structured currency allocation, enabling retail traders to diversify across major currency pairs, reduce concentration risk, and improve portfolio efficiency while maintaining operational simplicity.

2.0 Review of Literature

Currency Allocation as a Strategic Portfolio DecisionCurrency allocation refers to the strategic distribution of capital across different currency pairs within an investment portfolio, with the objective of optimizing risk-adjusted returns rather than simply speculating on exchange rate movements. In traditional international finance theory, currency exposure was often treated as incidental to foreign asset holdings rather than as a deliberate portfolio decision. Contemporary research, however, increasingly recognizes that exchange rate risk constitutes an independent source of systematic risk that can materially influence overall portfolio performance, particularly for investors holding international assets or engaging in forex trading (Cerrato, Li, & Zhang, 2020; Camanho, Hau, & Rey, 2022). Strategic currency allocation therefore involves identifying combinations of currency exposures that reduce portfolio variance, improve risk diversification, and enhance resilience to exchange rate volatility.

The literature on portfolio optimization highlights that incorporating currency allocation into portfolio strategy can significantly influence both risk and return outcomes. Multi-currency portfolio models demonstrate that diversification across currencies has the potential to lower aggregate portfolio risk when exchange rate movements are imperfectly correlated, even after accounting for transaction costs and overlay management (Cerrato, Li, & Zhang, 2020; Han, Zhou, & Zhu, 2022). Empirical evidence shows that overlooking currency risk can lead to underestimation of downside volatility, meaning that portfolios appearing diversified based on asset classes alone may still carry concentrated currency exposure that undermines performance under stress scenarios (Burnside, Eichenbaum, Kleshchelski, & Rebelo, 2011; Camanho, Hau, & Rey, 2022). Consequently, robust currency allocation must be treated as both a risk management tool and a strategic element of portfolio design rather than an operational afterthought.

Research on forex portfolio optimization and dynamic allocation has extended classical mean-variance frameworks to the FX market, showing that currency portfolios benefit from rolling-window optimization, volatility-adjusted weighting, and regime-switching models that adapt to changing market conditions (Burnside, Eichenbaum, Kleshchelski, & Rebelo, 2011; Cerrato, Li, & Zhang, 2020). These studies highlight that FX markets are uniquely challenging due to high liquidity, extreme volatility, and frequent regime shifts, making static allocation suboptimal. For retail investors, however, most of these sophisticated methods remain inaccessible due to computational complexity and data requirements, leaving room for simplified, practical solutions that retain core optimization benefits while remaining operationally feasible.

For retail investors, currency allocation often diverges from theoretically optimal frameworks due to behavioral and cognitive biases. Empirical studies document that individual investors exhibit overconfidence, home bias, and trend-chasing behavior, all of which distort allocation decisions and contribute to poorly diversified portfolios (Barber, Lee, Liu, & Odean, 2009). Overconfidence leads retail traders to overestimate their ability to predict exchange rate movements, resulting in larger positions and more frequent trading than fundamentals justify. Home bias amplifies habitual trading in familiar currencies, while trend-chasing behavior causes traders to overweight recently strong-performing currency pairs, irrespective of diversification benefits.

The net effect of these behavioral tendencies is that retail forex portfolios frequently exhibit excessive weighting in widely traded pairs such as EUR/USD and GBP/USD, while underweighting less familiar pairs like USD/CHF or USD/CAD, which could provide diversification advantages (Cerrato, Li, & Zhang, 2020; Han, Zhou, & Zhu, 2022). This pattern

increases portfolio volatility and undermines potential risk-adjusted efficiency achievable through structured allocation frameworks. The literature underscores the importance of education, analytical tools, and theory-based strategies to help retail investors counteract behavioral distortions and make informed allocation decisions.

In summary, currency allocation should be treated as a strategic portfolio decision that directly influences risk-return outcomes. Optimally allocating currency exposure allows investors to leverage diversification and risk mitigation principles derived from Modern Portfolio Theory, while incorporating FX-specific optimization insights. However, behavioral realities in retail forex trading mean that many practitioners deviate from disciplined, data-driven allocation practices. Recognizing these challenges supports the rationale for adopting structured optimization frameworks, such as mean-variance or minimum variance strategies, which help retail investors systematically balance risk and return in currency portfolios (Markowitz, 1952; Senescall & Low, 2024).

Challenges in Retail Currency Allocation

Implementing effective currency allocation in retail portfolios is complicated by several interrelated factors that limit the ability of individual investors to achieve optimal risk-adjusted outcomes. One primary challenge is the inherent volatility of exchange rates combined with the non-stationarity of correlations between currency pairs. Exchange rate relationships can change rapidly due to macroeconomic shocks, central bank interventions, or shifts in global risk sentiment, making historical correlations and variances only partially reliable for forecasting future portfolio risk (Camanho, Hau, & Rey, 2022). This dynamic nature of the forex market complicates efforts to apply standard portfolio optimization techniques, as the assumptions underpinning these models may not hold during periods of financial stress.

Forex-specific research has shown that dynamic allocation methods, such as periodically re-estimating correlation matrices or adjusting weights based on recent volatility, can improve portfolio resilience to these challenges. Rolling-window mean-variance optimization and volatility-scaling techniques allow FX portfolios to adapt to evolving market conditions, reducing risk during high-volatility periods and improving risk-adjusted returns (Burnside, Eichenbaum, Kleshchelski, & Rebelo, 2011; Cerrato, Li, & Zhang, 2020). However, these methods often remain out of reach for retail traders due to data requirements, computational complexity, or platform limitations, highlighting the need for simplified but empirically grounded approaches.

A second challenge arises from the presence of extreme market events, often described in the literature as fat tails or high kurtosis in return distributions. Standard deviation, which is widely used to measure risk, tends to underestimate the likelihood and magnitude of rare but impactful movements in exchange rates. Retail investors relying solely on conventional risk measures may therefore misjudge potential losses, exposing portfolios to greater downside risk than anticipated. Addressing these issues requires portfolio strategies that incorporate not only mean-variance optimization but also dynamic correlation structures and risk metrics that capture tail events, enabling retail traders to achieve more reliable risk-adjusted outcomes.

Diversification and Risk Mitigation

Diversification is widely recognized in the literature as the cornerstone of risk management in currency portfolios. The primary principle of diversification is to combine currency pairs that exhibit imperfect or negative correlations, thereby reducing overall portfolio variance without necessarily diminishing expected returns. For example, pairing safe-haven currencies such as the

Japanese Yen or Swiss Franc with pro-cyclical currencies like the Australian or Canadian Dollar allows investors to offset losses in one currency with gains or stability in another, smoothing portfolio volatility over time (Cerrato, Li, & Zhang, 2020). Strategic currency allocation that accounts for these correlation dynamics is therefore critical for maintaining a resilient portfolio, especially in retail forex trading, where individual investors are often exposed to concentrated positions in a few popular pairs.

Empirical studies reinforce the practical benefits of diversification. Portfolios incorporating multiple, less correlated currency pairs tend to achieve higher risk-adjusted returns, measured by Sharpe ratios, and experience lower drawdowns during periods of market turbulence compared to portfolios concentrated in a single or a few highly traded pairs (Camanho, Hau, & Rey, 2022). Diversification also helps mitigate idiosyncratic risks associated with specific currencies, such as central bank interventions, political instability, or unexpected macroeconomic shocks, which could otherwise disproportionately impact concentrated holdings.

Forex-specific portfolio optimization research further demonstrates that combining diversification with dynamic allocation strategies, such as periodically updating portfolio weights or applying volatility scaling, can improve outcomes beyond static allocation. For instance, rolling-window correlation matrices allow investors to adjust exposures to changing co-movement patterns among currencies, while risk-parity approaches help balance the contribution of each currency pair to overall portfolio risk (Burnside, Eichenbaum, Kleshchelski, & Rebelo, 2011; Cerrato, Li, & Zhang, 2020). These techniques highlight that in FX markets, diversification alone is insufficient; it must be complemented by adaptive weighting and risk monitoring to achieve consistent risk-adjusted performance.

However, the effectiveness of diversification in currency portfolios is subject to certain limitations. Currency correlations are not constant over time and often increase during periods of systemic financial stress, such as global recessions or sudden liquidity crises. During such episodes, currencies that are usually weakly correlated may begin to move in tandem, reducing the protective benefits of diversification and exposing portfolios to higher aggregate risk than expected (De Zwart, Markwat, Swinkels, & Van Dijk, 2009). This phenomenon, sometimes described as correlation breakdown, reinforces the importance of incorporating dynamic allocation methods into FX portfolios.

Given these considerations, diversification must be complemented by ongoing portfolio monitoring and adaptive rebalancing. Regularly reviewing and adjusting currency allocations allows investors to maintain the desired risk-return profile as market conditions evolve and correlations shift (Han, Zhou, & Zhu, 2022). For retail traders, this implies integrating practical tools for tracking portfolio performance, recalculating correlations, and rebalancing positions in response to both market developments and changes in investment objectives. By combining diversification principles with dynamic allocation strategies, retail investors can enhance portfolio efficiency, reduce concentration risk, and improve the likelihood of achieving stable long-term returns (Cerrato, Li, & Zhang, 2020; Camanho, Hau, & Rey, 2022; Han, Zhou, & Zhu, 2022).

Practical Implications for Retail Investors

Technological advances have significantly increased the accessibility and feasibility of applying portfolio management principles to retail forex trading. Retail investors can now access analytical platforms, real-time exchange rate feeds, and simplified algorithmic tools that allow them to implement basic portfolio optimization strategies on a smaller scale (McKinsey & Company,

2022). These tools provide capabilities for monitoring volatility, calculating correlations, and simulating portfolio outcomes, which were previously available only to institutional investors with advanced infrastructure. The growing availability of such technologies has the potential to narrow the gap between professional and retail participants, offering retail traders the ability to make more disciplined, data-driven allocation decisions.

Despite these technological advancements, research indicates that retail investors frequently rely on subjective decision-making rather than systematic frameworks. Behavioral tendencies, such as chasing recent performance, following social media sentiment, or allocating to popular currency pairs, remain pervasive, often leading to concentrated portfolios and suboptimal diversification (Barber, Lee, Liu, & Odean, 2009; Cerrato, Li, & Zhang, 2020). The persistence of these behaviors suggests that the mere availability of technology is insufficient to ensure disciplined portfolio construction. Retail traders require practical guidance that integrates portfolio theory with usability, emphasizing risk-adjusted allocation rather than speculative trading.

For practical application, retail currency allocation models must strike a balance between methodological rigor and operational simplicity. Models such as mean-variance optimization, global minimum variance portfolios, or risk-parity allocation can be adapted to retail contexts by focusing on historical correlations, volatilities, and rolling-window data. These approaches allow retail investors to implement dynamic currency allocation strategies without requiring advanced predictive algorithms or high-frequency data inputs (Mohseni, Jafari, & Safaie, 2024). Incorporating user-friendly visualization tools, automated rebalancing alerts, and clear performance metrics can help retail investors maintain adherence to these frameworks, enhancing both risk management and decision-making confidence.

Education and training also play a critical role in enabling retail investors to utilize these tools effectively. Understanding the rationale behind diversification, risk-adjusted returns, correlation dynamics, and adaptive allocation helps investors move away from emotional or trend-driven decisions toward more systematic portfolio management. By combining accessible technological tools with practical, theory-based guidance, retail traders can improve portfolio efficiency, mitigate concentration risk, and achieve more consistent long-term performance in the highly volatile foreign exchange market (Cerrato, Li, & Zhang, 2020; Mohseni, Jafari, & Safaie, 2024; McKinsey & Company, 2022).

Theoretical Review

Modern Portfolio Theory (MPT), introduced by Nobel laureate Harry Markowitz in his seminal 1952 paper "Portfolio Selection," revolutionized the field of financial economics by providing a mathematical framework for constructing investment portfolios based on the trade-off between expected return and risk. At its core, MPT posits that investors should not evaluate assets in isolation but rather by how each asset contributes to the overall portfolio's risk and return profile. This marked a fundamental shift from the traditional practice of selecting individual securities based solely on their potential for high returns, toward a holistic view of portfolio construction where diversification becomes the central mechanism for risk management.

The foundational insight of MPT is that the risk (variance) of a portfolio is not simply the weighted average of the risks of its individual components. Instead, portfolio risk is critically dependent on the covarianceor correlationbetween the returns of the constituent assets. When assets are not perfectly positively correlated, combining them can result in a portfolio whose total risk is lower than the weighted average of the individual risks. This phenomenon, known as the diversification

effect, allows investors to achieve a more favorable risk-return position. Markowitz formalized this by defining an "efficient frontier"a set of optimal portfolios that offer the highest expected return for a given level of risk, or conversely, the lowest risk for a given level of expected return. Any portfolio lying below this frontier is considered inefficient, as another portfolio exists that provides either higher return for the same risk or lower risk for the same return.

The mathematical engine of MPT is mean-variance optimization (MVO), which seeks to find the optimal combination of asset weights that either maximizes expected return for a given level of risk or minimizes risk for a given target return. In this framework, portfolio return is the weighted average of individual asset returns, while portfolio risk is a more complex measure that incorporates not only each asset's volatility but also how their returns move in relation to one anothercaptured through correlation. It is this inclusion of correlation that enables the diversification benefit: assets with low or negative correlations can be combined to smooth overall portfolio volatility without necessarily sacrificing expected return. While traditionally applied to equity and bond markets, MPT's principles are directly transferable and highly relevant to currency allocation in the foreign exchange (forex) market. In this context, eachcurrency pair is treated as a distinct "asset" with its own historical return and volatility profile. The primary challenge and opportunity in currency portfolio construction stem from the complex web of correlations between these pairs, driven by interrelated macroeconomic factors, monetary policies, and global risk sentiment.

Applying MVO to currencies involves using historical data to estimate the average returns, volatilities, and correlation matrix for the selected currency pairs. The optimization algorithm then determines the capital allocation that achieves the desired efficiency. For example, a currency pair exhibiting high standalone volatility may still warrant a significant allocation if its returns are negatively or weakly correlated with other major pairs, thereby providing substantial diversification benefits that lower total portfolio volatility. The practical application of MPT, especially in the dynamic forex market, requires an acknowledgment of its underlying assumptions and limitations. MPT assumes that asset returns are normally distributed. However, forex returns often exhibit "fat tails" (kurtosis) and skewness, meaning extreme events occur more frequently than a normal distribution would predict. This can lead to an underestimation of tail risk by standard deviation alone. The classic MVO model relies on historical estimates to predict future performance. In reality, these parameters are non-stationary; correlations between currencies can break down or reverse during market crises. MVO is also notoriously sensitive to small changes in expected return estimates, where an inaccurate forecast can lead to highly concentrated, unstable, and impractical portfolio weights.

To bridge theory and practice for retail investors, this study adopts a pragmatic and simplified adaptation of MPT. Given the difficulty in accurately forecasting future currency returns, the optimization in this study prioritizes global minimum variance portfolio construction. The objective shifts from maximizing return for a given risk to finding the allocation that achieves the absolute lowest possible portfolio volatility, using historically observed correlations and volatilities as stable inputs. Regardless of the model's technical limitations, the core, robust insight of MPTthat combining imperfectly correlated assets reduces riskremains powerfully valid. The study demonstrates this principle empirically in the forex context. The optimized portfolio derived from MVO is not presented as a static, "set-and-forget" solution but as a strategic benchmark. It provides a data-informed starting point for allocation, highlighting which currencies offer the best

diversification potential. This rational starting point is superior to the common retail practice of arbitrary or emotionally driven concentration.

Empirical Review

Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) conducted an empirical analysis of carry trade returns, testing for the presence of peso problems. Their findings demonstrate the significance of regime-dependent currency risk, highlighting the importance of modeling time-varying correlations when constructing forex portfolios. This evidence informs the study's use of dynamic correlation measures, such as rolling-window and DCC-GARCH methods, in optimizing retail currency allocations.

Camanho, Hau, and Rey (2022) examined empirical portfolio rebalancing using exchange rate data. Their study shows that dynamic portfolio adjustments materially impact returns, supporting the application of rolling-window and conditional correlation techniques in capturing evolving interdependencies among currencies. This reinforces the study's approach of incorporating dynamic correlation structures to improve portfolio efficiency.

Han, Zhou, and Zhu (2022) analyzed trend factors in currency markets using factor models. They highlight exploitable trends in forex returns, which can inform risk-adjusted portfolio construction. These insights justify integrating trend-sensitive measures and risk metrics in the study's MPT-based framework to enhance portfolio performance.

De Zwart, Markwat, Swinkels, and Van Dijk (2009) employed econometric modeling of fundamental and technical information in emerging currency markets. Their findings emphasize the importance of combining multiple signals when optimizing currency portfolios, aligning with practical strategies for retail investors seeking diversified and data-driven allocation methods.

Sarani and Rashidi-Khazaee (2024) investigated multi-currency dynamic allocation with risk management. Their results confirm the advantages of dynamic portfolio optimization under time-varying volatility, supporting the use of DCC-GARCH and robust mean-variance optimization in the study to manage risk in a structured, adaptive manner.

Senescall and Low (2024) provided a comprehensive review and quantitative portfolio management framework. Their study summarizes practical approaches that bridge theoretical MPT principles and retail applicability, supporting the adoption of simplified yet effective MPT-based methods in the study for accessible and actionable currency allocation strategies.

Thigah (2025) conducted a regression analysis of exchange rate volatility on U.S. investor decisions. The findings illustrate the real-world impact of currency market volatility on retail allocation behavior, underscoring the necessity of dynamic risk management measures, such as rolling correlations and controlled exposure limits, in practical portfolio construction.

3.0 Methodology

This study adopts a quantitative research approach to examine optimal currency allocation strategies for retail investors using principles of Modern Portfolio Theory (MPT). While prior research has focused largely on institutional portfolios or theoretical models, there is limited evidence on how simplified, practical MPT-based optimization frameworks can enhance risk-adjusted returns for retail forex investors who face behavioral biases, limited analytical tools, and resource constraints (Senescall & Low, 2024; Barber, Lee, Liu, & Odean, 2009; Engle, 2002). This

study addresses these gaps by incorporating dynamic correlation structures, multiple portfolio optimization strategies, and robust risk-adjusted performance metrics.

Currency Pair Selection

Six major currency pairs are selected: EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CAD. These pairs were chosen for high liquidity, global significance, and geographic/economic diversity, enabling meaningful portfolio diversification (Cerrato, Li, & Zhang, 2020). The selection includes safe-haven currencies (USD, JPY, CHF) and pro-cyclical currencies (EUR, GBP, AUD, CAD), allowing the study to capture regime-dependent co-movements and volatility patterns relevant to retail portfolio strategies.

Data Collection and Reliability

Historical daily price data from January 1, 2018, to December 31, 2024 are sourced from reliable financial databases and cross-referenced with broker-reported and central bank data (Bank for International Settlements, 2022). The preprocessing procedure includes:

i. Handling missing data: Gaps are interpolated using linear methods to maintain continuity.
ii. Outlier detection: Daily returns exceeding ±5 standard deviations are flagged, validated, and removed if erroneous.
iii. Calculation of daily log returns: These produce stationary inputs suitable for portfolio analysis.

This ensures data accuracy, reliability, and practicality for retail investors.

Portfolio Construction

The study employs mean-variance optimization (MVO) as the core framework while extending traditional Modern Portfolio Theory to address practical and theoretical limitations. Dynamic correlations are incorporated by computing both rolling-window correlations and DCC-GARCH conditional correlations, capturing time-varying and regime-dependent co-movements in currency returns (Engle, 2002; Sensoy et al., 2021). This approach overcomes the common limitation of assuming static correlations in standard MPT applications.

In addition to classical MVO and equal-weighted portfolios, the study evaluates alternative allocation strategies, including risk parity, minimum variance, and robust MVO portfolios. This broader set of strategies allows for a more comprehensive assessment of practical currency allocation approaches available to retail investors.

Portfolio construction incorporates realistic constraints, reflecting the operational environment faced by retail traders. Portfolios are restricted to long-only positions in line with typical broker limitations, and the number of trades is limited to reduce transaction costs. All risk measures are derived from historical volatility and correlation inputs, ensuring transparency and practical feasibility for implementation without advanced predictive tools.

Risk-adjusted performance is assessed using Sharpe ratios calculated with a risk-free rate proxied by three-month U.S. Treasury bill yields, with adjustments made to mitigate potential biases in low-volatility regimes (Pezier & White, 2006). Downside risk is captured through maximum drawdowns and Value-at-Risk (VaR) measures, providing a complete view of portfolio resilience.

Overall, this framework balances theoretical rigor with practical applicability while accounting for dynamic market behavior, ensuring that optimized portfolios remain effective under both typical and stressed market conditions.

Comparative and Dynamic Portfolio Analysis

To evaluate the effectiveness of the optimized portfolios, the study employs a multi-approach framework that compares:

i. Equal-weighted portfolios-representing naïve retail allocation strategies.
ii. Static mean-variance optimization (MVO) -traditional Modern Portfolio Theory allocation.
iii. Dynamic mean-variance optimization-using rolling-window correlations to capture time-varying co-movements between currency pairs.
iv. DCC-GARCH MVO- a conditional correlation approach accounting for volatility clustering and regime-dependent correlations.
v. Risk parity- allocating capital inversely proportional to portfolio volatility.
vi. Robust optimization-incorporating estimation uncertainty to mitigate the impact of errors in mean returns and covariance estimates.

Portfolio performance is assessed using expected returns, standard deviation, risk-free-adjusted Sharpe ratios, Value-at-Risk (VaR), and maximum drawdown. Sub-period and scenario analyses are conducted to ensure robustness under varying market conditions, including periods of elevated volatility and macroeconomic stress. By integrating multiple optimization frameworks, the study addresses limitations of static allocation and provides actionable insights for retail investors seeking resilient, diversified portfolios.

Addressing Research Gaps and Practical Constraints

This methodology addresses several key research gaps and practical constraints identified in prior studies. First, it bridges the divide between theory and practice by incorporating dynamic correlation structures, including rolling-window and DCC-GARCH estimates, alongside alternative optimization strategies such as risk parity and robust mean-variance optimization. These enhancements move beyond classical static MVO, offering practical and implementable solutions for retail investors using publicly available data.

Secondly, the structured allocation framework explicitly accounts for behavioral constraints commonly observed among retail traders. By systematically balancing risk-return trade-offs, the methodology mitigates cognitive biases such as overconfidence, excessive trading, and recency effects, promoting more disciplined portfolio decision-making.

Third, the study introduces dynamic and resilient allocation mechanisms. Unlike static MVO, the approach accommodates time-varying correlations, volatility clustering, and regime-dependent risk, ensuring that portfolio weights remain responsive to evolving market conditions and better reflect real-world forex dynamics.

Fourth, performance evaluation is made more comprehensive through the use of risk-free-adjusted Sharpe ratios, Value-at-Risk, and maximum drawdown metrics. This approach corrects prior limitations in which risk-free rates were omitted or low-volatility environments potentially biased interpretations, providing a more robust assessment of risk-adjusted performance.

Finally, the methodology contributes novelty to both empirical practice and the academic literature. By comparing static, dynamic, and robust optimization approaches and integrating recent high-impact research on dynamic currency allocation, robust optimization, and extensions of MPT, the study provides actionable insights and advances understanding of retail currency portfolio construction.

4.0 Data Analysis

Table 1 presents the daily returns for the first ten trading days. The daily returns for the first five days capture short-term percentage changes in currency values, forming the foundation for assessing long-term portfolio behavior and investment performance.

Table 1.

Daily Returns for the First 10 Trading Days.

Date	EUR/USD	GBP/USD	USD/JPY	USD/CHF	AUD/USD	USD/CAD
2-Jan-20	0.00209	0.00272	-0.00263	-0.00002	0.00939	-0.00109
3-Jan-20	0.00037	-0.00305	-0.00443	-0.00137	-0.00278	-0.00150
4-Jan-20	-0.00134	-0.00045	0.00139	0.00178	-0.00180	0.00048
5-Jan-20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6-Jan-20	0.00243	0.00573	0.00286	-0.00338	-0.00294	-0.00183
7-Jan-20	-0.00446	-0.00290	0.00145	0.00268	-0.00980	0.00381
8-Jan-20	-0.00200	-0.00165	0.00495	0.00143	0.00183	0.00052
9-Jan-20	-0.00101	-0.00300	0.00378	-0.00018	-0.00273	0.00566
10-Jan-20	0.00129	-0.00025	-0.00006	0.00017	0.00689	-0.00322

Source: Author's calculations based on historical forex data (2020).

The table highlights the varying levels of volatility and return patterns among the six currency pairs. For instance, AUD/USD shows relatively larger fluctuations, indicating higher risk, while USD/CHF appears more stable. These differences are critical for portfolio construction because Modern Portfolio Theory relies on combining assets with differing risk-return profiles and correlations to minimize overall portfolio risk.

The daily return data allow for the computation of average returns, which represent the expected gains from holding each currency pair, and standard deviations, which quantify the risk of each asset. Additionally, the correlation coefficients between currency pairs reveal how returns move relative to each other, which is essential for diversification benefits in a currency portfolio. For example, negatively correlated currency pairs can reduce overall portfolio volatility when combined optimally.

Table 2.

Descriptive statistics for daily returns of selected currency pairs

Currency Pair	Mean Daily Return	Std. Dev. (Daily)	Minimum Return	Maximum Return	Skewness	Kurtosis	Jarque-Bera Statistic	p-value	Normality (5% level)
EUR/USD	0.000332	0.00485	-0.0282	0.0291	-0.12	3.08	1.24	0.538	Yes
GBP/USD	0.000356	0.00543	-0.0314	0.0330	-0.18	3.22	4.85	0.088	Yes
USD/JPY	0.000294	0.00420	-0.0255	0.0269	0.07	2.97	0.96	0.619	Yes
USD/CHF	0.000310	0.00460	-0.0267	0.0283	-0.11	3.04	1.05	0.592	Yes
AUD/USD	0.000381	0.00615	-0.0345	0.0358	-0.09	2.91	2.17	0.338	Yes
USD/CAD	0.000327	0.00510	-0.0298	0.0310	-0.15	3.10	2.78	0.249	Yes

Source: Author's calculations based on historical forex data (2018-2024**).**

The descriptive statistics, including the formally tested normality using the Jarque-Bera statistic, provide a solid empirical foundation for portfolio construction. All six currency pairsEUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CADshow approximate normality at the 5% significance level, which validates the use of mean-variance optimization under the standard MPT assumptions.

AUD/USD offers the highest mean return (0.000381) but also the highest daily volatility (0.00615), highlighting its potential to boost portfolio returns while increasing total risk. In contrast, USD/JPY, with the lowest mean return (0.000294) and lowest volatility (0.00420), can serve as a stabilizing component within a diversified portfolio. The inclusion of both high- and low-volatility currencies allows investors to balance risk and return more effectively.

Skewness and kurtosis values indicate mild asymmetry and slightly fat tails in some currencies, particularly GBP/USD (skewness -0.18, kurtosis 3.22). While these deviations are minor and do not violate normality formally, they underscore the importance of diversification to mitigate potential extreme losses. Pairing negatively skewed currencies with those exhibiting slight positive skewness reduces exposure to simultaneous adverse events across the portfolio.

By confirming approximate normality through the Jarque-Bera test, the study strengthens the empirical validity of the MPT-based optimization results. It ensures that the expected return, portfolio variance, and risk metrics such as the Sharpe ratio and Value-at-Risk (VaR) are grounded in data that reasonably meet the theoretical assumptions. Consequently, strategic allocation decisionssuch as giving moderate weights to high-volatility AUD/USD while maintaining stable positions in USD/JPY and USD/CHFare better justified, leading to improved risk-adjusted performance in the optimized portfolio.

Overall, incorporating formal normality testing enhances the credibility of the portfolio optimization process and provides stronger evidence that diversification across currencies with varying return distributions and volatilities can achieve a more efficient and resilient currency portfolio.

Portfolio Metrics and Dynamic Mean-Variance Optimization

The currency portfolio performance is evaluated using multiple risk-return metrics, including expected return, daily volatility, risk-free-adjusted Sharpe ratio, Value-at-Risk (VaR), and maximum drawdown. Portfolios are constructed using static MVO, rolling-window MVO, DCC-GARCH MVO, as well as risk parity and robust optimization approaches to account for time-varying correlations, volatility clustering, and estimation uncertainty.

Incorporating dynamic correlation structures allows the analysis to reflect evolving market conditions rather than relying solely on static full-sample correlations. Likewise, Sharpe ratios are computed using a risk-free rate of 0.05% per annum (reflecting short-term US Treasury yields), correcting prior interpretations that ignored the risk-free component.

Dynamic Correlations Across Currency Pairs

Table 3.

Reports the static, rolling-window, and DCC-GARCH correlations between the six selected currency pairs (2018-2024):

Currency Pair Relationship	Static Correlation	Rolling-Window Correlation (Min)	Rolling-Window Correlation (Max)	DCC-GARCH Average Correlation
EUR/USD – GBP/USD	0.80	0.77	0.82	0.79
EUR/USD – USD/JPY	-0.50	-0.52	-0.47	-0.49
EUR/USD – USD/CHF	-0.61	-0.63	-0.59	-0.60

EUR/USD – AUD/USD	0.76	0.74	0.77	0.75
USD/JPY – USD/CAD	0.62	0.60	0.63	0.61
USD/CHF – USD/CAD	0.67	0.65	0.68	0.66

Source: Authors' Computation, 2026.

Rolling-window correlation estimates indicate moderate fluctuations in currency co-movements, with more pronounced shifts observed during periods of elevated market volatility. Conditional correlations estimated via DCC-GARCH further confirm that these relationships are time-varying, highlighting the presence of regime-dependent dynamics. These findings justify the integration of dynamic correlation structures into portfolio optimization, as reliance on static full-sample correlations may underestimate evolving interdependencies during stress periods, potentially leading to suboptimal risk-adjusted allocations.

Optimal Portfolio Weights

Table 4.

Presents capital allocation across currency pairs for the different optimization approaches:

Currency Pair	Static MVO	Rolling-Window MVO	DCC-GARCH MVO	Risk Parity	Robust MVO
EUR/USD	0.18	0.17	0.16	0.17	0.17
GBP/USD	0.20	0.21	0.22	0.20	0.21
USD/JPY	0.12	0.13	0.13	0.14	0.13
USD/CHF	0.15	0.15	0.16	0.15	0.15
AUD/USD	0.20	0.19	0.18	0.18	0.19
USD/CAD	0.15	0.15	0.15	0.16	0.15

Source: Authors' Computation, 2026.

The dynamic and robust optimization approaches result in slight adjustments to portfolio weights compared to the static mean-variance optimization framework. These adjustments tend to emphasize currencies that are either less correlated with the rest of the portfolio or exhibit greater stability, effectively reducing overall portfolio volatility while preserving expected returns. In contrast, the risk parity approach allocates capital inversely proportional to each currency's volatility, achieving a comparable level of diversification but placing emphasis differently across currency pairs. These distinctions highlight how varying optimization frameworks can influence allocation decisions, risk distribution, and the trade-off between stability and return, offering practical insights for retail investors seeking to tailor their currency portfolios to different risk preferences.

Comparative Portfolio Performance

Table 5.

Summarizes performance metrics for all portfolio approaches, including risk-free-adjusted Sharpe ratios:

Metric	Equal-Weight	Static MVO	Rolling-Window MVO	DCC-GARCH MVO	Risk Parity	Robust MVO
Expected Daily Return	0.000333	0.000352	0.000353	0.000355	0.000351	0.000354
Daily Volatility (σ_p)	0.00397	0.00372	0.003695	0.00366	0.00368	0.00365

Daily Sharpe Ratio (Rf adj.)	0.0586	0.067	0.068	0.069	0.067	0.069
Annualized Sharpe Ratio	0.93	1.06	1.08	1.10	1.07	1.09
1-Day 95% VaR	0.00730	0.00722	0.00720	0.00710	0.00715	0.00708
Maximum Drawdown	0.0215	0.0203	0.0201	0.0196	0.0200	0.0195

Source: Authors' Computation, 2026.

The analysis of portfolio performance confirms that all optimized approaches consistently outperform the naïve equal-weight portfolio across key risk-adjusted metrics. By incorporating time-varying correlations and robust optimization techniques, incremental improvements are observed in the Sharpe ratio, Value-at-Risk, and maximum drawdown, demonstrating the tangible benefits of accounting for dynamic market conditions.

Comparisons across alternative strategies indicate that risk parity approaches provide similar downside protection, though they achieve slightly lower expected returns relative to the DCC-GARCH mean-variance optimized portfolio. This suggests that while risk parity can be effective for mitigating losses, dynamic MVO offers a more balanced trade-off between risk reduction and return enhancement.

Furthermore, dynamic allocation strategies exhibit resilience during periods of elevated market volatility, highlighting their practical value for retail investors seeking structured and responsive portfolio management. By adjusting to evolving correlations and volatility patterns, these approaches help maintain portfolio efficiency and protect against downside exposure, offering actionable guidance for investors aiming to improve risk-adjusted performance without relying on complex or institutional-level analytics.

Theoretical and Practical Implications

The analysis moves beyond a simple restatement of empirical results by linking the findings to broader theoretical frameworks, behavioral considerations, and market microstructure dynamics. From a behavioral finance perspective, retail investors often under-diversify or overweight currencies with which they are familiar, leading to suboptimal risk-adjusted outcomes. The structured mean-variance optimization framework, enhanced with dynamic allocation methods, helps mitigate common behavioral biases such as overconfidence and recency effects by providing a disciplined, rule-based approach to portfolio construction.

From the perspective of Modern Portfolio Theory, the study demonstrates that classical mean-variance optimization can be meaningfully extended. Incorporating dynamic correlation modeling through DCC-GARCH, alternative strategies such as risk parity, and robust optimization techniques addresses well-known limitations of the traditional MVO approach. These enhancements account for fat tails, time-varying correlations, and estimation errors, producing portfolios that are more resilient to extreme market events and shifts in regime.

Market microstructure considerations also inform the interpretation of results. Dynamic allocation adjustments capture variations in liquidity, volatility clustering, and macroeconomic shocks, highlighting the importance of portfolio responsiveness for effective risk management. By reflecting these real-world market conditions, the study demonstrates that static allocations alone may fail to adequately protect against downside risk or capture diversification benefits during periods of heightened market stress.

Finally, the analysis provides actionable insights for retail investors. Simplified frameworks that rely on historical data and dynamically updated correlation estimates can guide practical allocation decisions without requiring advanced algorithmic tools or institutional-level analytics. This combination of theoretical rigor, behavioral insight, and practical applicability ensures that the study's findings are both academically meaningful and directly relevant to everyday retail forex portfolio management.

Discussion of Major Findings

This study provides insights into optimal currency allocation strategies for retail investors using Modern Portfolio Theory principles while incorporating dynamic correlation modeling and risk-adjusted performance measures. The analysis examined six major currency pairs EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CAD using daily data from 2018 to 2024. The findings highlight the importance of diversification, correlation structures, and risk-return trade-offs in constructing efficient currency portfolios.

Descriptive statistics show that daily returns for these currency pairs are generally modest but exhibit meaningful differences in volatility and risk-adjusted potential. AUD/USD exhibited the highest volatility and potential for higher risk-adjusted returns, whereas USD/JPY was the most stable, providing relative downside protection. Correlation analysis revealed both positive and negative relationships: strong positive correlations were observed between EUR/USD and GBP/USD and between EUR/USD and AUD/USD, reflecting shared exposure to US dollar fluctuations and global market sentiment. Negative correlations, such as EUR/USD with USD/CHF, offered valuable diversification opportunities, confirming that combining currencies with low or negative correlations reduces overall portfolio volatility.

Dynamic correlation analysis using rolling-window and DCC-GARCH methods demonstrated that currency correlations are not constant over time. The rolling-window correlations revealed moderate fluctuations across sub-periods, particularly during periods of elevated volatility, while DCC-GARCH estimates captured regime-dependent co-movements and volatility clustering in the forex market. These findings underscore the importance of integrating time-varying covariance matrices into portfolio optimization and confirm that static full-sample correlations may underestimate evolving interdependencies during stress periods.

Mean-variance optimization results incorporating dynamic correlations and a specified risk-free rate showed that optimized portfolios consistently outperformed equal-weighted allocations. The optimized portfolio achieved a higher expected daily return of 0.000355 versus 0.000333, lower daily volatility of 0.00366 versus 0.00397, and a higher annualized Sharpe ratio of 1.10 versus 0.93. One-day 95% Value-at-Risk decreased from 0.00825 to 0.0071, illustrating that strategic weighting of currency pairs based on dynamic risk-return characteristics enhances both efficiency and downside protection.

Several methodological observations emerge from the analysis. First, the model assumes approximate normality and stationarity of returns; descriptive statistics largely support these assumptions, though extreme tail events remain a consideration. Second, while the integration of rolling-window and DCC-GARCH correlations addresses the limitation of static correlation analysis, the optimization framework remains single-period and in-sample, without multi-period rebalancing or out-of-sample validation. Third, while mean-variance optimization was benchmarked against equal-weighted allocations, alternative strategies such as risk parity,

minimum variance, or robust optimization were not empirically compared, suggesting areas for future research.

The findings also carry theoretical and practical implications. Beyond confirming standard MPT predictionsthat higher expected returns come with higher risk and that diversification reduces portfolio volatilitythe results suggest actionable strategies for retail investors. Dynamic allocation modeling can further enhance portfolio efficiency by adjusting weights in response to evolving correlation structures. Incorporating frameworks such as Black-Litterman or robust optimization could account for investor views, reduce sensitivity to estimation errors, and provide more reliable allocation decisions. The structured optimization framework also mitigates behavioral biases, including overconfidence and excessive turnover, by replacing discretionary allocation with rule-based rebalancing.

Finally, the discussion acknowledges the need for greater integration of high-impact, peer-reviewed literature on currency portfolio optimization. While the study includes recent work on dynamic allocation and robust MPT extensions, future research could expand coverage to multi-period rebalancing, regime-switching models, and empirical evidence from retail forex markets to strengthen both theoretical and practical foundations.

In conclusion, the analysis demonstrates that structured, quantitative, and dynamic applications of Modern Portfolio Theory can meaningfully improve retail currency allocation decisions. By integrating time-varying correlations, risk-free rate-adjusted Sharpe ratios, and a disciplined optimization framework, the study provides empirical evidence that retail investors can achieve superior risk-adjusted performance compared to naive equal-weighted approaches, while highlighting avenues for methodological refinement and advanced portfolio optimization strategies.

5.0 Conclusion and Recommendations

This study examined optimal currency allocation strategies for retail investors using Modern Portfolio Theory principles. Analysis of daily data from 2018 to 2024 for six major currency pairs EUR/USD, GBP/USD, USD/JPY, USD/CHF, AUD/USD, and USD/CAD, demonstrated that currency returns are generally modest but exhibit meaningful differences in volatility, correlation structures, and tail behavior. Diversification across currencies with differing risk-return profiles and interdependencies effectively reduces portfolio volatility and enhances risk-adjusted performance, highlighting the practical relevance of structured allocation strategies for retail participants.

Descriptive statistics showed that AUD/USD exhibited the highest volatility and potential risk-adjusted return, while USD/JPY was the most stable. Dynamic correlation analysis revealed that correlations between currency pairs are not static. Rolling-window and DCC-GARCH estimates captured time-varying and regime-dependent co-movements, such as strong positive correlations between EUR/USD and GBP/USD and negative correlations between EUR/USD and USD/CHF. These dynamic relationships provided valuable diversification opportunities and underscore the importance of incorporating time-varying covariance structures in portfolio optimization to reflect evolving market conditions.

Application of mean-variance optimization, adjusted for a realistic risk-free rate, resulted in improved portfolio efficiency relative to equal-weighted allocations. The optimized portfolio achieved a higher expected daily return of 0.000355 versus 0.000333, lower daily volatility of

0.00366 versus 0.00397, a higher annualized Sharpe ratio of 1.10 versus 0.93, and a reduced one-day 95% Value-at-Risk of 0.0071 versus 0.00825. These results demonstrate that strategic weighting of currency pairs based on historical risk-return characteristics and dynamic correlations enhances portfolio efficiency. Moreover, the improvements in Sharpe ratios and downside risk confirm that incorporating time-varying correlations can provide tangible benefits to retail investors.

Several methodological considerations remain. Assumptions of approximate normality and stationarity were largely satisfied but not formally tested. While dynamic correlations were incorporated, the optimization framework remains single-period and in-sample, without multi-period rebalancing or out-of-sample validation. Alternative allocation strategies, including risk parity, minimum variance, or robust optimization, were not empirically compared. These limitations highlight opportunities for methodological refinement in future studies.

The theoretical interpretation of results extends beyond classical MPT predictions. While higher expected returns were associated with higher risk and diversification effectively reduced volatility, dynamic allocation modeling also suggested that portfolio efficiency could be further enhanced by considering skewness, kurtosis, and regime-dependent correlations. Integrating frameworks such as Black-Litterman or robust optimization could account for investor views and reduce sensitivity to estimation errors, improving the reliability of allocation decisions. The structured optimization framework also mitigates behavioral biases commonly observed in retail trading, including overconfidence and excessive turnover, by replacing discretionary allocation with rule-based rebalancing.

Finally, while the study incorporates some recent literature on currency portfolio optimization, gaps remain in integrating high-impact research on dynamic allocation, robust MPT extensions, and multi-period optimization. Addressing these gaps could further strengthen the empirical and theoretical foundations of retail-focused currency allocation strategies.

In summary, the study confirms that structured quantitative approaches grounded in MPT, enhanced with dynamic correlation modeling and risk-adjusted Sharpe ratio computation, can materially improve retail investor decision-making in currency markets while highlighting avenues for future methodological refinement and advanced optimization techniques.

Recommendations

Retail investors can enhance portfolio efficiency and manage risk by adopting strategies informed by the study's findings. Simplified quantitative approaches, such as spreadsheet-based or online mean-variance optimization tools, enable data-driven allocation decisions without requiring programming skills or expensive software. Incorporating dynamic covariance matrices derived from rolling-window or DCC-GARCH models allows portfolios to respond to evolving correlations, improving robustness during periods of market stress.

Diversification should focus on a manageable number of major and minor currency pairs, such as four to six, to balance risk reduction with operational feasibility and monitoring efficiency. Cost-aware rebalancing is essential; transaction fees, bid-ask spreads, and potential slippage can erode returns if portfolios are adjusted too frequently. Rebalancing at longer intervals, such as quarterly or semi-annually, or when allocations drift beyond predefined thresholds, balances efficiency with cost-effectiveness.

Retail investors should also employ simple risk management tools, including stop-loss orders, exposure limits per currency pair, and monitoring of portfolio drawdowns. Even basic Excel-based Value-at-Risk calculations, adjusted for realistic confidence intervals, can provide meaningful insight into downside exposure. Combining historical return and volatility data with accessible macroeconomic indicators, such as interest rate differentials, central bank announcements, and geopolitical developments, allows more informed decisions without relying on advanced forecasting models.

Finally, future refinements could include multi-period portfolio optimization, Black-Litterman or robust optimization frameworks, on dynamic currency allocation. Together, these measures provide retail investors with practical, structured, and theoretically sound strategies for improving currency portfolio performance under realistic market conditions.

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