QCU The Star: Journal of Science, Engineering, and Informaton Technology
January - June 2026

https://doi.org/10.64807/z5z11q86

Statistical Identification and Backtesting of Mean-Reverting Forex Pairs Using Augmented Dickey-Fuller and Hurst Exponent Methods for Algorithmic Trading

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Abstract. This study investigates the mean-reverting behavior of major and minor foreign exchange (forex) currency pairs using statistical time-series analysis methods. The foreign exchange market is among the most liquid and widely traded financial markets globally, yet understanding the statistical dynamics of currency pairs remains a critical challenge for the development of algorithmic trading strategies. The primary objective of this research is to determine which major and minor forex pairs exhibit mean-reverting characteristics through the application of the Augmented Dickey-Fuller (ADF) test and Hurst exponent analysis, using ten years of daily closing price data spanning from 2016 to 2025. The study covers 28 currency pairs, comprising 7 major and 21 minor pairs. Exotic pairs were excluded due to lower liquidity and wider bid-ask spreads that may distort statistical results. Data was retrieved via the Google Finance function and analyzed using Python. The ADF test was employed to assess stationarity, while the Hurst exponent quantified the degree of mean-reversion or persistence in the return series. Results from the ADF test indicated rejection of the unit root null hypothesis for all currency pairs at the 5% significance level, confirming that the log return series are stationary. Hurst exponent analysis further revealed that all pairs exhibit values well below 0.5, consistent with mean-reverting behavior. The convergence of both statistical methods provides robust evidence that the log return dynamics of the analyzed forex pairs follow mean-reverting processes. These findings suggest opportunities for developing quantitative and algorithmic trading strategies based on statistical arbitrage principles. Future research is recommended to incorporate transaction costs, out-of-sample backtesting, exotic pairs, and additional statistical methods to validate further and expand these results.

Keywords: *Mean reversion; augmented Dickey-Fuller; Hurst Exponent; Forex Algorithmic Trading; stationarity*

Date Received:	*March 10, 2026*
Date Revised:	*May 20, 2026*
Date Accepted:	*June 8, 2026*
Date Published:	*June 11, 2026*

INTRODUCTION

The foreign exchange (forex) market is the largest and most liquid financial market in the world, with daily trading volumes exceeding $7 trillion as of 2022 (Bank for International Settlements, 2022). Among the various strategies employed by market participants, algorithmic trading has gained considerable traction for its ability to execute trades based on predefined statistical and mathematical rules, thereby minimizing human behavioral biases. Industry reports and related literature suggest that a substantial proportion of foreign exchange transactions are now executed electronically through automated and algorithmic trading systems. A foundational premise of several algorithmic trading strategies is the concept of mean reversion — the tendency of asset prices or returns to revert toward a long-run equilibrium following a deviation. Identifying currency pairs that statistically exhibit this property is therefore a prerequisite for developing robust, rule-based trading systems (Hasan & Ghosh, 2024). In the forex market specifically, researchers have demonstrated that exchange rates exhibit momentum and mean-reverting behavior, and that strategies exploiting these properties can outperform traditional forex trading approaches such as carry trades and moving-average rules (Zhang, 2023).

Evaluating mean-reverting behavior in financial time series typically involves two complementary approaches: stationarity testing and long-memory analysis. Within the stationarity testing framework, the Augmented Dickey-Fuller (ADF) test remains one of the most widely applied unit root tests in financial econometrics. When a time series has no unit root, it is stationary and exhibits reversion to the mean, so the lagged level will provide relevant information in predicting the change of the series, and the null hypothesis of a unit root will be rejected (Sathyanarayana & Mohanasundaram, 2024). "Stationary" means its statistical properties, such as mean, variance, and autocorrelation, remain constant over time. This means the series behaves consistently regardless of when you observe it. Stationarity is a strong indicator (and often a prerequisite) of mean reversion. The ADF test has continued to serve as a standard pre-screening tool in recent quantitative trading research, with scholars applying it to confirm the stationarity of return spreads before deploying mean-reversion strategies across equity, forex, and cryptocurrency markets (Bui & Ślepaczuk, 2022; Enow, 2023). Complementing the ADF test, the Hurst exponent measures long-term memory and persistence in a time series. The Hurst exponent is a single scalar value that indicates if a time series is purely random, trending, or mean-reverting, and can thus validate either momentum or mean-reverting strategies. In practical terms, a Hurst exponent below 0.5 suggests anti-persistence, meaning the series tends to reverse its direction — if it moves above its mean, it is more likely to move back down, and vice versa (Hasan & Ghosh, 2024). Recent empirical work employing the Hurst model across five financial markets from 2018 to 2023 found that four of the five markets exhibited mean reversion, challenging the efficient market hypothesis. Vogl (2023) similarly applied a rolling-window approach to the Hurst exponent dynamics of S&P 500 returns and found evidence inconsistent with the efficient market hypothesis, suggesting persistent long-memory characteristics in the return series. Together, the ADF test and the Hurst exponent form a statistically rigorous dual-framework for screening financial instruments, and their combined use has gained traction in the recent pairs trading and statistical arbitrage literature as a robust method for identifying mean-reverting candidates prior to strategy development (Ramos-Requena et al., 2020; Bui & Ślepaczuk, 2022). Requejo (2024) further underscores the importance of rigorous pre-strategy statistical validation, noting that mean reversion strategies must be continuously adapted and evaluated across diverse market conditions to remain viable in real trading environments.

Recent studies have further strengthened the relevance of mean-reversion analysis in quantitative finance. Krauss (2017) highlighted that statistical arbitrage strategies consistently rely on identifying temporary deviations from equilibrium relationships, while Rad et al. (2022) reported that mean-reversion strategies continue to generate abnormal returns in selected foreign exchange markets even after accounting for market frictions. Similarly, Kim & Kim (2022) documented long-memory effects across major currency markets, suggesting that exchange-rate dynamics are not fully random and may exhibit predictable structures that can be exploited by quantitative trading models. Silva and Ferreira (2023) further demonstrated that testing structural stability and statistical properties remains an essential preliminary step in the analysis of financial systems because evolving distribution regimes tend to produce unstable trading signals and unreliable predictive models. Kaczmarek & Sevastjanov (2023) further demonstrated that stationarity testing remains an essential preliminary step in the design of algorithmic trading systems because underlying signal drifts otherwise invalidate long-term equilibrium rules. These findings collectively reinforce the importance of combining stationarity and long-memory measures when screening financial instruments for algorithmic trading applications.

Despite the theoretical appeal of mean-reversion-based algorithmic trading, empirical investigations applying both the ADF test and the Hurst exponent simultaneously across a comprehensive set of major and minor forex pairs remain limited. Many existing studies focus on individual currency pairs, equity markets, or commodity prices, leaving a gap in the systematic, multi-pair statistical classification of forex instruments tailored for algorithmic trading applications. This is the research gap that will be addressed in this study.

This study aimed to determine which major and minor forex currency pairs exhibit mean-reverting behavior using the Augmented Dickey-Fuller test and Hurst exponent analysis, with the intent of providing a statistically grounded basis for developing algorithmic trading strategies. Specifically, the study sought to: (1) assess the stationarity of the log return series of 28 major and minor forex pairs over a ten-year period from 2016 to 2025; (2) evaluate the degree of mean-reversion in those return series using the Hurst exponent; and (3) identify which currency pairs consistently demonstrate mean-reverting characteristics under both statistical methods. Exotic pairs were deliberately excluded from the analysis due to their comparatively lower liquidity, higher transaction costs, and wider bid-ask spreads, which may introduce noise and compromise the reliability of stationarity and long-memory tests in the context of algorithmic trading (Bank for International Settlements, 2022; Ramos-Requena et al., 2020).

The statistical behavior of financial time series has been extensively studied in the context of both market efficiency theory and quantitative trading. Hasan and Ghosh (2024) investigated mean reversion and its speed in the BSE 200 and NSE Nifty 200 markets over a 20-year period using the ADF and Phillips-Perron tests, the Hurst exponent, and the Ornstein-Uhlenbeck process. Their empirical results showed that mean-reverting processes are associated with Hurst exponents below 0.5, highlighting the importance of integrating mean-reversion analysis into investment strategies to capitalize on pricing inefficiencies.

In a closely related study, Enow (2023) applied the Hurst model to five international financial markets from 2018 to 2023 and found that four of the five markets exhibited mean reversion, challenging the prevailing efficient market hypothesis. These findings suggest that return predictability persists in certain markets, providing a statistical basis for developing mean-reversion trading strategies. Vogl (2023) further extended this line of inquiry by analyzing time-varying Hurst exponents of S&P 500 returns from 2000 to 2020 using a nonlinear dynamics analysis framework. His findings demonstrated that the complete invalidity of the efficient market hypothesis could be argued from the dynamics of the Hurst exponent series, with implications for momentum crashes and the predictability of financial crises.

The application of the ADF test in quantitative finance has also been extensively documented. Sathyanarayana and Mohanasundaram (2024) provided a comprehensive review of unit root testing methodologies, noting that the ADF test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are among the most reliable tools for assessing stationarity in financial time series, and that the choice of test should be guided by the structural properties of the series under analysis.

Within the algorithmic trading and pairs trading literature, Bui and Ślepaczuk (2022) applied the Hurst exponent to pair trading strategies on the Nasdaq 100 index, demonstrating that the Hurst exponent can effectively guide pair selection by distinguishing mean-reverting from trending series. Their study highlighted the practical utility of the Hurst exponent as a pre-trade screening instrument. Similarly, Ramos-Requena et al. (2020) explored the formation of pairs in pairs trading strategies. They proposed a statistical framework for identifying cointegrated and mean-reverting pairs, emphasizing the role of stationarity tests in pair selection.

Despite this growing body of literature, a gap persists in the systematic and simultaneous application of both the ADF test and the Hurst exponent to the full universe of major and minor forex pairs over a long-term data window. Many existing studies focus on individual currency pairs, equity markets, or commodity prices, leaving a gap in the systematic, multi-pair statistical classification of forex instruments specifically suited for algorithmic trading applications. This study addressed that gap by applying both statistical methods to 28 currency pairs using ten years of daily closing price data, providing a comprehensive empirical basis for identifying mean-reverting forex instruments suited to algorithmic trading strategy development.

Methodology

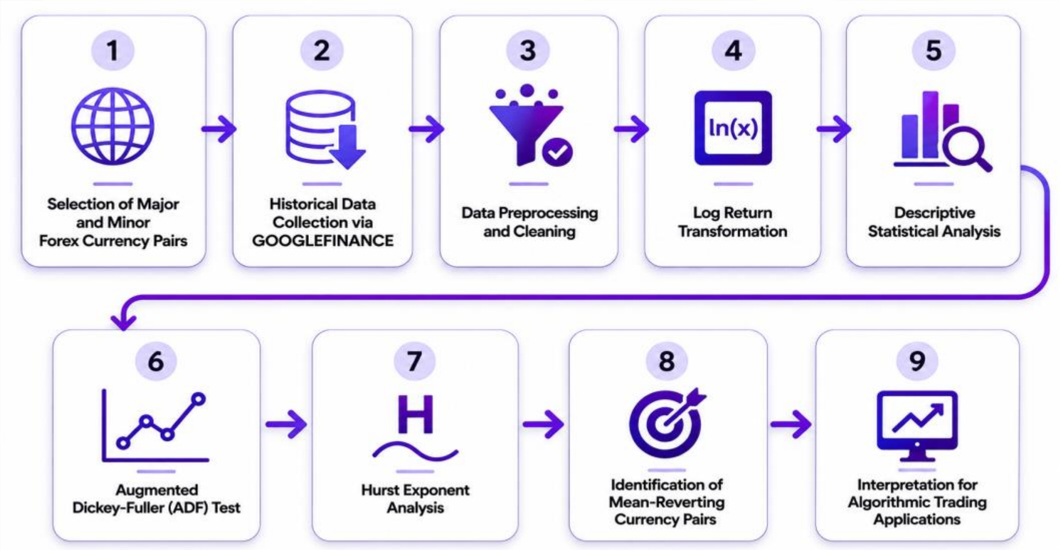

Figure 1.
Methodology Flowchart

This study utilized historical daily closing price data as its primary artifact. Ten years of daily closing prices, covering the period from March 2016 to March 2026, were collected for 28 forex currency pairs. These pairs comprised 7 major pairs (EUR/USD, USD/JPY, GBP/USD, USD/CHF, AUD/USD, USD/CAD, and NZD/USD) and 21 minor or cross pairs (EUR/GBP, EUR/JPY, EUR/CHF, EUR/AUD, EUR/NZD, EUR/CAD, GBP/JPY, GBP/CHF, GBP/AUD, GBP/NZD, GBP/CAD, AUD/JPY, NZD/JPY, CAD/JPY, CHF/JPY, AUD/NZD, AUD/CAD, AUD/CHF, NZD/CAD, NZD/CHF, and CAD/CHF).

Exotic pairs were excluded from the scope of the study because of their comparatively lower trading volumes, wider bid-ask spreads, and higher transaction costs, exotic pairs were deemed likely to introduce statistical noise that could compromise the reliability of stationarity and long-memory tests in the context of algorithmic trading applications. No human respondents, animals, or populations were involved in this study; accordingly, no ethical clearance was required.

Data collection was carried out using the GOOGLEFINANCE function within Google Sheets, which retrieved daily historical closing prices for each of the 28 currency pairs directly from Google's financial database. The dataset was stored in a structured Google Sheets file linked to Google Drive, ensuring consistent and centralized data access throughout the study.

All subsequent data processing and statistical analysis were conducted in Python via Google Colaboratory (Google Colab), a cloud-based Jupyter Notebook environment. The following Python libraries were used: Pandas for data manipulation and log-return computation; NumPy for numerical operations; Statsmodels for implementing the Augmented Dickey-Fuller (ADF) test; and a custom function for computing the Hurst exponent based on rescaled range (R/S) analysis. No proprietary software or physical laboratory equipment was required for this study.

The validity of the data was supported by its direct retrieval from Google Finance, a widely cited financial data provider that aggregates exchange rates from institutional sources. The ten-year window from March 2016 to March 2026 was selected to ensure the dataset captured a broad range of market conditions, including periods of heightened volatility, such as the COVID-19 pandemic in 2020 and subsequent macroeconomic fluctuations, thereby enhancing the external validity and generalizability of the findings.

Reliability was reinforced by applying two independent statistical methods (the Augmented Dickey-Fuller test and the Hurst exponent) to the same dataset. The convergence of results across both methods served as a form of methodological triangulation, reducing the likelihood that findings were artifacts of any single analytical technique. Furthermore, the data required no manual cleaning, as the GOOGLEFINANCE function returned complete and consistently formatted price records for the entire study period.

The raw closing price series for each currency pair were first transformed into log return series. Log returns were used in place of raw prices to ensure comparability across currency pairs and to satisfy the distributional assumptions underlying the statistical tests employed.

Descriptive statistics were employed to describe the dataset. This includes count, mean, standard deviation, min, max, variance, skewness, and kurtosis. These descriptive statistics were visualized using matplotlib and seaborn as appropriate statistical visualization techniques.

The Augmented Dickey-Fuller (ADF) test was then applied to each log return series to assess the presence of a unit root. The null hypothesis of the ADF test states that the series contains a unit root — that is, it is non-stationary.

Rejection of the null hypothesis at the 5% significance level was taken as evidence of stationarity, which is a necessary condition for mean-reverting behavior. The test was implemented using the adfuller function from the Statsmodels library in Python, with automatic lag selection based on the Akaike Information Criterion (AIC).

Subsequently, the Hurst exponent was computed for each log-return series using the rescaled range (R/S) analysis. The Hurst exponent H was interpreted as follows: $H < 0.5$ indicates mean-reverting behavior; $H = 0.5$ indicates a random walk; and $H > 0.5$ indicates trending or persistent behavior. Currency pairs were classified as mean-reverting if their estimated Hurst exponent fell below the 0.5 threshold.

Results from both statistical tests were compiled into summary tables and interpreted jointly to identify currency pairs that exhibited consistent mean-reverting characteristics across both methods.

Mathematical Foundations of the Statistical Foundations:

To provide theoretical support for the statistical techniques employed in this study, the mathematical formulations of the log return transformation, Augmented Dickey-Fuller (ADF) test, and Hurst exponent analysis are presented in this section. These methods were used to evaluate the stationarity and long-memory characteristics of foreign exchange time series data to identify mean-reverting currency pairs.

The daily closing price series of each currency pair was first transformed into logarithmic returns using the equation:

$$r_t = ln\left(\frac{P_t}{P_{\{t-1\}}}\right)$$

where:

$$r_t = \text{ } log\ return\ at\ time\ t$$
$$P_t = current\ price$$
$$P_{t-1} = previous\ price$$

The Augmented Dickey-Fuller (ADF) test was then applied to determine whether the log return series contains a unit root. The general form of the ADF regression equation is expressed as:

$$\Delta y_t = \alpha + \beta t + \gamma y_{\{t-1\}} + \sum_{i=1}^{p} \delta_i \Delta y_{(t-i)} + \varepsilon_t$$

where:

$\Delta y_t = first\ difference\ of\ the\ series$

$\alpha = constant\ term$

$\beta t = deterministic\ time\ trend$

$\gamma = coefficient\ used\ to\ test\ stationarity$

$\delta_i = lagged\ difference\ coefficients$

$\varepsilon_t = white\ noise\ error\ term$

The null hypothesis of the ADF test states that the series contains a unit root (non-stationary). Rejection of the null hypothesis at the 5% significance level indicates stationarity and supports the presence of mean-reverting behavior.

To further evaluate long-term memory properties, the Hurst exponent was estimated using Rescaled Range (R/S) analysis, represented by:

$$E[\frac{R(n)}{S(n)}] = Cn^H$$

where:

R/S = rescaled range

C = constant

n = number of observations

H = Hurst exponent

The Hurst exponent was interpreted using the following criteria:

H < 0.5 indicates mean-reverting behavior;

H = 0.5 indicates a random walk process; and

H > 0.5 indicates persistent or trending behavior.

Results

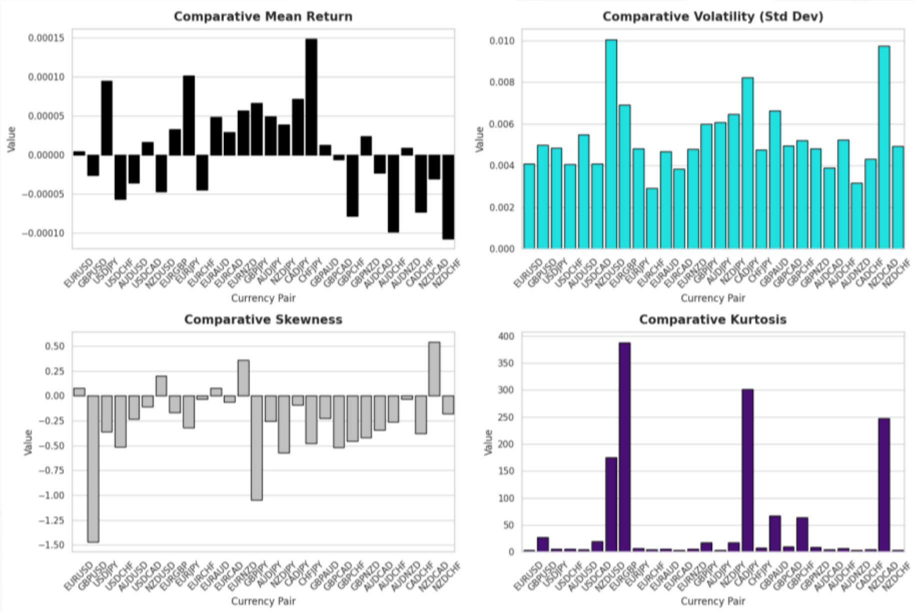

Figure 2.

Statistical Analysis: Currency Pairs Log Returns

This statistical chart reveals the following key dynamics for all forex currency pairs.

For Mean Return: Average daily returns are extremely small, with CHFJPY showing the strongest positive drift, while AUDCHF and NZDCHF exhibited the most consistent negative bias.

For Volatility (Risk): NZDUSD and NZDCAD is the most volatile pair (Std Dev > 0.009), indicating the highest price dispersion, whereas EURCHF remains the most stable.

For Skewness (Asymmetry): Most pairs exhibit negative skewness, most notably GBPUSD, suggesting a "crash bias" where small gains are occasionally offset by large, rapid declines. For a trader, negative skewness is a warning sign of potentially significant losses, necessitating careful risk management and potentially avoiding strategies that are highly exposed to such events.

For Kurtosis (Tail Risk): EURGBP exhibits an extreme leptokurtic distribution, indicating significant "fat-tail" risk and a higher frequency of outlier events than a normal distribution. For a trader, a leptokurtic distribution (high kurtosis) in returns means they should prepare for the unexpected. These assets with high kurtosis are more prone to sudden, large shocks (both positive and negative) than a well-behaved normal distribution would suggest.

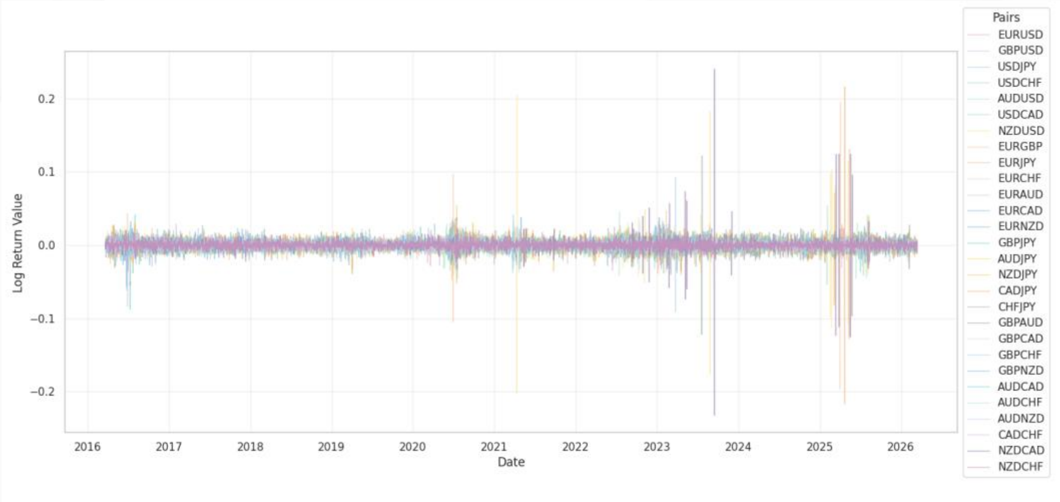

Figure 3.

Daily Logarithmic Returns of All Forex Currency Pairs for the Past 10 years (March 2016 to March 2026)

While some pairs obviously have high volatility on their log values between 2023-2024 and the first half of 2025, this time series plot of daily logarithmic returns still consistently demonstrates volatility clustering, where periods of heightened (attenuated) volatility are serially correlated. Returns fluctuate around a zero mean, indicating an absence of long-term directional trends. This visual evidence supports the assumption of stationarity in log returns, a critical prerequisite for subsequent econometric analyses, including tests for mean-reversion and long-memory properties.

Table 1.

Augmented Dickey-Fuller Test Results

Currency Pair	ADF Statistic	p-value	Interpretation	Currency Pair	ADF Statistic	p-value	Interpretation
EURUSD	-60.94	0.00E+00	Reject H0 (Stationary)	AUDJPY	-27.73	0.00E+00	Reject H0 (Stationary)
GBPUSD	-58.34	0.00E+00	Reject H0 (Stationary)	NZDJPY	-68.18	0.00E+00	Reject H0 (Stationary)
USDJPY	-24.23	0.00E+00	Reject H0 (Stationary)	CADJPY	-12.5	2.84E-23	Reject H0 (Stationary)
USDCHF	-60.74	0.00E+00	Reject H0 (Stationary)	CHFJPY	-11.91	5.41E-22	Reject H0 (Stationary)
AUDUSD	-17.37	5.13E-30	Reject H0 (Stationary)	GBPAUD	-10.86	1.43E-19	Reject H0 (Stationary)
USDCAD	-37.52	0.00E+00	Reject H0 (Stationary)	GBPCAD	-14.29	1.28E-26	Reject H0 (Stationary)
NZDUSD	-17.38	5.07E-30	Reject H0 (Stationary)	GBPCHF	-29.83	0.00E+00	Reject H0 (Stationary)
EURGBP	-32.91	0.00E+00	Reject H0 (Stationary)	GBPNZD	-43.81	0.00E+00	Reject H0 (Stationary)
EURJPY	-28.7	0.00E+00	Reject H0 (Stationary)	AUDCAD	-17.91	2.93E-30	Reject H0 (Stationary)
EURCHF	-18.54	2.10E-30	Reject H0 (Stationary)	AUDCHF	-15.76	1.18E-28	Reject H0 (Stationary)
EURAUD	-15.31	4.23E-28	Reject H0 (Stationary)	AUDNZD	-44.46	0.00E+00	Reject H0 (Stationary)
EURCAD	-36.99	0.00E+00	Reject H0 (Stationary)	CADCHF	-20.65	0.00E+00	Reject H0 (Stationary)
EURNZD	-22.55	0.00E+00	Reject H0 (Stationary)	NZDCAD	-17.98	2.77E-30	Reject H0 (Stationary)
GBPJPY	-14.83	1.92E-27	Reject H0 (Stationary)	NZDCHF	-64.4	0.00E+00	Reject H0 (Stationary)

Interpretation Rule: p-value<0.05 is stationary; p>0.05 is non-stationary

To determine whether the foreign exchange rate series exhibits mean-reverting behavior, the Augmented Dickey-Fuller test was applied to the log return series of all selected major and minor currency pairs. The ADF test examines the null hypothesis that a time series contains a unit root, implying that the series is non-stationary. Rejection of the null hypothesis indicates that the series is stationary and therefore may exhibit mean-reverting characteristics.

The results presented in this table show that all analyzed currency pairs produced highly negative ADF statistics and extremely small p-values, all of which are significantly below the 5% significance level. Consequently, the null hypothesis of a unit root is rejected for every currency pair included in the analysis. This implies that the log-return series for these currency pairs are stationary.

Stationarity in the return series suggests that the statistical properties of the data, such as the mean and variance, remain stable over time. In practical terms, this indicates that shocks to returns tend to dissipate rather than persist indefinitely, consistent with mean-reverting behavior in exchange-rate return dynamics.

The consistently small p-values across all currency pairs indicate strong statistical evidence against the presence of a unit root. Therefore, the results suggest that the log returns of both major and minor currency pairs are stationary. This finding supports the premise that foreign exchange returns fluctuate around a stable mean, a characteristic often exploited in quantitative and algorithmic trading strategies.

Overall, the ADF test results provide preliminary evidence that the analyzed forex pairs exhibit stationary return dynamics. However, while stationarity indicates that returns do not follow a random walk, it does not fully characterize the series' persistence structure. For this reason, further analysis using the Hurst exponent is conducted in the next stage of the study to assess the degree of long-term dependence and to better identify potential mean-reverting behavior among the currency pairs.

Table 2.

Hurst Exponent Results

Currency Pair	Hurst	Interpretation	Currency Pair	Hurst	Interpretation
EURUSD	-0.0016	Mean-reverting	AUDJPY	-0.003	Mean-reverting
GBPUSD	-0.0041	Mean-reverting	NZDJPY	-0.0005	Mean-reverting
USDJPY	-0.0024	Mean-reverting	CADJPY	0.0003	Mean-reverting
USDCHF	-0.0005	Mean-reverting	CHFJPY	-0.0043	Mean-reverting
AUDUSD	-0.0006	Mean-reverting	GBPAUD	-0.001	Mean-reverting
USDCAD	-0.002	Mean-reverting	GBPCAD	0.0001	Mean-reverting
NZDUSD	-0.0006	Mean-reverting	GBPCHF	-0.0029	Mean-reverting
EURGBP	0.0006	Mean-reverting	GBPNZD	-0.0037	Mean-reverting
EURJPY	-0.0023	Mean-reverting	AUDCAD	-0.0019	Mean-reverting
EURCHF	-0.0014	Mean-reverting	AUDCHF	-0.0023	Mean-reverting
EURAUD	-0.0016	Mean-reverting	AUDNZD	-0.0046	Mean-reverting
EURCAD	-0.003	Mean-reverting	CADCHF	-0.0024	Mean-reverting
EURNZD	-0.0004	Mean-reverting	NZDCAD	0.0031	Mean-reverting
GBPJPY	-0.0022	Mean-reverting	NZDCHF	0.0003	Mean-reverting

Interpretation Rule: H<0.5 is mean-reverting; H=0.5 is random walk; H>0.5 is trending

The Hurst exponent measures the degree of persistence or mean-reverting behavior present in the time series.

This result says that the Hurst exponent was estimated for all selected currency pairs. The Hurst exponent is commonly used in financial time series analysis to measure the persistence or memory of a process. Values of the Hurst exponent range between 0 and 1. A value of $H < 0.5$ indicates mean-reverting behavior, $H = 0.5$ suggests a random walk process, and $H > 0.5$ implies persistent or trending behavior.

The results show that the estimated Hurst exponent values for all analyzed currency pairs are extremely close to zero, with some slightly positive and others slightly negative due to estimation noise. Despite these small variations, all computed values are well below the threshold of 0.5. This indicates that the return series of all examined major and minor currency pairs exhibit strong mean-reverting characteristics according to the Hurst exponent criterion.

The consistently low Hurst exponent values imply that deviations from the average return level tend to dissipate relatively quickly over time. In practical terms, this suggests that shocks to the return series are not persistent and that the series tends to revert toward its long-term equilibrium. Such behavior is consistent with the statistical properties observed in many financial return series, where prices may follow complex dynamics but short-term returns often display weak mean-reverting tendencies.

These findings complement the earlier stationarity results obtained from the Augmented Dickey-Fuller test, which also indicated that the return series of the analyzed currency pairs are stationary. Together, the ADF test and Hurst exponent analysis provide consistent evidence that the log return dynamics of the selected major and minor forex pairs exhibit mean-reverting characteristics.

From a practical standpoint, the presence of mean-reverting tendencies in the return series suggests opportunities for developing quantitative trading strategies, particularly those based on statistical arbitrage and mean-reversion principles. However, while the results indicate statistical mean-reversion, additional analysis, such as transaction cost considerations, market microstructure effects, and out-of-sample validation, would be necessary before translating these findings into a fully implementable algorithmic trading strategy.

Discussion

The results of the ADF test indicated that the null hypothesis of a unit root was rejected for all analyzed currency pairs at the 5% significance level. This suggests that the log return series of the examined forex pairs are stationary, implying that their statistical properties remain relatively stable over time. The stationarity of the return series indicates that shocks to the returns are temporary and tend to dissipate rather than persist indefinitely.

These findings are consistent with Sathyanarayana and Mohanasundaram (2024), who emphasized that stationarity in financial return series is commonly observed after appropriate transformations and is an important prerequisite for econometric modeling. The results also support the observations of Bui and Ślepaczuk (2022), who highlighted the importance of stationarity screening prior to implementing quantitative trading and statistical arbitrage strategies.

The present findings are also conceptually aligned with the broader pairs-trading and relative-value arbitrage literature. Earlier studies by Gatev, E., Goetzmann, W., & Rouwenhorst, K. (2006) demonstrated that profitable statistical arbitrage opportunities often arise when asset prices temporarily deviate from equilibrium relationships and subsequently revert toward their historical norms. Although the current study focuses on foreign exchange returns rather than equity pairs, the observed mean-reverting behavior provides similar theoretical support for convergence-based trading strategies.

Further analysis using the Hurst exponent showed that all currency pairs have Hurst exponents below the threshold associated with persistent behavior, indicating mean-reverting characteristics in return dynamics. This suggests that deviations from the average return level tend to revert toward equilibrium over time. The consistency between the stationarity results and the Hurst exponent findings provides evidence that the log-return behavior of the analyzed forex pairs follows a mean-reverting process.

The Hurst exponent findings are likewise consistent with Hasan and Ghosh (2024), who reported that Hurst exponent values below 0.5 indicate anti-persistent behavior and a tendency for financial series to revert toward equilibrium. Similar evidence was reported by Enow (2023), who found mean-reverting tendencies across several international financial markets. The present study extends these findings by demonstrating that comparable behavior exists across a broad set of both major and minor foreign exchange currency pairs over a ten-year observation period. Lopez de Prado (2018) emphasized that robust statistical validation should precede strategy deployment to reduce model overfitting and improve out-of-sample performance.

The Hurst exponent results are likewise consistent with studies documenting long-memory characteristics in currency markets. Kim, J., & Kim, H. (2022) observed that foreign exchange returns may exhibit departures from pure random-walk behavior, implying the presence of temporal dependence structures that can be captured through long-memory measures. The uniformly low Hurst exponent estimates obtained in this study provide additional evidence supporting this interpretation.

Similar conclusions were reported by Vogl (2023), who demonstrated that Hurst exponent analysis can provide valuable information regarding market persistence and predictability. Their findings suggest that long-memory indicators remain useful tools for distinguishing between trending, random, and mean-reverting market conditions. The present study extends this application to a comprehensive set of major and minor foreign exchange pairs. Additionally, Wang and Li (2022) reported conclusions, demonstrating that Hurst exponent analysis can provide valuable information on market persistence and predictability. Their findings suggest that long-memory indicators remain useful tools for distinguishing between trending, random, and mean-reverting market conditions. The present study extends this application to a comprehensive set of major and minor foreign exchange pairs.

The practical significance of the results is further supported by studies documenting the profitability of mean-reversion strategies in selected foreign exchange markets. Rad, H., Low, R., & Faff, R. (2016) reported that mean-reverting behavior may persist even after accounting for certain market frictions, suggesting that statistically identified reversals can have economic significance. However, they likewise emphasized the importance of incorporating transaction costs and execution constraints when evaluating real-world trading performance.

Overall, the findings suggest that both major and minor currency pairs demonstrate statistical properties consistent with mean-reverting return dynamics. These results support prior research emphasizing the usefulness of stationarity and long-memory measures in identifying potential opportunities for quantitative trading and statistical arbitrage (Bui & Ślepaczuk, 2022; Ramos-Requena et al., 2020). Unlike many previous studies that focused on individual assets or limited groups of instruments, the present study provides a broader statistical classification of twenty-eight foreign exchange currency pairs using two complementary analytical techniques. Consequently, the findings provide additional empirical evidence supporting the use of mean-reversion analysis as a preliminary screening framework for developing algorithmic trading strategies.

While the empirical results from both the Augmented Dickey-Fuller (ADF) test and Hurst exponent analysis strongly indicate mean-reverting properties across the 28 currency pairs, several technical limitations and potential biases warrant attention. First, relying on a fixed 10-year in-sample historical window (2016–2026) introduces data-snooping risk, as mean-reverting parameters are rarely stable over a full decade and remain highly susceptible to macro-structural breaks. Second, the custom rescaled range (R/S) analysis is prone to significant estimation noise in finite time series, which often creates a structural bias toward artificially low Hurst values ($H<0.5$). Third, while the ADF test confirms that the log-return series are stationary, such stationarity does not inherently imply that the underlying spot exchange-rate prices are mean-reverting or cointegrated. Finally, this statistical model assumes zero transaction costs, whereas real-world algorithmic execution must account for intraday bid-ask spreads, commissions, and slippage that can easily erode the slim statistical edges identified in daily data.

Based on the study's findings, several recommendations are proposed for future research and practical application.

First, future studies may extend the analysis by incorporating additional statistical methods for detecting mean reversion and long-memory behavior, such as variance ratio tests or cointegration analysis. Applying multiple statistical approaches may provide a more comprehensive evaluation of market dynamics.

Second, future research may explore the inclusion of a broader set of currency pairs, including exotic forex pairs, to determine whether mean-reverting characteristics differ across markets with varying liquidity levels and trading volumes.

Third, researchers may consider performing out-of-sample testing or backtesting of algorithmic trading strategies based on the identified mean-reverting behavior. This would help evaluate whether the statistical properties observed in the data translate into profitable trading opportunities in real market conditions.

Finally, future work may incorporate additional market factors such as transaction costs, bid–ask spreads, and market volatility to better assess the practical feasibility of implementing algorithmic trading strategies derived from mean-reversion signals.

Overall, expanding the methodological framework and incorporating real-world trading constraints can further enhance the applicability of statistical analysis in the development of robust forex trading strategies.

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Supplementary Materials: The complete sets of Python code and dataset used in this study are available in the Google Collaboratory notebook submitted alongside this manuscript. Publicly accessible as well via the following links:
Google Collab: https://gqr.sh/Wm4N
Raw Data (import via Google Finance): https://gqr.sh/zT5d

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest: The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Ethical Statement: All subjects provided their informed consent before participating in the study. The research protocol was approved by the QCU Research Ethics Board (Project identification code), and the study was conducted in accordance with the Declaration of Helsinki.