A Cointegration Approach for Selection of Currency Pairs

Farhat Akhtar [1]
Munesh Kumar [2]
N.S. Malik [3]

Abstract

Pairs trading is a statistical arbitrage strategy based on the construction of mean reversion in prices of securities. While these strategies tend to perform well in equities, their effectiveness and performance in the currency market is yet to be tested, which is generally inefficient and predictable. The purpose of this study was to select the pairs for pairs trading in the forex market of select currencies: EUR/USD, GBP/USD, USD/CAD, USD/INR, USD/JPY, and USD/NZD during the period starting from October 1, 2010 – October 20, 2020. The research was organized into three parts to determine the possible pairs of six currencies over different time periods. First, the closeness of potential pairs of six currencies was established using the distance approach for 10 years, 5 years, and 2 years. After that, the Engle – Granger two-step test for cointegration was applied to examine the validity of the top 10 closest pairs of currencies for pairs trading in the study. Based on the empirical results of the cointegration approach, we found very few good pairs in the forex market in our study. USD_INR/USD_NZD was found to be statistically significant at a 10% level of significance over the 10-year sample period, and the same pair of currencies was also found to be statistically significant over a 5-year sample period, but this pair was not found to be statistically significant in the 2-year sample period; whereas, USD_JPY/USD_NZD was found to be statistically significant in the 2 - year period at a 10% level of significance.

Keywords : **forex market, currency, pairs trading, cointegration**

JEL Classification Codes: C32, G11, G15

Paper Submission Date : April 10, 2021 ; Paper sent back for Revision : November 20, 2021 ; Paper Acceptance Date : November 30, 2021 ; Paper Published Online : December 15, 2021

The fundamental evolution and execution of moneymaking investment strategies with an economic risk profile is a challenging task that speculative traders, policymakers, and academia continuously follow in financial markets. In the contemporary era, the foreign exchange market is one of the fascinating and fastest-growing financial markets globally. Yet, the microstructure of the foreign exchange market is only now receiving serious attention. Generally, it is considered one of the most liquid markets in the world. Its liquidity does not have a slippage problem and acts as a favorable market for speculators to trade-in. Learning about currency trading is pretty straightforward in the investment market, but finding the winning trading strategies is too tricky and needs a lot of practice. In the forex market, all currency trading is done in duos. The first currency in the pair of currencies for buying/selling is called the base currency. In contrast, the other currency is known as the

[1] *Research Scholar,* Haryana School of Business, Guru Jambheshwar University of Science & Technology, Hisar - 125 001, Haryana. (Email : farhatakhtar2805@gmail.com) ; ORCID iD : https://orcid.org/0000-0001-7924-892X
[2] *Research Scholar,* Haryana School of Business, Guru Jambheshwar University of Science & Technology, Hisar - 125 001, Haryana. (Email : munesh130315@gmail.com) ; ORCID iD : https://orcid.org/0000-0002-1770-9855
[3] *Professor,* Haryana School of Business, Guru Jambheshwar University of Science & Technology, Hisar - 125 001, Haryana. (Email : nsmalik2002@gmail.com) ; ORCID iD: https://orcid.org/0000-0002-0165-2719

DOI : https://doi.org/10.17010/ijf/2021/v15i12/160018

quoted or counter currency (Chen, 2009). In this context, Wall Street has long been interested in quantitative methods of speculation (Vidyamurthy, 2004). Pairs trading is considered one of the most popular short-term speculation strategies (Gatev et al., 2006), especially in the field of investment banking and hedging, and capable of gaining profits regardless of the market direction.

The application of the pairs trading strategy is based on exploiting mean reversion and looking at the historical price relationship between two securities to identify which is overvalued or undervalued concerning the other one. By adopting long strategies on relatively undervalued stock while adopting short strategies on relatively overvalued stock, large profits can be made by disentangling the position upon the convergence of the spread or taking a measure of the comparative mispricing (Huck & Afawubo, 2015). It became rigid to know the fundamentals of currencies and find robust pairs with easier access to data.

The present study explores the combination of the most promising pair of currencies in the forex market. The top traded currencies are selected randomly by distance approach and then investigated for validation purpose by Engle and Granger residuals-based cointegration technique. It is essential to study the market-neutral strategy in the forex market because it is essential to determine the suitable pairs to find out which pair is more robust and profitable. It also became helpful for speculators to anticipate the financial behavior with vital clues to take an informed position in the forex market with effective currency candidates.

The increase in the cross dependence of economies due to comparative advantages of manufacturing has led to exponential growth in international trade across national boundaries. The demand for currency pairs trading, especially the most dominating currency pairs, has substantially increased manifold over the years due to arbitrage opportunities. Hence, the approach to the selection of currency pairs plays a very advantageous role in finding the opportunities and cashing thereon. The present study thus introduces the concept of pairs trading in the forex market with available data.

Literature Review

Pairs trading strategy is considered a market-neutral strategy applied to intricate the statistical arbitrage profits. In this strategy, temporary deviations from the long-term equilibrium level are considered for a pair of asset prices. It is one of the popular strategies that gained its importance in the mid-1980s when the team of the Wall Street quants first utilized it (Vidyamurthy, 2004). There are many approaches and techniques of pairs trading, out of which the distance approach and cointegration model have great importance and are the widely practiced techniques. The distance approach identifies the most suitable pairs that minimize the historical sum of the square distance between the two price series. Later, Gatev et al. (2006) introduced a seminal paper having more emphasis on this approach. Their research was performed on the US equity market and further extended on other data sets with robust results. In their study, Gatev et al. (2006) pointed out GGR with some improvements in the distance approach for selecting pairs with minimum distance.

Similarly, Cohen and Frazzini (2008) also worked on the US market to better predict the return. GGR methodology was also used in Do and Faff's (2010, 2012) studies, but with an extension of the sample period and found confirmation of declining profitability in the pairs trading. Chen et al. (2017) formed a long-short portfolio with Pearson correlation as a selection metric with the same data set of Gatev et al. (2006) and found robust results. Bowen and Hutchinson (2014) replicated the GGR model to the UK equity market to predict the futures prices following a similar study by Broussard and Vaihekoski (2012). They confirmed the statistically significant excess returns. Aggarwal and Aggarwal (2020) studied the futures daily prices of the Indian stock market listed on NSE over 2011 – 2017. They investigated the most suitable techniques to identify the better pairs in pairs trading techniques.

Vidyamurthy (2004) proposed a theoretical framework of the cointegration methodology of pairs trading to identify the optimal pairs for trading. Since then, different analyses have been carried out by applying the same method in different markets. Puspaningrum (2012) used the same methodology to identify the stocks in the stock markets. Tsay (2010) also followed the same methodology.

Cummins and Bucca (2012) studied the crude oil-based commodity market, and a total of 861 spreads were taken for analysis. Burgess (1999) discussed the statistical arbitrage with the cointegration approach along with computational neural networks and genetic algorithms model. Liu and Chou (2003) discussed the fractional cointegration to find the genuine parity relationship between silver and gold for forecasting the market. Karakas (2009) also adopted the same approach for dual-class firm analysis. Gatarek et al. (2011, 2014) used a single set of securities for cointegration testing in their respective studies. Only Cheng et al. (2011) worked with mixed mode. Chen et al. (2017) investigated the Chinese commodity futures market with daily data from 2006 – 2016 to examine the pairs trading. This article studied commodity price behavior with a cointegration model and generated an average of 26% returns.

Huck and Afawubo (2015) evaluated various pairs of trading methods to explore the best selection approach in the literature. In this pairs trading strategy, they used the S&P 500 index for empirical application. This article tested the well-known approaches of pairs trading like distance, cointegration, and stationary for highlighting computational finance. The stationary test revealed the weak performance in the finance market; whereas, both distance and cointegration techniques generated stable and robust results. Clegg and Krauss (2018) dealt with a data set of S&P 500 to identify promising pairs with the help of a cointegration approach.

Tokat and Hayrullahoğlu (2021) suggested using a cointegration-based pairs trading framework to generate trading rules of different asset classes, which performed well with a 15% average annual return during the bear market conditions. Ramos-Requena et al. (2020a, 2020b) considered different models for the formation of a pair in pairs trading. The results of this study showed that the new methodology or method provided better results as compared to the old equal-weighted strategy.

In particular, results obtained by both distance and cointegration approaches proved to be very promising. The supporting literature on pairs trading consists of studies of Avellaneda and Lee (2010), Chen et al. (2017), Puspaningrum (2012), Hong and Susmel (2003), Cummins and Bucca (2012), Ramos-Requena et al. (2020 a, b) among others.

Khuntia and Jamini (2017) studied the adaptive market hypothesis (AMH), an alternative economic theory of efficient market hypothesis (EMH), which implies that markets are efficient and market efficiency is a time-variant element. They tried to reconcile the theory in the Indian foreign exchange market context. The data were collected by the daily bilateral exchange rate between the Indian rupee and the US dollar. The study's findings proved that market efficiency works as an element that goes around with sentiments of the different market conditions. Integration of exchange rate and stock market were investigated by Yadav (2016) to know the relationship between the Nifty index and the Indian exchange rate in consideration with the US dollar. The main motive of conducting this research was to determine the impact of change in the foreign exchange rate in India trading with the Nifty index. The results showed a negative correlation between the two variables. Hence, as per the study, investors could opt for the volatile stock market for trading to minimize the fear of risk.

Dadhich et al. (2015) and De and Chakraborty (2015) also tried to assess the foreign portfolio investment and stock market volatility in India. They explored the equity and commodity markets and obtained satisfactory results of different trade durations. But the pairs trading technique in the foreign exchange or currency markets remains unexplored. Therefore, in the present study, two different approaches for pairs selection: the distance approach and cointegration model were used on the data set of most tradable currencies of the foreign exchange market.

Objective of the Study

The study endeavors to check the validity of the selected six pairs of currencies for pairs trading in the forex market : EUR/USD, USD/CAD, USD/CAD, USD/INR, USD/JPY, and USD/NZD.

Research Methodology

Dataset and Time Frame

The present study is empirical, and the pairs trading mainly applies to daily data of the six currency exchange rates: EUR/USD, GBP/USD, USD/CAD, USD/INR, USD/JPY, and USD/NZD. Table 1 contains the information about the variables and time frame used in the study. Three sample time frames were taken to determine the possible pairs over different time frames. The first 10-year data from October 1, 2011 – October 20, 2020, named Panel A in the study, represents a large span of time. The second 5-year data from October 1, 2015 – October 20, 2020, named as Panel B, represents the medium time duration. The last 2-year sample data from October 1, 2018 – October 20, 2020 is named Panel C, which represents the small duration of time. The data were obtained from https://www.investing.com/ and analyzed using MS Excel and Eviews 11 software.

Table 1. ***Variables and Sample Period of the Study***

		Period		
S. No.	**Exchange Rates**	**Panel A (10 years)**	**Panel B (5 years)**	**Panel C (2 years)**
1	EUR_USD	October 1, 2010 to	October 1, 2015 to	October 1, 2018 to
2	GBP_USD	October 20, 2020	October 20, 2020	October 20, 2020
3	USD_CAD			
4	USD_INR			
5	USD_JPY			
6	USD_NZD			

Methodology

The present study applied a distance approach to measure the closeness of two currency prices, and the cointegration approach was used to check the validity of the pairs. Engle – Granger's residual-based approach was used to establish the long-run association between the currency's pairs, and ECM was further applied to know the speed of adjustment in the long-run relationship.

Distance Approach

First of all, the currency prices were normalized by the following formula :

$$norm\,P_{it} = \frac{P_{it} - \overline{X}_p}{Sd_p} \qquad (1)$$

where, $norm\ P_{it}$ = normalized currencies, P_{it} = currencies price, $\overline{X}_p$ = mean of the currency series, and SD_p = standard deviation of the currency price.

The next step was to find the sum of the squared difference between the prices of the two assets. The pairs with the smallest distance numbers are the most suitable for pairs trading (Gatev et al., 2006). In the third step, all the sum of squared differences were ranked from most minor to the largest, and then out of all, the top 10 ranks were selected for testing the validity by using the cointegration approach.

Unit Root Test

A time series is considered strictly stationary if its probability distribution remains invariant over time (Brooks, 2008), that is, all higher-order moments are constant. However, time-series having strict stationarity are hardly found. Thus, weakly stationary processes are appropriate to be viewed as stationary. A weakly time series consists of constant mean, variance, and autocovariance (Enders, 2010).To know the level of integration of series to fulfill the assumption of the Engle – Granger test, the following equation of ADF test was applied with constant and trend:

$$\Delta y_t = \mu + \beta_T + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-1} + \varepsilon_t \qquad (2)$$

where, y_t = the time series being tested, T = a time trend term, t = the first difference operator, k = the optimal lag length, and ε_t = a white noise disturbance term.

Cointegration Test

Two variables are said to be cointegrated if they have a common stochastic trend in the long run. If a linear combination of non-stationary variables is stationary, that is, $I(0)$, then cointegration between them would exist.

$$y_t = \mu + \beta x_t + \varepsilon_t \qquad (3)$$

where, y_t and x_t are the currencies of the forex market, and ε_t is the residual of the OLS equation.

Error Correction Model (ECM)

According to Engle and Granger's representation theorem (1987), if two variable quantities y_t and x_t are $I(1)$ and residuals obtained by estimating these are $I(0)$, then cointegration in these two variables exists. Further, either the time series Y_t Granger-causes X_t or X_t Granger-causes Y_t and rate of speed of adjustment in equilibrium in the subsequent error-correction model (ECM) can then be depicted as:

$$\Delta y_t = \alpha_1 + \sum_{i=1}^{p-1} \lambda_i \Delta x_{t-i} + \sum_{i=1}^{p-1} \delta_i \Delta y_{t-i} + \eta_1 ECT_{t-1} + v_t \qquad (4)$$

where, Δx_t and Δy_t are the stationary currencies series, ECT is the lagged residuals of eq (3), and v_t is the white noise error term.

Empirical Analysis and Results

Summary Statistics

Table 2 presents the descriptive statistics figures of the data for Panel A, Panel B, and Panel C. It comprises sample

Table 2. ***Descriptive Statistics of the Sample***

	Mean	Median	Max	Min	*SD*	Skew.	Kurt.	Jarque-Bera	Obs.
October 1, 2010 – October 20, 2020									
Panel A									
EUR_USD	1.22	1.18	1.48	1.04	0.11	0.39	1.78	0*	2623
GBP_USD	1.45	1.50	1.72	1.15	0.15	–0.11	1.47	0*	2623
USD_JPY	102.60	107.08	125.62	75.82	13.68	–0.66	2.24	0*	2623
USD_INR	62.23	64.11	76.98	43.93	8.44	–0.64	2.56	0*	2623
USD_CAD	1.19	1.26	1.46	0.94	0.15	–0.29	1.42	0*	2623
USD_NZD	1.37	1.37	1.76	1.13	0.13	0.13	1.97	0*	2623
October 1, 2015 – October 20, 2020									
Panel B									
EUR_USD	1.13	1.13	1.25	1.04	0.04	0.48	2.90	0*	1319
GBP_USD	1.32	1.30	1.55	1.15	0.08	1.07	3.70	0*	1319
USD_JPY	110.24	109.97	123.64	99.89	4.27	0.61	4.09	0*	1319
USD_INR	68.70	68.03	76.98	63.34	3.44	0.48	2.27	0*	1319
USD_CAD	1.32	1.32	1.46	1.21	0.04	0.35	3.97	0*	1319
USD_NZD	1.47	1.47	1.76	1.33	0.08	0.56	3.35	0*	1319
October 1, 2018 – October 20, 2020									
Panel C									
EUR_USD	1.13	1.12	1.19	1.07	0.03	0.58	3.01	0*	537
GBP_USD	1.28	1.28	1.34	1.15	0.03	–0.69	3.16	0*	537
USD_JPY	108.86	108.61	114.53	102.36	2.28	0.34	2.49	0*	537
USD_INR	72.08	71.45	76.98	68.41	2.23	0.41	2.05	0*	537
USD_CAD	1.34	1.33	1.45	1.28	0.03	1.56	5.41	0*	537
USD_NZD	1.53	1.52	1.76	1.44	0.06	1.13	4.28	0*	537

Note. * marks indicate a significant *p*-value at a 5% level of significance.

mean, median, standard deviation, skewness, minimum, maximum, kurtosis, Jarque – Bera, probability, and no. of observations in the sample. In Panel A, the kurtosis value for all the currencies is less than 3, indicating that the curve's tails are shorter and thinner. Out of six currencies, four currencies are negatively skewed, implying that extreme values are located on the negative side of the distribution. The probability value of the Jarque – Bera test is near zero for all currencies; this implies that the series is not normally distributed. As the pairs trading and cointegration model requires the dates to be matched in the data, the number of observations is equal for all six currencies.

Screening of Graphs

The graphs are studied to ascertain the simultaneous movement and comovement of two currencies, which is the first step in pairs trading. This mainly helps in the selection of currencies for pairs trading. Figure 1, Figure 2, and Figure 3 show graphs of six currencies in Panel A (10-year duration), Panel B (5-year duration), and Panel C (2-year duration). Although graph screening is the primary step in pairs trading, it is sometimes difficult to decide

Figure 1. ***Graphs of the Currencies for Panel A (October 1, 2010 – October 20, 2020)***

Figure 2. ***Graphs of the Currencies for Panel B (October 1, 2015 – October 20, 2020)***

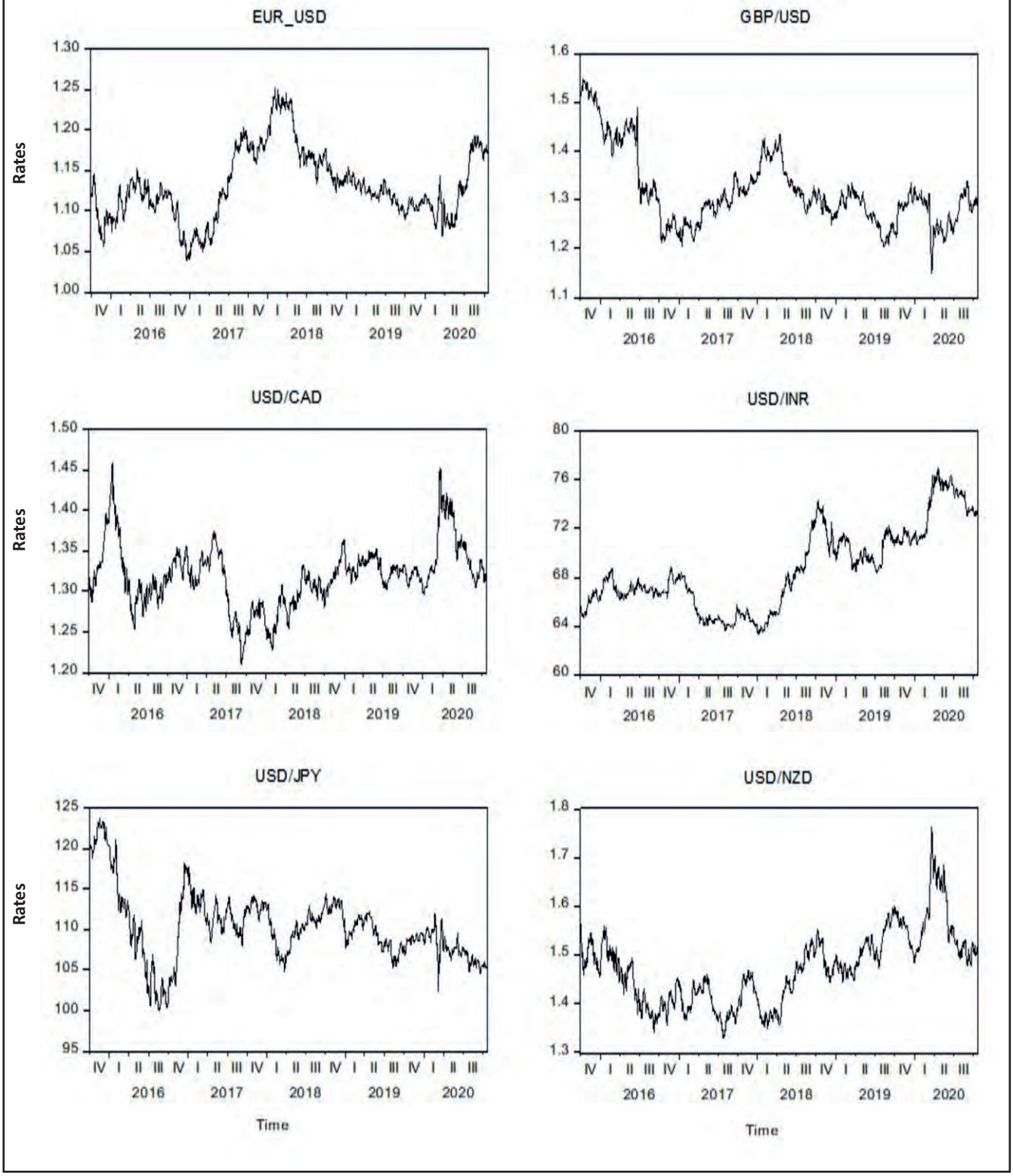
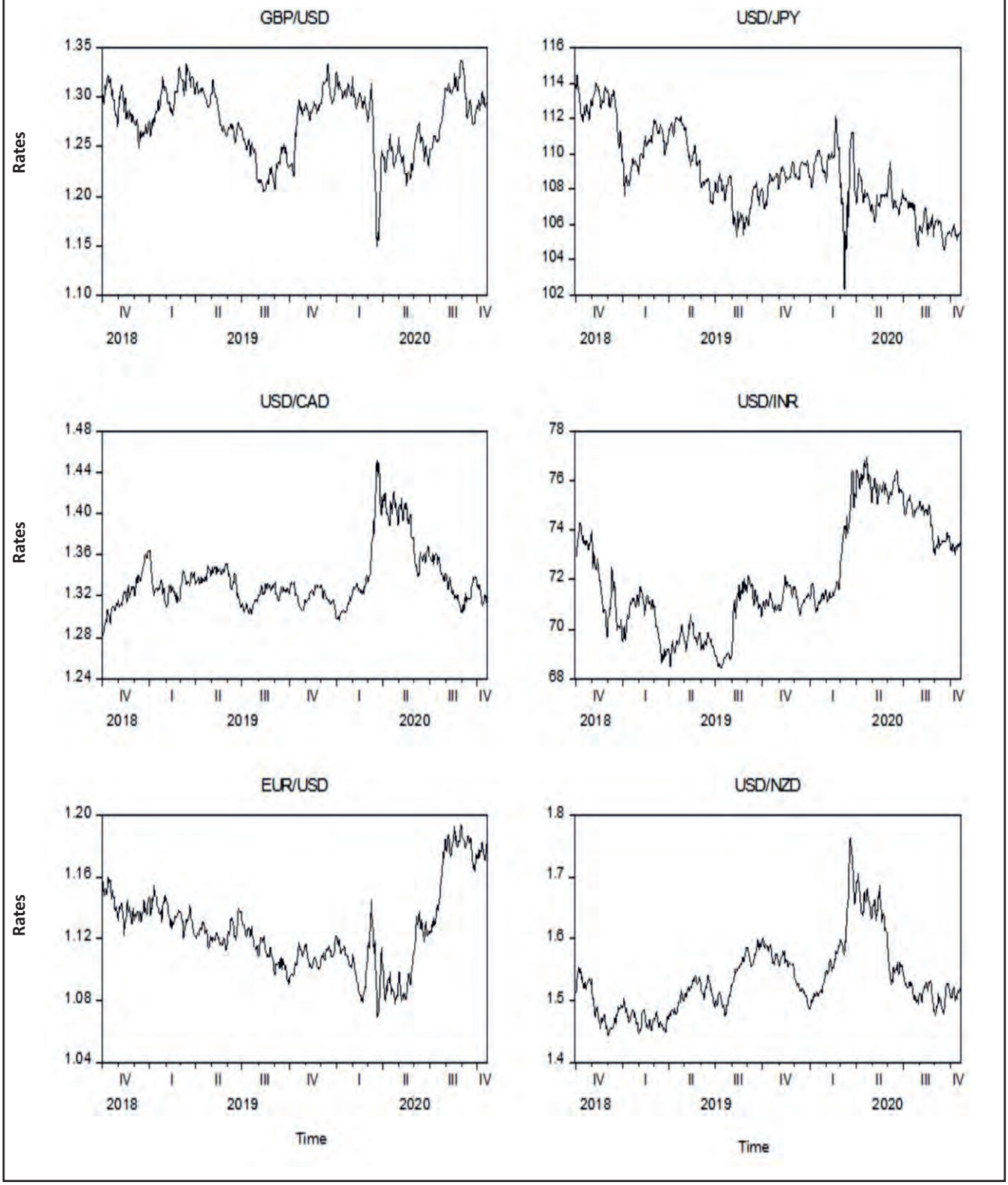


Figure 3. ***Graphs of the Currencies for Panel C (October 1, 2018 – October 20, 2020)***



the pairs by conducting the screening test alone. Similarly, from Figure 1, it is difficult to identify a clear comovement of two and more than two currencies. Therefore, the study is being expanded with the help of advanced techniques of pairs selection, that is, distance approach and cointegration approach.

Unit Root Test Results

Table 3 presents the results of the ADF test applied on level data and the first difference data for the unit root test. The table is divided according to three time periods in the study: Panel A, Panel B, and Panel C.

In Panel A, at level form, we do not reject the null hypothesis of ADF as the *p*-value exceeds the 5% significance level; whereas at the first difference, the *p*-value is less than the 5% significance level. This means that all the series are integrated of order *I*(1).

In Panel B, two currencies: USD_JPY and USD_CAD are found to be integrated of order *I*(0) as the null

Table 3. ***ADF Test for Unit Root Test***

	At Level		1st Difference	
	***t*-statistic**	**Prob.***	***t*-statistic**	**Prob.***
October 1, 2010 – October 20, 2020				
Panel A				
EUR_USD	–1.82495	0.3686	–51.91413	0.0001*
GBP_USD	–1.28036	0.6408	–50.56684	0.0001*
USD_JPY	–1.53446	0.5161	–51.83197	0.0001*
USD_INR	–1.67795	0.4424	–25.53973	0*
USD_CAD	–1.18759	0.682	–52.21013	0.0001*
USD_NZD	–1.65075	0.4564	–51.34009	0.0001*
October 1, 2015 – October 20, 2020				
Panel B				
EUR_USD	–2.02047	0.2781	–36.43782	0*
GBP_USD	–2.83935	0.0531	–34.51227	0*
USD_JPY	–2.9213	0.0432*	–	–
USD_INR	–1.06677	0.7307	–37.03934	0*
USD_CAD	–2.95068	0.04*	–	–
USD_NZD	–2.3885	0.1452	–35.04102	0*
October 1, 2018 – October 20, 2020				
Panel C				
EUR_USD	–1.57979	0.4923	–22.25916	0*
GBP_USD	–3.00625	0.035*	–	–
USD_JPY	–2.8539	0.0516	–25.68026	0*
USD_INR	–1.50441	0.5308	–23.92173	0*
USD_CAD	–2.63363	0.0868	–23.04532	0*
USD_NZD	–2.07809	0.2538	–20.72065	0*

Note. * marks indicate a significant *p*-value at a 5% level of significance.

Null hypothesis of ADF test (H0 : The series has unit root).

hypothesis is rejected at level form. The remaining four currencies are integrated of order *I*(1) as the series is found to be stationary after first differencing.

Similarly, in Panel C, GBP_USD currency is integrated of order *I*(0) because it is found to be stationary at level. The remaining five currencies are integrated of order *I*(1) because they turn stationary after the first differencing.

Rank According to Distance Approach

Table 4 presents the ranks of pairs for Panel A, Panel B, and Panel C as obtained by the distance approach. The maximum number of combinations of two pairs each of six currencies can be 15 pairs. The ranks are given based on the lowest sum of squared in ascending order. The top 10 out of 15 pairs are selected to test the validity. The same procedure is adopted for Panel B and Panel C. Overall, 30 pairs are available in three-time durations for testing the validity. The empirical results reveal that some new pairs that form in Panel A are not in the top 10 ranks of Panel B and Panel C, such as USD_JPY/USD_INR and EUR_USD/USD_INR — these are selected in Panel B but are not in Panel A.

While in Panel C, five new pairs are available for validity testing, which are not available in Panel A and three pairs (EUR_USD/USD_INR,GBP_USD/USD_NZD, GBP_USD/USD_CAD) are not in Panel B also. The results of the distance approach show that the new pairs are formed in different periods. Thus, we can find the new closest pairs for pairs trading by changing the time frame.

Table 4. ***Ranks of Pairs by Distance Approach***

Panel A : 1st Oct 2010 to 20th Oct 2020			Panel B : 1st Oct 2015 to 20th Oct 2020			Panel C : 1st Oct 2018 to 20th Oct 2020		
Pairs	Sum of Square	Rank	Pairs	Sum of Square	Rank	Pairs	Sum of Square	Rank
USD_INR/USD_CAD	566.51	1	USD_INR/USD_NZD	587.28	1	USD_CAD/USD_NZD	327	1
USD_CAD/USD_NZD	670.36	2	USD_CAD/USD_NZD	962.89	2	USD_INR/USD_NZD	461.09	2
USD_JPY/USD_CAD	938.62	3	USD_INR/USD_CAD	1291.22	3	USD_INR/USD_CAD	497.19	3
EUR_USD/GBP_USD	1046.88	4	GBP_USD/USD_JPY	1494.78	4	EUR_USD/GBP_USD	541.36	4
USD_JPY/USD_INR	1099.5	5	EUR_USD/GBP_USD	1966.26	5	GBP_USD/USD_JPY	758.09	5
USD_INR/USD_NZD	1298.4	6	USD_JPY/USD_CAD	2273.51	6	EUR_USD/USD_INR	1017.28	6
USD_JPY/USD_NZD	2092.57	7	USD_JPY/USD_NZD	2499.75	7	EUR_USD/USD_JPY	1231.43	7
GBP_USD/USD_JPY	7934.85	8	EUR_USD/USD_INR	3144.69	8	USD_JPY/USD_CAD	1265.84	8
EUR_USD/USD_JPY	9196.65	9	GBP_USD/USD_NZD	3161.47	9	GBP_USD/USD_INR	1346.36	9
GBP_USD/USD_INR	9217.48	10	GBP_USD/USD_CAD	3214.25	10	USD_JPY/USD_NZD	1425.21	10
GBP_USD/USD_NZD	9431.73	11	EUR_USD/USD_JPY	3317.13	11	USD_JPY/USD_INR	1473.18	11
EUR_USD/USD_INR	9458.76	12	USD_JPY/USD_INR	3344.11	12	EUR_USD/USD_CAD	1531.93	12
EUR_USD/USD_NZD	9531.84	13	EUR_USD/USD_NZD	3544.43	13	GBP_USD/USD_CAD	1679.65	13
GBP_USD/USD_CAD	9618.08	14	GBP_USD/USD_INR	3781.73	14	EUR_USD/USD_NZD	1739	14
EUR_USD/USD_CAD	10012.32	15	EUR_USD/USD_CAD	4304.47	15	GBP_USD/USD_NZD	1751.56	15

Engle – Granger Two-Step Test for Cointegration

Table 5 presents the results of Engle – Granger's two-step test for cointegration of Panel A, Panel B, and Panel C.

The third column of the table contains the estimated parameter of equation 2 for respective pairs, and the fourth column contains the computed *t*-values of the ADF test applied on the residuals obtained from the respective regression equations. These *t*-values are used to make the decision to accept/reject the null hypothesis for the Engle – Granger test of cointegration.

The empirical analysis of Panel A suggests that out of the top 10 closest pairs of residuals, only one currency pair equation, USD_INR/USD_NZD, is found integrated of order *I*(0) at the 10% level of significance. This means that the cointegration exists between USD_INR/USD_NZD in Panel A time frame. We fail to reject the null hypothesis for the remaining nine pairs because the computed value is less than the critical value of the Engle – Granger test.

In Panel B, out of four pairs, only one residual from the USD_INR/USD_NZD pair of currencies is found integrated of order *I*(0) at the 10% and 5% levels of significance. This implies that the cointegration exists between USD_INR/USD_NZD in Panel B timeframe. We fail to reject the null hypothesis for the remaining three pairs because the computed value is less than the critical value of the Engle – Granger test. Only four out of 10 pairs satisfy the assumption that the series must be integrated of order *I*(1) for the Engle – Granger test, that is, the reason the remaining six cells are blank in Panel B is because the test cannot apply on these pairs.

Similarly, in Panel C, three out of 10 pairs are not fulfilling the assumption (the series must be integrated of order *I*(1) of the Engle – Granger test); so, three cells are blank in Panel C because we cannot apply the test on these pairs. However, out of seven pairs, only one residual from the USD_JPY/USD_NZD pair of currencies is integrated of order *I*(0) at the 10% significance level. This implies that the cointegration exists between USD_JPY/USD_NZD in Panel C timeframe. We fail to reject the null hypothesis for the remaining three pairs because the computed value is less than the critical value of the Engle – Granger test.

When the coefficient of error correction term (ECT) is found to be statistically significant in the error correction model (ECM), only then the selected pairs are said to be cointegrated, and the long-run and short-run relationships exist between the series. Therefore, in the next section, the results of the error correction model are presented.

Table 5. ***ADF Test on Residuals (Level)***

Rank	Currencies Pair	OLS Equation (2)	*t*-value
October 1, 2010 – October 20, 2020			
Panel : A			
1	USD_INR/USD_CAD	1.0218 + 51.3350 × USD_CAD	–2.7824
2	USD_CAD/USD_NZD	–0.1276 + 0.9647 × USD_NZD	–3.0225
3	USD_JPY/USD_CAD	11.26634 + 76.60389 × USD_CAD	–2.2879
4	EUR_USD/GBP_USD	0.345568 + 0.599459 × GBP_USD	–2.172
5	USD_JPY/USD_INR	22.86351 + 1.281373 × USD_INR	–1.8927
6	USD_INR/USD_NZD	–3.306978 + 47.89871 × USD_NZD	–3.1261*
7	USD_JPY/USD_NZD	17.73243 + 62.0292 × USD_NZD	–2.0137
8	GBP_USD/USD_JPY	2.030963 + –0.005636 × USD_JPY	–1.3987
9	EUR_USD/USD_JPY	1.852708 + –0.006202 × USD_JPY	–2.2403
10	GBP_USD/USD_INR	2.292506 + –0.013496 × USD_INR	–2.2545
October 1, 2015 – October 20, 2020			
Panel : B			
1	USD_INR/USD_NZD	15.93228 + 35.83815 × USD_NZD	3.450282**

2	USD_CAD/USD_NZD	–	–
3	USD_INR/USD_CAD	–	–
4	GBP_USD/USD_JPY	–	–
5	EUR_USD/GBP_USD	0.938594 + 0.146304 × GBP_USD	1.9059
6	USD_JPY/USD_CAD	–	–
7	USD_JPY/USD_NZD	–	–
8	EUR_USD/USD_INR	1.298446 + –0.002432 × USD_INR	1.9562
9	GBP_USD/USD_NZD	1.614464 + –0.201608 × USD_NZD	2.9841
10	GBP_USD/USD_CAD	–	–
October 1, 2018 – October 20, 2020			
Panel : C			
1	USD_CAD/USD_NZD	0.810854 + 0.342352 × USD_NZD	3.0161
2	USD_INR/USD_NZD	39.04027 + 21.54715 × USD_NZD	1.865
3	USD_INR/USD_CAD	17.04801 + 41.19749 × USD_CAD	2.1547
4	EUR_USD/GBP_USD	–	–
5	GBP_USD/USD_JPY	–	–
6	EUR_USD/USD_INR	1.080204 + 0.000628 x USD_INR	1.6126
7	EUR_USD/USD_JPY	1.310579 + –0.001701 x USD_JPY	1.6618
8	USD_JPY/USD_CAD	127.6134 + –14.03859 x USD_CAD	2.7279
9	GBP_USD/USD_INR	–	–
10	USD_JPY/USD_NZD	128.2579 + –12.65022 x USD_NZD	3.139795*

Note. *, **, & *** marks indicate the significant *t*-value at 10%, 5%, & 1% levels, respectively,

Critical values for Engle – Granger test at 10%, 5%, & 1% levels are 3.04, 3.43, & 4.00, respectively.

Error Correction Model

Table 6 presents the results of the error correction model (ECM). In Column 2, the cointegrated currencies pairs are mentioned for respective periods, and Column 3 contains the coefficient of error correction term (ECT). Finally, only three pairs are available to apply the error correction model. In the empirical analysis, the coefficient of ECT is interpreted as the speed of adjustment, which is .2% and .8% per day between the exchange rates USD_INR/USD_NZD in Panel A and Panel B, respectively as the coefficient of ECT is found negative and significant. Similarly, for the USD_JPY/USD_NZD pair, the coefficient of ECT is found negative and significant. Therefore, the speed of adjustment betweenUSD_JPY/USD_NZD is 2.3% in Panel C.

Table 6. ***Results of ECM***

Sample	Pairs	Coefficient of ECT	*t*-value	Prob.
Panel A	USD_INR/USD_NZD	–0.002511	–2.663625	0.0078*
Panel B	USD_INR/USD_NZD	–0.008955	–3.053324	0.0023*
Panel C	USD_JPY/USD_NZD	–0.023914	–2.417581	0.016*

Note. * marks indicate the significant *p* - value at the 5% level.

Conclusion

The present study is related to the forex market, therefore, the currencies were selected randomly to find out the suitable pairs for pairs trading by using the cointegration approach. The cointegration technique for selecting the pairs is tested in three-time durations: large sample, medium sample, and small sample. In the first step, the closest pairs are determined using the lowest sum of the square method of the distance approach, where we find different ranks for the same pairs in the different time frames.

In the next step, the validity of the top 30 pairs is tested by using the Engle–Granger residuals-based cointegration technique. Based on the empirical results, in Panel A, out of 10 pairs of currencies, only USD_INR/USD_NZD pair is found valid at a 10% level of significance. The same pair of currency is also significant at the 5% level in Panel B, but the same pair is not valid in Panel C; whereas, a new pair USD_JPY/USD_NZD is found valid in Panel C at a 10% level of significance. The ECM model results also reveal that the pairs have a significant short-term relationship because the equilibrium adjustment speed is significant.

With these results, we can say that the new pairs are formed and break according to time, and in this study, very few good pairs are found for pairs trading in the forex market according to the cointegration approach compared to the studies related to the stock market. Although pairs trading is prevalent in the stock market due to the fundamental nature of stocks, for example, in the stock market, we generally observe common comovement in shares of a holding company and subsidies company, but in the forex market, due to the lack of such close fundamental relations, it is difficult to find good pairs for pairs trading. The study results also suggest that investors can find pairs in a small duration of time rather than a large duration.

Managerial and Theoretical Implications

Currency fluctuations are a natural outcome of the floating exchange rates, which is the norm for most major economies across the world. Numerous factors influence exchange rates, including a country's economic performance, the outlook for inflation, interest rate differentials, growth trajectory projection of a country, capital flows, and so on. A currency's exchange rate is typically determined by the strength or weakness of the underlying economy. Therefore, any change in a currency's value impacts merchandise trade, economic growth, capital flows, inflation, and interest rates. Merchandisers/ investors hedge their foreign currency risk via instruments such as futures, forwards, and options by trading in various currency pairs, thereby resulting in the emerging demand for choosing the right kind of currency pairs.

Limitations of the Study and Scope for Further Research

Since the study focuses on the cointegration model, the model has some assumptions, such as that the series must integrate with the order $I(1)$, but is not fulfilled in some cases. Due to these limitations, further studies with some other econometric models like ARDL can be conducted to know the long-run relationship between the series. Further research may be conducted over a shorter period (such as a year) or with fewer observations to find more pairs. Other aspects can be examined through risk-return techniques to predict the market conditions in advance. Ultimately, the objective is to envisage the opportunities and threats of future research in this area and provide an effective solution with the best model for pairs trading to invest in practice.

Authors' Contribution

Farhat Akhtar conceived the idea of exploring the demand of currency pairs and approaches of pairs trading in the

context of the foreign exchange market and extracted the existing pertinent literature with high repute, filtered these based on keywords, and generated concepts and codes relevant to the study design. Munesh Kumar applied appropriate statistical tools to achieve the set objective and reported the findings. N. S. Malik verified the analytical and conceptual methods. Farhat Akhtar wrote the manuscript in consultation with both other authors.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Funding Acknowledgement

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

References

Aggarwal, G., & Aggarwal, N. (2020). Risk-adjusted returns from statistical arbitrage opportunities in Indian stock futures market. *Asia-Pacific Financial Markets, 28,* 79 – 99. https://doi.org/10.1007/s10690-020-09317-1

Avellaneda, M., & Lee, J.-H. (2010). Statistical arbitrage in the US equities market. *Quantitative Finance, 10*(7), 761–782. https://doi.org/10.1080/14697680903124632

Bowen, D. A., & Hutchinson, M. C. (2014). Pairs trading in the UK equity market: Risk and return. *The European Journal of Finance, 22*(14), 1363 – 1387. https://doi.org/10.1080/1351847X.2014.953698

Brooks, C. (2008). *Introductory econometrics for finance*. Cambridge University Press.

Broussard, J. P., & Vaihekoski, M. (2012). Profitability of pairs trading strategy in an illiquid market with multiple share classes. *Journal of International Financial Markets, Institutions and Money, 22*(5), 1188 – 1201.https://doi.org/10.1016/j.intfin.2012.06.002

Burgess, A. N. (1999). *A computational methodology for modelling the dynamics of statistical arbitrage* (PhD Thesis). University of London, London Business School.

Chen, D., Cui, J., Gao, Y., & Wu, L. (2017). Pairs trading in Chinese commodity futures markets: An adaptive cointegration approach. *Accounting & Finance, 57*(5), 1237–1264. https://doi.org/10.1111/acfi.12335

Chen, H., Chen, S., Chen, Z., & Li, F. (2009). Empirical investigation of an equity pairs trading strategy. *Management Science, 65*(1), 370 – 389. https://doi.org/10.1287/mnsc.2017.2825

Cheng, X., Yu, P. L., & Li, W. K. (2011). Basket trading under cointegration with the logistic mixture autoregressive model. *Quantitative Finance, 11*(9), 1407 – 1419. https://doi.org/10.1080/14697688.2010.506445

Clegg, M., & Krauss, C. (2018). Pairs trading with partial cointegration. *Quantitative Finance, 18*(1), 121–138. https://doi.org/10.1080/14697688.2017.1370122

Cohen, L., & Frazzini, A. (2008). Economic links and predictable returns. *The Journal of Finance, 63*(4), 1977–2011. https://doi.org/10.1111/j.1540-6261.2008.01379.x

Cummins, M., & Bucca, A. (2012). Quantitative spread trading on crude oil and refined products markets. *Quantitative Finance, 12*(12), 1857–1875. https://doi.org/10.1080/14697688.2012.715749

Dadhich, G., Chotia, V., & Chaudhry, O. (2015). Impact of foreign institutional investments on stock market volatility in India. *Indian Journal of Finance, 9*(10), 22 – 35. https://doi.org/10.17010/ijf/2015/v9i10/79561

De, S., & Chakraborty, T. (2015). Foreign portfolio investment and stock market volatility in India. *Indian Journal of Finance, 9*(1), 49 – 59. https://doi.org/10.17010/ijf/2015/v9i1/71535

Do, B., & Faff, R. (2012). Are pairs trading profits robust to trading costs? *The Journal of Financial Research, 35*(2), 261 – 287. https://doi.org/10.1111/j.1475-6803.2012.01317.x

Do, B., & Faff, R. (2018). Does simple pairs trading still work? *Financial Analysts Journal, 66*(4), 83–95. https://doi.org/10.2469/faj.v66.n4.1

Enders, W. (2010). *Applied econometric time series* (3rd ed.). John Wiley & Sons.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55*(2), 251–276. https://doi.org/10.2307/1913236

Gatarek, L. T., Hoogerheide, L. F., Van Dijk, H. K. (2011). *A simulation-based Bayes' procedure for robust prediction of pairs trading strategies*. Tinbergen Institute Discussion Paper, 09–061.

Gatarek, L. T., Hoogerheide, L. F., & Van Dijk, H. K. (2014). Return and risk of pairs trading using a simulation-based Bayesian procedure for predicting stable ratios of stock prices. *SSRN Electronic Journal*. http://dx.doi.org/10.2139/ssrn.2412455

Gatev, E., Goetzmann, W. N., & Rouwenhorst, K. G. (2006). Pairs trading: Performance of a relative-value arbitrage rule. *The Review of Financial Studies, 19*(3), 797 – 827. https://doi.org/10.1093/rfs/hhj020

Hong, G., & Susmel, R. (2003). *Pairs-trading in the Asian ADR market* (Working Paper). The University of Houston. https://doi.org/10.1093/rfs/hhj020

Huck, N., & Afawubo, K. (2015). Pairs trading and selection methods: Is cointegration superior ? *Applied Economics, 47*(6), 599–613. https://doi.org/10.1080/00036846.2014.975417

Karakas, O. (2009). *Mean reversion between different classes of shares in dual-class firms: Evidence and implications* (Working Paper). London Business School.

Khuntia, S. P., & Jamini, K. (2017). Dynamics of Indian foreign exchange market efficiency: An adaptive market hypothesis approach. *Indian Journal of Finance, 11*(9), 39–52. https://doi.org/10.17010/ijf/2017/v11i9/118088

Liu, S.-M., & Chou, C.-H. (2003). Parities and spread trading in gold and silver markets: A fractional cointegration analysis. *Applied Financial Economics, 13*(12), 899–911. https://doi.org/10.1080/0960310032000129626

Puspaningrum, H. (2012). *Pairs trading using cointegration approach* (PhD Thesis). The University of Wollongong.

Ramos-Requena, J. P., Trinidad-Segovia, J. E., & Sánchez-Granero, M. Á. (2020a). Some notes on the formation of a pair in pairs trading. *Mathematics, 8*(3), 348. https://doi.org/10.3390/math8030348

Ramos-Requena, J.P., Trinidad-Segovia, J.E., & Sánchez-Granero, M.Á. (2020b). An alternative approach to measure comovement between two time series. *Mathematics, 8*(2), 261. https://doi.org/10.3390/math8020261

Tokat, E., & Hayrullahoğlu, A. C. (2021). Pairs trading: Is it applicable to exchange-traded funds? *Borsa Istanbul Review*. https://doi.org/10.1016/j.bir.2021.08.001

Tsay, R. S. (2010). *Analysis of financial time series. Wiley series in probability and statistics* (3rd edition). John Wiley & Sons.

Vidyamurthy, G. (2004). *Pairs trading: Quantitative methods and analysis.* John Wiley & Sons.

Yadav, S. (2016). Integration of exchange rate and stock market: Evidence from the Indian stock market. *Indian Journal of Finance, 10*(10), 56 – 63. https://doi.org/10.17010/ijf/2016/v10i10/103015

About the Authors

Farhat Akhtar is a Research Scholar at Haryana School of Business, GJUS&T, Hisar, Haryana (India). Her areas of interest include financial management, foreign exchange management, business statistics, and business research methods. Her research focuses on exploring and analyzing the approaches on pairs trading in financial markets.

Munesh Kumar is a Research Scholar at Haryana School of Business, GJUS&T, Hisar, Haryana (India). His areas of interest include financial management, risk management, portfolio management, business statistics, and econometrics.

Prof. N. S. Malik is a Senior Professor at Haryana School of Business, GJUS&T, Hisar, Haryana (India). He is committed to contributing his knowledge to research in empirical asset pricing, trading strategies, financial markets, technical analysis, and personal financial planning. He is also a Visiting Faculty for institutes of national and international repute.