Do Lagged Terms Affect Exchange Rate Volatility in India? An Analysis Using ARIMA Model

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Abstract

Under a flexible exchange rate regime, a stable exchange rate is considered a prerequisite condition to attract capital inflows into any economy. Consistency in the exchange rate has become a key objective of the economic policy of developing nations. However, more integration of financial markets under flexible exchange rate policy led to an increase in capital mobility affecting exchange rate volatility. This paper addressed the issue of variation in the exchange rate of the Indian rupee against the US dollar under a flexible regime using monthly data spanning from January 2005 to December 2020. By employing an autoregressive integrated moving average model, the study found that volatility in the exchange rate had the potential to affect the exchange rate for a duration of almost three years, which is quite a long duration. The study's findings suggested that apart from other factors, the sharp changes in the exchange rate should be controlled by the economy because their effect will be reflected in the next period and thus create a chain event to bring further instability to the exchange rate.

Keywords : **exchange rate, time series analysis, ARIMA, structural break, India**

JEL Classification Codes : C22, C52, F31

Paper Submission Date : June 30, 2021 ; Paper sent back for Revision : June 22, 2022 ; Paper Acceptance Date : July 15, 2022 ; Paper Published Online : October 15, 2022

As part of the reform process initiated in the year 1991, the Government of India introduced comprehensive changes in foreign exchange management and control through the Reserve Bank of India (RBI). Measures in this direction were initiated with the introduction of the Liberalized Exchange Rate Management System (LERMS), carried out by a partial flotation of the rupee in February 1992. With the introduction of LERMS, RBI became obliged to supply foreign exchange to the Authorized Dealers (ADs) but only for the import of specific items and to the extent authorized by the Ministry of Finance, Government of India. Later, LERMS was severely criticized for its discriminatory treatment of exporters. Thus, in 1993, LERMS was replaced with the Unified Exchange Rate System. The new arrangement did away with the dual exchange rate system. Indian rupee (INR) was made fully convertible on the trading account. Receipts and payments under the trading account of the balance of payments (BOP) could be converted by the ADs at the market-determined rate of exchange.

The market-determined exchange rate system worked satisfactorily until 2011, except for a few episodes of minor volatility. In the initial half of the first decade of this century, the country enjoyed robust external sector performances with a relatively high level of macroeconomic stability in terms of price stability, comfortable

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DOI : https://doi.org/10.17010/ijf/2022/v16i10/172385

foreign exchange reserves, stability on the fiscal and financial front, and a high growth rate ("External Sector," 2005). The episode of volatility in the exchange rate began from the year 2011–12 onwards and continued until 2013–14. This volatility introduced uncertainty in the domestic market and influenced business confidence negatively. The exchange value of the Indian rupee plunged to ₹ 61.01 per US dollar in March 2014 from ₹ 44.37 per US dollar in April 2011. Generally, a depreciation in domestic currency led to an increase in exports and enhances its competitiveness in the international market. In the case of the Indian economy, it did not happen due to various factors such as decreasing global market volume and an increase in the import content of Indian exports (Rangarajan & Mishra, 2013). On the other hand, there was a risk of capital outflow because of fears arising out of a weakening currency, which in turn triggered another round of currency depreciation and was responsible for another round of negative macroeconomic response in a developing economy (Kandil, 2009). A sharp decline in the value of the rupee also put additional pressure on domestic inflation by making imports costlier.

The stability of exchange rates promotes growth through trade (Frankel & Rose, 2002) and macroeconomic stability. A reduction in exchange rate uncertainty increases the efficiency of the price mechanism at the international level (Schnabl, 2008), which affects growth performance by increasing capital market efficiency in capital allocation (McKinnon, 1963). Lower exchange rate volatility is also associated with the enhancement of economic growth through higher foreign direct investment (FDI) and higher credit excess (Arratibel et al., 2011). Therefore, a need to develop a model that can be successfully applied to forecast the exchange rate of the Indian currency was greatly felt, which could help in framing a suitable policy to maintain the consistency of the exchange rate. The available literature indicates that the research, especially in terms of its forecast accuracy, has not extensively discussed the issue of exchange rate volatility in the context of the Indian currency.

Furthermore, the economic time series, like the exchange rate, provides vital input in policy development through its own dynamics as well as its interaction with other macroeconomic series. Therefore, in this paper, we try to address the issue of volatility in the exchange rate through the lagged values of the exchange rate and random error term. We have considered the periods from January 2005 because in the financial year 2005 – 06, the Indian economy experienced an increase in current account deficit by 300% and a decrease in capital account surplus by 8.9 % from the previous financial year 2004 – 05 (Rangarajan & Mishra, 2013).

Review of Literature

The issue of exchange rates and the factor affecting them is one of the intense debatable subjects among researchers. Yet, a consensus on the determinants of exchange rates has been lacking in the literature. Some studies are based on monetary models of exchange rates determination which consider money supplies, real output, interest rates, and inflation rates as the key factors of exchange rate volatility (Bhanumurthy et al., 2019; Hina & Qayyum, 2015; Hsing, 2015; Ibhagui, 2019; Kurihara, 2012; Maitra & Mukhopadhyay, 2011; Papadamou & Markopoulos, 2012; Sharma & Raghavender Raju, 2013; Sharma & Setia, 2015; Shastri & Shastri, 2016; Xie & Chen, 2019). The study of Lakshmanasamy (2022) explained that the volatility in other markets (oil and gold markets) and its spillover impact caused volatility in the exchange rate.

There are studies based on the optimum currency area models that point out trade linkages, an economic shock to output, and country size as determinants of exchange rate volatility (Bannaga & Badawai, 2014; Mohapatra & Rath, 2017; Petreski, 2010; Rashid & Saedan, 2013). In literature, the evidence of new open economy macroeconomic models is also available, which suggest trade openness and financial openness as the vital factors of exchange rate determination (Jayaraman & Choong, 2011; Kaltenbrunner, 2015; Raksong & Sombatthira, 2021).

The purchasing power parity hypothesis that advocates price differential as a major factor behind exchange rate determination is also examined in some studies (Aixalá et al., 2020; Gözen et al., 2016; Kargbo, 2011; Xie et al., 2021). Some studies are based on the portfolio balance approach, which suggests a positive link between exchange rate and stock prices (Bagchi, 2016; Hsing, 2016; Jayashankar & Rath, 2017; Kumar, 2010; Kumari & Mahakud, 2012; Morana, 2017; Mishra, 2016; Yadav, 2016). The interest rate parity hypothesis, which proposes the difference in interest rate as a determinant of exchange rate volatility, has also been observed in the literature (Božović, 2021; Çorakcı et al., 2017; Garg & Prabheesh, 2021; Perera et al., 2018; Tsen, 2014). The finding of some studies revealed a causal relationship between GDP growth and exchange rate (Adusei & Gyapong, 2017; Habib et al., 2017; Rai & Sharma, 2017).

Research Gap

Most of the available studies on exchange rate determination evaluate the impact of the variables such as money supply, asset price, the openness of the economy, trade linkage, inflation, external reserve, capital flow, interest rate, oil prices, stock prices, etc. A review of available studies reveals the fact that there is a paucity of studies in which the concerned issue has been examined by univariate analysis, especially in the context of Indian currency. However, in some studies, such as Petrică et al. (2016) and Ouyang (2011), in which integrated autoregressive moving average (ARMA) model has been applied to forecast the exchange rate. In the Indian context, the study of Thomakos and Bhattacharya (2005) was based on forecasting accuracy of the ARIMA model and bivariate analysis, but the study was performed before the great episode of depreciation of the Indian currency. Recently, Agarwal (2022) applied artificial neural networks (ANN) to examine the accuracy of forex rate prediction from an Indian perspective. The study found the proficiency of ANN modeling to predict the forex rates with two autoregressive lags.

A comparative study between the Box-Jenkins technique and multivariate analysis to measure the accuracy of short-term forecasting found that the Box-Jenkins forecast was, on an average, better than the forecast by multivariate analysis (Young, 1977). This happens because the 'Student's *t*-test' method for evaluating and testing mean changes is not appropriate for time series, which are usually serially dependent, often non-stationary, and reflect seasonality. Hence, any tests, parametric as well as non-parametric, that rest on the assumption of normality, constancy of variance, and independence of the observations are comparatively less efficient than models based on the ARIMA methodology (Box & Tiao, 1975). Therefore, in the present study, an attempt has been made to predict the exchange rate of Indian rupees (IR) against the US dollar (USD) through the ARIMA model. In the present study, the Box-Jenkins methodology (ARIMA) has been applied to examine its efficacy in forecasting the exchange rate of the Indian currency.

Research Methodology

A monthly average rate of the nominal exchange rate of Indian rupees (IR) against the United States dollar (USD) from January 2005 – December 2020 has been considered for analysis in the present study. The period for the study is considered from January 2005 because the Indian economy experienced an increase in current account deficit by 300% and a decrease in capital account surplus in the financial year 2005–06 by 8.9 % from the previous financial year 2004–05. Data were collected from the *Handbook of Statistics on the Indian Economy* published by the Reserve Bank of India (Reserve Bank of India, 2021). The entire data is divided into two parts: the first part covering the period from January 2005 – April 2019 is considered for the development of a model, and the second part of the data set from May 2019 – December 2020 is used to check the forecasting accuracy of the developed model. Eviews software has been used for the analysis.

Unit Root Tests

To check the stationarity of the series, the augmented Dickey – Fuller (ADF), Phillips – Perron (PP), Kwiatkowski, Phillips, Schmidt, and Shin (KPSS), and Zivot – Andrews (ZA) tests are used in the model. The equation for ADF test estimation is given as follows :

$$\Delta y_t = \alpha + \gamma y_{t-i} + \Sigma^{m}_{i=m} \alpha_i \Delta y_{t-i} + e_t \qquad (1)$$

Where, Δ indicates the difference order, t denotes the periods, i refers to the lagged difference terms number, and e_t is an error term. In the ADF test, we check whether the value of γ is 0 or not. If it is equal to zero, we conclude that the concerned series is non-stationary. Alternatively, the negative value of γ confirms that the series is stationary.

The PP test is based on non-parametric statistical methods to handle the issue of serial correlation in the error terms with the exclusion of the lagged difference terms (Phillips & Perron, 1988). For conducting the PP test, the equation and hypothesis are similar to the ADF test with the omission of lagged difference term from the equation as mentioned below:

$$\Delta y_t = \alpha + \gamma y_{t-1} + e_t \qquad (2)$$

According to the classical hypothesis-testing procedure, we cannot accept the null hypothesis. The null hypothesis should have to be either rejected or not rejected. This infers that a null hypothesis could not be rejected because either it is correct or there is a lack of information in the given sample to allow rejection. In the background of the above argument, the ADF and PP tests have been considered poor tests for unit roots, especially with small sample sizes. Therefore, Kwiatkowski, Phillips, Schmidt, and Shin (1992) developed another method to test stationarity. The joint use of stationarity and unit root tests is known as confirmatory data analysis (Brooks, 2014). The null hypothesis of the KPSS test is that a series is trend stationary. KPSS test model is as follows:

$$X_t = \alpha_t + y_t + \varepsilon_t \qquad (3)$$

Where, t represents the deterministic trend, y denotes random walk, and ε indicates the stationary error. The random walk can be shown as:

$$y_t = y_{t-1} + e_t \qquad (4)$$

where, e is iid[1] $(0, \sigma^2_e)$. The initial value of y (y_0) is equal to the intercept. Since ε is stationary, therefore, a null hypothesis of trend stationary infers that σ^2_e will be equal to zero. On the other hand, if α is equal to zero, the null will be stationary at level. The stated critical values of the KPSS test are derived from the Lagrange Multiplier (LM) statistics.

Structural break is a concern with most of the economic time-series data that can generate difficulties in unit root tests. A structural break is an abrupt change in any economic phenomenon that happens due to a change in policy direction, external shock, and regime of the government. Zivot and Andrews (2002) introduced a method for unit root tests with structural change that considers the break endogenously. Zivot-Andrews test is as follows:

$$\Delta y_t = \Psi y_{t-1} + \mu + \alpha\tau_t(t_{used}) + \gamma_t + \Sigma^{p}_{i=1} \alpha_i \Delta y_{t-i} + \mu_t \qquad (5)$$

where, $t_{used} = T_b / T$. The test will occur repetitively for different values of T_b (break-date) for the optimum set of data. The break permitted by $\tau_t(t_{used})$ can exist in two scenarios. In the first case, it can be found in the level (where τ_t

[1] Independent and identically distributed random variables.

$(t_{used}) = 1$ if $t > t_{used}$ and 0 otherwise); while in the second scenario, it can exist in the deterministic trend (where $\tau_t (t_{used}) = t - t_{used}$ if $t > t_{used}$ and 0 otherwise). The null hypothesis of Ψ is equal to 0, it implies that the series $\{y_t\}$ contains a unit root with drift and rejects the possibility of any structural break, while the alternative hypothesis that Ψ is negative indicates that the series is a trend-stationary with a one-time break happening at an unknown point in time.

Box-Jenkins Model

The Box-Jenkins methodology (ARIMA) has been used to examine the probabilistic, or stochastic, characteristics of time series data on their own value under the view 'let the information evaluate for itself.' Contrasting the regression models, ARIMA models permit Y_t to be described by its own lagged values and the current and lagged values of error term u_t. The error term should have to be normally distributed. ARIMA model is based on the assumption of stationarity of time series. In the case of non-stationary time series, the series should have to be changed in stationary by differencing it. This is identified as ARIMA *(p,d,q)* model, where '*d*' indicates the number of differences needed to get the series stationary while '*p*' and '*q*' denote autoregressive and moving average terms, respectively. An autoregressive (AR) model of order *p* is :

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots\ldots\ldots + \beta_p Y_{t-p} + u_t \qquad (6)$$

$$Y_t = \beta_0 + \Sigma^p{}_{i=1} \beta_i Y_{t-i} + u_t \qquad (7)$$

where, u_t= white noise error term, and β_i = autoregressive coefficient. The moving average (MA) model of order *q* is :

$$Y_t = \alpha_0 + \alpha_1 u_t + \alpha_2 u_{t-1} + \ldots\ldots\ldots + \alpha_q u_{t-q} \qquad (8)$$

$$Y_t = \alpha_0 + \Sigma^q{}_{j=1} \alpha_j u_{t-j} \qquad (9)$$

where, α_j = moving average coefficient. At the point when two comparisons consolidate, then ARIMA :

$$Y_t^* = \gamma_0 + \Sigma^p{}_{i=1} \beta_i Y_{t-i} + \Sigma^q{}_{j=1} \alpha_j u_{t-j} + \varepsilon_t \qquad (10)$$

where, Y_t^* = First difference or integrated (*I*) at first order.

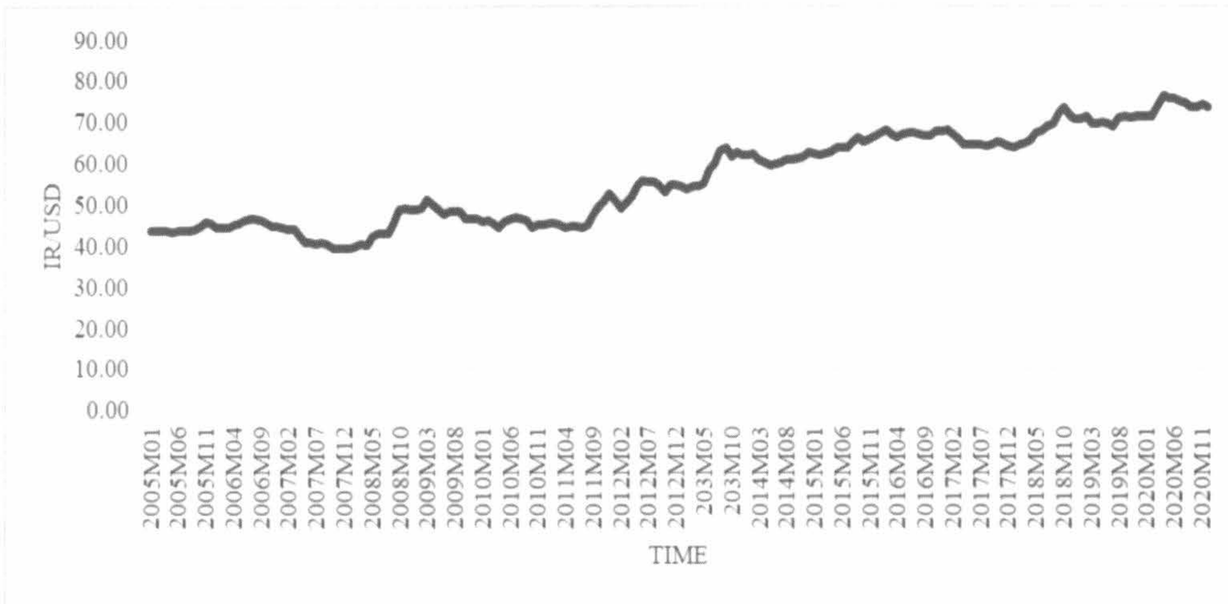
The above-said ARIMA (autoregressive integrated moving average) model has been applied to estimate the variation in the exchange rate (Y_t) under the floating exchange rate regime. The data used in this paper are monthly observations from January 2005 to December 2020, making a total of 192 observations.

Finally, a series of diagnostic tests, such as the Lagrange multiplier test for residual serial correlation, the autoregressive conditional heteroscedasticity test, and the Jarque-Bera normality test, have been used to check the robustness of the estimated model.

Analysis and Results

In regression analysis involving time series data, a critical assumption is that the time series under consideration must be stationary. In the case of non-stationary time series, we can only examine behavior for the period considered, and that does not allow us to generalize our findings to the other periods. For the reason stated above, it

Figure 1. *Movement of Indian Rupee – US Dollar Exchange Rate*



is important to find out whether the exchange rate series is stationary or not. The time paths of the nominal rupee/US dollar exchange rates have been depicted in Figure 1, which advocates that the exchange rate series is non-stationary and usually moves upward with a higher degree of variation.

Unit Root Test Outcomes

To confirm the non-stationarity of the exchange rate series, unit roots such as augmented Dickey – Fuller (ADF), Phillips – Perron (PP), Kwiatkowski, Phillips, Schmidt, and Shin (KPSS), and Zivot–Andrews (ZA) tests have been conducted. The results of the unit root tests have been reported in Table 1. The ADF test statistics indicate that

Table 1. *Unit Root Test Results*

Tests	Exchange Rate			
	Level		First Difference	
	t-statistic	*p*-value	*t*-statistic	*p*-value
ADF-test	–2.7555	0.2161	–9.5472	0.0000*
PP-test	–2.1699	0.5028	–9.3632	0.0000*
KPSS	LM-statistics		LM-statistics	
	0.1925		0.0638*	
Zivot-Andrews	*t*-statistic	*p*-value	*t*-statistic	*p*-value
one break test	–4.0971 (2012M03)	0.0068	–9.7661 (2011M08)*	0.1605

Note. The critical values for LM-stat are 0.21, 0.14, and 0.11 at the 1%, 5%, and 10% levels of significance, respectively. The critical values for the Zivot-Andrews test are –5.57, –5.08, and –4.82 at the 1%, 5%, and 10% levels of significance, respectively. *Significant at 1% level; in parentheses, the breakpoint is given.

the null hypothesis of a unit root cannot be rejected at the 5% significance level. Perron's test also shows that the series is non-stationary at the level. The results of the KPSS test confirm the findings of the non-stationarity of the exchange rate series. Further, the result of the Zivot – Andrews unit root test suggests the presence of a break-point in August 2011. This can be associated with the withdrawal of funds by foreign institutional investors (FIIs) between August and November 2011 (Securities and Exchange Board of India, 2012). During the same period, the IR depreciated by 12.22 % against the USD.

Since the exchange rate series is not stationary at level, we have to make it stationary for the application of the ARIMA model in order to get the value of differencing *(d)*. The results of the unit root tests indicate that the exchange rate series is stationary at its first difference and integrated at first order ($I = 1$).

ARIMA Model Outcomes

For the identification of an appropriate ARMA model, the correlogram of the integrated exchange rate series has been shown in Table 2. To know the statistically significant correlations, the standard error of the correlation coefficient has been calculated by $\sqrt{1/n} = \sqrt{1/171} \approx 0.0762$, where n denotes the size of the sample. Further, the 95% confidence interval for the true correlation coefficients is calculated by using the value of the estimated standard error of the correlation coefficient, which is about $0 \pm 1.96\ (0.0762) = (-0.1493$ to $0.1493)$. The value of

Table 2. ***Correlogram of Exchange Rate*** **(Δy_t)**

Autocorrelation	Partial Correlation	Lags	AC	PAC	Q-Stat
.|** |	.|** |	1	0.295#	0.295#	15.167
.|. |	*|. |	2	–0.008	–0.104	15.179
.|. |	.|. |	3	–0.031	0.003	15.343
*|. |	.|. |	4	–0.066	–0.064	16.110
.|* |	.|* |	5	0.117	0.171#	18.549
.|* |	.|. |	6	0.078	–0.022	19.643
.|. |	.|. |	7	–0.045	–0.058	20.012
.|. |	.|. |	8	–0.055	–0.024	20.567
.|. |	.|. |	9	–0.041	0.002	20.881
*|. |	*|. |	10	–0.102	–0.121	22.799
*|. |	*|. |	11	–0.107	–0.071	24.901
.|. |	.|. |	12	–0.043	0.011	25.249
*|. |	*|. |	13	–0.146	–0.154#	29.260
.|. |	.|* |	14	–0.002	0.086	29.260
.|* |	.|* |	15	0.105	0.085	31.335
.|. |	.|. |	16	–0.006	–0.042	31.342
*|. |	**|. |	17	–0.176#	–0.220#	37.291
*|. |	.|. |	18	–0.131	0.027	40.585
*|. |	*|. |	19	–0.110	–0.094	42.937
.|. |	.|. |	20	0.043	0.038	43.296

.|* |	.|. |	21	0.123	0.034	46.303
.|. |	.|. |	22	0.013	0.020	46.336
.|. |	*|. |	23	–0.053	–0.081	46.892
.|. |	.|. |	24	0.010	0.057	46.911
.|. |	.|. |	25	–0.042	–0.057	47.277
.|. |	*|. |	26	–0.034	–0.074	47.515
.|* |	.|. |	27	0.076	0.070	48.713
*|. |	*|. |	28	–0.083	–0.150#	50.148
.|. |	.|. |	29	–0.051	–0.010	50.691
.|. |	.|. |	30	0.055	–0.007	51.331
*|. |	.|. |	31	–0.070	–0.049	52.376
.|. |	.|. |	32	–0.021	–0.017	52.469
.|. |	.|* |	33	0.046	0.109	52.921
.|. |	*|. |	34	–0.039	–0.090	53.243
.|. |	.|. |	35	0.062	0.052	54.073
.|* |	.|* |	36	0.189#	0.116	61.937

Note. The # denotes statistically significant ACF and PACF at different lags.

correlation coefficients that are lying beyond these bounds (– 0.1493 to 0.1493) is statistically significant at the 5% level of significance (Gujarati, 2011). On this basis, it seems ACF at lags 1, 17, and 36 and PACF at lags 1, 5, 13, 17, and 28 appear to be statistically significant. The statistically significant value of ACF at different lags will provide the value of AR (p), while the value of PACF will give the value of MA (q) for the ARMA model.

On the basis of the obtained value of autoregressive (AR) and moving average (MA), the possible sets of 15 ARIMA models have been shown in Table 3. ARIMA model (36,1,1) is found to be more significant among all the possible ARIMA models because the Akaike and Schwarz information criteria were found to be lowest for this model. Both coefficients of the opted model are statistically significant, and AR (36) and MA (1) explain around 13% variation in the exchange rate in this model. The study's findings are consistent with the results of other studies, such as Rai and Sharma (2017) and Thomakos and Bhattacharya (2005).

Diagnostic Tests Outcomes

Diagnostic tests are applied to check the robustness of the estimated coefficients. The estimated ARIMA model has passed a series of diagnostic tests of normality, heteroscedasticity, and serial correlation of the estimated residual. The results of the test have been depicted in Table 4, and it is evident that the estimated model is a stable one.

After a particular ARIMA model is fitted, it can be applied for forecasting, and the result of the dynamic forecast is shown in Figure 2. The forecast period is considered from May 2019 to December 2020. The value of the Theil Inequality Coefficient and root mean squared error is quite low and signifies the relevancy of the fitted model. This can also be verified from Figure 3, which depicts how closely the actual and forecast values of the exchange rate (i.e., ER and ERF, respectively) track each other.

Table 3. *ARIMA Model Results*

	ARIMA (1,1,1)	ARIMA (1,1,5)	ARIMA (1,1,13)	ARIMA (1,1,17)	ARIMA (1,1,28)	ARIMA (17,1,1)	ARIMA (17,1,5)	ARIMA (17,1,13)	ARIMA (17,1,17)	ARIMA (17,1,28)	ARIMA (36,1,1)	ARIMA (36,1,5)	ARIMA (36,1,13)	ARIMA (36,1,17)	ARIMA (36,1,28)
AR (1)	–0.2094	0.3051*	0.3039*	0.2907*	0.3024*										
AR (17)						–0.1978*	–0.2138*	–0.2349*	0.6110*	–0.2277*					
AR (36)											0.2536*	0.2788*	0.2543*	0.2260*	0.2601*
MA (1)	0.5358*					0.3358*					0.3283*				
MA (5)		0.1913*					0.1716*					0.1826*			
MA (13)			–0.2137*					–0.2227*					–0.1726*		
MA (17)				–0.2544*					–1.0000					–0.2130*	
MA (28)					–0.1164					–0.1185					–0.0683
Adj. R^2	0.0902	0.0997	0.1093	0.1155	0.0882	0.1186	0.0462	0.0651	0.1524	0.0405	0.1327	0.0644	0.0664	0.0701	0.0462
D-W Statistics	1.9812	1.9412	1.9281	1.9438	1.9348	2.0263	1.3992	1.4106	1.4859	1.4223	2.0084	1.3947	1.4082	1.4220	1.4125
AIC	2.7842	2.7745	2.7663	2.7623	2.7884	2.7564	2.8361	2.8201	2.8350	2.8442	2.7503	2.8294	2.8256	2.8209	2.8462
SC	2.8577	2.8480	2.8397	2.8358	2.8619	2.8299	2.9096	2.8936	2.9085	2.9177	2.8238	2.9029	2.8991	2.8944	2.9197
F-statistics	6.6227	7.2815	7.9601	8.4051	6.4844	8.6278	3.7501	4.9511	11.1954	3.3931	9.6708	4.9039	5.0320	5.2731	3.7464
Prob.	0.0002*	0.0001*	0.0000*	0.0000*	0.0003*	0.0000*	0.0121*	0.0025*	0.0000*	0.0193*	0.0000*	0.0027*	0.0023*	0.0016*	0.0122*

Note. * denotes significant at 5% level.

Table 4. ***Diagnostic Test Results***

Model	LM-Test		ARCH-Test		Normality Test	
ARIMA (36,1,1)	Obs.*R-squared	Prob. Chi-Square	Obs.*R-squared	Prob. Chi-Square	Jarque – Bera	P-value
	0.1071	0.9478*	1.4610	0.2268*	4.1539	0.0924*

Note. The * denotes statistical insignificance at the 5% level; LM-test, ARCH test, and normality test refer to the Breusch – Godfrey Lagrange Multiplier Test for residual serial correlation, the autoregressive conditional heteroscedasticity test, and the Jarque – Bera normality test.

Figure 2. ***Dynamic Forecast of Exchange Rate***

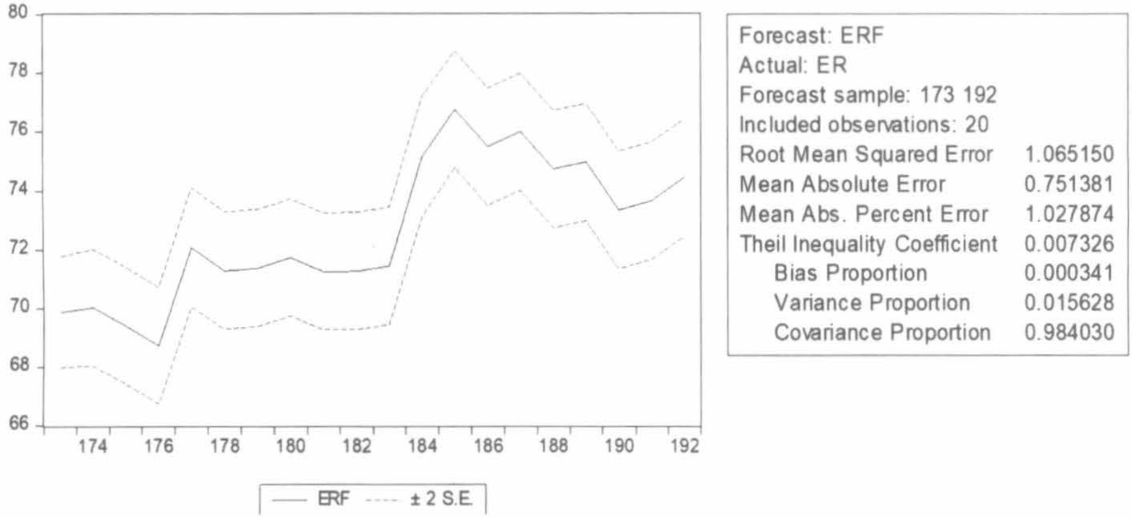
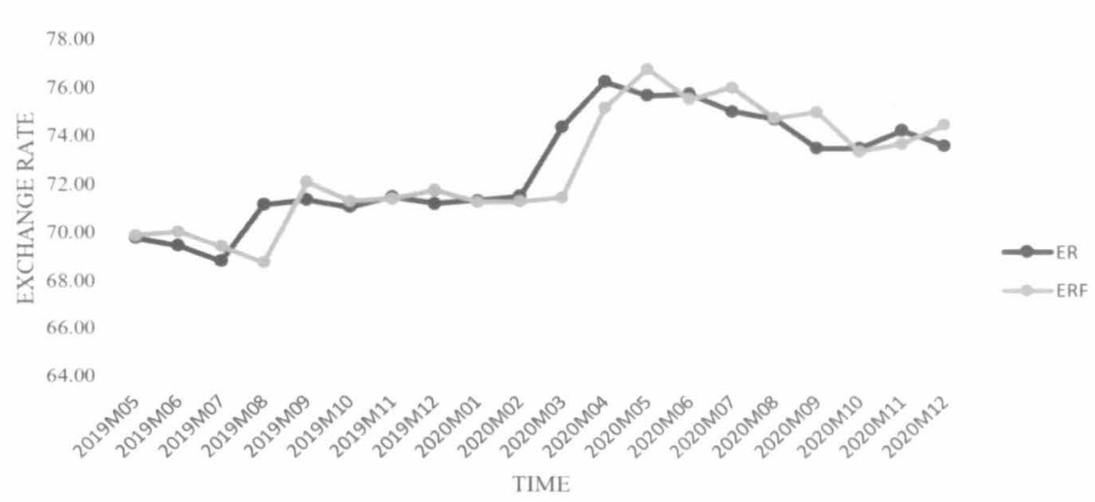


Figure 3. ***Actual and Forecast Value of Exchange Rate***



Conclusion and Research Implications

The purpose of this study is to examine the issue of variation in the exchange rate of the Indian rupee (IR) against the US dollar (USD) under a flexible regime by employing an autoregressive integrated moving average (ARIMA) model during the period between January 2005 and December 2020. India is one of the fastest growing economies in the world and needs capital inflows to fill the capital deficit in the domestic market to maintain its high growth. The volatility in the exchange rate adversely affects macroeconomic stability and, subsequently, the capital inflows need to achieve a high growth rate of the economy. Therefore, the identification of a model that can successfully predict the volatility in the exchange rate may be highly useful to policymakers, researchers, and other stakeholders. In many theoretical and empirical research, it has been observed that the volatility of the exchange rate is affected by its own previous values. However, this aspect has been less attended to in the Indian context.

The paper tries to address the issue of volatility in an exchange rate through its own lagged values, lagged values of the random error term, and demonstrates that the selected ARIMA (36, 1, and 1) model can be used to predict the exchange rate of Indian currency against USD with a high degree of accuracy. The findings indicate that the value of the exchange rate in the Indian economy for a period is affected by its 36^{th} month's previous value by around 13%. It infers that volatility in the exchange rate has the potential to affect the exchange for a duration of almost three years, which is quite a long time duration under a flexible exchange rate. Further, it also emphasizes the role of government in monitoring factors other than the exchange rate, which affects its volatility.

A highly volatile exchange rate market, on the one hand, discourages traders from exporting or importing or investing in financial assets and, on the other hand, encourages speculative activities in the foreign exchange market that may further accentuate fluctuations in it. From the policymakers' perspective, apart from other factors, the policymakers are advised to control the sharp changes in the exchange rate because its effect will be reflected in the next period and thus create a chain of instability in the exchange rate. The paper potentially adds to discussions on the determination of exchange rate volatility and appropriate model specification.

Limitations of the Study and Scope for Further Research

The present study uses lagged values of exchange rates and lagged values of random error terms as an explanatory variable to estimate the variations in exchange rates of IR against USD. Although the model sufficiently explains the variation in the exchange rate in terms of its lag value and there is a high degree of similarity in the actual value and forecasted value of exchange rate using the model, the addition of other relevant variables in the model as predictors may enhance the usefulness of the model. However, this will discard the objectives of the present study. Future research in this area could use its own lagged value of exchange rates as a determinant to increase the efficacy of the study based on a different hypothesis of exchange rates theory. Moreover, the results of this analysis may be seen as exploratory, and the validity of the results entirely depends on the data quality.

Authors' Contribution

Dr. Sushil Kumar Rai conceived the idea, reviewed the literature, developed the quantitative design to undertake the empirical study, analyzed the data, and prepared the initial draft. Dr. Akhilesh Kumar Sharma verified the concept note, developed the analytical method, and finalized the manuscript.

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 publication of this article.

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