

Exchange Rate Volatility and Remittances in India: A GARCH Approach

Tazeem Akhter^{*}

*Ph.D. Scholar, Department of Economics, Baba Ghulam Shah Badshah University, Rajouri,
Jammu and Kashmir, India*

Abstract: Remittances sent home by the Indian diaspora have become one of the largest and most stable items in India's current account, yet their rupee value depends directly on the exchange rate. This paper examines the volatility of India's exchange rate using quarterly data from 1996 to 2026 and a GARCH (1,1) model, and then discusses what the estimated volatility dynamics mean for remittance inflows. Descriptive statistics, Augmented Dickey-Fuller tests and ARCH-LM tests are applied before the model is estimated. The exchange-rate return series is stationary and shows significant ARCH effects ($F = 15.73$, $p = 0.0001$). In the GARCH (1,1) model both the ARCH term (0.35) and the GARCH term (0.54) are statistically significant, and their sum of 0.89 points to highly persistent volatility; no ARCH effect remains in the residuals ($p = 0.73$). Remittances are recorded within the current account, which enters the dataset through the current account deficit, but the remittance series itself is not modelled. The results are therefore used to discuss, rather than to estimate, the valuation, uncertainty and stabilisation channels through which volatility and remittances interact.

Keywords: exchange rate volatility, GARCH, remittances, India, current account.

1. Introduction

The exchange rate, the price of one currency in terms of another, is among the most important indicators of an economy. It shapes international trade, foreign investment, tourism, remittances and growth, which is why its stability matters for development. India imports crude oil and machinery and exports software services, pharmaceuticals and textiles, while foreign firms and investors operate within the country. Excessive fluctuation in the rupee makes planning difficult for all of them: exporters are unsure of future earnings, importers face uncertain costs and investors may postpone decisions.

India's exchange rate regime has changed greatly over time. Until 1991 the rupee was largely administered by the government. After the balance of payments crisis of 1991 the Liberalisation, Privatisation and Globalisation reforms opened the economy, and in 1993 India moved to a market-determined, managed floating system [1]. The rupee has since been driven by demand and supply, which respond to inflation, interest rates, foreign investment, oil prices and global conditions, with the Reserve Bank of India (RBI) intervening to curb excessive swings. Friedman argued that flexible rates act as a shock absorber against external disturbances [2], but excessive volatility increases uncertainty and can discourage investment and trade.

Remittances give this question an additional dimension. India has been the largest recipient of remittances in the world for well over a decade; according to the RBI's sixth remittances survey, inward remittances more than doubled from US\$ 55.6 billion in 2010-11 to US\$ 118.7 billion in 2023-24 [3]. They are recorded as private transfers in the current account, and for many households they are a primary source of income. The exchange rate links directly to this flow: it determines how many rupees a recipient family obtains for each dollar, dirham or pound sent, and it influences when, how much and through which channel migrants choose to send. In the opposite direction, steady remittance inflows help finance the current account deficit and support the rupee. Understanding how volatile the rupee is, and how long that volatility lasts, is therefore relevant to remittance senders, recipients and policymakers alike.

Financial time series such as exchange rates display volatility clustering: calm periods and turbulent periods tend to follow one another. The ARCH model [4] and its generalisation, the GARCH model [5], were developed to capture exactly this behaviour. This paper applies a GARCH(1,1) model to quarterly data on India's exchange rate and interprets the results in the context of remittance inflows. The paper is organised as follows: Section 2 reviews the literature, Section 3 states the objectives, Section 4 describes the data and methodology, Section 5 presents the results and discusses their implications for remittances, and Section 6 concludes.

2. Review of Literature

2.1 GARCH-based studies of exchange rate volatility

Singh examined exchange rate volatility in India with several weighted and unweighted real exchange rate series and found that GARCH effects dominated ARCH effects in most of them; estimated volatility was

sensitive to the exchange rate measure used, while persistence was fairly stable across sample periods [6]. Samsubheen and Shanmugasundaram studied how India's shift from a pegged regime to the liberalised and then the market-determined regime affected volatility, using forty years of data (1973-2012) and ARCH, GARCH, EGARCH and TGARCH models; volatility was highly persistent in all three sub-periods, and especially in the post-LERMS period, with asymmetric models showing leverage effects [7]. For Pakistan, Rehman and Salamat found strong volatility clustering and showed that the best-fitting GARCH variant changed once a structural break was allowed for [8]. Zhou et al. linked higher relative economic policy uncertainty between China and the United States to higher long-run volatility of the Chinese exchange rate using a GARCH-MIDAS model [9]. Madtha applied GARCH and EGARCH models to daily USD/INR data for 2005-2024 and highlighted the role of RBI policy variables such as the repo rate, CRR, SLR, money supply and foreign exchange reserves [10].

2.2 Determinants and macroeconomic effects of exchange rate movements

Dua and Sen found that India's real effective exchange rate is cointegrated with capital flows, the volatility of those flows, high-powered money, the current account surplus and government expenditure, with net capital inflows and their volatility the most important determinants [11]. Mirchandani concluded that the rupee was highly volatile during 1991-2010 under the influence of macroeconomic factors and capital inflows [12], and Ramasamy and Abar reported that investor confidence and psychological factors can dominate economic variables [13]. Banik reviewed crude oil prices, gold prices, inflation, FDI, the balance of payments and capital flows as drivers of the rupee during 2010-2024 [14], while Jacob et al. showed that foreign portfolio investment tends to appreciate the rupee and that its withdrawal leads to depreciation [15].

Studies of consequences are equally varied. Megaravalli and Vikram found negative associations of inflation, GDP growth and interest rates with the exchange rate in India, and a positive one for FDI [16]; Gona and Sahoo reported that volatility is positively related to FDI and GDP and negatively to consumption [17]. Mahmood et al. found that volatility affects macroeconomic variables in Pakistan [18], Shaikh and Hongbin found that volatility is negatively associated with the trade volume of Pakistan and India [19], and Jannat reported a significant negative impact of volatility on FDI inflows in South Asia, partly offset by trade openness [20]. Zhugri and Vangelj concluded from a literature review that depreciation promotes exports and reduces imports, while appreciation does the reverse [21]. Goyal argued that a flexible rate with intervention against excess volatility suits inflation-targeting emerging markets [22]. Sahu found no effect of the introduction of currency futures on spot volatility in India [23], and related work on crude oil, gold and equity markets shows how closely exchange rates move with other financial variables [24], [25].

2.3 Remittances and the exchange rate

The remittance literature suggests several two-way links with the exchange rate. Amuedo-Dorantes and Pozo found that large remittance inflows are associated with real exchange rate appreciation in Latin America and the Caribbean [26]. Chami et al. argued that remittances behave more like compensatory transfers between family members than like profit-driven capital flows [27], and Lueth and Ruiz-Arranz showed that bilateral remittance flows respond to macroeconomic conditions in both the sending and the receiving economy [28]. Most of the Indian exchange rate volatility literature reviewed above, however, treats remittances only implicitly, if at all. This paper contributes by modelling the volatility of the rupee with a GARCH framework and then interpreting its persistence from the standpoint of remittance inflows.

3. Objectives of the Study

The study has two objectives: (i) to analyse the volatility of India's exchange rate using the GARCH model; and (ii) to discuss, in the light of the estimated volatility dynamics, the implications for remittance inflows into India.

4. Data and Methodology

4.1 Data

The study uses quarterly secondary time-series data for 1996 to 2026 collected from the Reserve Bank of India and other official macroeconomic databases. The variables are the exchange rate (INR per US dollar, quarterly average), the exchange rate return (ERR), inflation measured by the wholesale price index (WPI), foreign exchange reserves (US\$ million), the current account deficit (CAD) and the CAD as a percentage of GDP, together with GDP growth and the growth of the M1 and M3 money supply. Remittances are classified as private transfers within the current account, so the CAD series is net of remittance receipts. Remittances are thus reflected in the data indirectly but cannot be separated from the other items of the current account, and the paper does not estimate a remittance equation.

4.2 Methodology

The analysis begins with descriptive statistics, followed by the Augmented Dickey-Fuller (ADF) test for stationarity:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum \delta_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

Since the exchange rate is non-stationary in levels, it is converted into continuously compounded quarterly returns, expressed in per cent:

$$ERR_t = 100[\ln(EXCH_t) - \ln(EXCH_{t-1})] \quad (2)$$

A mean equation, an ARMA(1,1) model, is fitted to the returns, and the ARCH-LM test is applied to its residuals to check whether the variance is time-varying:

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_q \varepsilon_{t-q}^2 + u_t \quad (3)$$

Where ARCH effects are present, the conditional variance is estimated with the GARCH(1,1) model:

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \quad (4)$$

where h_t is the conditional variance, ω the constant, α the effect of recent shocks and β the persistence of past volatility. The sum $\alpha + \beta$ measures overall persistence; a value close to one means that shocks die out slowly. Finally, the ARCH-LM test and the Durbin-Watson statistic are applied to the standardised residuals to check that no serial correlation or ARCH effect remains.

5. Results and Discussion

5.1 Descriptive statistics

Table 1 shows that every variable varied considerably over the study period. The current account deficit averaged 2.79 per cent of GDP (median -2.64), with a minimum of -9.92 and a maximum of 3.95, so that the current account was in surplus in a few quarters. The exchange rate averaged 57.86 rupees per dollar with a standard deviation of 15.19 and ranged from 35.81 to 92.76, a depreciation of more than 150 per cent over the sample. Quarterly exchange rate returns averaged 0.49 per cent, a steady average depreciation, with a standard deviation of 1.64. Their kurtosis of 4.02 indicates fatter tails than the normal distribution, and inflation averaged 4.26 per cent.

The Jarque-Bera statistics reject normality for most variables, the exceptions being the current account deficit, inflation and M3 growth. GDP growth is the most extreme case, with a kurtosis of 34.17, reflecting the sharp contraction of 2020. Overall, the macroeconomic variables moved considerably during the period.

Table 1: Descriptive statistics of the variables

Panel A	Mean	Median	Maximum	Minimum	Std. Dev.
CAD % GDP	-2.79	-2.64	3.95	-9.92	2.77
Exch	57.86	50.78	92.76	35.81	15.19
ERR	0.49	0.27	5.71	-3.46	1.64
Growth	6.35	6.66	19.29	-23.33	3.82
Inflation	4.26	4.29	15.04	-5.74	3.63
M1GR	0.12	0.12	0.37	-0.21	0.06
M3GR	0.13	0.13	0.21	0.05	0.04
Forex US\$ Mln	303542.3	294605.0	705782.3	27034.0	204286.8
Panel B	Skewness	Kurtosis	Jarque-Bera	Observations	
CAD % GDP	-0.27	2.88	1.46	116	
Exch	0.56	2.00	10.90	116	
ERR	0.65	4.02	13.06	116	
Growth	-3.98	34.17	5004.16	116	
Inflation	0.18	3.54	2.04	116	
M1GR	-0.93	14.40	645.48	116	
M3GR	0.16	2.11	4.32	116	
Forex US\$ Mln	0.33	2.08	6.18	116	

Note: ERR = exchange rate return (per cent); Exch = exchange rate (INR per US\$); M1GR, M3GR = growth of M1 and M3.

5.2 Unit root test

Table 2: Result of Augmented Dickey-Fuller unit root test

No.	Variable	t-Statistic	p-value	Result
1	Exchange rate	1.0215	0.9363	Non-stationary
2	Current account deficit	-3.2278	0.0209	Stationary
3	Inflation	-2.9016	0.0483	Stationary
4	WPI	-2.1588	0.5077	Non-stationary
5	Forex reserves (US\$ Mln)	0.7049	0.9918	Non-stationary
6	CAD as % of GDP	-2.2444	0.1920	Non-stationary
7	ERR	-9.9088	0.0000	Stationary

At the 5 per cent level a variable is stationary when its p-value is below 0.05. The current account deficit, inflation and the exchange rate return are stationary at level, whereas the exchange rate, WPI, foreign exchange reserves and the CAD-to-GDP ratio have p-values above 0.05 and are non-stationary at level. The result for the exchange rate itself ($p = 0.9363$) confirms that the series should not be modelled in levels, and the strongly stationary return series ($p = 0.0000$) justifies using ERR as the basis for the volatility analysis.

5.3 Volatility clustering

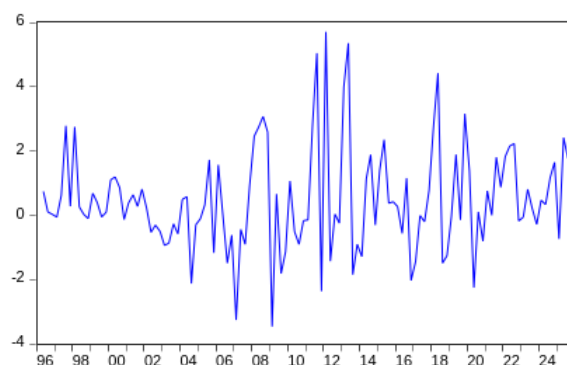


Figure 1: Quarterly exchange rate returns (ERR), India, 1996-2025

Figure 1 shows that the returns fluctuate around a small positive mean. Fluctuations are mild in some periods, such as 1999-2004, and much larger in others, with several sharp movements after 2008. Large changes tend to be followed by large changes, which is preliminary evidence of volatility clustering and supports the use of ARCH/GARCH models.

5.4 Mean equation and ARCH effects

Table 3: ARMA(1,1) estimates for the exchange rate return (119 observations)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.488	0.194	2.516	0.013
AR(1)	0.286	0.784	0.364	0.717
MA(1)	-0.205	0.784	-0.262	0.794
SIGMASQ	2.582	0.287	8.995	0.000
R-squared			0.007	
Adjusted R-squared			-0.019	
Akaike / Schwarz criterion			3.85 / 3.95	
Durbin-Watson stat			2.00	

In the ARMA(1,1) model the constant (0.488, $p = 0.013$) is significant, indicating an average depreciation of about 0.49 per cent per quarter. The AR(1) and MA(1) terms are insignificant, and the R-squared of 0.007 shows that past returns explain very little of the movement in the return itself. The Durbin-Watson statistic of 2.00 indicates no first-order autocorrelation in the residuals.

Table 4: ARCH-LM test on the residuals of the mean equation

Lags	F-statistic	Prob. F	Obs*R ²	Prob. χ^2
1	15.730	0.0001	14.090	0.0002
2	9.199	0.0002	16.259	0.0003

Both tests reject the null hypothesis of no ARCH effect at the 5 per cent level (Table 4). In the one-lag test equation the coefficient on the lagged squared residual is 0.345 ($p = 0.0001$), and in the two-lag equation the first lag (0.29, $p = 0.00$) is significant while the second (0.15, $p = 0.10$) is not. The variance of the exchange rate therefore changes over time, and a parsimonious GARCH(1,1) specification is appropriate.

5.5 GARCH(1,1) estimates

Table 5: GARCH(1,1) model for the exchange rate return (118 observations, 1996Q3-2025Q4)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Mean equation				
C	0.39	0.16	2.49	0.01
AR(1)	0.34	0.45	0.76	0.45
MA(1)	-0.16	0.50	-0.31	0.76
Variance equation				
C (ω)	0.36	0.19	1.87	0.06
RESID(-1) ² (α)	0.35	0.15	2.42	0.02
GARCH(-1) (β)	0.54	0.16	3.37	0.00
Akaike / Schwarz criterion			3.68 / 3.82	
Log likelihood			-211.29	
Durbin-Watson stat			2.21	

Note: probabilities for the variance equation are computed from the reported z-statistics (normal distribution).

In the mean equation only the constant is significant (0.39, $p = 0.01$). In the variance equation the ARCH coefficient $\alpha = 0.35$ ($z = 2.42$) shows that past shocks significantly affect current volatility: a large unexpected move in the rupee raises volatility in the next quarter. The GARCH coefficient $\beta = 0.54$ ($z = 3.37$) shows that last period's volatility also feeds into the current one. The two together give $\alpha + \beta = 0.89$, below one, so volatility is mean-reverting, but close enough to one to indicate high persistence. With persistence of 0.89, a volatility shock loses half of its effect after about six quarters ($\ln 0.5 / \ln 0.89$). Exchange rate volatility in India is thus neither random nor short-lived.

5.6 Diagnostic check

Table 6: ARCH-LM test after estimating the GARCH(1,1) model

Statistic	Value	Prob.
F-statistic (1,115)	0.1189	0.7308
Obs*R ² (χ^2 , 1 d.f.)	0.1209	0.7281
WGT_RESID ² (-1) coefficient	0.03	0.73

After estimation the ARCH-LM test gives probability values of 0.7308 (F) and 0.7281 (Obs*R²), both well above 0.05, so the null of no remaining ARCH effect is not rejected (Table 6). Together with a Durbin-Watson statistic of 2.21 and lower information criteria than the ARMA model (Akaike 3.68 against 3.85), this indicates that the GARCH(1,1) model has adequately captured the time-varying volatility of the exchange rate.

5.7 Implications for remittances

The remittance series is not part of the estimated model, so the following points are interpretations of the results and not estimated effects. They work through three channels.

Valuation channel: Over the sample the rupee depreciated from about 35 to about 93 per dollar, with an average quarterly depreciation of 0.49 per cent (Table 3). Each dollar sent home therefore buys more rupees over time, which can raise the rupee value of remittances and give migrants an incentive to send more when the

rupee is weak. The compensatory-transfer view of remittances [27] suggests that senders may also respond to the economic needs of their families at home.

Uncertainty channel: The persistence found in Table 5 means that turbulent episodes last for several quarters. For senders and recipient households, this raises uncertainty about the best time to remit and about the rupee value of savings that are being accumulated abroad. Because remittance flows respond to macroeconomic conditions on both sides of the corridor [28], prolonged volatility can be expected to affect the timing and channel of transfers, and to make remitting through unofficial channels more attractive when the official rate is unstable.

Stabilisation channel: The current account deficit averaged 2.79 per cent of GDP, and remittances are one of the items that offset it. Their steady growth, which the RBI survey puts at more than a doubling since 2010-11 [3], means that they have become an important buffer for the rupee, in addition to foreign exchange reserves. The international evidence that large remittance inflows may appreciate the real exchange rate [26] suggests that this buffer should itself be monitored. A natural extension of this study is to include remittances directly, for example as an additional regressor in the variance equation of a GARCH-X model, or to test for causality between remittance inflows and rupee volatility.

6. Conclusion

This paper analysed the volatility of India's exchange rate with a GARCH(1,1) model on quarterly data for 1996-2026, and related the findings to remittance inflows. The exchange rate is non-stationary in levels, but its returns are stationary and show significant ARCH effects, so volatility is time-varying. In the GARCH(1,1) model both past shocks (0.35) and past volatility (0.54) significantly influence current volatility, with a persistence of 0.89, and diagnostic tests show no remaining ARCH effect. Exchange rate volatility in India is therefore clustered and persistent rather than constant.

These findings matter for remittances. Because volatility tends to last for roughly six quarters after a shock, remittance senders and recipients operate in an environment where rupee uncertainty is not momentary, while the same remittances help to finance the current account deficit and support the rupee. For policymakers this strengthens the case for the RBI's policy of curbing excess volatility, maintaining adequate reserves, controlling inflation and keeping formal remittance channels attractive. A limitation of the study is that remittances were not modelled directly; future research could use remittance data in a GARCH-X or multivariate framework to test the channels discussed here.

References

- [1]. F. Yagci, "Choice of Exchange Rate Regimes for Developing Countries," *World Bank Africa Region Working Paper Series*, No. 16, 2001.
- [2]. M. Friedman, "The Case for Flexible Exchange Rates," in *Essays in Positive Economics*, University of Chicago Press, Chicago, pp. 157-203, 1953.
- [3]. Reserve Bank of India, "Changing Dynamics of India's Remittances – Insights from the Sixth Round of India's Remittances Survey," *RBI Bulletin*, March 2025.
- [4]. R. F. Engle, "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica*, 50 (4), pp. 987-1007, 1982.
- [5]. T. Bollerslev, "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics*, 31 (3), pp. 307-327, 1986.
- [6]. T. Singh, "On the GARCH Estimates of Exchange Rate Volatility in India," *Applied Economics Letters*, 9 (6), pp. 391-395, 2002.
- [7]. K. Samsubheen and G. Shanmugasundaram, "[Title and publication details to be completed]," (study of ARCH-family models and India's exchange rate regime changes, 1973-2012).
- [8]. M. A. Rehman and A. Salamat, "Modeling Exchange Rate Volatility with GARCH Models: A Comparison Based on a Volatility Breaks," *Asian Finance Research Journal*, 3 (1), pp. 1-14, 2021.
- [9]. Z. Zhou, Z. Fu, Y. Jiang, X. Zeng and L. Lin, "Can Economic Policy Uncertainty Predict Exchange Rate Volatility? New Evidence from the GARCH-MIDAS Model," *Finance Research Letters*, 34, 101258, 2020.
- [10]. P. S. Madtha, "Influence of Reserve Bank of India Monetary Policy Indicators on Indian Rupee (USD/INR) Exchange Rate Volatility: An Empirical GARCH and EGARCH Analysis," *International Research Journal of Web*, [volume/issue to be completed], 2026.
- [11]. P. Dua and P. Sen, "Capital Flow Volatility and Exchange Rates: The Case of India," Working Paper No. 144, Centre for Development Economics, Delhi School of Economics, 2006.

-
- [12]. A. Mirchandani, "Analysis of Macroeconomic Determinants of Exchange Rate Volatility in India," *International Journal of Economics and Financial Issues*, 3 (1), pp. 172-179, 2013.
- [13]. R. Ramasamy and S. K. Abar, "Influence of Macroeconomic Variables on Exchange Rates," *Journal of Economics, Business and Management*, 3 (2), pp. 276-281, 2015.
- [14]. A. Banik, "[Title and publication details to be completed]," (review of macroeconomic factors behind exchange rate fluctuations in India, 2010-2024), 2025.
- [15]. T. Jacob, R. Raphael and A. Antony, "Relationship between Foreign Portfolio Investment and Exchange Rate: The Case of India Using VECM Testing Approach," *BIMTECH Business Perspective*, 5 (2), pp. 1-17, 2022.
- [16]. A. V. Megaravalli and K. Vikram, "Exchange Rate Volatility & its Impact on Macro-Economic Factors with Respect to Indian Economy," *International Journal of Social Science & Management*, 4 (6), 2016.
- [17]. B. R. Gona and M. Sahoo, "Examining Exchange Rate Volatility and its Impact on Macroeconomic Indicators in India," *International Journal of Management and Development Studies*, 7 (1), pp. 108-119, 2018.
- [18]. I. Mahmood, M. Ehsanullah and A. Habib, "Exchange Rate Volatility & Macroeconomic Variables in Pakistan," *Business Management Dynamics*, 1 (2), p. 11, 2011.
- [19]. S. A. Shaikh and O. Hongbin, "Exchange Rate Volatility and Trade Flows: Evidence from China, Pakistan and India," *International Journal of Economics and Finance*, 7 (11), pp. 121-127, 2015.
- [20]. Z. Jannat, "The Impact of Exchange Rate Volatility on Foreign Direct Investment Inflows: Evidence from South Asia," 2020.
- [21]. E. Zhugri and R. Vangiel, "The Effect of Exchange Rate Volatility on Economic Growth," [publication details to be completed], 2022.
- [22]. A. Goyal, "India's Exchange Rate Regime under Inflation Targeting," *The Indian Economic Journal*, 73 (1), pp. 69-86, 2025.
- [23]. D. Sahu, "Dynamics of Currency Futures Trading and Underlying Exchange Rate Volatility in India," *Research Journal of Finance and Accounting*, 3 (7), 2012.
- [24]. S. Singhal, S. Choudhary and P. C. Biswal, "Return and Volatility Linkages among International Crude Oil Price, Gold Price, Exchange Rate and Stock Markets: Evidence from Mexico," *Resources Policy*, 60, pp. 255-261, 2019.
- [25]. P. K. Mishra, J. R. Das and S. K. Mishra, "Gold Price Volatility and Stock Market Returns in India," *American Journal of Scientific Research*, 9 (9), pp. 47-55, 2010.
- [26]. C. Amuedo-Dorantes and S. Pozo, "Workers' Remittances and the Real Exchange Rate: A Paradox of Gifts," *World Development*, 32 (8), pp. 1407-1417, 2004.
- [27]. R. Chami, C. Fullenkamp and S. Jahjah, "Are Immigrant Remittance Flows a Source of Capital for Development?," *IMF Staff Papers*, 52 (1), pp. 55-81, 2005.
- [28]. E. Lueth and M. Ruiz-Arranz, "Determinants of Bilateral Remittance Flows," *The B.E. Journal of Macroeconomics*, 8 (1), 2008.

Author Profile

Tazeem Akhter is an Assistant Professor in the Department of Economics, Baba Ghulam Shah Badshah University, Rajouri, Jammu and Kashmir, India and is publishing this paper as a Ph.D. Scholar based on her Ph.D. research.