Pricing of Currency Futures and their effect on Currency Market Volatility

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Abstract

Derivatives have been actively employed by corporations and financial institutions particularly in the past two decades as a risk management tool. Derivatives are financial instruments which derive its returns from the underlying assets such as commodity price, interest rate, stock price, exchange rate, etc. Alternatively, volatility may be defined as the measure for its frequency of fluctuations for a time period. The objective of this paper was to investigate the volatility in Indian currency market. Further, it seeks to examine the specific volatility in EURINR in Indian markets post the introduction of derivative contracts in the relevant currency pair. The study investigates the currency pair of EURINR accessed from RBI website through April, 2006 - December, 2015 employing GARCH-family models. The study found that the volatility decreased after the introduction of currency futures trading in the Indian foreign exchange market. Thus, concluding that a Currency Futures market does help in combating the volatility in Foreign Exchange Markets.

1. Introduction

Derivatives on currency have been around for some time now, and their usage has been going up steadily. As the corporate world morphs into a border free phenomenon, transactions in multiple currencies by a firm based in one geographical region have become an accepted part of the daily workings. As opportunities flare up across the globe and substantial growth becomes synonymous with multinational expansion, almost every big firm trades and transacts in multiple currencies every day. This leads to significant exposure to the exchange rate fluctuations between any two currencies, on the firm's part. This exposure gives rise to a lot of risk for the company in question, obviously owing to their incapability to assert any control over the exchange rate fluctuations between any two economies. Thus throughout the world, the researchers and practitioners are driven by the quest of accurately forecasting the financial markets volatility. The forecasting of volatility, particularly with significant accuracy substantially impacts the investment behaviour of the investors which in turn influences the stock prices.

Derivatives have been actively employed by corporations and financial institutions particularly in the past two decades as a risk management tool. Derivatives are financial instruments which derive its returns from the underlying assets such as commodity price, interest rate, stock price, exchange rate, etc. For instance, swaps provides for changing the nature of an exposures, while futures and options (derivative instruments) are employed to hedge existing market exposures, credit derivatives facilitates an insurance against events such as defaults and options shields the exposure from downside movement while retaining upside potential.

Keywords:

Volatility, GARCH, Futures, Options, Derivatives, Pricing

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Thus, derivatives manages multitude of concerns for both corporations and institutions ranging from input costs, credit exposures, exchange rate risk to financial costs. The strengthening globalization and consequent inter-linkages had fuelled the use of derivatives market for the purposes described leading to its rapid growth globally. The collective gross market value of over-the-counter derivatives market exceeds USD 27 trillion whereas its outstanding amount worldwide is over USD 640 trillion. An immense world market exists for the derivatives.

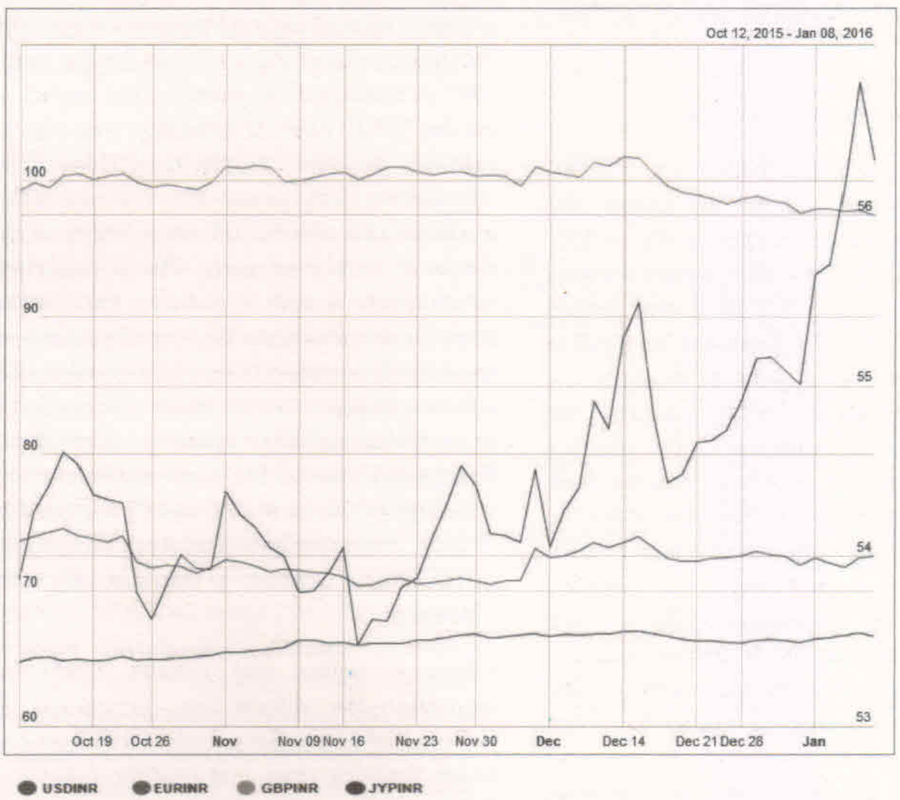
Currency derivatives in India are available on four currency pairs: US dollar (USD), Euro (EUR), British Pound (GBP) and Japanese Yen (JPY) vis-à-vis Indian Rupee (INR). Currency derivative contracts are traded in pairs like Rupee-Dollar, Rupee-British Pound and Rupee-Euro with a contract size of 1,000. The Rupee-Yen contract has a lot size of 1,00,000. For example, if the one dollar is at 62.4950, then the contract size will be at INR 62,495 (62.4950*1000).

These contracts are quoted till the fourth decimal point. For instance, if traders perceive that dollar value vis-a-vis rupee will increase, then they would take a long position (buy) in the rupee-dollar contract. If dollar derivative contract is bought by the trader at a rate of 62.4950, then the total contract value (lot size of 1,000) becomes INR 62,495. Suppose, during the course of trade the rate of dollar moves up to 62.4951 then the contract value will jump to INR 62,495.10. Hence, the upward or downward movement in the fourth decimal number results in a gain or loss of 10 paise for trading in INR.

The currency pairs are available to traders at a margin requiring the payment of only some per cent value of the contract, rather than the full value, thereby making it a lucrative trading option among the trade. The margins for these contracts are decided by brokers based on exchange guidelines. On an average, the contract can be bought by the traders by paying a margin of 3-5 per cent of the total value of the contract size.

The figure 1 below depicts the price swings of the four currency pairs' future contracts over the recent past from October 12, 2015 to January 8, 2016. The duration we are considering here is the past 3 months.

Table 1: Price Swings of Currency Pairs' Future Contracts



Source: NSE Website

One can see that three of the currency pairs have remained relatively stable over the past few months in terms of the pricing. The volatility in the JPY-INR pair futures can be attributed to the shrinking of the Japanese economy in October leading to its fifth recession in seven year. The ensuing chaos and the furious bond buyback by the Japanese government to infuse liquidity in the economy and to get it going again have led to volatility across its market and also in its currency. The issues with Japan notwithstanding, the other three pairs tell a story of how the currency futures are a great hedge against exchange rate fluctuations due to their relative stability. That is why they are so widely used to ward off exchange rate exposure risk.

In essence, the derivatives including futures and options facilitated the financial managers to profit from the inherent upward or downward movements of the assets through the creation of efficient portfolios. Now, the uncertainty attached with the prediction of future stock prices of these options and futures indicates at the volatility attached with these assets. Defining, Maris, et al., (2004) described the volatility of the underlying asset in stock market as the measure for its frequency of fluctuations for a time period. Alternatively, Wiklund (2012) defines volatility as the speed and magnitude of price movement of the underlying asset. Hence, the estimation and forecasting of volatility plagues the financial markets, their players and academicians.

Attempting to quell the quest, this paper was drafted. The objective of this paper was to investigate the volatility in Indian currency market, specifically on four currency pairs viz., USDINR (US Dollar-Indian Rupee), EURINR (Euro-Indian Rupee), GBPINR (Great British Pound-Indian Rupee) and JPYINR (Japanese Yen-Indian Rupee). Subsequently, the paper seeks to examine the specific volatility in EURINR in Indian markets post the introduction of derivative contracts in the relevant currency pair obtained from the website of Reserve Bank of India (RBI) for the period of April 1, 2006 -December 31, 2015. The literature is teeming with controversial results. For instance while certain studies found the volatility of assets under examination decreasing in the relevant spot market post the introduction of futures trading, others studies found an increase in the same settings. The relevant period in previous numerous studies had been found to be bifurcated into break-periods of pre- and post- the introduction of derivative trading. Likewise, this paper also employs the same approach analysing the volatility in EURINR in three periods namely, pre- derivative introduction period, post- derivative introduction period and the whole period. The paper employs the GARCH-family models to analyse the assets and capture the volatility. The result of the paper reveals that future pricing was in proximity to actual market prices. Further, significant impact of derivatives on volatility of Euro returns was uncovered in the analysis.

The rest of the paper had been structured as follows. Section 2 reviews the existing literature, Section 3 describes objective and Methodology, Section 4 deals with the analysis and interpretation while Section 5 succinctly presents the conclusion, ending the paper with Section 6 with References.

2. Literature Review

Extensive research on the issue of stock price-volatility had been examined for almost all the major markets of the world. However, how much the results derived from big and highly liquid markets of advanced economies stands true for Indian market also needs to be ascertained. Adding to the literature was the study of Sariannidis and Drimbetas (2008) that examined the impact of spill over from international volatility spill on the Greek market. The methodology of GJR-GARCH was employed for the encapsulation of asymmetries model for both stock index volatility and individual stocks for the period of August 1997 to January 2006. Further, the impact of derivatives on the FTSE/ASE 20 volatility was also conducted to examine the role of individual share futures (ISF) by considering daily prices of five shares. The study found the beneficial effect of ISF on volatility of the underlying stocks in numerous ways. The introduction of ISF was interestingly found to stabilize the Greek market and improve its valuation. Additionally found was the higher mean spillover effect from major markets of US, European Union and Japan on the stock returns in Greek market. In contrast, volatility spillover effect from markets of European Union on the Greek stock returns emerged i.e., volatility of Greek market was influenced by the shocks of EU's major markets. The study found a higher impact of 'old' news relative to 'current news on conditional volatility.

Likewise, Bollen and Whaley (1999) analyzed the expiration-day effects on derivatives (futures and options) of Hang Seng Index (HSI) on the underlying index through price and trading volume data of daily frequency for HSI during the period May,1986 to December, 1998. The maximum likelihood procedure was employed to measure the mean, variance of returns on expiration and non-expiration days for three markets of US, Japan, Australia and Hong Kong. The exploration was based on the premise that index derivative expirations have a significant and direct influence on the volatility in the stock market. However, the results failed to establish and verify this direct link in case of US, Japanese, and Australian markets. This was deduced from the observation that though higher trading volume surfaced during expiration days than normal days for index futures and options, the volatility of stock market remained was no different. Further, the stock market volatility failed to increase during the expiration period of derivative contracts of Hong Kong Futures Exchange's Hang Seng Index (HSI).

Studying a different perspective Jeanneau and Micu (2003) investigated the relationship between volatility and monthly activity in exchange-traded derivatives contracts of S&P 500 stock index and 10-year US Treasury note contracts. The study discovered a complete absence of any relationship between volatility and turnover in 10-year US Treasury note derivatives (or specifically futures and options contracts). Nonetheless, an inverse relationship emerged between volatility and turnover in S&P 500 stock index contracts. Further, the authors also found risk premium did not hold any significance in the volatility-turnover relationship, at least at the monthly level.

Another study found the presence of all types of relationships between index future introduction and volatility. Gulen and Mayhew (2000) in their study examined 25 countries for the impact of index future introduction on volatility. And they found an inverse relationship between the two factors in 15 out of 25 countries, a direct relationship with only two countries of US and Japan, and a neutral effect emerged for 7 countries. On the other hand, a study by Pilar and Rafael (2002) found different relationships while examining the effect of the introduction of derivatives on the volatility and trading volume of the underlying index belonging to Spanish market. The derivatives were examined for a period of October 1990 to December 1994 through the employment of three models of conditional volatility GARCH, EGARCH and GJR. While a significant negative relationship was observed between impact of derivatives on variance (or volatility), a positive relationship emerged for trading volume. Moreover, the results validated that uncertainty in the underlying market decreases with the introduction of derivative market whereas liquidity increases, thereby enhancing their efficiency.

Likewise Siopis and Lyroudi (2007) conducted a study on the Greek market examining the volatility in their stock post the introduction of derivatives trading through futures contracts on the FTSE/ASE-20 index. A weekly closing data of the FTSE/ASE-20 was employed for the period of between of 10 years from 1998 to 2007 was analyzed using GARCH - family models for pre-future period and post-futures period. The results indicated at the inverse relationship between volatility of the FTSE/ASE-20 and the introduction of futures. The results also vouched for the significant change in the spot market volatility after the introduction of derivative trading on FTSE/ASE-20 index.

Manda (2010) investigated the stock market volatility and different measures of volatility for three break periods of before, during and after crisis period of 2008. The volatility of VIX Index, S&P 500 returns, VIX Futures, VXV Index were analysed, and S&P 500 Implied Volatility Skew. The presence of leverage was examined for the same periods, particularly for the relationship between VIX Index, S&P 500 returns and VIX Futures. The analysis' results found an increase in stock market volatility during crisis period relative to pre-crisis period. And this was true for all the measures of volatility. Further, the leverage effect surfaced during crisis period. The relationship between VIX Futures and S&P 500 returns was also examined by Moran and Dash (2007) where they unearthed a negative correlation between the two.

Examining market prices and volatility from different perspectives, Brunetti, Büyükşahin and Harris (2015) essentially analyses the influence traders have on these two factors by investigating their trading in hedge funds and swap dealers in futures markets. Daily long and short position of these traders for the period 2005 through 2009 was employed to probe the trading in crude oil, natural gas and corn markets owing to their heightened price volatility during crisis period. Consequent to the examination of various sub-periods, little proof emerged that supported that speculators destabilize financial markets. In fact, positive correlation emerged between contemporaneous hedge fund positions and prices whereas negative correlation was found with volatility. In other words, price discovery was facilitated by hedge funds through their trading with contemporaneous returns besides reducing volatility. Interestingly, no correlation was found between swap dealer activity with contemporaneous returns and volatility.

To study the impact of asymmetric volatility of and jumps in volatility index (VIX) on the pricing of VIX derivatives i.e., futures and options, Park (2015) proposed affline jump-diffusion model. The model employed permitted for the asymmetry in volatility leading to a improvement in the pricing of the VIX derivatives, particularly options. Further, the impact of jumps in VIX was also examined for its impact on valuation of its derivatives. The study employed the daily data of VIX futures and options for the period of July, 2006 to January 2013. The analysis found that the inclusion of asymmetric volatility and upward jumps (or good surprises) in the estimation model which evaluates the VIX derivatives pricing proved to be beneficial. The same however cannot be claimed for downward jumps i.e., bad surprise.

Examining price discovery process of gold in Indian commodity markets Joshy and Ganesh (2015) analysed the long run relationship between two derivative markets of spot and futures. Their study peeps into the affect of volatility in future prices on spot prices and also of the volatility in spot prices on future prices for the period of 2008-2012 employing Johansen co-integration, VECM and GARCH. The result indicated at the dominance of spot market in the process of price discovery of underlying assets in consideration and implying at the information efficiency of spot market. Further, the volatility of futures and spot market prices were found to significantly impact their returns.

3. Data and Methodology

3.1 Data

All the data used in the study had been acquired from the public credit worthy source. The historical currency values time series data have been collected from the official website of Reserve Bank of India. The data set comprises of time series data on currency pair of EURINR. The data analysed for a span of 10 years daily data starting from1st April, 2006 -31st December, 2015 covering a total observations of 546 during Pre-Derivative Period and 1028in Post Derivative Period respectively. Ten years will be quite a good span of time to study the impact of any policy implication.

3.2 Methodology

The first objective of analysing the Indian currency market for the volatility, the methodology had been described in section 3.3.1.

Whereas, for the second objective investigating the volatility in EURINR currency pair after the introduction of derivatives in the said pair of currencies, methodology had been described in section 3.3.2

3.3.1 Futures Pricing

The study uses the data to calculate a theoretical price for each contract and then compare them with their specific market prices on the mentioned date - to determine fairness of value by the market.

Further,

As we know, the generally used formula for pricing of a futures contract is:

$$f_0(T) = S_0(1 + r)^T \qquad \textbf{Equation 1}$$

where, $f_0(T)$ = price of a futures contract at time 0 that expires at time T

S_0 = Spot rate of the underlying asset at time 0

r = Risk-free rate

When we talk about **Currency Futures**, pricing becomes more complicated as the economic variables of two different nations become involved. To gain some analogy with generic Stock futures, one can describe a currency as an asset paying a yield of r_f, which can be viewed as the foreign risk-free rate.

Consider a futures contract on one unit of the currency. If the arbitrageur purchases one unit of the currency up front, the accumulation of interest on the currency will result in having more than one unit at the futures expiration. To adjust for this problem, the arbitrageur should take $S_0/(1 + r_f)^T$ units of his own currency and buy $1/(1 + r_f)^T$units of the foreign currency. The arbitrageur holds this position and collects interest at the foreign rate. The accumulation of interest is accounted for by multiplying by the interest factor $(1 + r_f)^T$. At expiration, the number of units of the currency will have grown to $[1/(1 + r_f)^T]*[1 + r_f]^T = 1$. So, the arbitrageur would then have 1 unit of the currency. He delivers that unit and receives the futures price of $f_0(T)$.

To avoid an arbitrage opportunity, the present value of the payoff of f0(T) must equal the amount initially invested. To find the present value of the payoff, one must discount at the domestic risk-free rate, because that rate reflects the opportunity cost of the arbitrageur's investment of his own money. One must equate the present value of the future payoff, discounting at the *domestic risk-free rate*, to the amount initially invested:

$$f_0(T) / (1+r)^T = S_0 / (1+r_f)^T \quad \textbf{Equation 2}$$

We can solve this for the futures price to obtain:

$$f_0(T) / = [S_0 / (1+r_f)^T] * [(1+r)^T] \quad \textbf{Equation 3}$$

where, $f_0(T)$ = price of a futures contract at time 0 that expires at time T

S_0 = Spot rate of the underlying asset at time 0

r = Domestic Risk-free rate

r_f = Foreign Risk-free rate

This is the formula which is used to price the various currency futures pairs in the Indian forex market.

NIFTY futures contracts have a maximum of 3-month trading cycle - the near month (one), the next month (two) and the far month (three). A new contract is introduced on the trading day following the expiry of the near month contract. The new contract will be introduced for three-month duration. This way, at any point in time, there will be 3 contracts available for trading in the market i.e., one near month, one mid-month and one far month duration respectively. The objective is pricing the currency pairs for *all the three durations* for each of the four pair.

It should also be noted that the formulae used have taken the more natural approach of buying the asset and selling the futures. Because short selling is usually a little harder to do as well as to understand, the approach taken is preferable from a pedagogical point of view. It is important, nonetheless, to remember that the ability to sell short the asset or the willingness of parties who own the asset to sell it to offset the buying of the futures is critical to establishing the results. Otherwise, the futures pricing formulas would be inequalities—limited on one side but not restricted on the other.

3.3.2 The Volatility Conundrum

For the examination of second, the data had been divided into three periods namely, pre-derivatives periods, post-derivatives periods and whole period. Specifically, in order to study the impact of derivatives on currency market volatility, the whole study period for EURINR has been divided into:

Pre derivatives period: 1st April 2006 -31st January2010

Post Derivatives period: 1st February2010 -31st December 2015

This bifurcation is also the reason for choosing the EURINR pair for the paper, as it allows two equal periods of 5 years each - unlike the USDINR pair which was introduced in 2008 itself. This grants the much needed symmetry for such a comparison as we are embarking on.

And as for the methodology, foremost daily rate of return is calculated by taking log of the ratio of present day index level with the previous day index level. The return series over the period of study (Y_t) represents the time series currency market data for the purpose of the paper.

The methodology used in the paper of volatility can be explained by the following points:

a. Stationarity Test on the Data

b. Development of Volatility Models

Stationarity Test on the Data

Before estimating the models, the unit root properties for the time series data have been tested individually for Euro returns using ADF test statistic. Stationarityof the series has been checked by this test statistic. Augmented Dickey fuller test is given by the following equation:

$$\textbf{ADF} = \alpha \Delta y_{t-1} + x'_t \delta + e_t$$

Equation 4

Where α & δ are parameters to be estimated &e_t is the error term.

The ADF tests the following hypothesis:

H_0: α =0 (series has a unit root)

H_1: α <0 (series does not have a unit root) and is evaluated using t ratio.

Development of Volatility Models

GARCH model explains variance by two distributed lags, one on past squared residuals to capture high frequency effects or news about volatility from the previous period measured as the lag of the squared residual from mean equation, and second on lagged values of variance itself to capture long term influences. In the GARCH (1, 1) model, the variance expected at any given data is a combination of long run variance and the variance expected for the last period, adjusted to take into account the size of the last periods observed shock.

GARCH (1, 1) model is given as:

$$\sigma_t^2 = \alpha_0 + \sum \alpha_i \epsilon^2_{t-1} + \sum \beta_i \sigma_{t-1}^2 \qquad \textbf{Equation 5}$$

GARCH Framework helps to detect variations in both level & structure of volatility where alpha (ARCH coefficient) shows the impact of current news on volatility; GARCH coefficient shows the impact of old news on volatility indicating the persistence of previous information. The sum of both ARCH & GARCH coefficient shows the persistence in volatility i.e. the speed at which old shocks to the return die out.

A straightforward interpretation of the estimated coefficients of the GARCH equation is that the constant term is the long-term average volatility, i.e. conditional variance, whereas etand represent how volatility is affected by current and past information, respectively.

4.0 Analyses and Interpretation

Statistical Articulation

4.1 First Objective

USDINR

The inputs used in pricing the specific contracts of USDINR are provided in Table 1 below:

Table 1: Inputs for the pricing of contracts of USDINR

Variable	Reference	Value
S_0	INR/USD (RBI Reference Exchange Rate)	₹66.6690
R	India 10 yr. govt. bond date	7.75%
r_f	3 month Treasury rate	0.25%

Using these inputs, the paper prices the three futures contracts available on the USDINR pair for all the three duration using equation 3. The future price of USDINR for 1, 2 and 3 months duration are mentioned in Table 2 below.

Table 2: Future prices of USDINR

Contract	Time to Expiration	Pricing Formula used	Futures Price [f0(T)]
USDINR 270116	1 month	$f_0(T) = [S_0 / (1+r_f)^T] * [(1+r)^T]$	67.07103618
USDINR 250216	2 months		67.47549676
USDINR 290316	3 months		67.88239638

Comparing the calculated prices with the current market prices of the respective contracts, we get the results and the same is tabulated in Table 3 below:

Table 3: Comparison of estimated price with current market price of respective contracts

Contract	Calculated Futures Price [f0(T)]	Market Futures Price	Fairness of Value
USDINR 270116	67.07103618	66.8175	-0.3780%
USDINR 250216	67.47549676	67.1525	-0.4787%
USDINR 290316	67.88239638	67.48	-0.5928%

Some discrepancy does exist in the form of the market *apparently undervaluing* the contracts. But, as we have taken the market prices a *few days after* the contract initiation, the convergence of the futures price towards the spot exchange price might have begun – leading to miniscule drops in values.

EURINR

The inputs used inputs used in pricing the specific contracts of EURINR are provided in Table 4 below:

Table 4: Inputs for the pricing of contracts of EURINR

Variable	Reference	Value
S_0	INR/EUR (RBI Reference Exchange Rate)	₹ 72.5292
r	India 10 yr. govt. bond yield	7.75%
r_f	ECB yield curve (10 yr.)	0.70%

Using these inputs, the paper prices the three futures contracts available on the EURINR pair for all the three duration using equation 3. The future price of EURINR for 1, 2 and 3 months duration are mentioned in Table 5 below.

Table 5: Future prices of EURINR

Contract	Time to Expiration	Pricing Formula used	Futures Price [f0(T)]
EURINR 270116	1 month	$f_0(T) = [S_0 / (1+r_f)^T] * [(1+r)^T]$	72.93934705
EURINR 250216	2 months		73.35181346
EURINR 290316	3 months		73.76661232

Then, we compare the calculated contract prices to their specific market prices the same is tabulated in Table 6.

Table 6: Comparison of estimated price with current market price of respective contracts

Contract	Calculated Futures Price [f0(T)]	Market Futures Price	Fairness of Value
EURINR 270116	72.93934705	72.72	-0.3007%
EURINR 250216	73.35181346	73.0275	-0.4421%
EURINR 290316	73.76661232	73.35	-0.5648%

As explained with the USDINR pair, the undervaluation by market could be due to, **(a)** arbitrage opportunities existing, or **(b)** the futures price-spot price convergence characteristics of futures contracts.

GBPINR

Moving to the third currency pair for which futures contracts are traded in the Indian markets – the GB Pound – Indian Rupee pair. To price these contracts, the inputs provided are given Table 7.

Table 7: Inputs for the pricing of contracts of GBPINR

Variable	Reference	Value
S_0	INR/GBP (RBI Reference Exchange Rate)	₹ 97.4501
r	India 10 yr. govt. bond yield	7.75%
r_f	UK 10 yr. Gilt yield	1.80%

Using these inputs, the paper prices the three futures contracts available on the GBPINR pair for all the three duration using equation 3. The future price of GBPINR for 1, 2 and 3 months duration are mentioned in Table 8 below.

Table 8: Future prices of USDINR

Contract	Time to Expiration	Pricing Formula used	Futures Price [f0(T)]
GBPINR 270116	1 month	$f_0(T) = [S_0 / (1+r_f)^T] * [(1+r)^T]$	97.91248677
GBPINR 250216	2 months		98.37706749
GBPINR 290316	3 months		98.84385258

Lastly, we compare these calculated prices to their current market prices to check whether these contracts are fairly valued in the market and the same is reported in Table 9 below.

Table 9: Comparison of estimated price with current market price of respective contracts

Contract	Calculated Futures Price [f0(T)]	Market Futures Price	Fairness of Value
GBPINR 270116	97.91248677	97.715	-0.2017%
GBPINR 250216	98.37706749	98.13	-0.2511%
GBPINR 290316	98.84385258	98.6	-0.2467%

As we can see there is a bit of undervaluation by the market as in the case of the other two pairs with INR Though this valuation is lesser than the previous two, the same two reasons might be contributing to the discrepancy as above.

JPYINR

Moving on to the land of the rising sun – the last pair of Japanese Yen-Indian Rupee the inputs required are given in Table 10 below.

Table 10 Inputs for the pricing of contracts of JPYINR

Variable	Reference	Value
S_0	INR/JPY (RBI Reference Exchange Rate)	₹ 0.5632
r	India 10 yr. govt. bond yield	7.75%
r_f	Japan 10 yr. Govt Bond yield	0.50%

Using these inputs, the paper prices the three futures contracts available on the JPYINR pair for all the three duration using equation 3. The future price of JPYINR for 1, 2 and 3 months duration are mentioned in Table 11 below.

Table 11: Future prices of JPYINR

Contract	Time to Expiration	Pricing Formula used	Futures Price [f0(T)]
JPYINR 270116	1 month	$f_0(T) = [S_0 / (1+r_f)^T] * [(1+r)^T]$	0.566478695
JPYINR 250216	2 months		0.569776477
JPYINR 290316	3 months		0.573093457

Lastly, we compare these calculated prices to their current market prices to check whether these contracts are fairly valued in the market and the same is reported in Table 12 below.

Table 12: Comparison of estimated price with current market price of respective contracts

Contract	Calculated Futures Price [f0(T)]	Market Futures Price	Fairness of Value
JPYINR 270116	0.566478695	0.5645	-0.3493%
JPYINR 250216	0.569776477	0.5669	-0.5048%
JPYINR 290316	0.573093457	0.5693	-0.6619%

And as expected, we see a bit of Market Undervaluation in the case of this pair as well.

4.2 Second objective

The Table 13 presents the descriptive statistics in the form of mean, standard deviation, skewness and kurtosis of Euro returns over pre-derivative, post-derivative and whole period of study.

Table 13: Descriptive Statistics of Euro returns in three study-periods

Period	Mean	Std. Dev.	Skewness	Kurtosis
Pre-Derivative	0.00019	0.006878	-0.4207	6.9128
Post-Derivative	0.000152	0.00647	0.3254	5.49
Whole	0.000144	0.006652	-0.0385	6.2252

As we can see, the standard deviation of return during the post-derivative period is less than that of the pre-derivative period for EURINR this may lead to the fact that there has been a marginal decrease in volatility after the introduction of currency futures trading in the Indian foreign exchange market.

Table 14 below shows the ADF test of stationarity. It is seen that the values of t-statistics of EURINR during all the periods are statistically significant at 1% significance level. The test thus confirms that all the series under study are stationary.

Table 14: ADF test of stationarity on Euro returns in three study-periods

Period	No. of Observations	ADF Test t-statistics	Test critical value 1% t-statistics	5% t-statistics	10% t-statistics
Whole	2093	-44.665	-3.433	-2.862	-2.567
Pre-derivative	1166	-31.309	-3.437	-2.864	-2.568
Post-derivative	927	-31.787	-3.435	-2.863	-2.569

Table 15 Results of GARCH test.

GARCH(1,1) Analysis				
Period	Intercept(α_0)	ARCH(α_1)	GARCH(β_1)	$\alpha 1 + \beta 1$
Pre-Derivative	$2.87 * 10^{-7}$	0.05706	0.93653	0.9936
Post-Derivative	$4.31 * 10^{-6}$	0.09585	0.7999	0.8957
Whole	$6.34 * 10^{-7}$	0.06423	0.9219	0.9861

To examine the level of volatility prevailing in the Indian currency market, GARCH(1,1) equation has generated the values for different parameter, INR These parameter values have been found to be significant as p-value is zero for the constant, the ARCH term & the GARCH term.

Thus various values generated using GARCH (1,1) has been put into the above equation and the level of volatility has been estimated. The result derived for the whole period is 0.00004578. Level of volatility prevailing in the currency market was found to be significant at 0.00004578. Thus, it can be stated that the volatility was found in the Indian currency market.

The results in Table 15 show that there is an increase in ARCH term in the post derivatives period as compared to pre derivatives period i.e. from 0.057062 to 0.095854 which indicates that there is an increase in the impact of the recent news on spot market volatility in the post-derivative regime and the GARCH term has shown a decrease from 0.936535to 0.799903 indicating at the declining impact of old news on the volatility. The sum of ARCH & GARCH term has decreased i.e. the persistence of volatility has decreased in the post derivative period. Thus we can say that markets have become efficient after index introduction of derivatives. Hence, it can be proposed that currency market volatility significantly changed after the introduction of derivative. Also, the introduction of derivatives had emerged to significantly reduce the volatility.

5. Conclusions

The pricing of Futures Contracts was found to be in close proximity of market prices with certain small variations in market prices. These small variations, particularly the undervaluation of the currency pair by the market can be attributed to two factors, namely, existence of arbitrage opportunities and the futures price-spot price convergence characteristics of futures contracts. More specifically and succinctly, the analysis materializing a few days post the initiation of the contracts and the beginning of the convergence of the Futures Price to the underlying Spot Price are reasons for the small variations observed in the valuations.

Furthermore, the volatility of returns during post-derivative period emerged to be lesser than that of pre-derivative period in the analysis for Euro-Indian Rupee currency pair. These findings emphasized at the decrease in volatility after the introduction of currency futures trading in the Indian foreign exchange market.

On the other hand, the analysis found the significant presence of volatility in Indian currency market. The volatility in Indian currency market exhibited the characteristics with respect to the stylized features dominant in its daily return. The volatility in Indian currency markets increased during post-derivative period as compared to pre derivatives period indicating at the enhanced impact of recent news on spot market volatility in the post-derivative regime but impact of old news on the volatility was found to decrease in post-derivative period. Further, the persistence of volatility was found to decrease in the post derivative period underlining the fact that markets have become efficient after index introduction of derivatives. Essentially, the whole analysis underlined the significant change, specifically reduction in the currency market volatility after the introduction of derivative. Hence, it may be concluded that the currency Futures markets *does help* in combating the volatility in the Forex Markets.

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