An Empirical Analysis on Long Term Relationship between India VIX and IVIX Futures

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Abstract

The paper examines the long-term equilibrium relationship between Indian VIX (IVIX) and IVIX futures contract prices. IVIX is a measure of implied volatility which reflects markets' expectation of future short-term stock market volatility in India. NSE launched India VIX futures for traders who are willing to trade on volatility on February, 26th, 2014. The study is based on daily time series data from 26th Feb, 2014 to 26th Feb, 2016 comprising of a total of 491 observations. The study uses Engle Granger Cointegration test and error correction model (ECM) to empirically investigate existence of long-term relationship and short term dynamics between IVIX and IVIX futures. The results reveal that the IVIX and IVIX futures prices exhibit significant co-movement, however, the spot IVIX values are more volatile than IVIX futures contract prices. The price for IVIX futures with longer expiration period is higher and liquidity lower in comparison to short expiry contracts. The spread of IVIX and IVIX futures is mostly positive with the spread increasing with maturity period of the futures contracts. The study finds that the spot IVIX and IVIX futures price have positive relationship and are cointegrated revealing long-term equilibrium relationship between them. However, the degree of cointegration depends on the expiration period. Shorter maturity futures contract prices have higher cointegration with IVIX. The speed of adjustment of the IVIX and IVIX futures values to equilibrium is slow. It indicates lack of liquidity and arbitrage forces in the IVIX futures market.

Keywords: India Volatility Index, IVIX Futures, Spot and Futures Price, Cointegration

Introduction

Stock prices volatility has received a great attention from both academies and practitioners over the last two decades because it can be used as a measure of risk in financial markets. Over recent years, there has been a growth in interest in the study of stock market volatility. Volatility has become a topic of enormous importance to almost anyone who is involved in the financial markets. The volatility observed in financial markets worldwide during the recent global financial crisis and Eurozone crisis has made the topic more prominent (Bagchi, 2012). There are various measures of stock market volatility. The volatility can also be measured through volatility indices. The first

volatility index was VIX introduced by Chicago Board of Options Exchange (CBOE). After that, the volatility index has also been introduced in several developed and emerging markets.

VIX is calculated on the basis of implied volatility derived from option prices. These volatility indices are measure of market expectation of volatility over a short-term period (Whaley, 2009). Often referred to as the 'investor fear gauge', the VIX aims to track the market expectation of volatility, giving an indication about how nervous the market is about the future. It reflects investors' consensus view of future expected stock market volatility (Harvey and Whaley, 1992). When the VIX level is low, it implies that investors are optimistic and complacent rather than fearful in the market, which indicates that investors perceive no or low potential risk. On the contrary, a high VIX reading suggests that investors perceive significant risk and expect the market to move sharply in either direction. VIX generally moves inversely to stock markets, rising when stocks fall and vice-versa. Globally known as a 'fear index', VIX is actually one of the best contrarian technical indicators in the world (Koutmos, 1999).

In India, the National Stock Exchange (NSE) introduced a volatility index for the Indian market in April 2008 called the India volatility index (India VIX). India VIX is a measure of implied volatility calculated by the NSE from prices of options on the CNX Nifty 50 index. It represents the level of price volatility implied by the option markets, not the actual or historical volatility of the index itself. This volatility is meant to be forward looking and is calculated from both calls and puts option premiums (Thenmozhi and Chandra, 2013). NSE launched India VIX Futures for traders who are willing to bet on volatility on February, 26th, 2014. The underlying asset for the VIX futures contact is the India VIX. India VIX Futures enables participants to more easily hedge, trade and arbitrage the expected volatility (Slivka et al. 2015).

In a no-arbitrage world, the futures price and cash or spot price reflect the value of the same underlying asset. The differences in prices is attributed to the cost-of-carry in the relationship. Any deviation from the relationship will be eliminated by arbitrage activities, wherein, investors would take offsetting positions in the two markets to earn an assured risk free return and in turn bringing the prices in the two markets in line with each other (Zhang, 2010). If the futures price does not correspond with the spot price adjusted for cost of carry, the arbitrage opportunity would be incurred and then market forces will bring the two back into balance (Brenner and Zhang, 2005). According to Zhang (2010), the cost of carry model implies that a pair of spot price and futures price should be cointegrated in the long-run. Spot and futures are found to have contemporaneous and lead-lag relationships in linear models (Zhang and Zhu, 2006) and nonlinear models (Rhoads, 2011). However, there is no consistent conclusion on the lead-lag relationships between spot and futures. As the lead-lag relationships between stop and futures is affected by investor structure. And if the futures market will lead the spot market if the futures market has more institutional investor, and vice versa (Giot, 2004). The relationships study between VIX futures prices and VIX are shown to have linear and nonlinear tow way causalities (Ryu, 2012).

The spot/forward relationship between VIX and VIX futures has two noteworthy consequences. First, the price of a VIX futures contract can be lower, equal to or higher than VIX, depending on whether the market expects volatility to be lower, equal to or higher in the 30-day forward period covered by the VIX futures contract than in the 30-day spot period covered by VIX. Second, there is no cost-of-carry relationship between the price of VIX futures and VIX. This is simply because there is no “carry” arbitrage between VIX futures and VIX as there is between a stock index futures and the underlying asset. VIX is a volatility forecast, not an asset. Hence, one cannot create a position equivalent to one in VIX futures by buying VIX and holding the position to the futures expiration date while financing the transaction. The spot and futures prices are normally found to have long term equilibrium relationship. The study attempts to empirically analyze the long-term relationship between spot IVIX and IVIX futures price.

VIX and VIX Futures

Uses of Volatility Index

Volatility Index offers great advantages in terms of trading, hedging and introducing derivative products on this index. Investors can use volatility index for various purposes. First, investors' portfolios are exposed to volatility of the market. Investors could hedge their portfolios against volatility with an off-setting position in India VIX futures or options contracts (Banerjee and Sahadev, 2006). Second, volatility index depicts the collective consensus of the market on the expected volatility and being contrarian in nature helps in predicting the direction. Investors therefore could appropriately use this information for taking trading positions. Third, investors could also use the implied volatility information given by the index, in identifying mispriced options (Jian and Tian, 2007). Fourth, short sale positions could expose investors to directional risk. Derivatives on volatility index could help investors in safeguarding their positions and thus avoid systemic risk for the market (Lu et al., 2012). Fifth, based on the experience gained with the benchmark broad based index, sector specific volatility indices could be constructed to enable hedging by investors in those specific sectors (Dixit et al. 2010).

The investor expectation of market total risk is captured by the VIX. The VIX index affects the expected return of stock markets (Glosten et al., 1993). The VIX index provides better forecast quality than historical volatility (Corrado and Miller, 2005; Poon and Granger, 2001). Large amount of options trading are form hedgers. When the stock market index is expected to drop, the hedgers will buy index puts for portfolio insurance (Whaley, 2009). The VIX index will increase when the stock index option price increases since the option price is positively related to volatility. As a measure of fear and complacency, implied volatility is often used as a contrarian indicator: prolonged and/or extremely high VIX readings indicate a high degree or anxiety or even panic among traders, and are regarded as a bullish indicator. Prolonged and/or extremely low readings indicate a high degree of complacency, and are generally regarded as a bearish indicator (Clorrado amd Miller, 2005). Volatility indices are sometimes also referred to as the Fear Gauge because as the volatility index rises, one should become careful as the markets can move steeply into any direction (Banerjee and Kumar, 2011). Investors use volatility indices to gauge the market volatility and make their investment decisions.

India VIX

India VIX (IVIX) is a volatility index computed by NSE based on the order book of NIFTY Options. For this, the best bid-ask quotes of near and next-month NIFTY options contracts which are traded on the F&O segment of NSE are used. India VIX indicates the investor's perception of the market's volatility in the near term (Sarwar, 2012). A high India VIX value would suggest that the market expects significant changes in the Nifty, while a low India VIX value would suggest that the market expects minimal change. It has also been observed that historically, a negative correlation exists between the two (Chakrabarti, 2015; Kumar, 2010; Karmakar, 2003)). Volatility indices like India VIX are often perceived to display mean reverting characteristics by oscillating around a long-term variance.

The India VIX reflects the expected movement in the Nifty index over the next 30-day period, which is then annualized. For example, if India VIX is 16.8025, this represents an expected annualized change of 16.8025% over the next 30 days. Volatility Index is different from a market index like Nifty 50. Nifty index measures the direction of the market and is computed using the price movement of the underlying stocks whereas. While Nifty is a number, India VIX is denoted as an annualized percentage (Aggrawal et al., 1999). Although India VIX is often called the "fear gauge", a high India VIX is not necessarily bearish for stocks. Instead, the India VIX is a measure of market perceived volatility in either direction, including to the upside. India VIX uses the computation methodology of CBOE, with suitable amendments to adapt to the NIFTY options order book. The formula used in the India VIX calculation is:

$$\sigma^2 = \frac{2}{T}\sum \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2$$

Where, T = time to expiration, Ki = strike price of ith out-of-the-money option, R = risk-free interest rate to expiration, Q(Ki) = midpoint of the bid ask quote for each option contract with strike Ki, F = forward index taken as the latest available price of Nifty future contract of corresponding expiry and K0 = first strike below the forward index level F.

IVIX Futures

Derivatives trading commenced in India in June 2000 after SEBI granted the final approval to this effect in May 2000. SEBI permitted the derivatives segments of two stock exchanges NSE and BSE, and their clearing house to commence trading and settlement in approved derivatives contracts. To begin with, SEBI approved trading in index futures contracts based on S&P CNX Nifty and BSE-30 (Sensex) index. This was followed by approval for trading in options which commenced in June 2001 and the trading in options on individual securities commenced in July 2001. Futures contracts on individual stocks were launched in November 2001. The derivatives trading on the NSE commenced with S&P CNX Nifty Index futures on June 12, 2000. The trading in S&P CNX Nifty Index options commenced on June 4, 2001. In June 2003, SEBI-RBI approved the trading on interest rate derivative instruments. The Mini derivative Futures & Options contract on S&P CNX Nifty was introduced for trading on January 1, 2008 while the long term option contracts on S&P CNX Nifty were introduced for trading on March 3, 2008. The trading on volatility futures, the Indian VIX futures commenced on Feburary, 2014.

Globally exchanges are offering derivative products based on the volatility index. These products have become quite popular among the participants as it expands the opportunities available to participants and provide efficient means to hedge against volatility (IMF, 2014). India VIX Futures enables participants to more easily hedge, trade and arbitrage the expected volatility. The benefits of trading volatility with India VIX futures are: India VIX futures can be used to hedge equity portfolios, investors can diversify the portfolio by adding India VIX futures, option traders can hedge volatility risk, investors will be able to take directional views on volatility, and calendar spread trading can be explored across weekly contracts. Derivatives on volatility indices enable the investors to treat volatility as an asset class. In accordance with SEBI guidelines prescribing minimum contract size of Rs. 10 lakhs for India VIX futures contracts, NSE periodically reviews the lot size based on the criteria. Like other equity derivatives contract, India VIX

futures shall be marked-to-market (MTM) on a daily basis. The MTM shall be netted along with other equity derivatives contract at the clearing member level. The contracts are cash settled.

Methodology

Nature of Data

The study is based on daily time series data of Indian VIX and IVIX futures. India VIX is a volatility index computed by NSE based on the market prices of Nifty options. India VIX's historical data is available from Mar 02, 2009. Futures contract trading on India VIX commenced from Feb 26, 2014. Hence, the study comprises of a total of 491 observations of daily time series data of IVIX and IVIX futures from 26th Feb, 2014 to 26th, Feb 2016 covering a two years period. All the required data on NSE indices, IVIX, VIX futures have been collected from the NSE database.

Model Specification

This paper aims to investigate the long-run and short-run relationships between spot prices and future prices. In order to test these relationships, all variables used in the model are required to be stationary in the same order and have the long-run relationship or cointegrated. Hence, the time series analysis that should be used in this paper are (1) unit root tests in order to test the stationarity properties of the time series, (2) cointegration test to test the existence of long-run relationship (3) error-correction test to test the short-run dynamics in the relationship between spot prices and futures prices.. All time series data are transformed to be in natural logarithm form. This section provides a brief explanation of these tests as follows:-

Unit Root Test:

The stock market indices series that are used in this study may possess unit roots as indicated by the substantial evidence in literature in time series analysis. Since, the presence of non-stationary variables in the estimation process may yield spurious result, the study begins with the unit root test for the variables under study using Augmented Dickey Fuller (ADF) test. The study test all time series used in the study for presence of unit root in their levels and in their first difference form. The presence of unit root implies non-stationary time series. The simple equation of unit root test is:

$$R_t = \alpha + \rho R_{t-1} + \varepsilon_t$$

Where, E_t is the error term with zero mean, constant variance and α is the intercept. If $\rho = 1$, means unit root is present. The popular ADF unit root test of the null hypothesis of non-stationary is expressed as:

$$\Delta R_{kt} = \alpha_0 + \alpha_1 t + \rho_0 R_{kt-1} + \sum_{k=1}^{q} \rho_i \Delta R_{kt-k} + \varepsilon_{kt}$$

Where, R_{kt} denotes the return for the k-th market at time t and $\Delta R_{kt} = R_{kt} - R_{kt-1,}$ p are coefficients to be estimated, q is the number of lagged terms, t is the trend term, $\alpha 1$ is the estimated coefficient for the trend, $\alpha 0$ is the constant, and ε is white noise. MacKinnon's critical values are used in order to determine the significance of the test statistic associated with $\rho 0$. The unit root tests the null hypothesis H0 : $p = 1$ against the one-sided alternative H1: $p<1$. The null hypothesis of a unit root is rejected in favour of the stationary alternative in each case if the test statistic is more negative than the critical value.

Cointegration Test:

The cointegration test could be used to discover the existence of the long-run relationship between the spot and futures prices. If the result in unit root test shows that two or more time series are non-stationary in their levels but integrated of the same order, the cointegration test would be conducted to test whether their linear combination is stationary at I(0) implying that they are cointegrated. The two or more time series are said to be cointegrated when the residual of their cointegrating regression is stationary. Statistically, the long-term relationship implies that the variables move together in the long-run, therefore the short-run deviations from the trend in long-run would be corrected. Generally, the cointegration test would clarify that if two or more series move closely together in the long-run, although these series are trended, the difference between them is stationary, these series could be considered to have long-run equilibrium relationship. However, a lack of cointegration relationship means that the two or more series do not have a long-run relationship or they can deviate away from each other (Dickey, Jansen, and Thornton, 1991).

The Engle and Granger (1987) proposed the single equation based method by the two-step procedure in order to model the relationship between cointegrated variables. This test is very popular in the recent years, since it reduces the number of coefficients to be estimated; hence, it would also reduce the multicollinearity problem. Their steps are as follows. First, estimating the long-run relationship cointegrating regression by OLS regression:

$$s_t = \beta_1 + \beta_2 f_t + \varepsilon_t$$

Where, st represents the time series of spot prices, ft represents the time series of futures prices, and E_t represents the residuals. Second, retaining the residuals from cointegrating regression in first step:

$$\varepsilon_t = s_t - \beta_1 - \beta_2 f_t$$

Then applying the ADF tests to these residuals as in the equation below:

$$\Delta\hat{\varepsilon}_t = \gamma\,\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \alpha_i\,\Delta\hat{\varepsilon}_{t-1} + u_t$$

The E_t values are estimated residuals. The test statistic is the estimated 't' statistic on γ, denoted by T_y The null hypothesis, H0: γ = 0, i.e. the two time series are non-cointegrating. If the null hypothesis is rejected, it means that spot VIX (st) and futures price (ft) are cointegrated and the residual E_t is a I(0) process or stationary. On the other hand, if st and ft are not cointegrated, the residual E_t is a unit root process (non-stationary).

Error Correction Model (ECM)

An important theorem, known as the Granger Representation Theorem, says that if the two variables are co-integrated, then the relationship between them can be expressed as an error correction model (ECM). The ECM specification used in the study is:

$$\Delta s_t = \varphi + \gamma\,\varepsilon_{t-1} + \sum_{i=1}^{p} \alpha_i\,\Delta f_{t-i} + u_t$$

Where, E_t is the error obtained from regressing st on ft. The E_t is an equilibrium error (e.g. the difference between the spot and futures price). If it is non-zero, then the model will be out of equilibrium. The ECM model has both long run and short run properties built on it.

Results Discussion

NSE launched IVIX futures contracts on 26 February 2014. The Table II provides descriptive statistics for IVIX (spot) and IVIX futures from 26 February 2014 to 25 February 2016. The IVIX futures have three expiry cycles which are one, two and three weeks. Hence, the futures price for the three maturity periods are presented along with the spread. The spread or basis is the difference between the spot and futures price as is calculated as futures minus spot price. The basis for the futures contract for the three expiry periods has also been shown. The average value for IVIX in the two years is 17.62. Similarly, the average IVIX futures value are 17.5, 17.6 and 17.9 respectively for expiry periods of one, two and three weeks respectively. The lower difference between the spot and futures price is considered good for investors and it is a measure of liquidity and efficiency of futures market. The average price for futures contract is higher for contracts with longer maturity. Longer expiry futures are less liquid instruments. Hence, the results shows liquidity is priced in the IVIX futures market.

Table II: Descriptive Statistics for IVIX and IVIX Futures (2014-2016)

	IVIX	India VIX Futures					
		Price			Spread (Basis)		
		1 week	2 week	3 week	1 week	2 week	3 week
26 Feb-25 May 2014	23.7909	24.0243	24.5597	25.0461	0.2334	0.7688	1.2553
26 May-25 Aug 2014	16.0855	16.3775	16.7739	17.1640	0.2920	0.6884	1.0786
26 Aug- 25 Nov 2014	13.5079	13.6422	13.9550	14.0206	0.1343	0.4470	0.5126
26 Nov 2014 - 25Feb 2015	16.7980	16.2391	16.1618	16.4193	-0.5589	-0.6362	-0.3787
26 Feb-25 May 2015	16.4588	15.7027	16.5793	16.6634	-0.7561	0.1205	0.2046
26 May-25 Aug 2015	16.6461	17.0602	16.5736	16.4107	0.4141	-0.0725	-0.2355
26 Aug- 25 Nov 2015	19.9547	20.1799	20.3915	20.5640	0.2253	0.4369	0.6093
26 Nov 2015 - 25Feb 2016	18.1470	17.4232	17.5611	18.0159	-0.7239	-0.5859	-0.1312
Aggregate Descriptive Statistics							
Mean	17.6287	17.5360	17.7606	17.9773	-0.0927	0.1319	0.3486
Median	16.8200	16.7700	16.9350	16.9525	0.0475	0.4475	0.3925
St Dev	4.4680	4.3143	4.3665	4.4471	2.3887	2.7443	2.8998

The values of both IVIX and IVIX futures contract are highest in 26 Feb to 25 May 2014 while they are lowest in the quarter 26 Aug to 25 Nov 2014. The two values are seen to move together. The spread is found to be positive in some quarters and negative in other. However, the spread is positive in more periods. It means the futures price is normally higher than spot IVIX in India. The mean values of the spread show that longer maturity IVIX futures have higher spreads. Moreover, the longer maturity futures also have positive average spread. In contrast, the one week expiry futures contract has negative spread. Finally, the value of standard deviation shows that the volatility of spot IVIX is higher than futures price volatility.

Figure I, and II illustrate the trend and co-movement of IVIX and IVIX futures with one and three week expiry periods. Both the figures reveal that IVIX and IVIX futures values are in declining trend. They also reveal that the two series move closely together. It indicates the presence of long-term equilibrium relationship between the two series. The issue is further examined with co-integration test in the coming section. The figures offer support for the results from the previous table. The spread for longer expiry contract is seen to be higher as compared to lower expiry contracts. Similarly, for one week contract, the spot price tends to be above the futures price revealing negative spread but for three weeks contract the futures price is above the spot IVIX revealing positive spread. The figures show that the spot IVIX and futures price fluctuate; however, they tend to move together as the two values do not deviate highly from each other.

Figure I: Spot IVIX and IVIX Futures Contract Price with One Week Expiry Period

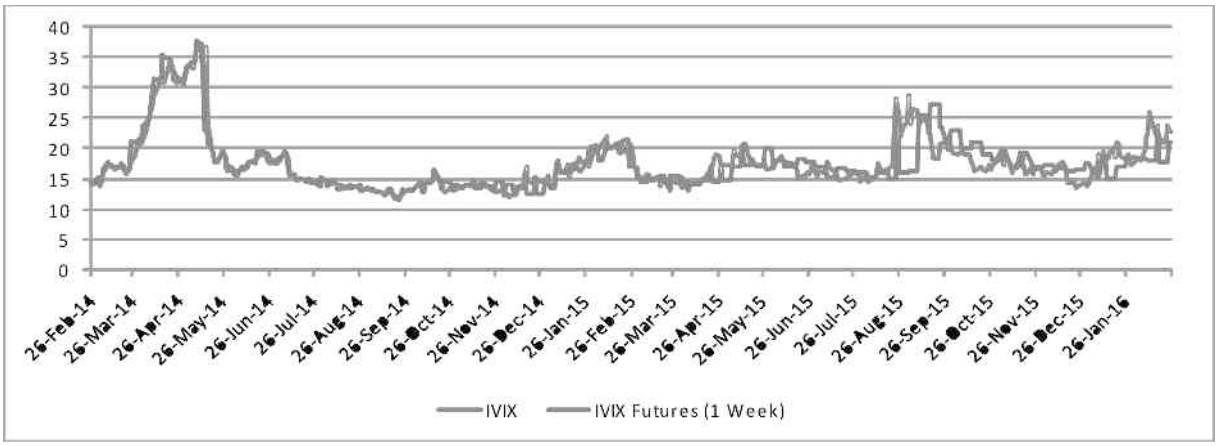

Figure II: Spot IVIX and IVIX Futures Contract Price with Three Week Expiry Period

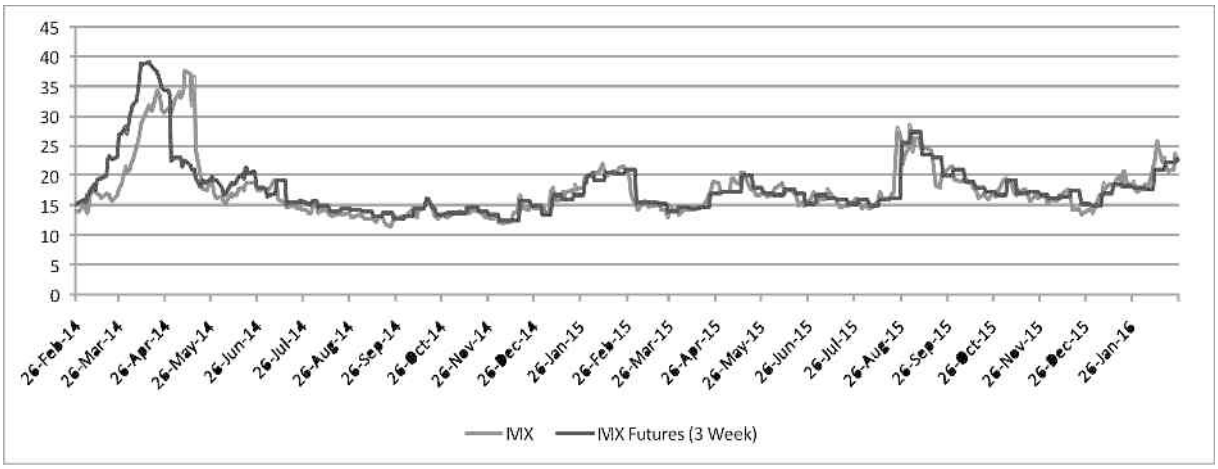

Table III presents correlation between IVIX and IVIX futures (IVIXF) prices for one week expiry (E1), two week expiry (E2), three week expiry (E3) period. The correlation IVIX with spread is also exhibited. The correlation of IVIX is significant for all future prices and spreads. The correlation of IVIX with futures price is found to be positive while the correlation with spread is negative. It means increase in spot IVIX value will increase futures price and vice-versa while increase in IVIX will decrease the spread and vice-versa. The correlation of IVIX is largest for futures price with one week expiry. It is found that the correlation declines for longer expiry futures contracts.

Table III: Correlation Matrix for IVIX and IVIX Futures

	IVIX	IVIX Futures					
		Price			Spread		
		Week 1	Week 2	Week 3	Week 1	Week 2	Week 3
VIX	1						
IVIXF Price (E1)	.853**	1					
IVIXF Price (E2)	.807**	.874**	1				
IVIXF Price (E3)	.788**	.770**	.899**	1			
IVIXF Spread (E1)	-.331**	.211**	0.069	-0.083	1		
IVIXF Spread (E2)	-.344**	0.003	.277**	.147**	.648**	1	
IVIXF Spread (E3)	-.332**	-.132**	.135**	.319**	.382**	.755**	1

Finally, Table IV presents the output of the Engle-Granger cointegration test to examine the long-term equilibrium relationship between spot IVIX and futures price. The results of ADF unit root test revealed that the IVIX and IVIX futures series contain unit root in level form. Financial theories as well as prior studies have suggested that long-term equilibrium relationship should exist between spot and futures price. The cointegration of IVIX with IVIX futures with one, two and three week expiry period is examined. Both the Tau and Z statistics associated with the Engle-Granger cointegration test are found to be highly significant for all the three cointegration tests as revealed by the prob values. Hence, IVIX and IVIX futures contract are found to be cointegrated.

Table IV: Co-integration between IVIX and IVIX Futures

Pair	Dependent Variable	Tau Statistics	Prob	Z- Statistics	Prob
IVIX- IVIXF (E1)	VIX	-6.641820	0.0000	-89.01920	0.0000
	IVIXF(E1)	-6.704360	0.0000	-90.33406	0.0000
IVIX- IVIXF (E2)	VIX	-6.316347	0.0000	-73.95204	0.0000
	IVIXF (E2)	-6.087221	0.0000	-69.04525	0.0000
IVIX- IVIXF (E3)	VIX	-5.045015	0.0000	-54.16585	0.0000
	IVIXF (E3)	-5.538268	0.0000	-57.90370	0.0000

The findings reveal that long-term equilibrium relationship exit between IVIX and IVIX futures. If the two values become different to greater extent, then arbitrage opportunities will be available. The arbitrage process than brings the market to equilibrium by bringing the two values closer. The presence of cointegration between IVIX and IVIX futures price reveal that the arbitrage forces are present in the IVIX futures market. Finally, the value for Z statistic of -90.33 is highest for one week expiry which reveals that the stronger cointegration of IVIX is with futures of one week expiry. Hence, the equilibrium relationship of IVIX and IVIX futures is relatively stronger for short maturity contracts as compare to contracts with longer maturities.

Table V: Output of the Error Correction Model

	Model I	Model II	Model II
Panel A: OLS Model			
C	2.144	2.958	3.388
f_t	0.882***	0.826***	0.792***
Panel B: Error Correction Model			
C	0.010 (0.053)	0.010 (0.055)	0.011 (0.055)
ε_{t-1}	0.165*** (0.023)	0.117*** (0.021)	0.097*** (0.021)

Δf_t	0.227*** (0.038)	0.173*** (0.052)	0.173*** (0.055)
Δf_{t-1}	0.093** (0.039)	0.043 (0.052)	-0.023 (0.055)
Δf_{t-2}	0.081** (0.037)	0.090 (0.052)*	0.033 (0.056)

, **, and * means the coefficient is significant at 10%, 5%, and 1% level of significance respectively. The figures in the parentheses are standard errors. The value of residuals ε_t are from the model $s_t = \beta_1 + \beta_2 f_t + \varepsilon_t$. The estimation output of the model is given in panel A.*

Table V shows the output of the error correction model to understand short run behavior between IVIX spot and IVIX futures prices. Model I, Model II and Model III present output for IVIX futures with 1, 2, and 3 week expiry respectively. The panel A of the table presents OLS output of regression of spot IVIX (st) on IVIX futures (ft). The beta coefficient of the model provides estimation of long run multiplier or the long run influence of IVIX futures price on spot IVIX. The value of the coefficients are all highly significant and positive which reveals that the IVIX futures price effect IVIX spot prices and they move together. The estimate of long run multiplier are 0.882, 0.826 and 0.792 for 1, 2 and 3 week expiry IVIX futures respectively. Hence, the results depict that long-run relationship exists between the IVIX spot and IVIX futures price, however, the degree of the relationship is higher for low expiry futures contract. It means the prices of the short term maturity futures contract have relatively higher impact on the spot IVIX.

The Panel B of the Table V presents the output of the error correction model employed to understand the short-term dynamic between spot IVIX and IVIX futures price. The coefficients associated with error correction term; E_{t-1} are all positive and highly significant. The coefficients are measures of how much the spot IVIX responds to equilibrium errors. The significant values reveal that if spot IVIX is out of equilibrium, it will be pulled towards equilibrium in the next period. The positive value of the error correction term reveal that the IVIX futures price normally tend to be above the spot IVIX values which will result in positive error correction term. Hence, if the IVIX futures are above the spot IVIX, the value of spot IVIX will tend to increase to restore equilibrium. The lagged values of the first differenced IVIX futures for lags upto two periods are found to be significant. It depicts that the spot IVIX is affected by both the error correction term as well as past changes in IVIX futures prices. However, the speed of adjustment to equilibrium of spot IVIX and IVIX futures prices is found to be slow. The speed of adjustment is found to be relatively higher for short expiry futures.

Conclusions

The IVIX and IVIX futures prices are found to move together. However, the spot IVIX values are more volatile than IVIX futures contract prices. The price for IVIX futures with longer expiration period is higher and liquidity lower in comparison to short expiry contracts. The spread of IVIX and IVIX futures is normally positive with the spread increasing with maturity period of the futures contracts. The study results reveal that the spot IVIX and IVIX futures price have positive relationship. They are found to be cointegrated revealing long-term equilibrium relationship between them. However, the degree of cointegration depends on the expiry. Shorter maturity futures contract prices have higher cointegration with IVIX. It is found that the spot IVIX adjusts to restore equilibrium between spot and futures prices. However, the speed of adjustment of the IVIX and IVIX futures values to equilibrium is slow. It indicates lack of liquidity and arbitrage forces in the IVIX futures market.

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