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Carbon Trading in Indian Derivative Market: An Econometric Validation

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Abstract

Global climate change has already had observable effects on the environment. Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. According to Intergovernmental Panel on Climate Change the net damage cost of climate change are likely to be significant and is likely to be increase over overtime.Carbon dioxide is a big cause of global panic as its concentration has been rising alarmingly in the atmosphere. On the other side it has created a global carbon market also. Hence with growing concerns owing to Kyoto Protocol amongst countries to curtail pollution levels along with sustaining their economic growth, the Emission Trading (ET) industry has started actively providing support to bring down green house gas emission by allocating a monetary value and is expected to come forward as a massive market of global emission trading. The developed countries are supposed to meet certain carbon emission targets fixed by their respective governments. Conversely if they are unable to do so they have an option of buying these in the market from those companies which have surplus of them. This practice is known as carbon trading. Even for developing nations it is a very lucrative as it endow them with fiscal gains for swapping carbon credits with latest technology. This modified technology ultimately facilitates them to condense carbon emanation. In India it's trading started in Multi Commodity Exchange of India from the month of April, 2008. The main objective of the paper is to discuss information spillover in the carbon emissions derivative market in India under the VAR framework and to understand volatility spillover in the future and spot market by using bivariate E-GARCH model. The results reveal that there is a co-integrating relationship between future and spot prices of Carbon Emission Reduction (CER), traded on MCX. The error correction mechanism exhibits bi-lateral adjustments to attain equilibrium with more adjustments in future prices is seen, and to add robustness in the results of VECM, Variance Decomposition and Impulse response were also conducted. To understand the direction of causality, Granger causality test was done, the results of which show bi-lateral causality in the price pairs. The results signify that this market is informationally efficient with the lead role of spot market. Volatility dynamics also show bilateral spillover i.e. from future to spot market and vice versa. Generally, our findings demonstrate numerous imperative inferences for portfolio hedgers in creating optimal portfolio allotment, appealing in risk management and forecasting Carbon market potential volatility.

Keywords: Multi Commodity Exchange (MCX), Carbon Emission Reduction (CER), Clean Development Mechanism (CDM), Granger Causality Test, Kyoto Protocol, ADF, Volatility Spillover

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1. Introduction

Carbon Dioxide being one of the major gasses contributing to green house is becoming a cause of concern worldwide as its concentration in the atmosphere has been mounting at an alarming rate. The emission of carbon dioxide by burning of fossil fuels along with fuel combustion taking placing in various industries has contributed maximum to the green house effect. The climate is adversely getting affected as the result of activities of the industries like cement, fertilizer, steel and power. They release harmful greenhouse gases (GHG) which lead to entrapping of infrared energies in the atmosphere and hence escalating the temperature. All this has lead to the global warming and incidentally to the need for providing certain incentives to the companies to take few concrete steps to lessen its adverse effects. The Carbon Credit Trading is a welcome step in this regard which came into existence as a result of agreement between more than 170 countries in Kyoto Protocol allowing the companies to trade their carbon credits either among themselves or in international market. The carbon credits are an important element of emission trading scheme that

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offer inducement to the companies to trim down their GHG effect caused by industrial emission by putting a cap on overall annual emission and in case of any shortfall they can be brought or sold in market. These credits can be employed to invest in carbon diminution schemes between trading partner across the world. The carbon development companies which have accumulated the credits from their individual projects offer them for buying to other companies popularly known as carbon off setters who are anxious of reducing their carbon footprints on intentionally. The substantiation procedure along with the class of fund or sponsor Development Company determines the worth of credits. Its get revealed in the credit price because the voluntary units usually low priced than the non voluntary sold units. The augmented price is a signal of improved involvement as well as severe competition indicating an ever expanding popularity of these credits worldwide. The government of India has given recognition to Multi Commodity Exchange of India Ltd (MCX) on 31st march, 2008. It offers the option of futures trading in Carbon credits along with other commodities like bullion, energy, grains, plastics, metals, oil and oilseeds, fibers, spices, pulses, sugar, plantations.

1.1 Carbon Trading in Indian Set-Up

As per the conventions of Kyoto Protocol, India being a developing country has as such no emission targets to achieve though it is eligible to enter into CDM projects. It has emerged as a key performer in the global carbon credits markets. As per the data (FICCIAs 2011), India had 2,123 approved CDM projects. Out of all these around 700 are listed with the United Nations Framework Convention on Climate Change (UNFCC). Numerous companies like SRF Ltd and Shell Trading International have initiated sale and purchase of Credit Emission Reduction. One of the major examples is the Delhi's Delhi Metro Rail Corporation (DMRC) which is the first rail project in the world to earn carbon credits. It has accumulated the carbon credits by incorporating regenerative braking system in its train which reduces 30% of electricity consumption. In 2007, the project got registered with UNFCCC. India's leading commodity exchange, Multi Commodity Exchange (MCX), has taken inventiveness to become Asia's first-ever commodity exchange to propose trades in carbon credits likewise the European Climate Exchange and Chicago Climate Exchange (CCE). In 2008, The National Commodity and Derivatives Exchange (NCDEX) also has instigated futures contract in Carbon Trading.

1.2 Future of Carbon Trading

Indian companies have apprehended that they too can mint money by becoming eco-friendly like their international counterparts. Though, there is vagueness that appears over the future of the Kyoto Protocol. Carbon Forum Asia 2011 was conducted in Singapore with the objective to iron out differences and arrive at new solutions. In 2011, it was observed that Global carbon markets saw 3.6 billion tonnes of carbon-dioxide equivalent exchanged with an estimated value of $71 billion with 3 per cent growth rate. Conversely, a steep fall was witnessed in the unit value of per-tonne-of-carbon traded in the European markets. As on October 2013, Asia accounted for a total of 3,800 projects out of which more than 75 percent of the projects got registered. International carbon markets have perceived exponential growth since 1990s. In Conference at Durban, governments decided that the Kyoto Protocol would enter into a second commitment period in 2013 and also decided to make few modifications to the Protocol. These adjustments can decide the future of carbon trading in international scenario.

The main objectives of the paper are:

1. To discuss information spillover in the carbon emissions derivative market in India under the VAR framework from future to spot market and vice a versa.
2. To comprehend volatility dynamics i.e. Volatility Clustering, Volatility spillover and volatility persistence from futures to spot and vice-versa., using Bivariate E-GARCH model.

1.3 Testable Hypothesis

In the light of above objectives, this study intends to test the following research hypothesis:

1) H1: There exists a co-integrating vector which confirms a long run equilibrium relationship between Future and spot markets.
   H0: There is no existence of co-integrating vector which confirms a long run equilibrium relationship between Future and spot markets.
2) H2: Futures market does Granger cause Spot market.
   H0: Futures market does not Granger cause Spot market.
3) H3: Spot market does Granger cause Futures market.
   H0: Spot market does not Granger cause Futures market
4) H4: There is a Volatility Spillover from Future market to Spot Market
   H0: There is no Volatility Spillover from Future Market to Spot Market.
5) H5:There is a Volatility Spillover from Spot Market to Future Market
   H0: There is no Volatility Spillover from Spot Market to Future Market.

In order to achieve the objective of the paper, it is divided in the following sections. Section 1 discusses about the understanding of the Carbon trading in India. Section 2 gives Review of Literature, Section 3 describes about Data and Methodology used in the study. Section 4 explains about analysis and interpretation of results. Section 5 involves the Conclusion. References form the part of last section i.e. Section 6.

2. Review of Literature

In this section an attempt has been made to carry out an extended review of literature related to carbon trading in Indian derivative market and its spillover effect in spot and future market.

A study was conducted by Paul and Bhattacharya[17] to re-examine the relationship between the CO_2 emission intensity and energy intensity or carbon factor of four groups of countries- OECD, Asian, non OECD European and Latin American countries. The Bi variate regression technique was used on the data which was obtained from International Energy Agency. The empirical results show in the Latin American and non-OECD countries the energy concentration leads to elevated CO_2 emission intensity whereas in the Asian and in the OECD countries, it's the superior level of the carbon factors which result in advanced the CO_2 emission intensity. Latter on an attempt was made by Bataller et al (2007) to study the fundamental rationality of pricing behavior. They tested the impact of both weather and non-weather variables that are considered by academic and market agents as the main rudiments of the CO_2 price levels. The data they worked on encompasses daily future price levels of Brent and Natural Gas, both traded at International Petroleum Exchange (IPE) and coal forward price levels published by Tradition Financial Services (TFS). The correlation technique was used which revealed that in the determination of CO_2 price levels, the energy sources are the prime factor which are affected only by the extreme temperatures . It was also discovered that mainly the Brent and natural gas price changes are the vital variables in the determination of CO_2 price changes. In another study Carraro and Favero[2] attempted to find out the monetary and pecuniary mechanism of carbon dioxide prices from the short term as well as long term perspective in European Union Region. They also determined the standard deviation of average carbon price for diverse future time sphere. It was discovered that though gas and coal prices result in CO_2 price uncertainty in the short term, but policy and regulatory issues also have considerable effect on it. However in the long term, it's the Economic factors that have an impact on carbon prices like CDM and JI credits supply, economic growth, ambiguity about the upcoming polices and overall allocation of carbon credits. CO_2 prices are also affected by the financial factor like cost of abatement technologies. The purpose of Molinas[15] research was firstly, to challenge the Neo Malthusian Hypothesis of incongruity between demographic expansion and conservation of the environment in the upcoming nations and secondly, to examine the role of demographic variable in the growth of carbon emissions and economic development. The technique used was IPAT model which articulate the dynamics of the Neo Malthusian framework by disaggregating the determinants of Environmental impact into Population growth (P), Affluence (A) i.e. economic growth and Technology (T). The findings advocate that the economic growth is the principal pointers for environmental impact and the hypothesis is not suitable in describing the demographic collision on the environmental variable in India. In their study Yu and Mallory[18] tried to investigate the outcome of a currency exchange rate on the carbon prices when substitutable energies coal and natural gas are denominated in different currencies. They also attempted to examine how exchange rate impact the energy prices which initiate a reallocation in the utilization of the fuel leading to variation in CO_2 emissions and ultimately in carbon prices. The data worked upon comprises of spot EU/USD exchange rates, EUA carbon credit prices, and natural gas and coal prices. The methodology used in this study is structural vector auto regression to establish the interdependencies amid the exchange rates, carbon market and energy prices. The experiential investigation illustrates that the decline in Euro results in coal's price to rise, carbon credit's price to fall and natural gas's price to remain neutral. The study discovers that through the energy substitution mechanism, variation in local currencies leads to variation in carbon prices. In another study the mutual interactions of electricity, gas and carbon prices in the UK was investigated by Bunn and Fezzi (2009). They applied Structural, co-integrated vector error-correction model to find out the degree of potential impacts on carbon credit prices of various activities from production to environmental circumstances. They originated the forceful navigation of carbon prices to power prices and the reaction of carbon and power prices to variations in gas prices.

To find the causality between CER spot market and CER future market of the National Commodity and Derivatives Exchange Ltd, India[3]. For this purpose the data used was the daily closing data of NCDEX CER spot index and NCDEX CER future index w.e.f April 10th, 2008 to March 31st, 2009, he used various techniques like Unit root test through Phillips - Perron test, Granger Causality test was carried out after converting the non-stationary data as stationary and Johansen co integration test to test co-integration. The findings revealed that though CER spot prices and CER future prices are co integrated variables still there is no causal effect of spot CER prices on future prices however a causal effect of future prices of CER on spot prices can be seen. Similarly, Huang[7] tried to examine the correlation between energy stock and carbon price in the energy sector in European Union. He applied Structural Equation Modeling (SEM) using partial least squares (PLS) method to test the hypothesis on the data consisting of Bluenext EUA daily close price, EXX EUA daily close price, Blunext CER daily close price and twelve energy companies covered by EU ETS as a portfolio. The findings show that conventional energy stock is positively related to carbon price which signifies that carbon market might be buyer's market for huge energy producer and elevated emission cost of carbon was overweighed by the financial performance of energy companies. In one of the recent study by Chevallier[4] an attempt was made to study the inter-relationships between the EU 27 industrial production index and the price of CO2 in a nonlinear framework. He applied VAR framework to verify the relationship between macroeconomic activity and carbon future prices on the data obtained from the European Climate Exchange (ECX), Thomson Financial DataStream, and Eurostat. The data sample goes from the opening of ECX on April 22, 2005 to January 25, 2013 (i.e. a sample of 2,008 daily observations). The results revealed that CO2 emissions increases with the increase in economic activity i.e. industrial production in this case, then in absence of short-term energy efficiency gain translates in carbon price increases, ceteris paribus.

3. Data and Methodology

This section elucidates Data and Methodological issues. The data regarding Spot and Future prices of Carbon Credits has been collected from MCX's official Statistical database portal. The time period considered for the same is June'08 to June 14 on a daily basis. Given the nature of the problem and the quantum of data, we first study the data properties from an econometric perspective and find that co-integration and error correction models are required to establish the equilibrium. To test the causality Granger Causality Test is performed and the findings are provided in detail in results section. The regression analysis would yield efficient and time invariant estimates provided the variables are stationary over time. However, many financial and macroeconomic time series behave like a random walk. We first test whether or not the sample series are co-integrated. The concept of co-integration becomes relevant when the time series being analyzed are non-stationary. The time series stationarity of sample series has been tested using Augmented Dickey Fuller (ADF) 1981. The ADF test uses the existence of a unit root as the null hypothesis. To double check the robustness of the results, Phillips and Perron[17] test of stationarity has also been performed for the series. Vector Error Correction Model is used to deeply understand short term dynamics between spot and future markets and to add robustness to VECM results Variance Decomposition Analysis is done followed by graphical representation by Impulse Response method.

Further, to quantify and study volatility spillover, we use bivariate EGARCH framework which is covered in the next section. To test the causality block Exogeneity Test is performed. Volatility spill over reveals that future trading could intensify volatility in the underlying spot market due to the larger trading program and the speculative nature of the future trading. The volatility spill over hypothesis involves testing for the lead-lag relations between volatilities in the futures and spot markets. Clearly, reliable tests require common good measure of volatilities. Bollerslev's[1] generalize autoregressive conditional Heteroscedasticity (GARCH) model cannot be used due to certain regularities where it assumes that positive and error terms have a symmetric effect on the volatility. In other words, good news (market advances) and bad news (market retreats) have the same effect on the volatility in this model. This implies the leverage effect (price rise and fall) is neutralized in this model. The second regularity is that all coefficients need to be positive to ensure that the conditional variance is never negative (i.e. measure of risk). To overcome these weaknesses of the GARCH model in handling financial time series, Nelson's[16] exponential GARCH (EGARCH) model is used in order to capture the asymmetric impacts of shocks or innovations on volatilities and to avoid imposing non-negativity restrictions on the values of GARCH parameters. There are many studies in which symmetries in stock return are documented[5,6,10,15][Koutmos and Booth (1995)].

In this study, the estimation process is not concentrated on the return series but about the direct spill over between futures and spot markets volatility. The empirical analysis reported here is based on two-stage estimation. The first step is to apply VECM and the second step is to use the residuals of VECM in the bivariate EGARCH model. This two step approach (the first step for the VECM and the second step for the bivariate EGARCH model is asymptotically equivalent to a joint estimation for the VECM and EGARCH models (Greene, 1997). Estimating these two models simultaneously in one step is not practical because of the large number of parameters involved. Our EC-EGARCH model allows the conditional volatilities and covariance to adjust to deviations from long-run price disequilibria, whereas traditional EGARCH models do not. As such, the model facilitates the testing of both short run and long run volatility spill over hypotheses. The EC-EGARCH model may further prove useful for portfolio managers in formulating optimal hedging strategies. Some studies e.g., Yang, Bessler, and Leatham[8] emphasize the need to incorporate any existing cointegration between spot and futures prices into hedging decisions, while others such as Lien and Lou[11] underscore the importance of GARCH effects in such decisions.

We use the following EGARCH MODEL

$$\ln(\sigma_{ft}^2) = \beta_{ff}(e^2 f_{t-1}) + \beta_{fs}(e^2 s_{t-1}) + \Upsilon_f(\sigma^2 f_{t-1}) \quad (5)$$

$$\ln(\sigma_{st}^2) = \beta_{ss}(e^2 s_{t-1}) + \beta_{sf}(e^2 f_{t-1}) + \Upsilon_f(\sigma^2 s_{t-1}) \quad (6)$$

The unrelated residuals e_{ft} and e_{st} are obtained from the equations (3) and (4). This two step approach (the first step for the VECM and the second step for the bivariate EGARCH model is asymptotically equivalent to a joint estimation for the VECM and EGARCH models (Greene, 1997). Before estimating the EGARCH model, it is necessary to check the model adequacy by performing the diagnostic tests that involve serial correlation, normally distributed error and goodness of fit measures. All diagnostic tests are primarily carried on the standardized residuals via OLS and it is found that all are significant at 5% level. The diagnostic statistics with respect to EGARCH model are not reported here to conserve space. The results of Volatility spill over relationships between futures and spot market for sample commodity using bivariate E-Garch model are reported in Table 5 for entire sample commodities and indexes. The coefficient β_{sf} indicates the volatility spill over from futures to spot and β_{fs} means reverse direction. The coefficients β_{ss} and β_{ff} show the volatility clustering, while the coefficients λ_s and λ_f measure the degree of volatility persistence. The residuals of the model are tested for additional ARCH effects using ARCH LM test.

4. Analysis and Interpretation of Data

This section gives the analysis of information spillover in the carbon emissions derivative market in India under the VAR framework and volatility spillover in the future and spot market by using bivariate E-GARCH model.

4.1 Information Spill Over (LEAD-LAG)

To examine the relationship of future and spot prices OF CER Traded on MCX, first we calculated stationarity of data. Results are exhibited in Table 1, which clearly exhibits non-stationarity of both the variables i.e. they are integrated to order 1 using ADF test. To add robustness Philip Perron Test is also done which gives the same results.

The association between sample data is examined using co-integration[11] analysis that has several advantages. First, co-integration analysis reveals the extent to which two markets move together towards long run equilibrium. Secondly, it allows for divergence of respective markets from long-run equilibrium in the short run. The co-integrating vector identifies the existence of long run equilibrium, while error correction dynamics describes the price discovery process (LEAD LAG) that helps the markets to achieve equilibrium (Schreiber and Schwartz, 1986). Co-integrating methodology fundamentally proceeds with non-stationary nature of level series and minimizes the discrepancy that arises from the deviation of long-run equilibrium. The observed deviations from long-run equilibrium are not only guided by the stochastic process and random shocks in the system. Theoretically it is claimed that if sample series are co-integrated, then it implies presence of causality at least in one direction. On the other hand, if some level series are integrated of the same order, it does not mean that both level series are co-integrated. Co-integration implies linear combinations of both level series cancelling the stochastic trend, thereby producing a stationary series. Johansen's co integration test is more sensitive to the lag length employed. Besides, inappropriate lag length may give rise to problems of either over parameterization or under parameterization. The objective of the estimation is to ensure that there is no serial correlation in the residuals. Here, Akaike Information Criterion (AIC) is used to select the optimal lag length (Table 2).

All related calculations have been done embedding that lag length. The co-integration results are reported in Table 3. The results confirm the co integration between sample series, see Table 3. P-value of both the sample series are significant at 5 % level. This clearly exhibits long term relationship between the two.

H1: There exists a co-integrating vector which confirms a long run equilibrium relationship between Future and spot markets.

H0: There is no existence of co-integrating vector which confirms a long run equilibrium relationship between Future and spot markets.

The results of co integration test confirm the rejection of the null hypothesis, stating that there exists at least one co integrating relationship in sample series.

Table 1. Stationarity Test for Sample Series

	ORIGINAL SERIES(Panel A)		RETURN SERIES (Panel B)	
	ADF (T-STATS)	PHILIP PERRON (T-STATS)	ADF (T-STATS)	PHILIP PERRON (T-STATS)
CER Futures price	-1.09	-0.51	-41.9 8 **	-41.9 8 **
CER Spot Prices	0.78	0.65	-41.35 **	-41.32 **

The table 1 describes the sample price series that have been tested using Augmented Dickey Fuller (ADF) 1981. The ADF test uses the existence of a unit root as the null hypothesis. To double check the robustness of the results, Phillips and Perron (1988) test of stationarity has also been performed for the series and then both the test are performed on return series also as shown in Panel-A (price series) and Panel B (Return Series) are integrated to I (1). All tests are performed using 5%level of significance (**).

Table 2. VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria Endogenous variables: LNfutures LNSPOT Exogenous variables: C						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	26.76697	NA	0.000729	-1.547935	-1.456327	-1.517570
1	80.45924	97.31724	3.27e-05	-4.653702	-4.378877	-4.562605
2	84.53327	6.874921	3.27e-05	-4.658329*	-4.200287*	-4.506501
3	120.1119	55.59158*	4.58e-06*	-6.631992	-5.990733	-6.419433*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 3. Results of Johansen's Co-Integration Test

Name of variable	Lag Length	Max Eigen Value	Trace Statistics	Critical Value	P- Value
Futures	2*	0.516613	24.96919	15.48471	0.0016
Spot		0.335333	8.986494	3.831466	0.0028

This table provides the Johansen's co-integration test, maximal Eigen value and Trace test statistics are used to interpret whether null hypothesis of r=0 is rejected at 5 % level and not rejected where r=1. Rejection of null hypothesis implies that there exists at least one co-integrating vector which confirms a long run equilibrium relationship between Future and spot markets. The null hypothesis is rejected which reveals that two co-integration relationship exists between them.

Table 4. Adequacy Test for VAR Model

Name of Commodity		Var adequacy test	Critical values	Lags
CER	1	Stability (modulus values of roots of characteristics polynomials	0.94,.89, 0.24, 0.081 (Stable)	2*
FUTURE-PRICE & SPOT-PRICE	2	Normality Chi-Square values	4.81 (Jarque-Bera) P Val (0.0900)(Normal)	2*
	3	Serial Correlation LM-Test	18.55(p val 0.0806) (no serial correlation)	2*

The asterisk (*) shows significance at 2, lags. Diagnostic tests are performed for sample commodity.. Vector Auto Regression (VAR) estimated with various lags selected by AIC is used to check whether the model satisfies the stability, normality test as well as no serial correlation criterion among the variables in the VAR Adequacy model. Therefore, it leads us to take the position that our model fulfils the adequacy criterion for sample series.

Despite determining a co integrating vector for sample series, it is customary to produce the diagnostic checking criterions before estimating the ECM model. Diagnostic tests are performed only for sample price series after confirming long run relationship between spot and future prices is confirmed based on Johnson co integration test. Vector Auto Regression (VAR) estimated with various lags selected by AIC is used to check whether the model satisfies the stability, normality test as well as no serial correlation criterion among the variables in the VAR Adequacy model. Testing the VAR adequacy of the sample series as shown in Table 3, it was revealed that sample series are satisfying the stability test. In normality test the sample commodities are found to be normal. In verifying the VAR Residual Serial Correlation LM Tests it was found that in all sample series no serial correlation was present. Therefore, it leads us to take the position that our model fulfils the adequacy criterion for sample commodity i.e. CER which exhibited a long run relationship between spot and futures prices as shown by Johansson Co integration Test.

To understand short term dynamics between the sample series i.e. to know the level of adjustment between them VECM (error correction mechanism is done to know the short term dynamics between the sample series).The results are exhibited in Table 4. The results reveal that ECT of spot is greater in magnitude compared to Futures price i.e. spot prices are playing a lead role and is impacting futures although co integration equation both sample series have significant ECT i.e. both participate in the adjustment process, to attain equilibrium but more adjustments are done by future prices.

Table 5. Vector Error Correction Estimates

Sample (adjusted): 4 1088 Included observations: 1085 after adjustments Standard errors in ( ) & t-statistics in [ ]		
Cointegrating Eq:	**CointEq1**	
FUTURE_PRICE_RS__(-1)	1.000000	
SPOT_PRICE_RS__(-1)	-1.036625	
	(0.01260)	
	[-82.2797]	
C	19.18673	
Error Correction:	D(FUTURE_PRICE_RS__)	D(SPOT_PRICE_RS__)
CointEq1	-0.137723	0.026053
	(0.01267)	(0.02057)
	[-10.8682]	[1.26652]
D(FUTURE_PRICE_RS__(-1))	0.042831	0.113531
	(0.03029)	(0.04918)
	[1.41381]	[2.30859]
D(FUTURE_PRICE_RS__(-2))	-0.002801	0.069952
	(0.02989)	(0.04852)
	[-0.09372]	[1.44168]
D(SPOT_PRICE_RS__(-1))	-0.025774	-0.130307
	(0.02200)	(0.03571)
	[-1.17151]	[-3.64867]
D(SPOT_PRICE_RS__(-2))	-0.000366	-0.025665
	(0.02106)	(0.03419)
	[-0.01740]	[-0.75063]
C	-0.879934	-0.829135
	(0.40774)	(0.66189)
	[-2.15807]	[-1.25267]
R-squared	0.127521	0.023703
Adj. R-squared	0.123478	0.019179
Sum sq. resids	192939.8	508425.5
S.E. equation	13.37212	21.70716
F-statistic	31.54123	5.239378
Log likelihood	-4350.131	-4875.782
Akaike AIC	8.029735	8.998676
Schwarz SC	8.057326	9.026267
Mean dependent	-0.892627	-0.854839
S.D. dependent	14.28298	21.91836
Determinant resid covariance (dof adj.)		74363.82
Determinant resid covariance		73543.64
Log likelihood		-9158.153
Akaike information criterion		16.90719
Schwarz criterion		16.97157

To add robustness and support the results of VECM, Variance Decomposition Analysis is done the results of which are reported in Table 5.

The results support the lead role of Spot prices. The results of Variance Decomposition Analysis is shown graphically using Impulse response (Figure 1).

After knowing the VECM results, it is important to understand direction of causality between the sample series. Granger Causality test is conducted and are reported in Table 5. The results show bilateral causality between Futures and spot prices as P Value is less than 0.05 in both cases (Table 6).

H2: Futures market does Granger cause Spot market.
H0: Futures market does not Granger cause Spot market.
H3: Spot market does Granger cause Futures market.
H0: Spot market does not Granger cause Futures market.

The result of VAR Granger Causality Test confirms the rejection of Null Hypothesis, stating that there exists a Bi-lateral causality between the futures and spot market and vice a versa.

4.2 Bi-variate EGARCH Model and Volatility Spill Over

H4: There is a Volatility Spillover from Future market to Spot Market

H0: There is no Volatility Spillover from Future Market to Spot Market.

Table 6. Variance Decomposition of Future and Spot Prices

Period	S.E.	FUTURE_PRICE_RS__	SPOT_PRICE_RS__
1	13.35850	100.0000	0.000000
2	18.74412	98.39015	1.609845
3	22.87463	94.76434	5.235665
4	26.50553	89.96131	10.03869
5	29.89963	84.63918	15.36082
6	33.16280	79.26978	20.73022
7	36.33785	74.14035	25.85965
8	39.44000	69.39991	30.60009
9	42.47249	65.10652	34.89348
10	45.43390	61.26437	38.73563
Period	**S.E.**	**FUTURE_PRICE_RS__**	**SPOT_PRICE_RS__**
1	21.67654	11.67144	88.32856
2	28.83042	14.47628	85.52372
3	34.59908	15.42958	84.57042
4	39.44105	15.99347	84.00653
5	43.68725	16.36972	83.63028
6	47.49953	16.64697	83.35303
7	50.97843	16.86348	83.13652
8	54.19053	17.03937	82.96063
9	57.18272	17.18631	82.81369
10	59.98950	17.31158	82.68842

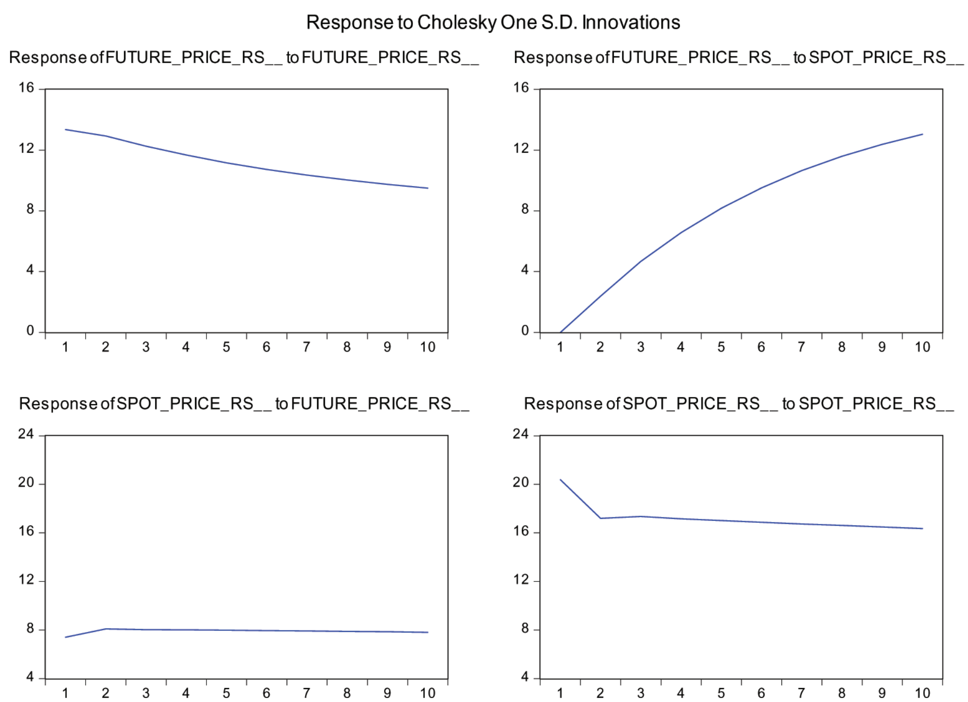

Figure 1. Results of Variance Decomposition Analysis.

H5: There is a Volatility Spillover from Spot Market to Future Market

H0: There is no Volatility Spillover from Spot Market to Future Market.

In this section, we evaluate volatility dynamics as regards clustering, spill over and persistence from future to spot market.

BI-VARIATE EGARCH Results confirms the rejection of Null Hypothesis, stating the bi-lateral spill over between the futures and spot market and vice a versa.

Volatility estimation is important for several reasons and for different people in the market pricing of securities is supposed to be dependent on volatility of each asset. Market prices tend to exhibit periods of high and low volatility. This sort of behaviour is called volatility clustering. Volatility clustering is tested for all indices and commodities, which means "large changes tend to be followed by large changes, of either sign, and small changes tend to be followed by small changes," as noted by Mandelbrot[14]. A quantitative manifestation of this fact is that, while returns themselves are uncorrelated, absolute returns |rt| or their squares display a positive, significant and slowly decaying autocorrelation function: corr (|rt|,|rt+τ|) > 0 for τ ranging from a few minutes to a several weeks. The market-specific volatility clustering coefficients β_{ff} and β_{ss} are all positively significant at 5% level in the future and spot markets. Of course, we can understand the efficiency degree in spot-futures market from one side according to the magnitude of correlative coefficients. Therefore, the Bivariate EGARCH model indicates that past innovations in futures significantly influence spot volatility, but the volatility spillovers from spot to futures are much weaker. Finally ARCH Lagrange Multiplier (LM) tests are used to test whether the standardized residuals of bivariate E-Garch model exhibit additional ARCH. The results reveal that EGARCH (1, 1) capture all the volatility dynamics.

The table shows ARCH LM Test which carries out a Lagrange multiplier tests to test whether the standardized residuals exhibit additional ARCH, with probability values in square brackets. The results show that EGARCH (1, 1) capture all the volatility dynamics.

Table 7. Results of VAR Granger Causality/Block Exogeneity Wald Tests

VAR Granger Causality/Block Exogeneity Wald Tests **Sample: 1 1088** **Included observations: 1086**			
Dependent variable: FUTURE_PRICE_RS__			
Excluded	Chi-sq	Df	Prob.
SPOT_PRICE_RS__	146.0431	2	0.0000
All	146.0431	2	0.0000
Dependent variable: SPOT_PRICE_RS__			
Excluded	Chi-sq	Df	Prob.
FUTURE_PRICE_RS__	6.925875	2	0.0313
All	6.925875	2	0.0313

Table 8. Volatility Relationship

Dependent Variable: STDSPOT					
COMMODITY **CER**		**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
A. B_{ff} (volatility clustering)	LAGSPOTEST	-0.015014	0.138296	-0.108567	0
B. β_{fs} (volatility spillover)	LAGFUTUREEST	0.005146	0.135064	0.0381	0
C. λ_f (volatility persistence)	LAGSTDSPOT	0.187058	0.025306	7.391859	0
Dependent Variable: STDFUTURE					
A. B_{ff} (volatility clustering)	LAGFUTUREEST	0.012811	0.136463	0.093881	0
B. β_{fs} (volatility spillover)	LAGSPOTEST	-0.007464	0.139679	-0.053439	0
C. λ_f (volatility persistence)	LAGSTDFUTURE	0.187746	0.025328	7.412626	0

The table describes volatility spillover (β_{sf} and β_{fs}) volatility persistence (λ_f and λ_s) and volatility clustering (β_{ff} and β_{ss}) from the spot to future or future to spot respectively. Volatility spillover is observed in sample commodity. Volatility persistence is significant for both spot and future prices CER, the market-specific volatility clustering coefficients β_{ff} and β_{ss} are all positively significant at 5% level in the future and spot markets.

Table 9. Archlm-Test

Commodity **CER**		**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
Dependent Variable: STDSPOT	STD_RESID^2(-1)	0.04	0.02	2.11E+00	[0.23]
Dependent Variable: STDFUTURE	STD_RESID^2(-1)	0.05	0.02	2.15	[0.3]

5. Summary and Conclusion

Commodity markets in emerging economies like India have been growing exponentially, commodities and commodity derivatives are neither popular asset classes, nor have they been adequately researched. The present study evaluates price discovery and volatility spill over effects in Indian commodities market (CER) to bridge the important gap in the literature. Carbon credits has shaped a market for reducing Greenhouse Gases emissions by giving a financial value at the cost of polluting the air. Emissions have become an in-house cost of carrying out business. The augmented demand of carbon credits and introduction of newer financial instruments for emission trading are signs of amplified activity of carbon trading scheme. It can be clinched that India has appeared as a leader in carbon trading. Though, there are few qualms and obscurity regarding the future of this business. If the countries across globe assent and concede their responsibility to keep the environment clean and carry on business along with showing obligation towards environment, the carbon trading business will undeniably have a bright future .The results reveal that there is a co-integrating relationship between future and spot prices of Carbon Emission Reduction (CER), traded on MCX. The error correction mechanism exhibits bi-lateral adjustments to attain equilibrium with more adjustments in future prices is seen, and to add robustness in the results of VECM, Variance Decomposition and Impulse response were also conducted. To understand the direction of causality, Granger causality test was done, the results of which show bi-lateral causality in the price pairs. The results signify that this market is informationally efficient with the lead role of spot market. Volatility dynamics also show bilateral spillover i.e. from future to spot market and vice versa. Overall, our findings illustrate several important implications for portfolio hedgers for making optimal portfolio allocations, engaging in risk management and forecasting future volatility in Carbon markets. Indian environmental conditions and the industrial practices have a huge potential of gaining from carbon trading. The Carbon accounting and its disclosure has become an important issue for the Indian companies. Public and private initiatives are urgently much required for encouraging industries and societies to understand the different facets of environmental pollution, its reduction strategies and the carbon financing in particular.

5.1 Implications of the Study

- The existing study contributes to alternating investment literature for nascent markets. Imminent research on comparative analysis of emerging economies can clench the true picture of improvements that are needed to seizure the gains of derivative market in India.
- India has outsized potential to earn carbon credits and carbon consultancy service has a greater part to play and can add a new dimension to the Environmental consultancy and financial services arena. Therefore, deep understanding of these dynamics is imperative to make the vital policies.
- An improved understanding of the mean and variance dynamics of the spot and futures market can advance risk management and investment decisions of the market agents.
- The results of the present study can be of interest for different groups of market participants such as market makers, speculators and regulatory authority.
- The present study can be very useful to the investors, producers and academicians who are very keen in observing the trends of futures and spot market.

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