Unbiasedness and Predictive Efficiency of Derivative Markets: Evidence from Indian Equity Future Markets

KEYWORDS
Derivative Markets, Cointegration, Error Correction Model, Predictive Efficiency
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ABSTRACT *This research is based on 1982 observations on cash and future equity prices with one month horizon spread over a period from January, 2006 to December, 2013. It seems from the discussions in this chapter that Indian future market bears equilibrating long period relationship with the spot market. As both the series are integrated of same order and cointegrating co-efficient is highly negative significant. However, relationship could not satisfy the criteria of unbiasedness and efficiency (both in short period and long periods) irrespective of the models used (Futures Price, ECM, ARIMA and GARCH-M). But the risk premium is not available in Indian stock market. So far the predictive efficiency of the models used is concerned, future prices turned out to be most effective model and ECM proved to be least useful*

1. Introduction

This research effort has been devoted to ascertain the role of future markets' efficiency in predicting the spot markets' prices. The introduction of derivative markets has received a considerable attention of academicians, traders and policy makers for exploring the role of such markets. So, in literature, along with other models of predictions, future markets are also being used for such purpose. Since the stock market prices experience severe volatility, hence, there is inbuilt risk in investing in such instruments. Futures market is recognized as a useful instrument to identify and manage price risk to minimize value at risk (VaR). Traders in both the categories (with short and long positions) may manage the price risk by taking equal but opposite position, technically called 'hedging'. Market participants have varied objectives by being in futures market. As it may enable the current future prices to act an accurate indicator of the spot price expected at the maturity of the future contract. This is also referred to as the price discovery function of the future market. Only an efficient future market can perform these functions (risk management and price discovery).

A financial market can be considered as efficient if prices fully factor in all information available in the system and no profit opportunities are left unexploited (Fama, 1970). The notion that the future price may act as the best forecast of the spot price is an implication of efficient market hypothesis. New information reflects instantaneously in equity prices in case efficient markets prevail. Consequently, stock prices display unpredictable (or random walk) behavior. A market following random walk is consistent with equity being appropriately priced at an equilibrium level. Accordingly, the agents form their expectations rationally and rapidly arbitrage away any deviation of the expected returns consistent with super-normal profits. However, the absence of a random walk infers distortation in the pricing of capital and risk. The reason is both that bubbles above or below fundamental values is a violation of market efficiency, and that the fundamental value itself and deviations from it can only be defined with reference to a framework of informational efficiency/ inefficiency in a market.

Fama (1970, 1991) asserts that market efficiency as such is not testable and it must be tested together with some asset pricing models. The model that future prices are unbiased estimators of future spot prices may proved to be the appropriate framework to test efficiency. Hence, no system based on past market behavior can do other than break-even. The link between efficiency and forecastability arises from recognizing that the difference between the current futures price and future spot price represents both forecasting error and the opportunity gain or loss realized from taking certain positions. The requirement that the forecasting error is zero on average is consistent with both market efficiency and unbiasedness property of the forecaster.

Divergent methodological techniques have been used in relevant literature to examine the efficiency of future markets. The earlier studies employed largely regression analysis (Frenkel, 1979; Huang, 1984; Goss, 1986). However, the price series are not stationary, a phenomenon typical in financial markets, then standard tests of parameter restrictions are not reliable (Elam & Dixon, 1988). Thus, to overcome the problem of non-stationarity, the cointegration procedure has been used to examine the efficiency of various markets (MacDonad & Taylor, 1988; Baillie, 1989, Hakkio & Rush, 1989; Shen & Wang, 1990; Chowdhury, 1991, Lai & Lai, 1991; Beck, 1994; Brenner and Kroner, 1995; Laws & Thompson, 2004; Floros and Vougas, 2008; Zhang et al, 2010).

Financial sector reforms in India combined with information technology progress have attracted foreign portfolio investments. Stock index futures have relatively lower transaction costs and capital requirements, so the arrival of external information is quickly incorporated into prices as investors' expectations are updated. As a consequence stock index futures markets have experienced a substantial growth in trading activity since the introduction of futures on indices. Information plays a vital role not only in efficient price discovery but also in the creation of bubbles (lack of information flow). The role of bubbles in financial markets is intricately connected to the question of informational efficiency.

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The efficiency of future markets also depends on the level of development in capital markets. Developed countries have very advanced capital markets supported by adequate institutions and information disseminating mechanism. Therefore, future markets in such countries are significant instrument to ascertain the levels of future spot prices. Indian capital market is relatively under-developed and future equity market is also in infancy. Though, it is expected, that such role may be considerably played by future markets in Indian set up but, given its slow movement of information and supporting institutions are relatively less strengthened, with less power to show the efficiency. Here, an attempt has been made to find the unbiasedness and efficiency of future equity markets. This research is based on 1982 observations on cash and future equity prices with one month horizon spread over a period from January, 2006 to December, 2013. Such data has been culled from the official website of the national stock exchange.

2. Literature Review

This section provides brief review of earlier studies on market efficiency of future markets. There are numerous studies that analyses the efficiency of future markets in the developed countries. However, such studies are sparse in developing country like India. Literature available so far, has revealed mixed results regarding efficiency of future markets. Market efficiency is exclusively debated in the existing literature. These studies concentrated on Cointegration and error-correction models to identify the unbiasedness and efficiency of future markets. This has been proved in almost every study that degree of efficiency is higher in long-period horizon as compared to short-period.

Undoubtedly, the work on efficiency of markets had begun half a century ago, but the central philosophy of market efficiency was consolidated in 1970 by Eugene Fama. He defined efficient market is that which fully reflect the available information and classified them into weak form, semi-strong form and strong form to concretize the available information. These three categories have become the standard in descriptions of market efficiency. Kendall (1953) established that stock prices grew randomly and such data offer no base for future price movement. However, gradually such relationship had been modeled in various frameworks such as expected return efficient markets, random walk models and market models. Such efficiency had also been modeled in the form of Capital Asset Pricing Models (CAPM) as developed by Sharpe (1964), Lintner (1965), Mossin (1996).

Most studies based on CAPM during 1950 and 1970 found evidence in harmony with efficient market hypothesis. However, such idea was not completely supported by the variance based methodology using literature. Even then markets were considered as efficient in semi-strong format. Shiller (1981) by using variance based techniques reported that stock prices are too volatile to be considered as the base of efficient market. There exists number of studies investigating the efficiency of future markets. Stensis (1983), Garbade and Sibler (1983), Protopapadakis and Stoll (1983), French (1986), Kawaller (1987), Cheung and Fung (1997), Hall (2001), Yang (2001), Singh (2001), Thomas and Karande (2002), Sahadevan (2002), Campbell and Diebold (2002), and Zhong (2004) have investigated the price discovery efficiency of commodity futures market in different countries viz., USA, United Kingdom, Malaysia, India, Mexico etc. respectively and found that futures market is efficient. Granger et al., (1998), Covrig and Melvin (2001), Anderson et al., (2002) and Yan and Zivot (2004) examined the price discovery efficiency of currency futures market in various economies like Hong Kong, Indonesia, Japan, South Korea, Malaysia, Philippines, Singapore, Thailand, Taiwan, USA respectively and found that futures market is efficient for underlying currencies. Chan (1992), Hasbrouck (1995), Jong and Donders (1998), Booth (1999), Turkington and Walsh (1999), Chuang (2003), Raju and Karande (2003), Barclay and Hendershott (2004), Sharma and Gupta (2005), So and Tse (2005) and Gupta and Singh (2006) evaluated the prices discovery efficiency of equity futures in different countries namely USA, Netherlands, Germany, Australia, Taiwan, India, Hong Kong respectively and observed significant evidence of efficient price discovery through equity futures market.

Yang (2001) applied different econometric methods in order to find the optimal variance ratio in the Australian Futures Market during the period 1 January 1988 to 12 December 2000. Specifically, he used the OLS Regression, the Bivariate Vector Autoregressive model (BVAR), the Error Correction model (ECM) and the multivariate diagonal VEC GARCH model. It was generally found that GARCH time varying hedge ratios provide the greater portfolio risk reduction but they do not produce the greater profit return. So, it is obvious that it is a matter of investor to decide in which product to invest, the less risky or the more profitable. Chuang (2003) examined the price discovery efficiency of TAISEX (Taiwan Stock Exchange Capitalization Weighted Index Futures) and MSCI (Morgan Stanley Capital International Taiwan Index Futures) during 1998-99 and found strong statistical evidence of market efficiency in its weak form. Hoque, Kim and Pyun, (2006) tested the market efficiency of eight different Asian emerging markets (Hong Kong, Indonesia, Malaysia, Korea, Singapore, Philippines, Taiwan and Thailand). They took weekly closing prices from April 1990 to February 2004. They used variance ratio test to find out whether these eight markets prove to be mean reverting or not. The basic findings were those five markets (Indonesia, Malaysia, Philippines, Singapore and Thailand), showed specific mean reverting and predictive behavior of stock prices while two markets (Taiwan and Korea) showed some mean-reverting and unpredictable patterns in the time series.

Gupta and Singh (2006) also made an attempt to investigate the price discovery efficiency of the Nifty futures by considering lengthy time frame and their results showed the evidences that futures market has been an efficient price discovery vehicle. Floros and Vougas (2008) examined efficiency of the Greek stock index futures market from 1999 to 2001. The results show that the Greek Futures markets are informationally more efficient than underlying stock markets. Zhang *et al* (2010) tests the random walk hypothesis and weak form market efficiency in the VIX futures market using variety of tests. A unit root in the aggregated market price series suggests that the VIX futures market is efficient. For the individual VIX futures price series, 51 of 54 futures contracts meet the sufficient condition for an efficient market: the prices are found to follow a random walk either because there is a unit root or because the increments are not correlated. Overall, the market for VIX futures has been efficient since the first day of trading. Thus, it is observed that the study of efficiency of the futures market is very important from the point of view of an emerging market like India. But the literature is relatively thin in this direction.

3. Data and Methodology

The time series data used for studying the dynamics between spot and derivative markets is the daily closing prices of S&P CNX Nifty index and S&P CNX Nifty future index. The data has been culled from the official website of National Stock Exchange (www.nseindia.com). This study covers the period of January 1, 2006 to December 20, 2013, resulting in 1983 observations. Since this period encompasses bullish as well as the sluggish market periods, therefore it is expected that it would provide better insights towards lead-lag relationships between the cash and derivative markets.

The concepts of market efficiency and unbiasedness are difficult to distinguish empirically. Market efficiency implies that futures prices will equal spot prices plus or minus a possibly time varying risk premium, while futures prices will be unbiased forecasters of future spot prices only if markets are both efficient and have no risk premium. The hypothesis that futures prices provide unbiased forecasts of spot prices is thus a joint hypothesis of market efficiency and risk neutrality. The issue is further complicated by a time dimension, whereby markets may be efficient and unbiased in the long-run, but may experience short-run inefficiencies. The objective here is to empirically test the two separate hypotheses of market efficiency and unbiasedness in both the long and short-term.

Eugene Fama, who put forward the 'Efficient Market Hypothesis', defines three categories of market efficiency tests: weak form, semi strong form and strong form. The weak form test examines whether current prices reflect the information contained in historical prices. The semi-strong form test examines how quickly prices reflect the announcement of public information. The strong form test examines whether investors have private information that is not fully reflected in the market prices. The concept of unbiasedness is a more restrictive version of Fama's weak-form efficiency. Unbiasedness implies that the current future prices of an asset should equal the expected cash price of the same asset at contract maturity. A common approach for the unbiasedness test is to regress cash prices S_t on the futures price F_{t-1} sometimes prior to contract maturity and test the null hypothesis that; $\alpha=0$ and $\delta=1$.

$$S_t = \alpha + \delta F_{t-1} + u_t \quad (1)$$

Where, u_t is a rational expectations error with the classical properties of zero mean and constant variance.

Market efficiency theory postulates that the prices of the assets traded on that market instantaneously reflect all available information. In general, if the efficient market hypothesis holds, the current future price of a contract expires at time t, F_{t-1} should equal the expectation of the spot price, S_t to prevail at time t. Otherwise market participants will use additional information to profitably buy or sell future contracts. Market efficiency implies that the futures price (F_{t-1}) for a contract expiring at time t is the unbiased predictor of the future spot price.

Mathematically this can be expressed as;

$$E_{t-1}(S_t) = F_{t-1} \quad (2)$$

Where $E_{t-1}(S_t)$ is expected future spot prices formed at time t-1.

$$S_t = E_{t-1}(S_t / \Omega_{t-1}) + \varepsilon_t \quad (3)$$

Where Ω_{t-1} is the information set available in period t-1. By combining (2) and (3)

$$S_t = F_{t-1} + \varepsilon_t \quad (4)$$

Equation (3) forms the basis for conventional unbiasedness and market efficiency tests between spot and futures prices. To carry out these tests, the standard form of the equation is;

$$S_t = \alpha + \delta F_{t-1} + u_t \quad (5)$$

typically estimated. If the null hypothesis of market efficiency ($\alpha=0$ and $\delta=1$) cannot be rejected, the futures price is an unbiased estimator of the future spot price. If the null hypothesis ($\delta=1$) cannot be rejected, then it implies that market is efficient. As a result, the hypothesis that a future price is an unbiased estimator of spot price is a joint hypothesis that markets are efficient and there is no risk premium. It should be noted that three separate conclusions might be inferred from the rejection of the null hypothesis (a) the market may indeed be inefficient; (b) a constant risk premium may exist which makes market forecasts biased but possibly efficient; (c) it may be that some possibly time varying risk premium is inherent to the market, thus preventing futures prices in isolation from providing unbiased forecasts of the spot prices.

Cointegration and Market Efficiency: Standard statistical techniques of parameter restrictions as those presented in relation to the equation (5) are not reliable in circumstances where data are non-stationary. However, Cointegration provides a satisfactory means to investigate equation (5) in the presence of non-stationary series. When two price series, such as the future and the spot price series, are both integrated of same order (d), a linear combination of two I(d) series can generate a linear combination that is stationary that is I(0). These two series are said to be cointegrated with a cointegrating relationship of the following form;

$$S_t - \alpha - \delta F_{t-1} = u_t \quad (6)$$

Cointegration of two price series is a necessary condition for market efficiency. If two series are cointegrated, S_t and F_{t-n} move together and will not tend to drift apart over time. If this is the case, then the futures price is an unbiased predictor of the future spot price. Alternatively, it implies that S_t and F_{t-n} cannot move too far from each other despite fact they are both non-stationary. Cointegration between the two series is necessary but not sufficient condition for market efficiency. Spot and future prices are determined by same fundamentals and so efficiency implies that they cannot move far apart.

Besides, Hakkio and Rush (1989) demonstrated that, while Cointegration is necessary condition for market efficiency, it is not a sufficient one for two reasons. Firstly, it is necessary to consider the values of parameters α and δ in the equation (5). For the future prices to be an unbiased predictor of the future spot price it is requires that $\alpha=0$ (for zero expected profits) and $\delta=1$. Further, along with the restricted Cointegration test, a test for serial correlation of S_t-F_{t-n} is needed to infer about the efficient market hypothesis (Liu & Maddala, 1992). The acceptance of the above restrictions imposed to α and δ (both jointly and individually) and serial independence of u_t is a necessary condition for market efficiency.

If both necessary conditions are met, as per Hakkio and Rush (1989), the short-run efficiency of the futures market (third condition) has to be tested. The Cointegration does not rule out short run market inefficiencies, whereby past information can improve future market forecasts of future spot prices. Since, in the short-run it is possible that there would be considerable departure from the long-run equilibrium relationship. This can be tested by using an error-correction model in the following form;

$$\Delta S_t = \alpha - \rho u_{t-1} + \beta \Delta F_{t-1} + \sum_{i=1}^{m} \beta_i \Delta S_{t-i} + \sum_{i=2}^{m} \gamma_i \Delta F_{t-i} + \varepsilon_t \quad (7)$$

Where α is the intercept, ΔS_t is the changes in spot prices, ΔF_{t-1} the changes in futures prices and $u_{t-1} = S_t - \alpha - \delta F_{t-1}$ is the error-correction term (ECT). In equation (7), Cointegration implies only that ρ>0 because spot prices changes respond to deviations from long-run equilibrium as this is described in equation (7). Short-term efficiency can be investigated by testing the following restrictions in equation (7): $\delta\rho = \beta \neq 0$ (in this way all new information concerning future spot price changes is immediately reflected in a change in the current price), $\beta_i = \gamma_i = 0$ (in this way past information is already completely incorporated in the current future prices) and if ρ=1 do not hold then the efficient market hypothesis is violated as past futures and spot prices (and not only the future prices of the last period F_{t-1}) contribute useful information for the formation/ prediction of the spot price of the present period.

δ is the coefficient of F_{t-1} in the cointegrating relationship and that for the market efficiency to hold this should be equal to 1. It can be finally concluded that the restrictions imposed for testing market efficiency are the following: $\beta_i = \gamma_i = 0$, ρ=1, β ≠ 0 and α=0 (not allowing the presence of risk premium according to the unbiasedness hypothesis). If the above restrictions hold, then equation (7) can be simplified to equation (6). These restrictions constitute the third condition for efficiency. If the three conditions are met, then the futures market is efficient and futures prices provide unbiased estimates of future spot prices both in the long-run and the short-run.

Finally, the above efficiency tests are also estimated using GARCH-M model to take into account a possibly short-run time varying risk premium. Stock prices exhibit extensive volatility over the sample period analyzed (as proved in the previous chapter). GARCH models provide a useful way to parameterize the time-varying conditional variances observed in stock market variables. In this case equation (7) can be rewritten as (8) to include ARCH terms and the time varying risk premium term σ_t, which is the conditional standard deviation of the change in spot prices.

$$\Delta S_t = \alpha - \rho u_{t-1} - \beta \Delta F_{t-1} + \sum_{i=1}^{m} \beta_i \Delta S_{t-i} + \sum_{i=2}^{m} \gamma_i \Delta F_{t-i} + \theta \sigma_t^2 + \varepsilon_t^2 \quad (8)$$

$$\sigma_t^2 = w + \sum_{i=1}^{m} \psi_i \varepsilon_{t-i}^2 + \sum_{i=1}^{m} \delta_i \sigma_{t-i}^2$$

Hence, risk premium is hypothesized to be a function of the conditional variance of the change in the spot price or the forecast error.

Autoregressive Integrated Moving Average Model *[ARIMA (1,1,1)]*: Since the discussion so far has proved that spot prices and future price series are integrated of order one, and by use of AIC and SIC information criteria, it has been decided to estimate the ARIMA (1, 1, 1) model in the following format;

$$S_t = \alpha + \delta F_{t-1} + AR(1) + MA(1) + e_t \quad (9)$$

The results of the model are used to establish the predictive efficiency of the model.

Predictive Efficiency: Four models (Futures Price, ECM, ARIMA and GARCH-M) used in this chapter to estimate the efficiency and unbiasedness of the future equity markets are also used to assess the quality of the accuracy of the prediction by using the following standard statistical measures.

Root Mean Square Error (RMSE): is a measure of the difference between values predicted by a model and the values actually observed. Basically, RMSE represents the sample standard deviation of the differences between predicted values and observed values.

Mean Absolute Error (MAE): is a quantity used to measure how close forecasts or predictions are to the eventual outcomes. This is the mean of the absolute values of the difference between the forecasted values and observed values.

Theil Inequality Coefficient (U): provides a measure of how well a time series of estimated values compares to a corresponding time series of observed values. The statistic measures the degree to which one time series, say X_t, differ from another, say Y_t, Thiel's U is calculated as:

$$U = \frac{\sqrt{\frac{1}{n}\sum_i (X_i - Y_i)^2}}{\sqrt{\frac{1}{n}\sum_i X_i^2} + \sqrt{\frac{1}{n}\sum_i Y_i^2}}$$

Thiel's inequality coefficient is useful for comparing different forecast methods: for example, whether a fancy forecast is, in fact, better than a naive forecast repeating the last observed value. The closer the value of U is to zero, the better the forecast method. A value of 1 means the forecast is no better than a naïve guess.

4. Empirical Analysis

The methodology described in the previous section has been used to establish whether the future equity markets are unbiased and efficient in determining the future spot prices. An initial consideration is to test the stationarity of the time series concerning the future and spot prices. It is important to establish the number of unit roots a series contains when testing for Cointegration. For two non-stationary series to be cointegrated they must be integrated of the same order. The stationarity of the series is then examined to determine whether they contain a single unit root. Two different unit root tests are used namely-Augmented Dickey-Fuller (ADF) test and Phillips-Perron test. The results presented in the table-1 and table-2 below.

Table-1: ADF Unit Root Tests for the Return Series

Equation Content	Log CNX Nifty				Log CNX Nifty Future			
	ADF (Levels)	**Lags**	**ADF (1st Difference)**	**Lags**	**ADF (Levels)**	**Lags**	**ADF (1st Difference)**	**Lags**
Without Drift	-0.94	1	-31.08*	1	-0.93	1	-31.41*	1
With Drift	-2.22	1	-31.11*	1	-2.23	1	-31.42*	1

Note: Lag Length has been determined by AIC and SIC Criteria

* Indicate statistic value is significant at 1% level of significance

- Critical Values are takes from the MacKinnon (1996) one sided P- Values

The tables highlight that CNX nifty spot price series and CNX nifty futures price series are non-stationary at the levels as they contain the unit roots. This is true for both the methods (ADF and PP) used. However, when the data series exposed to test the presence of unit root to the first difference series, both the series in both the methods turned out to be stationary. The optimum numbers of augmenting lags for the model is determined by using the AIC and SIC information criteria. Hence, both the series are integrated of same order I(1), hence, Cointegration technique can be used to determine if a long-run relationship exists between the spot and futures prices.

Table-2: Phillips-Perron (PP) Unit Root Tests for the Return Series

Equation Content	Log CNX Nifty				Log CNX Nifty Future			
	ADF (Levels)	**Lags**	**ADF (1st Difference)**	**Lags**	**ADF (Levels)**	**Lags**	**ADF (1st Difference)**	**Lags**
Without Drift	-0.96	1	-42.09*	1	-0.94	1	-43.92*	1
With Drift	-2.18	1	-42.11*	1	-2.22*	1	-43.94*	1

Note: Lag Length has been determined by AIC and SIC Criteria
* Indicate statistic value is significant at 1% level of significance
- Critical Values are takes from the MacKinnon (1996) one sided P- Values

The two stage Engle-Granger Cointegration tests indicated that residuals of OLS regressions on equation (5) are stationary. This result has been presented in table-4. The significant value of F-Statistic satisfies the model and the serial correlation is absent as the Durban Watson statistic is close to 2. The table-3 highlights the Cointegration equation results. The results show that the there is Cointegration relationship between F_{t-1} and S_t. The OLS coefficient estimates from equation (5) appear to be close to the (α=0, δ=1) restrictions, which may satisfy long-run unbiasedness. However, the Wald Test for (α=0, β=1) reject the hypotheses individually and jointly. Hence, a question mark is raised for the unbiasedness and efficiency of Indian futures market to determine the future spot prices.

Table-3: Cointegration Equation Results($S_t = \alpha + \delta F_{t-1} + u_t$)

Variable	**Coefficient**	**T-Statistic**	**Prob.**
α	-0.0163*	-2.4972	0.012
δ	1.0045*	563.3525	0.000
		Wald Test (H_0: α=0)	χ^2=6.2361 (0.0125)
R^2	0.9938		
F-Statistic	32436.4*	Wald Test (H_0: δ =1)	χ^2=6.5003 (0.0108)
(Prob.)	(0.0000)		
Durban Watson	1.8373	Wald Test (H_0: α=0,δ =1)	χ^2=5.0896 (0.0062)

Table-4: Unit Root Test for Residual ($S_t - \alpha - \delta F_{t-n} = u_t$)

Test Statistic	**Coefficient**	**MacKinnon Critical Values**	
ADF Test Statistic	**-19.3160***	At 1% level	-3.4366
		At 1% level	-2.8635
		At 1% level	-2.5678

The above tests do not provide support for the hypothesis of long run market efficiency and unbiasedness; the equity futures market may also expected to exhibit short-run inefficiencies. To test for short-run inefficiencies, the ECM model discussed in the methodology section is estimated, and the results are shown in Table-5. Given the long-run efficiency results, short-run dynamics are estimated by using equation (7). The significant value of F-statistic does not question the specification of the ECM. Moreover, it is free from the problem of serial correlation. The model estimation highlights that the risk premium is absent in the Indian stock market, for the coefficient of constant term is insignificant. The magnitude of error correction term coefficient indicates the speed of adjustment of any disequilibrium state of market efficiency and unbiasedness. Coefficient is significant and the adjustment rate of the spot market to future market is 33.19% per day. The results of table-5 also reveal that markets fail the test of short-run market efficiency and unbiasedness. The Wald test for the coefficients (ρ=1, β=1) are rejected and hence the conditions of efficiency are not satisfied.

Table-5: Results of Error Correction Model
($\Delta S_t = \alpha - \rho u_{t-1} + \beta \Delta F_{t-1} + {}_i\Delta S_{t-i} + {}_i\Delta F_{t-i} + \varepsilon_t$)

Variable	Coefficient	T-Statistic	Prob.
α	0.0012	0.6407	0.5218
ρ	-0.3319	-2.3609	0.0183
β	0.4583	2.7161	0.0067
β_1	-0.0869	-0.4602	0.6454
β_2	0.1188	0.6052	0.5451
β_3	0.0643	0.3350	0.7376
β_4	-0.2009	-1.0894	0.2761
β_5	-0.1116	-0.7188	0.4723
γ_1	-0.1358	-0.6681	0.5041
γ_2	-0.0838	-0.4217	0.6732
γ_3	0.1937	1.0144	0.3105
γ_4	0.0987	0.6141	0.5392

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R^2 **F-Statistic (Prob.)** **Durban Watson**	0.0878 2.5816 (0.0091) 2.0010	Wald Test (H_0: α=0) Wald Test (H_0: ρ =1) Wald Test (H_0: β =1) Wald Test (H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$) Wald Test ($H_0$: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$)	χ^2=0.4105 (0.5217) χ^2=89.73 (0.0000) χ^2=7.3777 (0.0061) Accepted Accepted

ECM is also modeled within GARCH-M framework. This model is estimated in an attempt to see if the short-run inefficiencies could be the result of time varying risk premium. The results are presented in Table-6. The estimated value of θ, which represents the coefficient of the time varying risk parameter, turned out to be insignificant. Therefore, the future spot price is not affected by the risk in the market. However, this specification of ECM has improved the speed of adjustment than the previous model. However, so far the efficiency conditions are concerned; it seems that Indian equity futures market is unable to exhibit the efficiency.

In the variance equation, constant (ω), ARCH effect and GARCH effect are highly significant with expected signs for both the markets. Hence, we may say that, lagged conditional variance and squared disturbance have an impact on the conditional variance. The news about the volatility from the previous period and innovations in the previous period has explanatory power on the current volatility. Moreover, the sum of ARCH and GARCH coefficients, technically known as 'persistence' is less than one, indicating the existence of the persistence effect with mean reverting variance process. Hence, it can be concluded here that news effect and persistence effect are present in spot and derivative markets in Indian stock markets. However, its effects die down in due course.

Table-6: Error Correction Model and GARCH-M (1,1) Processes

$\Delta S_t = \alpha - \rho u_{t-1} + \beta\ \Delta F_{t-1} + {}_i\Delta S_{t-i} + {}_i\Delta F_{t-l} + \theta\sigma_t^2 + \varepsilon_t^2$ (Mean Equation)

$\sigma_t^2 = w + {}_i\ \varepsilon_t^2 + {}_i\ \sigma_t^2$ (Variance Equation)

Variable	Coefficient	T-Statistic	Prob.
α	0.0002	0.5979	0.5498
ρ	-0.4184	-4.7470	0.0000
θ	0.0199	0.2818	0.7781
β	0.4599	5.0011	0.0000
β_1	-0.0861	-0.4203	0.6156
β_2	0.1108	0.7282	0.4664
β_3	0.2013	1.2907	0.1968
β_4	0.0033	0.1160	0.9839
β_5	0.0144	0.0201	0.9076
γ_1	-0.0971	-0.6106	0.5414
γ_2	-0.2359	-1.4487	0.1474
γ_3	0.0013	0.0076	0.9939
γ_4	-0.0346	-0.2699	0.7872
Variance Equation			
w	0.0756	5.2417	0.0000
ARCH(1)	0.1045	10.7445	0.0000
GARCH(1)	0.8856	88.3426	0.0000
R^2 **F-Statistic (Prob.)** **Durban Watson**	0.09753 2.7816 (0.0095) 2.0019		

To have further insights into the results obtained in the foregoing discussion, ARIMA (1, 1, 1) model has been estimated. It has already been proved that variables are integrated of order one and orders of AR and MA are determined through AIC and SIC information criteria. The results of the model are presented in Table-7. Undoubtedly, the specification of the model is justified as F-statistic is significant and the model is free from any serial correlation. The model also substantiates our previous result of ECM and GARCH-M model that risk premium is not present in the Indian stock market. Moreover, this model also reveals that the future markets are not efficient.

Table-7: Autoregressive Integrated Moving Average Model [ARIMA (1, 1, 1)] Results

$S_t = \alpha + \delta F_{t-1} + AR(1) + MA(1) + e_t$

Variable	Coefficient	T-Statistic	Prob.
α	0.0001	0.9451	0.3447
δ	0.4007	2.5671	0.0103
AR(1)	0.1228	1.8319	0.0671
MA(1)	-0.4829	-3.8931	0.0001
R^2 F-Statistic (prob.) Durban Watson	0.0433 2.2431 (0.0493) 2.0028	Wald Test (H_0: α=0) Wald Test (H_0: β =1) Wald Test (H_0: α=0,β =1)	χ^2=4.2371 (0.1255) χ^2=5.4003 (0.0089) χ^2=5.0896 (0.0062)

Why did we receive these results? That is Indian equity future markets are not efficient and unbiased in predicting the future spot prices. Indian set up is underdeveloped and the new information is processed in a very slow manner and most of the time in irrational manner. Besides, media hypes may also be responsible to distort the rational and logical opinions of the investors. Manipulation in the market cannot be overlooked. Hence, it can also be concluded that Indian capital market is under-developed and need to be strengthened for better market economy.

The Predictive Efficiency of Future Prices:
In this section we examine how well the futures price forecasts the subsequent final spot price. It is useful to have some yardsticks against which comparisons can be made. Four models namely futures, ECM, GARCH-M and ARIMA models are compared to see their predictive efficacy. The root mean square error, mean absolute error and Theil Inequality Coefficients are used for this purpose. The results are presented in Table-8.

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Table-8: Forecasting Performance under Different Variants of Models

Model→ Statistic↓	Futures	ECM	GARCH-M	ARIMA
Root Mean Square Error	0.0078	0.0082	0.0079	0.0082
Mean Absolute Error	0.0053	0.0057	0.0054	0.0057
Theil Inequality Coefficient	0.0010	0.7384	0.7902	0.7699

The results presented in table highlights that all three coefficients are least in the Futures followed by the GARCH-M models. It seems that predictive efficiency of futures prices towards the future spot prices is superior to other models. However, ECM proved to be least effective model.

5. Conclusion

It seems from the discussions in this chapter that Indian future market bears equilibrating long period relationship with the spot market. As both the series are integrated of same order and cointegrating co-efficient is highly significant. However, relationship could not satisfy the criteria of unbiasedness and efficiency (both in short period and long periods) irrespective of the models used (Futures Price, ECM, ARIMA and GARCH-M). But the risk premium is not available in Indian stock market. So far the predictive efficiency of the models used is concerned, future prices turned out to be most effective model and ECM proved to be least useful.

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