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Hedging Effectiveness of Index Futures Contract: The Case of CNX S & P Nifty

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Abstract

Futures market performs an important function which is to provide effective hedging besides price discovery at distant future date to the market participants. The hedging effectiveness of the futures contract shows its utility in reducing the amount of risk. We estimated the effective hedge ratio and its hedging effectiveness for the S&P CNX Nifty futures using daily data from 12 June 2000 to 24 December 2008 by three models. The study found that Nifty futures contract provides effective hedging to the market players for hedging purpose.

Keywords: Error correction models (ECMs), Minimum variance hedge ratio (MVHR), GARCH, OLS hedge.

Introduction

One of the important functions of the futures market is to provide hedging facilities to the market participants. The dictionary meaning of 'hedge' is to protect oneself financially by buying or selling futures contract as a protection against loss due to price fluctuations. The rationale behind futures trading is to provide hedging facilities to the economic agents by reducing or eliminating risks that cannot be insured or diversified away.

Hedging is done by taking opposite positions in the futures market. The significance of hedging in a volatile price environment is not difficult to imagine. To see the demise of an otherwise efficient firm or farmer as a consequence of adverse price fluctuations over which it had no control is really pitiable. This high degree of volatility in prices is often seen in the case of agricultural commodities where a good crop causes harvest prices to fall below a farmer's cost of production. In fact, it was this very situation which led to establishment of Chicago Board of Trade and introduction of commodity futures in 1860's. Similar volatility in prices of financial assets was also observed after the breakdown of Bretton Wood system, in early 1970's, which led to numerous financial innovations like financial futures. Even the Indian financial system has become increasingly global in nature and was exposed to the global financial market through channels of financial integration, development in information technology and telecommunication in recent years. This process of globalization has been accompanied by increasing volatility and uncertainty in prices of many commodities in financial markets. As a result some business risks like price risk, foreign exchange risks etc. have grown in importance. Management of these financial and commodity market risks required the use of financial instruments called derivatives.

Equity derivatives in India were started in June 2000. Four derivatives instruments viz. index futures, index option, stock futures and stock option are traded on the Indian stock exchanges. The moot question is whether the trading of stock index futures in the Indian market is performing its basic economic function of providing effective hedge. A hedge is said to be effective if price movements of the hedged item and the hedging instrument roughly offset each other. In fact, one of the important factors determining the success of futures contracts in market is its hedging effectiveness. Hedging decisions, as how many futures contracts to be used for hedging cash market position, are completely dependent upon finding optimal hedge ratio and hedging effectiveness.

Various methods have been adopted for estimating optimal hedge ratio. All the previous studies estimated optimal hedge ratio using simple Ordinary Least Squares (OLS) regression. Two criticisms leveled against using OLS, as OLS estimate suffers from the problem of autocorrelation in the OLS residuals and heteroskedasticity was often found in cash and futures prices (Herbst et al., 1993). Another problem arises from the fact that cash and futures prices might be co-integrated. If not taken into account, it can lead to an under-hedged position due to misspecification of the pricing behavior between these markets (Ghosh, 1993). In this connection, Error Correction Models (ECMs) may be more appropriate and numerous studies have used ECMs for estimating hedge ratio (Chou et al., 1996). Others have used both Error correction component as well as time-varying risk structure (e.g. Lien and Tse, 1999). However, all the earlier studies neglected the fact that the joint distribution of spot and futures prices varies over time (Cecchetti et al., 1988). This paper focuses on estimating optimal hedge ratio of S&P Nifty futures by various methods and compares its hedging effectiveness.

Theoretical Background

The futures market provides investors a number of benefits like instruments for reducing or eliminating risk, scope for speculating on price movements in the spot market or to diversify the portfolio. Futures contract is an agreement to take or make delivery of some commodity or stock at a later date. Futures contracts are standardized so that size, delivery procedures, expiration dates, and other terms are the same for all the contracts. This standardization allows futures to be traded on exchanges, which provides liquidity to market participants.

Futures contracts have a number of useful applications. Firstly, they can be used to hedge risk in the spot or cash market in which hedging is done by taking a position opposite to that held in the spot market to reduce or even eliminate risk. Secondly, because futures contracts are in essence costless, they can be used to speculate on the future prices of a commodity or stock. Thirdly, because the futures contracts are based on delivery of some assets or commodities in the spot market, there should be a relationship between the two prices. If these prices get out of line, there exists opportunity for arbitrage. And lastly, futures can be used to adjust the risks of a portfolio. Though there are various types of hedging strategies yet the objective of all strategies remain the same i.e. to reduce risk. Common hedges do not make or take deliveries, which makes it difficult to understand the futures. Instead, the seller (buyer) of the futures contract cancels his delivery commitment by buying (selling) a contract of the same futures prior to delivery (Ederington, 1979).

The hedge ratio is the ratio of the size of the position taken in futures contracts to the size of the exposure in the cash market. Before using futures contract to hedge a particular position established in the cash market, the market participants must decide on the optimal hedge ratio. Hedging decisions as such clearly depend on the hedge ratio which is the number of units traded in futures market to the number of units traded in the cash market. There are basically three hedging strategies namely traditional one to one; the beta hedge and the minimum variance hedge ratio (MVHR) proposed by Johnson (1960) and Ederington (1979).

The traditional hedging strategy involves taking equal and opposite position in the futures market i.e. hedge ratio of -1. This strategy will work if the proportional change in cash price exactly matches proportional change in futures price. However, such perfect correlation between spot and futures prices is rarely found. Hence, one-to-one strategy is not optimal and the hedge ratio that minimizes the variance must be different from -1.

Beta hedge ratio refers to portfolio's beta. The objective of beta hedge is similar to traditional 1:1 hedge ratio that involves taking equal and opposite position in the futures market. However, when the cash position is a stock portfolio, the number of futures contracts required to hedge the position, completely needs to be adjusted by the portfolio's beta. Very often the portfolio to be hedged will be a subpart of the portfolio underlying the futures contract and therefore, the beta hedge ratio will differ from -1. However, if the futures contracts have perfect correlation with the portfolio to be hedged then the beta hedge will be same as the traditional 1:1 hedge ratio.

Johnson (1960) proposed another hedge ratio called MVHR which is the ratio of covariance of spot and futures price changes to the variance of futures price changes. He applied modern theory of portfolio to the hedging problem and for the first time risks and returns in the terms of mean and variance of returns were used to hedge problems. He assumed that the main goal of hedging as to minimize the risk which is defined as the variance of return on a two-asset hedged portfolio. The hedge ratio is measured as:

$$h = -\frac{X_f}{X_s} = \frac{\sigma_{sf}}{\sigma_f^2} \tag{1}$$

Where X_f and X_s are amount invested in futures and spot market respectively. σ_{sf} and σ_f^2 are covariance of spot and futures price changes to the variance of futures price changes respectively. It is to be noted that the minimum variance hedge ratio (MVHR) is the regression coefficient of cash price changes on futures price changes.

A measure of hedging effectiveness was developed by Johnson (1960) and Ederington (1979). It is defined in terms of variance reduction of the hedged position over the variance of the unhedged position as given below:

$$HE = 1 - \frac{Var(h)}{Var(u)} \tag{2}$$

Where

$$\text{var}(u) = \sigma_s^2$$
$$\text{var}(h) = \sigma_s^2 + h^2\sigma_f^2 - 2h\sigma_{sf}$$

If we substitute and rearrange yields,

$$HE = 1 - \frac{X_s^2\sigma_{\Delta s}^2(1-\rho^2)}{X_s^2\sigma_{\Delta s}^2} = \rho^2 \tag{3}$$

where ρ^2 is the R^2 i.e. coefficient of determination. Alternately, it is the square of coefficient of correlation. Thus, in the MVHR model R^2 measure the hedging effectiveness of a futures contract.

Literature Review

Figlewski (1984) was the first to conduct study on hedging effectiveness of S&P 500 stock index futures for the period between June 1982 and September 1983. He estimated hedge ratio by OLS and found that MVHRs of out-of sample performance was better than beta hedge ratio. Junkus and Lee (1985) studied hedging effectiveness of three US stock index futures using different hedging strategies. They found that OLS hedge ratio outperformed other methods. Their study also established superiority of MVHR. Holmes (1995) examined ex ante hedging effectiveness of UK index futures contracts by using data from 1984 to 1992 and reported that FTSE-100 futures contract is very useful for portfolio managers for avoiding risk. Chou et al (1996) studied Japan’s NSA and NSA index futures contract and compared the hedging effectiveness using different time intervals. They documented that the conventional OLS hedge outperforms the error-correction hedge over the in-sample period. However, in out-of-sample period error-correction performed better than OLS hedge. Park and Switzer (1995a) investigated the hedging effectiveness of three stock index futures namely S&P 500, MMI futures and Toronto 35 index futures. Their results show that bivariate GARCH performs better than OLS hedge. Lypny and Powalla (1998) examined hedging effectiveness of German stock index DAX futures using bivariate GARCH (1, 1) and documented that dynamic model outperformed other models. Laws and Thompson (2002) examined the ex ante hedging effectiveness of stock index futures on LIFFE. Butterworth and Holmes (2000) studied hedging effectiveness of FTSE -100 and FTSE Mid 250 index futures contracts. They found that FTSE-100 provided effective hedge for portfolio dominated by large firms and FTSE Mid 250 was equally effective for portfolios dominated by small capitalizations stocks. Brailsford et al. (2000) estimated hedge ratio by several techniques for the Australian All Ordinary Share Price index futures contract. Yang (2001) showed that M-GARCH dynamic hedge ratio provides largest degree of reduction in variance of returns. Nonetheless, some recent studies for example Lien et al (2002) and Moosa (2003) have reported that basic OLS approach outperforms other advanced models of hedge ratio estimation.

In India very few studies were conducted on the hedging effectiveness of the futures contract. Roy and Kumar (2007) studied hedging effectiveness of wheat futures in India. They used conventional OLS method for hedge ratio estimation and found wheat futures contracts do not provide effective hedge in avoiding risk. Bhaduri and Durai (2008) examined hedging effectiveness of Nifty Futures. They found OLS based strategy provided better hedge in shorter time horizons. However, at higher time horizons bivariate GARCH clearly dominates. Further, Kumar et al (2008) examined hedging effectiveness of constant and time varying hedge ratio of Nifty Futures, Gold Futures and Soybean futures. Their results showed that the time varying hedge ratio provided greatest variance reduction as compared to other hedges based on constant hedge ratio.

Objective

The following are the objectives of the study:

- To identify the variance in each stock
- To know about the optimal hedge ratio to minimize the variance in each stock
- To have an idea about risk reduction when the optimal hedge ratio is applied

Research Methodology

Several methods have been used to estimate optimal hedge ratio such as conventional OLS method, bivariate vector autoregressive model and bivariate vector error correction model. These methods are discussed in detail below

Conventional Regression Model

The optimal hedge ratio in conventional regression method is obtained by regressing changes in spot prices on the changes in futures prices. This model is specified as follows:

$$\Delta S_t = \alpha + \beta \Delta F_t + \mu_t \quad (4)$$

Where μ_t is the residual, ΔS_t and ΔF_t are spot and futures price changes. The slope coefficient of the above model provides an estimate of optimal hedge ratio.

Bivariate VAR Model

One problem with the conventional regression model is that there may be possibility of error being autocorrelated. To remove this problem bivariate autoregressive (VAR) model can be preferred over OLS method. The VAR model can be specified as follows:

$$R_{st} = \alpha_s + \sum_{i=1}^{k} \beta_{si} R_{st-i} + \sum_{j=1}^{l} \delta_{Fj} R_{Ft-j} + \mu_{St} \quad (5)$$

$$R_{Ft} = \alpha_F + \sum_{i=1}^{k} \beta_{Fi} R_{Ft-i} + \sum_{j=1}^{l} \delta_{Sj} R_{St-j} + \mu_{Ft} \quad (6)$$

After estimating the system of equation, optimal hedge ratio is calculated from the residuals of spot and futures returns as follows:

$$H = \frac{\sigma_{SF}}{\sigma^2{}_F} \quad (7)$$

Where,

σ_{SF} = Covariance of μ_{st} and μ_{ft}

$\sigma^2{}_F$ = variance of μ_{ft}

The VAR model does not consider the possibility of co-integration between spot and futures returns.

Error Correction Model

Engle and Granger (1987) stated that if two series are integrated, then there exists an error correction representation of data as follows:

$$R_{st} = \alpha_s + \sum_{i=1}^{k} \beta_{si} R_{st-i} + \sum_{j=1}^{l} \delta_{Fj} R_{Ft-j} + \lambda_s Z_{t-1} + \mu_{St} \quad (8)$$

$$R_{Ft} = \alpha_F + \sum_{i=1}^{k} \beta_{Fi} R_{Ft-i} + \sum_{j=1}^{l} \delta_{Sj} R_{St-j} + \lambda_f Z_{t-1} + \mu_{Ft} \quad (9)$$

Where Z_{t-1} is the error correction term and λ_s and λ_f are adjustment parameters. Minimum variance hedge ratio is estimated as the ratio of covariance of residual of spot and futures return and variance of futures obtained from the error correction model.

Analysis of Results

At the outset, we plotted the Nifty and Nifty futures daily series for identifying the broad pattern in these two series over the sample period 12 June 2000 and 24 December 2008. Figure 1 shows the trend of Nifty and Nifty Futures over this period, showing a rising trend up to August-September 2008. With the onset of economic slowdown round the world, the Indian stock market also went into bearish mode which is quite visible from the time series plot. Both Nifty and Nifty futures showed a declining trend since then.

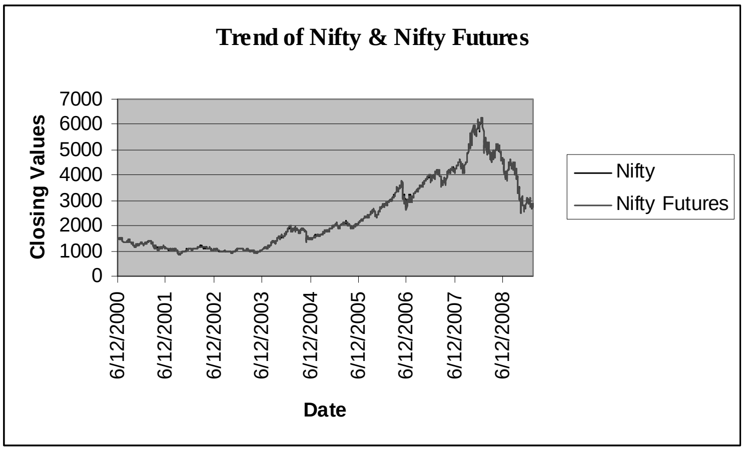

Figure 1

Next, we computed the descriptive statistics of returns of daily Nifty and Nifty Futures. The result is reported in Table 1. The mean returns over the sample period 12 June 2000 to 24 December 2008 of Nifty and Nifty Futures are 0.0454% and 0.0467% respectively. As evident from the coefficient of skewness and kurtosis that the Nifty and Nifty Futures returns are not normally distributed, therefore we reported median return of Nifty and Nifty futures which are 0.13% and 0.09% respectively over the sample period. The standard deviation of returns of Nifty and Nifty Futures over the sample period is 1.68 and 1.78 respectively which indicates that volatility of the futures market is comparatively higher than its underlying cash market. The value of skewness for Nifty and Nifty futures are -0.5718 and -0.6506 respectively which is different from zero indicating that the distribution is not symmetric. Besides this, kurtosis of Nifty and Nifty Futures are 7.92 and 9.72 respectively which are relatively large values compared to value of 3. This shows that returns is leptokurtic or heavily tailed and sharply peaked around the mean. Thus, the daily returns are not normal but leptokurtic and skewed. Jarque-Bera test indicate that the null of no normality of returns cannot be rejected at 1 percent level.

Table 1: Descriptive Statistics.

Indices/Summary Statistics	Nifty	Nifty Futures
Mean	0.0454	0.0467
Median	0.1363	0.0933
Maximum	8.2952	10.0684
Minimum	-12.23	-15.0052
Standard Deviation	1.6836	1.7808
Skewness	-0.5718	-0.6506
Kurtosis	7.92	9.27
Jarque - Bera	2299.77	3704.17

We proceeded further by testing stationarity of the series under question. The results of the OLS will be spurious if the variables in the regression model are not stationary. To determine the stationarity of Nifty and Nifty Futures, we take the help of one informal technique i.e. AR(1) model. We also conducted a formal test for stationarity by Augmented Dickey Fuller test. The results of AR (1) model with drift term is reported in Table 2.

Table 2: AR(1) Model for Testing Stationarity.

1. Nifty = 2.55 +0.99 Nifty (t-1) 2. Nifty Futures = 2.78 + 0.99 Nifty Futures (t-1)

The value of slope coefficient in each case is found to be 0.99. When the value of slope coefficient in AR (1) model is close to 1, we have unit root problem. The existence of unit problem implies that the series is not stationary. We also conducted a formal test of stationarity using Augmented Dickey –Fuller test. The results of ADF test is provided in Table 3. The results show that the Nifty and Nifty Futures are not stationary in level. However, the return series of Nifty and Nifty Futures are stationary. Since all the series, after first differencing, have turned out to be stationary, they are integrated of order one.

Table 3: Unit Root test in level and return series.

Level Series	ADF Test
Nifty Spot Nifty Futures	-1.047 1.034
Return Series	ADF Test
Nifty Nifty Futures	-43.1366 -45.4777

After checking the stationarity of all the series, we computed the optimal hedge ratio from the above three models and compared the hedging effectiveness of each model. The results from conventional regression model are reported in Table 4.

Table 4: Optimal Hedge Ratio by OLS Method.

ΔNifty = 0.0531 + 0.9253 Δ Nifty Futures
(0.026) (304. 0008)
R square = 0.97 df = 2160 F Statistic = 92416 (0.00)

The results show that the optimal hedge ratio for Nifty futures is 0.9253. In OLS regression model the hedging effectiveness of futures contract is ascertained by the R^2 value. The results show the hedging effectiveness of Nifty futures contract is 97 percent. In other words, 97 percent of the variation in spot Nifty is explained by the Nifty futures contract. Next, we estimated bi-variate vector autoregressive model (VAR) and vector error correction model (VECM) with five lags. The estimates of bi-variate VAR and VECM Model are reported in table 5 and table 6.

Table 5: Results of bi-variate VAR model for nifty and nifty futures.

Parameters	Estimated Coefficient	Parameters	Coefficients
α_s	0.0271 (0.45)	α_f	0.0270 (0.40)
B_{s1}	0.2097 (0.07)	B_{f1}	-0.4707 (0.00)
B_{s2}	0.0660 (0.59)	B_{f2}	-0.3501 (0.00)
B_{s3}	-0.0014 (0.99)	B_{f3}	-0.1438 (0.00)
B_{s4}	0.2107 (0.08)	B_{f4}	-0.3076 (0.25)
B_{s5}	0.1700 (0.13)	B_{f5}	-0.2748 (0.01)
δ_{f1}	-0.1148 (0.30)	δ_{s1}	0.5361 (0.01)
δ_{f2}	-0.1281 (0.27)	δ_{s2}	0.3044 (0.00)
δ_{f3}	0.0094 (0.93)	δ_{s3}	0.1581 (0.23)
δ_{f4}	-0.1885 (0.11)	δ_{s4}	0.3299 (0.01)
δ_{f5}	-0.1685 (0.12)	δ_{s5}	0.2781 (0.02)
R^2	0.013	R^2	0.014

(Figure in parentheses is the values for t-statistic)

To calculate optimal hedge ratio, we obtained residuals from estimated VAR and VECM model. Using equation (7), we computed the optimal hedge ratio.

Table 6: Results of bi-variate VECM model for nifty and nifty futures.

Parameters	Estimated Coefficient	Parameters	Coefficients
α_s	0.0141 (0.72)	α_f	0.014120 (0.72)
B_{s1}	0.6839 (0.30)	B_{f1}	-0.0283 (0.00)
B_{s2}	-0.0246 (0.88)	B_{f2}	-0.1481 (0.77)
B_{s3}	-0.0214 (0.86)	B_{f3}	-0.0008 (0.83)
B_{s4}	0.2290 (0.6)	B_{f4}	-0.2704 (0.03)
B_{s5}	0.1026 (0.48)	B_{f5}	-0.1822 (0.24)
δ_{f1}	-0.1225 (0.27)	δ_{s1}	0.5479 (0.50)
δ_{f2}	-0.0822 (0.53)	δ_{s2}	0.0718 (0.99)
δ_{f3}	0.0589 (0.66)	δ_{s3}	0.0366 (0.03)
δ_{f4}	-0.2105 (0.8)	δ_{s4}	0.2862 (0.20)
δ_{f5}	-0.1106 (0.41)	δ_{s5}	0.1767 (0.18)
λ	-0.4667 (0.47)	Λ	-0.4547 (0.28)
R^2	0.01	R^2	0.01

(Figure in parentheses is the values for t-statistic)

The optimal hedge ratio from VAR and VECM models are reported in table 7. Using equation (6), while the optimal hedge ratio from VAR model is 0.9282., the hedge ratio from VECM model is 0.9284 for Nifty Futures contract. From the results, given in the above table, it is clear that the hedge ratio from OLS, VAR and VECM models are almost same. The hedging effectiveness of the VAR and VECM models are 0.96 and 0.97 percent respectively.

Table 7: Estimates from VAR &VECM model for nifty futures.

	VAR	VECM
Covariance (μ_s, μ_f)	0.0002971	0.000296
Variance (μ_f)	0.00032	0.000318
Hedge Ratio	0.92	0.93
Var (U)	0.000286	0.000284
Var(H)	0.00001	0.000008
Hedging Effectiveness	0.96	0.97

We also found the hedging effectiveness of the nifty futures contract by examining the amount of mean returns generated by two strategies – hedged and unhedged. Also, mean variance reduced by the nifty futures contract. We used daily data from 12 June 2000 to 31 March, 2007 for within the sample estimate and from 1st April 2007 to 24 December, 2008 for out of the sample validation. The mean returns and mean variance reduction for 1 day, 5 days and 10 days time horizons has been computed for within the sample data. Tables 8 and 9 give mean returns and mean variance reduction for various hedge ratios.

Table 8: Mean return within the sample.

Method	Hedge Ratio	1-Day	5-Day	10-Day
OLS	0.9253	0.042%	0.041%	0.036
VAR	0.9260	0.043%	0.041%	0.036
VECM	0.9356	0.044%	0.042%	0.038

Table 9: Mean variance reduction within the sample.

Method	Hedge Ratio	1-Day	5-Day	10-Day
OLS	0.9253	93.46	91.48	89.68
VAR	0.9260	93.44	91.46	89.61
VECM	0.9356	93.43	91.45	89.64

The results show that mean returns generated using hedge ratio obtained from VECM model is higher than the hedge ratio from OLS and VAR models. The mean variances reduced in case of within the sample are almost same by all the models.

Table 10: Mean return out-of-the sample.

Method	Hedge Ratio	1-Day	5-Day	10-Day
OLS	0.9212	0.030%	0.024%	0.023
VAR	0.9234	0.030%	0.021%	0.020
VECM	0.9367	0.031%	0.018%	0.017

Table 11: Mean variance reduction out-of-the sample.

Method	Hedge Ratio	1-Day	5-Day	10-Day
OLS	0.9212	92.26	93.43	93.59
VAR	0.9234	92.21	93.41	93.54
VECM	0.9367	92.24	93.40	93.51

Tables 10 and 11 show the results for out of the sample data. The mean return is higher when hedge ratio is used from the VECM model. The mean variance reduction shows that OLS is out performing other two models.

Conclusion

One of the important functions of the futures market is to provide effective hedge besides price discovery at distant future date. The hedging effectiveness of the futures contract shows its utility in reducing the amount of risk. We estimated the effective hedge ratio and its hedging effectiveness for the S&P CNX Nifty futures. The study found that Nifty futures contract provide effective hedge to the market players for hedging purpose.

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