

Examining the Hedging Effectiveness of Futures Contracts Over Pre and Post Financial Crisis Period: Evidence from National Stock Exchange of India

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Abstract

Present study examines the efficiency of futures contracts in hedging unwanted price risk over highly volatile period i.e. June 2000 – December 2007 and January 2008 – June 2014, pre and post-financial crisis period, by using S&PCNXNIFTY, CNXIT and BANKNIFTY for near month futures contracts. The hedge ratios have been estimated by using five methods namely Ederington's Model, ARMA-OLS, GARCH (p,q), EGARCH (p,q) and TGARCH (p,q). The study finds that hedging effectiveness increased during post crisis period for S&PCNXNIFTY and BANKNIFTY. However, for CNXIT hedging effectiveness was better during pre crisis period than post crisis. The study also finds that time-invariant hedge ratio is more efficient than time-variant hedge ratio.

Keyword: Hedge Ratio, Hedge Horizon, Basis Risk, Heteroscedasticity, Conditional Volatility

Introduction

Risk is omnipresent in all financial transactions and has become the centre stage of every economic activity. The need to manage price risk against unwanted fluctuations in asset value by hedgers and risk-averse investors has led to the emergence of derivatives like futures, options, swaps etc. Specifically, hedging involves transferring price risk from entities less willing to take risk to those more willing or able to do so. Hence, hedgers transfer the burden of

price risk contained in their portfolio to speculators who wilfully enjoy taking risks with an intention to maximize their profits. The growth of futures market throughout the world is a proof that futures contracts have been considered as standard risk management tool that enables risk-averse investors to hedge price risks of underlying financial transaction/ inventory holding over a certain period of time. Not just hedgers, but futures market has been widely explored by speculators as well mainly due to its lower trading costs.

Pennings and Meulenberg (1997) suggest that hedging effectiveness of futures contract is an important determinant in explaining the success of financial futures contracts. A hedge is said to be effective if it reduces portfolio variance to the minimum level (Ederington, 1979). A strand of literature has found that hedging effectiveness is highly affected by behaviour of basis, liquidity of futures contracts, time-to-maturity of futures contract, risk aversion of investor, hedge horizon and price trends in the market. For instance, Chang, Lai and Chuang (2010) observed that hedge effectiveness is found to be higher in increasing pattern (termed as "bull" market) than in decreasing pattern (termed as "bear" market). The reason may be attributed to the fact that low volatility appears in uptick market and vice-versa which implies a strong co-movement between spot and futures market during up trend.

Due to an increased financial integration among different countries, financial crisis in one country always devastates financial health of other major economies of the world. For instance Asian Crisis of 1997-98 burst out

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in Thailand and gradually spread over Asia, Europe and other countries of the world. Similarly, recent financial crisis of 2008 originated in United States and spread over Europe and Asia, thus, weakening their economic and financial strength. A major impact has been observed over financial health of these nations in the form of significant change in the structure of price trends in their financial markets. The crisis drove down the equity levels across the globe (Joshi, 2012). All the major stock markets of the world, including India, exhibited higher volatility during crisis and post crisis period. For instance, Joshi (2012) found that volatility in the Asian stock markets exhibit persistence of volatility, mean reverting behaviour and volatility clustering. Furthermore, Ali and Afzal (2012) observed that Indian and Pakistani stock markets exhibited enhanced volatility and negative stock returns, however, this impact is stronger on Indian stock market.

It has been observed that global financial crisis of 2008 significantly impacted volatility of the Indian stock market. Furthermore, price trend in the market is an important determinant in affecting hedge effectiveness. Moreover, futures trading is not only popular in developed markets of the world but is equally popular in emerging markets like India, which is evident from the fact that Indian equity futures consistently ranks amongst top five markets of the world for last one decade (source: world federation of exchanges). However, to the best of our knowledge in Indian context only few attempts have been made to examine the hedge effectiveness¹ and these studies have majorly focussed on examining a superior methodology for determining optimal hedge ratio. Therefore, present study is an attempt to extend this literature by examining the impact of financial crisis on hedge effectiveness of equity futures contracts in India.

Further discussion in the study has been organised into five sections, where second section presents an overview of Indian equity futures market. Third section presents a detailed literature review of hedging. Fourth section discusses database and research methodology employed for estimating optimal hedge ratios and examining hedging effectiveness. Fifth section analyses the results obtained from the study and sixth section concludes the study.

1 Viz; Bhaduri and Durai (2007), Rao and Thakur (2008), Gupta and Singh (2009) and Pradhan (2011)

Indian Equity Futures Market

Indian financial market has undergone a sea change during the post-reforms process of the economy in 1990's. Opening up of economy to the rest of the world brought a huge benefit to the country which was also accompanied by increase in magnitude of risk. Thereby, realising the need for providing a risk management programme to the investors and industry as well as looking at the success of futures and options contracts in developed nations, SEBI granted approval in May 2001 on the recommendation of L.C. Gupta Committee for introducing derivative market in India.

Out of the two national stock exchanges of India, Bombay Stock Exchange of India Ltd. (BSE) and National Stock Exchange of India Ltd. (NSE), BSE launched first financial derivative Sensex futures which commenced its trading from June 9, 2000. Following this, NSE launched S&P CNX Nifty futures for near, next and far month which begun to trade from June 12, 2000. However, as of now, approximately 99 per cent of the total derivative trading in India takes place at National Stock Exchange of India Ltd. (NSE) which started its operations in the year 1994. The Exchange currently provides trading in Futures and Options contracts on 9 major indices and more than 100 securities.

Introduced in the year 2000, equity futures market in India has shown a phenomenal growth both in terms of volume of contracts and number of products. The total number of index futures traded on NSE is 105,270,529 and number of stock futures is 170,414,186 during the year 2013 – 14 (NSE Fact Book, 2014). The range of products, which started with index futures contracts, now includes index futures, individual stock futures, interest rate futures, currency futures and bond futures. Moreover, volume burst in equity futures segment ranked NSE among ten largest derivative exchanges of the world several times. Recently, NSE became fourth largest derivative exchange in terms of number of single stock futures traded and fifth largest derivative exchange in terms of index futures contracts traded in the world in year 2012 (World Federation of Exchanges).

Despite the encouraging growth and developments, research on derivative market is a road less travelled as compared to other developed nations of the world. The research in the area of equity futures market is just lying

at infant stage and needs to go a long way to realise full potential of derivative market.

Review of Literature

The relationship between cash and futures markets determines the success of an efficient hedge and has been widely tested in the academic literature. Numerous studies have supported the efficient information exchange role of futures market. It implies that futures market is an unbiased predictor of the cash market i.e. price movements in the futures market can be efficiently used to price the cash market transactions (Gupta & Singh, 2009). Another stylized fact found by voluminous studies is the strong and stationary price co-movements between both markets in the long-run. However, in the short-run, due to noise trading by uninformed traders, the relationship between both markets tends to be exploitable which opens an opportunity for the arbitrageurs to earn risk-free profits, thereby, restoring the market equilibrium. The efficient information exchange role of the futures market and the strong as well as stationary co-movement between futures and cash markets allow the hedger to hedge the risk contained in his/ her portfolio.

Prominent investigations in hedging literature has led to the development of three different hedging theories based upon varied objectives of investors which includes conventional (traditional or naive) hedging theory, Working's hedging theory and Portfolio hedging theory. The conventional/ naive hedging theory assumes that the price movement in cash and futures markets is perfectly correlated as both markets are exposed to common information set and investor is risk averter. Hence, it suggests that the optimal hedge ratio is to have equal number of futures contracts as the spot exposures, but in inverse direction i.e. long position in futures and short position in cash and vice versa. Thus, naive-hedging theory allows hedgers to transfer risk of price changes in the portfolio to speculators more willing to bear such risks (Floros & Vougas, 2004). However, this theory fails to cater the basis risk i.e. the spread between the spot and futures prices. Moreover, in practice, it is unlikely that there exists a perfect correlation between cash and futures prices. Therefore, in order to hedge both price risk and basis risk, Working (1953) unveiled a new approach to hedging where hedger acts as a speculator and not as a risk avoider. Thus, contradicting the naive hedging theory,

he argued that objective of hedging is not to minimize risk, but to maximize profits by speculating on the basis. This theory suggests that long hedger will hedge portfolio risk if the basis is expected to rise, whereas, short hedger will hedge if the basis is expected to fall (Gupta & Singh, 2009).

Nonetheless, Working's theory proved to be an improvement over the naive-hedging theory, yet, it suffers with an unrealistic assumption that hedgers can maximize their wealth at any level of risk. Johnson (1960) and Stein (1961) came out with portfolio approach to hedging which was further extended and quantified by Ederington (1979). As per this approach, hedger's objective is neither to minimize the portfolio risk (variance) nor to maximize the profits at any level of risk, but to optimize the risk-return trade off in the portfolio. An important contribution of the portfolio approach is the concept of the Minimum-Variance Hedge Ratio (MVHR) i.e. the hedge ratio that minimizes risk of the hedged position (Castelino, 1992). Conventional hedging theory and Working's hedging theory helps in estimating constant hedge ratio only, whereas, portfolio hedging theory allows for estimating constant as well as time-varying optimal hedge ratios.

Among the three hedging theories discussed above, portfolio hedging theory became most popular². As observed by Johanson (1960) and Stein (1961), hedger always prefers a portfolio that optimizes the risk and return. Hence, hedger may choose the best hedge ratio from a wide range of hedge ratios lying on efficient frontier, depending upon his/ her risk preference. Though both naive and Ederinton's hedge ratios assume investor to be risk averter, however, unlike naive-hedge ratio, Ederington's hedge ratio is slope coefficients, which is computed as the ratio of covariance of futures and cash market returns to the variance of future returns.

The traditional, Working's and Ederington's hedging theories have assumed the hedge ratios to be constant. However, it is a well established fact that financial time series observes time varying patterns and volatility clustering is their innate feature (Gupta & Singh, 2009). Hence, voluminous literature has found that time-varying hedge ratios are superior to constant hedge ratios (Myers,

² Because it allows for estimation of both constant as well as time-varying hedge ratios, unlike naive hedging theory and Working's hedging theory.

1991; Park & Switzer, 1995; Aggarwal & DeMaskey, 1997; Moschini & Myers, 2002; Harris & Shen, 2003; Pattarin & Ferretti, 2004; Kofman & Patrick, 2005; Floros & Vougas, 2006; Bhaduri & Durai, 2007; Lee & Yoder, 2007; Yang & Lai, 2009). Furthermore, Yang and Allen (2004) confirmed that time-varying hedge ratio performs better during out of sample hedging. However, Lien (2005) observed that the OLS hedge ratio outperforms the time-varying hedge ratio which is confirmed by the findings of Bhargava and Malhotra (2007) who found that OLS performs better during short-run. Furthermore, Lien and Luo (1994) commented that both constant as well as time-varying hedge ratios are equally efficient when the trader is extremely risk averter.

Ederington (1979) further suggested that futures hedging for longer period perform much better than for the shorter period which is also consistent with the findings of Figlewski (1984) who observed that one day hedge is comparatively less effective than one week hedging due to the presence of higher basis risk. Furthermore, Chen *et al.* (2002) also found that as the investment horizon increases, higher hedging effectiveness is observed, which may be due to the fact that market over-reactions are found in shorter horizons but rationally prevails in longer horizons. Chen, Lee and Shrestha (2004) also found that the hedge ratios and its efficiency have a positive relation with the hedging horizon which implies that if hedging horizon is long, then naive-hedge ratio will be close to minimum variance hedge ratio. Juhl, Kawaller and Koch (2012) also found that when cash and future prices are cointegrated, longer hedge horizon yields optimal hedge ratio close to naive hedge ratio. Moreover, In and Kim (2006) mention that hedging effectiveness does not only depend upon hedging horizon but risk aversion of hedger also affects the hedging effectiveness which implies that investors with low risk aversion have short-run hedge ratios and vice versa. Furthermore, Neuberger (1999) found that rollover of futures contract adds to the hedging effectiveness.

Basis risk is an important input for the construction of an effective hedge ratio. Figlewski (1984) found that basis risk arise from unexpected dividends on cash portfolio, transaction cost, hedge duration and time to expiration. Voluminous literature has investigated the behaviour of futures basis and found that basis risk is negatively associated with time-to-expiry of futures contracts. It implies that as the contract approaches

expiry, the basis risk keeps on decreasing and equates zero on the expiration date (Figlewski, 1984). Hence, on the contract expiry, hedger will be left with price risk only, implying that naive hedge ratio may be efficient hedge ratio in the short-run. Moreover, Monoyios and Sarno (2002) found that the speed of adjustment of basis towards its equilibrium value is an increasing function of size of deviations from equilibrium. It means higher the deviations, more the arbitrage opportunities taking place in the market which provides an opportunity for traders and investors to earn risk-free profits. However, it has also been found that larger arbitrage trading leads to lesser liquidity (higher bid-ask spread) which, further, granger cause spot-future basis (Kadapakkam & Kumar, 2013). Furthermore, empirical literature suggests that hedging effectiveness is also affected by time-to-expiry of futures contracts. Numerous studies have found that hedging effectiveness is more near the expiration date of futures contract. For instance, Ederington (1979) found that short term hedges in near month contract are more effective as compared to far month contracts. The reason may be attributed to the fact that basis risk keeps on decreasing as the contract approaches maturity (Gupta & Singh, 2007), thus exhibiting greater co-movement among cash and futures prices during near to expiration period.

As the cash and futures markets do not tend to move together³, therefore, estimation of optimal hedge ratio becomes essential for risk management. Advances in econometrics have lead to the development of numerous methodologies for estimating optimal hedge ratio which can be categorized under (i) Ordinary Least Square (OLS) methodology, (ii) Error Correction Model (ECM), and (iii) GARCH based models. The estimates of OLS and ECM gives constant hedge ratios whereas, GARCH based models give time-varying hedge ratios. Different models used for estimating the optimal hedge ratios have provided varied results over time. For instance, Floros and Vougas (2004) compared the hedge ratios estimated through four models i.e. OLS, ECM, VECM and M-GARCH, and their findings indicate that M-GARCH model provide lower hedge ratios as compared to other models, which is considered to be the best as it captures time variation. It implies that by using M-GARCH model for estimating the hedge ratios investors can improve

³ Due to presence of basis risk which affects co-movement between spot-future prices and disturbs the hedging effectiveness (Figlewski, 1984).

their hedging performance at lower cost. On the other hand, Gupta and Singh (2009) found that the hedge ratios estimated through VAR and VECM reduced the portfolio variance by maximum extent as compared to the other methodologies as cash and futures market observes long-run co-movement. However, Hatemi and Roca (2006) suggested that the use of Kalman Filter approach for estimating the time-varying hedge ratio has been found to be statistically more efficient and with better forecasting properties. They also suggested that the time path of the estimated hedge ratio can be analysed to determine the volatility in the hedge ratio which has implications in terms of cost of rebalancing the hedged portfolio. Thus, hedgers can evaluate the suitability of the hedging instrument to be used. Till date, most of the studies examining the effectiveness of optimal hedge ratios have found that time-varying hedge ratios are superior to constant hedge ratios.

Gupta and Singh (2009) also suggested that hedging through liquid futures contract by estimating the long-run hedge ratio involves low hedging cost and provides flexibility to hedgers with respect to timing of unwinding their position. Similarly, Bhaduri and Durai (2007) compared the optimal hedge ratios derived from four models i.e. OLS, VAR, VECM, and DVEC-GARCH (a class of M-GARCH) and their results indicate that time varying hedge ratio derived from M-GARCH provides better effectiveness of optimal hedge ratio in terms of mean returns and average variance reduction. However, hedge ratios estimated through OLS out-performs the hedge ratios estimated by other methods at short time horizons in terms of average variance reduction. Rao and Thakur (2007) examined the efficiency for Indian Futures market and Indian options markets by comparing the JSE (Johnson, 1960; Stein, 1961; Ederington, 1979) and HKM (Herbst, Kare & Marshall, 1993) methodology for futures and fBM (Fractional Brownian motion) and BSM (Black-Scholes model, 1973) methodology for options. The findings indicate that HKM methodology in case of futures and fBM methodology in case of options yields Optimal Hedge ratio in Indian Futures and Options market.

The determination of optimal hedge ratios in all models assume that distribution of returns on hedged portfolio is normal, which means that the mean and variance alone are sufficient to determine the optimal hedge ratio. However, there exists indisputable evidence to suggest that the

return distributions of risky assets depart from normality (Brooks, Cerny & Miffre, 2012). Therefore, Brooks *et al.* (2012) observed that ignorance of higher moments leads to sub-optimal hedge ratios and provides a new methodology considering the impact of higher moments on determination of optimal hedge ratios.

Moreover, volatility in spot market tends to invite more of hedging and speculation. Chang, Chou and Nelling (2000) observe that daily open interest for hedgers increase when unexpected volatility increases, implying that increase in the stock market volatility increases demand for hedging. In addition, hedge ratios have been found to be negatively associated with the volatility. It implies that hedge ratios appear significantly higher when the volatility in the market is low and vice versa. Moreover, a higher hedge ratio interprets higher co-movement between spot and future prices and vice-versa (Figlewski, 1984). Furthermore, Alizadeh and Nomikos (2004) observed that hedge ratios are significantly different across different states of market and found that more efficient hedge ratios may be obtained if the hedge ratios are allowed to be dependent upon the state of market.

A brief literature has also observed that effectiveness of hedge ratio depends upon price trends in the market. Hedging effectiveness is found to be higher in increasing pattern (termed as “bull” market) than in decreasing pattern (termed as “bear” market) (Chang *et al.*, 2010). The reason may be attributed to the fact that low volatility appears in uptick market and vice-versa which implies a strong co-movement between spot and futures market during up trend. Moreover, Figlewski (1984) has found that basis tends to widen when market is rising and falls even below spot price when market is falling. Furthermore, optimal hedge ratios have found to be dependent upon the future price expectation by investors. For instance, Khatib and Hatemi-J (2011) observed that optimal hedge ratios exhibit asymmetrical behaviour. It implies that optimal hedge ratio is different when investor expects a price increase at the maturity and is different when investors expect a price decrease at the maturity. The reason for this asymmetrical behaviour can be attributed to the fact that investors respond more to negative shocks than to positive ones which leads to asymmetric behaviour of the stock returns (Longin & Solnik, 2001). Moreover, financial asset returns are known to have leverage effect, i.e., negative shocks usually generate higher volatilities than positive shocks in the next time period (Goudarzi &

Ramanarayanan, 2012).

On the basis of above discussion, it can be observed that the debate relating to estimation of optimal hedge ratio has yet not settled. Some issues which require more extrapolation are; (i) Does optimal hedge ratio depend upon price trends in the market? (ii) Does volatility in stock markets affect the hedge effectiveness? (iii) Which statistical methodology can reduce portfolio variance to maximum extent? Most of the studies covering the above discussed issues of hedging effectiveness have been undertaken in the developed economies only⁴. Majority of the studies investigating the hedging effectiveness on stock index futures relate to U.S.A and U.K.⁵. However, to the best of our knowledge, only few studies have been undertaken in the emerging economies like India. The studies that have addressed the issue of hedging effectiveness on stock index futures market in India include Bhaduri and Durai (2007), Rao and Thakur (2008), Gupta and Singh (2009), and Pradhan (2011). The scope of all the above mentioned studies have been limited to find a superior methodology to determine optimal hedge ratio in equity futures market. Moreover, as mentioned in the first section, global financial crisis of 2008 enhanced volatility of Indian equity markets. Therefore, present study is an attempt to study the impact of financial crisis of 2008 on hedge effectiveness of Indian equity futures contracts.

Database and Research Methodology

The sample size of the study comprises of three indices i.e. S&P CNX NIFTY, CNXIT and BANKNIFTY. The data have been collected for near month contract for all three indices comprising sample size of study from official website of the National Stock Exchange of India (NSE) i.e. www.nseindia.com. Since near month contracts are more liquid as compared to next and far month contracts, hence, near month contracts have been used in the study in order to remove any bias. The period of the study is from inception date of respective indices till June 30, 2014 as presented in Table 1.

⁴ See Table 2 for details.

⁵ See Figlewski (1984), Homles (1995), Park and Switzer (1995), Theobald and Yallup (1997), Theobald and Yallup (2001), Butterworth and Holmes (2001), Chen et al. (2001), Chen et al. (2002), Floros and Vougas (2004), Chen et al. (2004), Pattarin and Ferretti (2004), Floros and Vougas (2006), In and Kim (2006), Kenourgios et al. (2008), Yang and Lai (2009).

Table 1: Period of study

Symbol	Period of study	Number of Observations	
		Pre crisis	Post Crisis
S&P CNX NIFTY	June 12, 2000 – June 30, 2014	1898	1612
CNXIT	August 29, 2003 – June 30, 2014	1092	1612
BANKNIFTY	June 13, 2005 – June 30, 2014	638	1612

Hedging theory requires that trader has to take simultaneous but opposite in sign trading positions in two markets with the magnitude of prediction of one market (cash market) through other (futures market), which is known as hedge ratio. Since, estimation of hedge ratio is a statistical process, which involves regressing cash market returns on futures returns, therefore, prior to undertake any statistical procedures, it would be more important to examine the time series properties of data under investigation. The very first step in any econometric investigation of a time series is to examine whether the time series under examination contains unit roots, if yes, then it should be transformed for further examination, otherwise the statistical results would be spurious. Therefore, stationarity of three indices under study has been checked by using the Augmented Dickey Fuller (ADF) test and it has been observed that the prices (both futures prices and cash prices) are non-stationary whereas, natural log of first difference of prices (i.e. $\ln(p_t / p_{t-1})$) is stationary (See Table 3). Thus, returns of futures contracts and cash market are considered for estimating hedge ratio.

Since both cash and futures markets are linked through arbitrage process and the price of futures contract determined through cost-of-carry model in long-run is not expected to be different from spot price plus risk premium to hold positions in the cash market. Therefore, appreciating the stationary and stable long-run relationship between two markets, different models have been constructed to hedge the portfolio risk. Five econometrical procedures have been undertaken, which address various economic as well as statistical issues involved in estimating an optimal hedge ratio and an efficient hedge ratio would be one, which can help hedgers to minimise portfolio variance to minimum level.

Ederington (1979) suggested an optimum hedge ratio, which presumes strong and stable long run relationship between two markets and hedging effectiveness will

Table 2: Literature Review of Hedging Effectiveness

Author (year of study)	Market under study	Symbols	Sample period	Methodology	Hedging effectiveness
Ederington (1979)	U.S.A.	GNMA and T-Bill Futures Markets	Jan. 1976 to Dec. 1977 and Mar. 1976 to Dec. 1977	OLS	Futures hedging is better for longer period than short period
Figlewski (1984)	U.S.A.	S&P500, NYSE, AMEX, NASDAQ, DOW	June 1982 to Sept 1983	OLS	Basis risk disturbs the hedging effectiveness therefore one week hedging is better than overnight hedging
Kamara and Siegel (1987)	U.S.A.	Soft Wheat and Hard Wheat	Jan. 1970 to March 1981	OLS	Far period hedging is better than near to expiration period
Myers (1991)	U.S.A.	Wheat Futures	June 1977 to May 1983	OLS and BGARCH	Time varying hedge ratio is better than constant hedge ratio.
Kroner and Sultan (1993)	U.S.A.	BP, CD, GM, JY and SF	Feb. 1985 to Feb. 1990	Naive, OLS, ECM and ECM-GARCH	Time varying error correction methodology takes care of transaction cost thus outperforms other methodologies.
Lien and Luo (1994)	U.S.A.	BP, CD, GM, JY and SF	March 1980 to Dec. 1988	OLS, BGARCH, ECM	If trader is extremely risk averter, both constant and time varying hedge ratios are equally efficient whereas to achieve utility maximisation objective GARCH hedge ratio is most efficient.
Homles (1995)	U.K.	FTSE100 Futures and FTSE100 Index	July 1984 to June 1992	Ex-Post MVHR, Ex-Ante MVHR and Beta	MVHR based upon historical data is better
Park and Switzer (1995)	U.S.A. and Canada	S&P500, MMI and TSE35	June 1988 to Dec. 1991	Naive, OLS, OLS with Cointegration and BGARCH	Time varying hedge ratio is superior to constant hedge ratio
Aggarwal and Demaskey (1997)	Hong Kong, South Korea, Singapore, Taiwan, Indonesia, Philippines and Thailand	BP, CD, GM, JY and SF	Jan. 1983 to Dec. 1992	Naive and OLS	Cross hedging is beneficial.

Author (year of study)	Market under study	Symbols	Sample period	Methodology	Hedging effectiveness
Theobald and Yalulup (1997)	U.K.	FTSE100 Futures and FTSE100 Index	Jan. 1985 to Dec. 1995	OLS	Futures contracts can provide hedging benefit only when both markets do not suffer with the problem of non synchronous trading.
Neuberger (1999)	U.S.A	Crude oil futures	July 1986 to Aug. 1997	Ex-ante and OLS	Rollover of futures contracts adds to hedging effectiveness
Theobald and Yalulup (2001)	U.K.	FTSE-100 Index Futures and FTSE-100 Index	Jan 28, 1999 to Dec 3, 1999	Autocorrelation	Partial adjustment coefficients induces mean reversion in the basis change, which are highest at shorter intervals (< 15 mins)
Butterworth and Holmes (2001)	U.K.	FTSE-100 Index Futures and FTSE-mid250 Index	Feb. 1994 to Dec. 1996	OLS, LTS	New contract is more effective in hedging ITCs than established FTSE100 contract.
Chen <i>et al.</i> , (2001)	U.S.A.	S&P500 Futures	April 1982 to Dec. 1991	M-GSV, MEG, Sharpe, OLS and Standard mean variance	M-GSV minimizes the portfolio variance by maximum
Moschini and Myers (2002)	U.S.A.	Corn Futures	Jan. 1976 to June 1997	BEKK, GARCH and OLS	Supports time varying hedge ratio
Chen <i>et al.</i> , (2002)	Taiwan	TAIFEX/TAIEX-TAIEX AND SGXMSCI	July 1998 to July 2000	OLS, Bayesian Approach	Hedging effectiveness observes positive relationship with hedging horizon.
Alizadeh and Nomikos (2004)	U.S.A. and U.K.	S&P500 Futures and S&P500 Index and FTSE100 Futures and FTSE100 Index	May 1984 to March 2001	OLS, ECM, GARCH and Markov Regime Switching Models	By allowing the hedge ratio to be dependent upon the state of market, one may obtain more efficient hedge ratio.
Floros and Vougas (2004)	Greece	FTSE/ASE-20 index and FTSE/ASE-40 index		OLS, VECM and M-GARCH	M-GARCH model provide best hedging ratios.
Chen <i>et al.</i> , (2004)	U.S.A., U.K., Canada, Japan, Australia	7 Stock Market Index futures, 11 Commodity futures, 2 metals and 5 currencies	June 1982 to Dec. 1997	OLS	Short-run hedge ratio is significantly < 1 but as the hedge horizon increases it approaches to 1 and the hedging effectiveness also improves.
Pattarin and Ferretti (2004)	Italy	Fib30 and Mib30 Index	Nov. 1994 to Sept. 2002	Naive, OLS, ECM, GARCH, EWMA	Time varying hedge ratio based upon EWMA is better
Lien (2005)	N/A	N/A	N/A	OLS, ECM	OLS is a superior model over error correction model.

Author (year of study)	Market under study	Symbols	Sample period	Methodology	Hedging effectiveness
Kofman and McGlenchy (2005)	Hong Kong	HSIF and HIS	Jan. 1994 to July 2003	Naive, Expanding window, Rolling window, EWLS and ROC	Dynamic hedging is better than constant hedging.
Hatemi and Roca (2006)	Australia	MSCI index	Jan 1, 1988 to Sept 8, 2001	Kalman Filter Approach	Kalman Filter Approach is statistically more efficient and with better forecasting properties.
Floros and Vougas (2006)	Greece	FTSE/ASE20 Index Futures and FTSE/ASE Mid 40 Index Futures	Aug. 1999 to Aug. 2001 and Jan. 200 to Aug. 2001	OLS, ECM, VECM and BGARCH	Time varying hedge ratio is superior to constant hedge ratios
In and Kim (2006)	U.S.A.	S&P500 Futures and S&P500 Index	April 1982 to Dec. 2001	Wavelet Analysis	Hedging effectiveness does not only depend upon hedging horizon but risk aversion of hedger also affects the hedging effectiveness. Investor with low risk aversion have short-run HE and vice versa.
Bhaduri and Durai (2007)	India	Nifty Index Futures and Nifty Index	Sept. 2000 to Aug. 2005	OLS, ECM, BVAR and M-GARCH	(i) GARCH model performs better in the long-run whereas OLS is a better measure during short-run. (ii) Time-varying hedge ratios is superior to constant HR
Bhargava and Malhotra (2007)	U.S.A.	Cotton and Soybeans Futures	Jan. 1994 to Dec. 1999 and Jan. 1995 to Dec. 2000	Traditional regression method, Modified regression method and ECM	Traditional regression method performs better than others
Lee and Yoder (2007)	U.K.	Corn and Nickel Futures and Spot Markets	Jan. 1991 to Dec. 2004	RS-BEKK, BEKK and OLS	Time varying hedge ratio performs better.
Rao and Thakur (2008)	India	Nifty Index Futures and Nifty Index Options	Jan. 1, 2002 to Mar. 28, 2002	HKM, JSE, fBN,	HKM methodology yields better Optimal Hedge ratio than JSE methodology in Indian Futures Market
Kenourgios <i>et al.</i> , (2008)	U.S.A	S&P500 stock Index futures	July 3, 1992 to June 30, 2002	OLS, ECM, GARCH, EGARCH	ECM is superior to other models and remains stable over time.

Author (year of study)	Market under study	Symbols	Sample period	Methodology	Hedging effectiveness
Gupta and Singh (2009)	India	Nifty Index Futures, Nifty Index, Nifty Stock Futures and Nifty Stock	2003-07	VAR, VECM, GARCH, TARCH and OLS	(i) VAR and VECM reduced the portfolio variance by maximum extent (ii) Hedging through liquid futures contract involves low hedging cost.
Yang and Lai (2009)	U.S.A and U.K.	DJIA, S&P500, Nasdaq100, FTSE100, CAC40, DAX30 And Nikkei225	Nov. 30, 1998 to Feb. 20, 2003	GJR-EC-GARCH, GJR-GARCH, EC-OLS AND OLS	Dynamic hedging (EC models) is better than static hedging.
Chang <i>et al.</i> , (2010)	U.S.	Crude oil and Gasoline spot and futures	Jan. 1, 1996 to Dec. 31, 2005	OLS, MD-GARCH, BEKK-GARCH, CCC-GARCH, ECM-MD, ECM-BEKK, ECM-CCC, State space models	Hedging effectiveness is higher in bull market than in bear market
Pradhan (2011)	India	Nifty index and Nifty index futures	-NA-	OLS, VAR, VECM, M-GARCH	Time-varying models (VEC-GARCH and VAR-GARCH) reduced portfolio variance to maximum extent
Chen and Tsay (2011)	U.S.A. and U.K.	S&P500 and FTSE100	May 9, 1984 to Aug. 1, 2007 and Aug. 8 2007 to July 29, 2008	OLS, GARCH, MRS-ARMA, MRS-MA	MRS-ARMA is superior over other models.
Juhl <i>et al.</i> , (2012)	U.S.A	Gasoline cash and futures	Jan. 2006 to April 2008	OLS and ECM	Longer hedge horizon yield optimal hedge ratio close to 1 when cash and future prices are cointegrated
Brooks <i>et al.</i> , (2012)	U.S.	Corn, cotton, gold, heating oil, silver, soybean oil and sugar future and spot market	Jan. 31, 1979 to Sep. 30, 2004	OLS, MINIMAX	Higher moments impact the optimal hedge ratios when returns from hedged portfolio depart from normality.

Source: Updated Table 2 in (Gupta & Singh, Estimating the Optimal Hedge Ratio in Indian Equity Futures Market, 2009)

Table 3: Augmented Dickey-Fuller Unit Root Test

Symbol	Variables	Period	Count	Intercept	Trend and Intercept	None
S&P CNX NIFTY	Futures Return	Pre-Crisis	1897	-42.28382 (0.0000)	-42.40741 (0.0000)	-42.1951 (0.0001)
		Post-Crisis	1611	-39.05475 (0.0000)	-39.09451 (0.0000)	-39.06484 (0.0000)
	Cash Return	Pre-Crisis	1897	-32.05822 (0.0000)	-32.21317 (0.0000)	-31.94448 (0.0000)
		Post-Crisis	1611	-37.87837 (0.0000)	-37.91909 (0.0000)	-37.88795 (0.0000)
	Basis	Pre-Crisis	1898	-7.024387 (0.0000)	-7.161892 (0.0000)	-6.64086 (0.0000)
		Post-Crisis	1612	-8.946755 (0.0000)	-10.85059 (0.0000)	-5.817175 (0.0000)
CNX IT	Future Return	Pre-Crisis	1113	-33.69178 (0.0000)	-33.69517 (0.0000)	-33.70008 (0.0000)
		Post-Crisis	1611	-40.02862 (0.0000)	-40.03789 (0.0000)	-40.01949 (0.0000)
	Cash Return	Pre-Crisis	1113	-33.53118 (0.0000)	-33.53465 (0.0000)	-33.53944 (0.0000)
		Post-Crisis	1611	-39.79589 (0.0000)	-39.80511 (0.0000)	-39.78649 (0.0000)
	Basis	Pre-Crisis	1114	-6.558473 (0.0000)	-6.695267 (0.0000)	-6.527749 (0.0000)
		Post-Crisis	1612	-9.694959 (0.0000)	-10.3016 (0.0000)	-9.045965 (0.0000)
BANK NIFTY	Future Return	Pre-Crisis	630	-21.98497 (0.0000)	-21.99498 (0.0000)	-21.87659 (0.0000)
		Post-Crisis	1611	-36.31004 (0.0000)	36.32899 (0.0000)	-36.31741 (0.0000)
	Cash Return	Pre-Crisis	630	-21.21695 (0.0000)	-21.22755 (0.0000)	-21.11321 (0.0000)
		Post-Crisis	1611	-35.56162 (0.0000)	-35.57969 (0.0000)	-35.56872 (0.0000)
	Basis	Pre-Crisis	631	-4.071571 (0.0012)	-4.538279 (0.0014)	-3.676035 (0.0002)
		Post-Crisis	1612	-8.571527 (0.0000)	-9.917905 (0.0000)	-7.909156 (0.0000)

depend upon the coefficient of R^2 , thus, higher the R^2 , more efficient will be the hedge ratio and vice versa. Equation (1) explains the procedure suggested by Ederington (1979), which will work efficiently when futures market returns are unbiased predictor of prospective cash market returns. In equation (1), $R_{s,t}$ is cash market returns, $R_{f,t}$ is futures market returns, α_0 is intercept term and ε_t is error

term. As already mentioned that futures contract price as per the cost-of-carry model is assumed to be unbiased predictor of prospective cash market price, therefore, intercept and error term should not be significantly different from 0, consequently R^2 will improve, hence, the hedging effectiveness.

$$R_{s,t} = \alpha_0 + \beta_1 R_{f,t} + \varepsilon_t \quad (1)$$

Equation (1) though may be economically justifiable but until the statistical properties of the estimation procedure are satisfied, the estimated value of β_1 won't be reliable. In addition to containing unit roots, another feature of financial time series is that these are autocorrelated, which implies that successive returns of one speculative asset are significantly predictable. Significantly autocorrelated cash and futures market returns suggest that successive stock and/or futures returns are not random, rather due to mean reversion, volatility clustering, information asymmetry or inefficient microstructure system⁶ are function of previous information set(s). Therefore, if stock returns are autocorrelated then avoidance of it may bias the estimated hedge ratio. Hence, equation (1) modified to equation (2) (to include autoregressive terms⁷ of cash market returns), may provide better results, hence improved R^2 , which otherwise could have been biased on account of significant serial correlation. In equation (2), $R_{s,t}$ is cash market returns, $R_{f,t}$ is (are) futures market returns, $R_{s,t-i}$ is autoregressive term(s) whose order varies between i to p determined as per Schwartz Information Criteria, α_0 is intercept term and ε_t is error term.

$$R_{s,t} = \alpha_0 + \sum_{i=1}^p \alpha_i R_{s,t-i} + \beta_1 R_{f,t} + \varepsilon_t. \quad (2)$$

The literature on financial econometrics has further observed that stock returns observes volatility clustering, which implies that an information set continues to affect stock return volatility of few periods ahead. In other words, volatility clustering implies that large price changes will be followed by large price changes and small price changes will be followed by small price changes. In equation (1 and 2), if the variance of error term is constant⁸,

the hedge ratio estimated through Ordinary Least Square (OLS) method will be valid, however, vast amount of academic literature has evidenced that stock returns are heteroscedastic in nature. Therefore, Autoregressive Conditional Heteroscedasticity model (ARCH) may be a better procedure to make robust statistical estimations. In ARCH model (first introduced by Engle (1982)), the mean equation is specified in the baseline scenario by an AR(p) process and other endogenous variables such as in equation (3) and the conditional variance will be regressed on constant (ω) and lagged values of squared error terms (ε_{t-p}^2) as shown in equation (3)

$$h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \quad (3)$$

This ARCH model was generalized by Bollerslev (1986) and it resulted into generalized ARCH class of models called GARCH (p,q) in which conditional variance depends not only upon the squared residuals of the mean equation but also on its own past values. The GARCH (p, q) model is given by equation (4)

$$h_t = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \beta_j h_{t-j} + v_t. \quad (4)$$

Where, h_t is the conditional volatility, α_i is the coefficient of ARCH term with order i to p and β_j is the coefficient of GARCH term with order j to q . The conditional volatility as defined in equation (4) is determined by three effects namely the intercept term given by ω , the ARCH term expressed by $\alpha_i \varepsilon_{t-i}^2$ and the forecasted volatility from the previous period called GARCH component expressed by $\beta_j h_{t-j}$. Parameters ω and α should be higher than 0 and β_j should be positive in order to ensure conditional variance (h_t) to be non negative. Besides this, it is necessary that $\alpha_i + \beta_j < 1$, which secures covariance stationarity of conditional variance. A straightforward interpretation of the estimated coefficients in equation (4) is that the constant term is the long term average volatility, whereas, α_i and β_j represents how volatility is affected by current and past information set(s) respectively. Moreover, the magnitude of parameters α_i and β_j determines the short-run dynamics of resulting time series volatility. Large β_j shows that shocks to the conditional variance takes long time to die out, thus volatility may persist for longer time periods. Large GARCH error coefficient indicates that volatility reacts quite intensely to market movements. Therefore, if variance of error term in equation (2) is not constant, equation (4) would be attached to equation (2),

6 For detailed discussion, see Fama (1970, 1991) and Dimson and Mussavian (1998).

7 Order of autoregression has been determined on the basis of Schwartz criteria. The Schwartz criterion uses a function of the residual sum of squares together with a penalty for large number of parameters. Specifically, the Schwartz information criterion minimizes the expression: $T * \log(\text{RSS}) + K * (\log T)$, where T is the number of observations, RSS is the sum of the squared residuals and K is the number of regressors. Lagged terms provide an explanation of the short-run deviations from the long-run equilibrium for the two test equations.

8 Lagrange Multiplier Test whose null hypothesis states that variance of error term is homoscedastic. Therefore rejection of null hypothesis will ask researcher to apply appropriate model out of GARCH family.

hence the estimation of hedge ratio (β_1) would be subject to the nature of stock/index return's volatility.

Furthermore, Nelson (1991) by taking into account the asymmetric relationship between conditional volatility and conditional mean, proposed an Exponential GARCH (EGARCH) model, which is based upon the logarithmic expression of conditional volatility in cash and futures market returns. Therefore, if the stock returns are asymmetric and the interaction between old and new information observes leverage effect, EGARCH model (i.e. equation (5)) may help to estimate an improved hedge ratio as compared to that estimated through GARCH process in equation (4).

$$h_t = \gamma_1 + \gamma_2 \left| \frac{\varepsilon_{t-1}^2}{h_{t-1}} \right| + \gamma_3 \frac{\varepsilon_{t-1}^2}{h_{t-1}} + \gamma_4 h_{t-1} \quad (5)$$

Equation (5) reports the leverage relationship between old and new information but in the speculative markets besides the leverage effect, it has been observed that traders react heterogeneously to positive and negative news. For instance, Karpoff (1987) in a survey on relationship between information arrival (trading volume as proxy for information arrival) and behaviour of stock market volatility has reported that volatility in the declining market was always higher than in the rising market. Therefore, it would be more appropriate (if conditional volatility behaves differently to positive and negative news) to segregate the impact of both positive and negative news, which can be done by specifying the variance equation in TARCH (Threshold Autoregressive Conditional Heteroscedasticity) framework and then estimate the optimal hedge ratio in the mean equation.

Equation (6) lays down the variance equation of TARCH model where, equation (4) is modified to include $\varepsilon_{t-1}^2 \xi_{t-i}$, which is a dummy for negative news having value 1 if there is negative news and 0 otherwise. Therefore, appropriate GARCH methodology would be able to capture the stylized behaviour of conditional volatility of cash market returns hence the estimated hedge ratio will be statistically robust.

$$h_t = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^p \alpha_k \varepsilon_{t-i}^2 \xi_{t-i} + \sum_{j=1}^p \beta_j h_{t-j} + v_t \quad (6)$$

where,

$$(a) \xi_{t-i} = 1, \text{ if } \varepsilon_{t-i} < 0$$

$$(b) \xi_{t-i} = 0, \text{ if } \varepsilon_{t-i} > 0$$

In the present study, equation (2) is estimated through OLS, GARCH, EGARCH or TARCH procedures to procure optimal hedge ratio, which may be constant or time-varying depending upon the property of the series under study. After estimating the optimal hedge ratio through above mentioned statistical procedures (i.e. OLS, GARCH, EGARCH and TARCH), the hedging effectiveness of all hedge ratios will be compared and the optimal hedge ratio, which reduces the portfolio variance to minimum level would be proposed as efficient hedge ratio. The efficiency of optimal hedge ratio will be measured as percentage decline in portfolio variance as shown in equation (7), where Var (U) and Var (H) represents variance of un-hedged and hedged portfolios respectively. σ_s and σ_f are standard deviation of the cash and futures returns respectively, $\sigma_{s,f}$ represents the covariability of the cash and futures returns and h^* is the optimal hedge ratio.

$$\text{Hedge effectiveness} = \frac{\text{Var (U)} - \text{Var (H)}}{\text{Var (U)}} \quad (7)$$

$$\text{Var (U)} = \sigma_s^2 \quad (8)$$

$$\text{Var (H)} = \sigma_s^2 + h^{*2} \sigma_f^2 - 2h^* \sigma_{s,f} \quad (9)$$

Results and Analysis

Before discussing the optimal hedge ratio estimation results through various econometric procedures proposed in third section and comparing their efficiency in reducing the portfolio risk, it is important to discuss the time series properties of series under examination. Results in Table 4 indicate important information relating to the summary statistics of futures and cash markets. Table 4 provides that returns of both futures and cash markets are significantly skewed (negatively skewed in most of cases) and their coefficient of kurtosis is significantly different from three, which implies that futures and cash market returns do not conform to normal distribution. The null hypothesis that futures and cash market returns follow normal distribution is further tested through Jarque-Bera test. The coefficient of Jarque-Bera test is statistically significant, which rejects the null hypothesis for all indices as well as individual stock futures and cash market returns. Finding asymmetric returns in futures and cash market is not a new observation and summary statistics in the current study are consistent with the findings of Kendall (1953),

Table 4: Descriptive Statistics

Symbol	Variables	Period	Count	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
S&P CNX NIFTY	Futures Return	Pre-Crisis	1897	0.000762	0.015545	-1.005812	12.42733	7344.651 (0.000000)
		Post-Crisis	1611	0.000134	0.017334	0.034925	12.39862	5929.756 (0.000000)
	Cash Return	Pre-Crisis	1897	0.000764	0.014686	-0.77982	8.738846	2795.453 (0.000000)
		Post-Crisis	1611	0.000133	0.016553	0.139501	13.30366	7131.576 (0.000000)
	Basis	Pre-Crisis	1898	-3.021286	10.72971	-1.162111	7.157253	1793.986 (0.000000)
		Post-Crisis	1612	8.365199	15.83275	-0.048249	4.749742	206.2627 (0.000000)
CNX IT	Future Return	Pre-Crisis	1113	-0.001025	0.07324	-30.20245	974.8229	43967608 (0.000000)
		Post-Crisis	1611	0.000458	0.019766	-1.118379	15.85492	11421.08 (0.000000)
	Cash Return	Pre-Crisis	1113	-0.001025	0.072955	-30.34406	981.087	44535639 (0.000000)
		Post-Crisis	1611	0.000457	0.019623	-0.997831	15.47627	10709.18 (0.000000)
	Basis	Pre-Crisis	1114	-6.558473	61.74875	-0.110987	33.78742	43999.03 (0.000000)
		Post-Crisis	1612	6.525481	20.73984	-0.500261	8.507673	2103.396 (0.000000)
BANK NIFTY	Future Return	Pre-Crisis	630	0.001607	0.01967	-0.342682	4.594616	79.07874 (0.000000)
		Post-Crisis	1611	0.000266	0.022433	0.169582	7.915824	1629.819 (0.000000)
	Cash Return	Pre-Crisis	630	0.001581	0.0191	-0.256535	4.497138	65.74739 (0.000000)
		Post-Crisis	1611	0.000268	0.021915	0.190462	7.790204	1549.994 (0.000000)
	Basis	Pre-Crisis	631	6.606973	23.53106	0.157329	5.978094	235.7851 (0.000000)
		Post-Crisis	1612	13.70149	36.37927	0.146542	3.834704	52.5666 (0.000000)

Fama (1965), Stevenson and Bear (1970), Chen (1996), Reddy (1997), and Kamath (1998).

Rejecting the null hypothesis that returns of speculative assets do not follow normal distribution suggests that information dissemination process in these markets may not be efficient and returns are not symmetrically

distributed among buyers and sellers. Significantly skewed returns imply that extremely divergent risk perceptions for same information set persists in the market, which may not allow futures and cash market returns to represent their cost-of-carry and intrinsic value respectively. It also indicates that two markets do not adequately discount risk premium component contained in the new information

set travelled to the market. Asymmetry in the cash and futures market returns is not an unexpected phenomenon because traders with varied trading interests interact in both markets and react heterogeneously to different news. For instance, the risk averse nature of traders in a speculative asset market may be a prominent cause for the asymmetric returns (Moolman, 2004) because due to high degree of volatility in speculative markets, both optimistic and pessimistic views of traders to new information set(s) causes unexpected variations in prices (Diagler & Wiley, 1999). Furthermore, in speculative markets like stock, derivatives and commodity markets, it has been observed that volume on uptick (positive news) is always higher than the volume on downtick (pessimistic news), because in bull market, traders consider every dip in the stock/index as an opportunity to buy, which in turn causes speculative asset's returns to behave asymmetrically (for detail see, Karpoff, 1987).

Type of traders in two markets may be a potential factor affecting the theoretical distribution of speculative asset's returns. It is an established fact that Indian cash market is predominantly driven by foreign as well as domestic institutional investors and retail investors plays little role in the market movements. On the other hand, in futures market retail investors participation is very significant and institutional investors have little role to play⁹. Therefore, asymmetric profile of investors in both markets may be a strong determinant for significant asymmetry in basis because institutional investors base their trading decision on sophisticated analysis undertaken by a team of professionals, whereas, retail traders base their decision on firm-specific or insider information (Thomas, 2006), which will be little stale or late, resultantly timing of trading by two group of investors will be different, hence, new information will take time to die out and will cause asymmetric jumps in the conditional volatility of both markets.

Moreover, exploitation of available arbitrage opportunities to secure reward out of market disequilibrium causes mean reversion in basis, which implies that increase in spread on account of reaction by different market agents

⁹ Retail participants drive approximately 60% of the total trading volume in the Indian equity futures market, however, the participation of institutional traders approximates to only 10% of the total trading volume. For reference, see Monthly Derivatives Market Update published by National Stock Exchange of India (www.nseindia.com).

reverts back to its intrinsic value because basis like any financial time series possesses asymptotic property. Therefore, stationary basis is presumed to observe mean reverting behaviour because when spread between two prices is different from cost-of-carry, arbitrageur's participation will correct the deviation and basis will start representing cost-of-carry of the underlying asset (Zeng, 2001; Theobald & Yallup, 2001; Monoyios & Sarno, 2002; Pattarin & Ferretti, 2004). Thus, mean reverting behaviour and negative correlation between basis and time-to-expiry of a contract may be another potential reason for negatively skewed basis.

In addition to the theoretical distributional properties of futures and cash markets, another important observation can be drawn from unit root test results, which suggests that returns in both futures and cash markets are significantly predictable, thus, refuting the null hypothesis of Efficient Market Theory that returns in speculative markets follow random walk model¹⁰. Random walk model requires that price changes in speculative markets should be a function of new information set and asset prices immediately discounts all relevant information as it becomes available, which implies weak form efficiency of the speculative asset (for detail, see Fama, 1970). However, stationary futures and cash market returns suggest that information dissemination efficiency in Indian equity futures and cash markets is weak and informed traders can frame market strategies to exploit arbitrage and/or speculative opportunities as these become available. These findings are consistent with early works on similar hypothesis in the Indian capital market by Barua (1981), Sharma (1983), Gupta (1985), Rao (1988), Chaudhuri (1991), Reddy (1997), Mishra (1999), Anshuman and Goswami (2000), Ranjan and Padhye (2000), Pant and Bishnoi (2001), Nath (2002), Marisetty (2003), Mangala and Mittal (2005), and Gupta and Singh (2006b).

Furthermore, Table 5 reports the hedge ratio estimated through Ederington's Model, ARMA (p,q), GARCH(p,q), EGARCH(p,q) and TGARCH(p,q). The hedge ratios estimated through five models are reported for near month contracts. Two major observations in Table 5 are (i) hedge ratios have found to be increased using all the five models

¹⁰ For reference on testing the Random Walk Hypothesis by applying Stationarity Tests, see Crowder and Phengpis (2005) and Evans (2006).

Table 5: Estimation of Optimal Hedge Ratio

Symbol	Period	OLS	ARMA OLS	GARCH (1,1)	EGARCH (1,1)	TGARCH (1,1)
S&P CNX NIFTY	Pre-Crisis	0.919121	0.944721	0.939287	0.931622	0.936941
	Post-Crisis	0.947727	0.961820	0.968201	0.971413	0.972002
CNX IT	Pre-Crisis	0.994782	0.999963	0.998962	0.996352	0.997334
	Post-Crisis	0.976806	0.98581	1.003836	1.004676	1.003553
BANK NIFTY	Pre-Crisis	0.953755	0.9773	0.983516	0.986877	0.983375
	Post-Crisis	0.970856	0.98061	0.982665	0.982165	0.985083

Table 6: Hedging Effectiveness (Percentage)

Symbol	Period	OLS	ARMA OLS	GARCH (1,1)	EGARCH (1,1)	TARCH (1,1)
S&P CNX NIFTY	Pre-Crisis	94.55	94.47	94.5	94.53	94.51
	Post-Crisis	98.37	98.35	98.32	98.31	98.30
CNX IT	Pre-Crisis	99.55	99.55	99.55	99.55	99.55
	Post-Crisis	96.69	96.68	96.63	96.63	96.63
BANK NIFTY	Pre-Crisis	96.17	96.10	96.06	96.04	96.06
	Post-Crisis	98.65	98.63	98.63	98.63	98.62

during post crisis period (except CNXIT) (ii) hedge ratio estimated through Ederington's model and ARMA (p,q) are constant hedge ratios and their hedging coefficients are relatively smaller than the hedge ratios estimated through time varying models i.e. GARCH, EGARCH and TGARCH.

From these two observations, one conclusion can be drawn that the cost of hedging through constant hedge ratio is higher than time varying hedge ratio and cost of hedging has been increased relatively during post crisis period. However, table 5 reports the hedge effectiveness in the form of variance reduction after taking hedging position by using the estimated hedge ratios. It has been observed that hedge effectiveness has been increased during post crisis period (except CNXIT). Moreover, there is no significant difference between the hedge effectiveness by using the hedge ratio estimated through Ederington's model and ARMA (p,q), GARCH (p,q), EGARCH (p,q)

and TGARCH (p,q). Therefore, the findings suggest that knowledge of sophisticated econometrical procedures does not help to construct a better portfolio and improve hedge effectiveness. The probable reason for increase in hedge effectiveness may be an increase in the co-movement between both the markets.

Conclusion

Indian derivative market has observed a remarkable growth in futures trading since its introduction in the year 2000. Spurt growth in the volume of the futures contracts is evidently supporting the fact that futures contract have been considered as standard risk management tool that enables risk-averse investors to hedge price risks of underlying financial transaction/ inventory holding over a certain period of time. However, research on hedging efficiency of futures market is still at its infancy. To the best of our knowledge, there have been only few attempts

(see, Bhaduri & Durai, 2007; Rao & Thakur, 2008; Gupta & Singh, 2009; Pradhan, 2011) all of which have restricted their scope to examine the optimal hedge ratio in Indian equity futures market. However, as mentioned in the first section, a brief literature has found that volatility in stock markets is an important determinant of hedging effectiveness. Therefore, present study is an attempt to examine the relationship between time-to-expiry of futures contracts and hedging effectiveness by using three benchmark indices of NSE (S&PCNXNIFTY, CNXIT and BANKNIFTY), thus, widening the horizon of hedging literature in Indian equity futures market.

The returns of both futures and cash markets are found to be significantly negatively skewed and kurtic which rejects the null hypothesis that market returns are symmetrically distributed among buyers and sellers implying that information dissemination process is inefficient in the market under study. Furthermore, basis has found to be negatively skewed which may be due to existence of negative correlation between basis and time-to-expiry of futures contracts.

Hedge ratios have been estimated for near month contracts for S&PCNXNIFTY, CNXIT and BANKNIFTY by employing five different methodologies namely, Ederington's Model, ARMA (p,q), GARCH(p,q), EGARCH(p,q) and TGARCH(p,q). The present study finds an increase in hedge ratios for S&PCNXNIFTY and BANKNIFTY during post crisis period. Moreover, it has been found that hedge ratios estimated through constant hedging models (Ederington's model and ARMA (p,q)) are relatively smaller than the hedge ratios estimated through time varying models (GARCH, EGARCH and TGARCH). Therefore, the study suggests the use of any econometric procedure for estimating optimal hedge ratio does not lead to an improvement in the hedging effectiveness of portfolio. The result of hedging effectiveness suggests that hedging effectiveness has been increased for S&PCNXNIFTY and BANKNIFTY during post crisis period.

The overall conclusion of the study suggests that hedging effectiveness has been increased post-financial crisis 2008, however, it is also accompanied by an increase in the cost of hedging. It also implies that hedging effectiveness is affected by persistence of volatility in market. Moreover, the study suggests use of time invariant hedging models for estimating optimal hedge ratio.

References

- Abdulnasser Hatemi-Ja, E. R. (2006). Calculating the optimal hedge ratio constant, time varying and the kalman filter approach. *Applied Economics Letters*, 13, 293–299.
- Aggarwal, R., & DeMaskey, A. L. (1997). Using derivatives in major currencies for cross-hedging currency risks in asian emerging markets. *The Journal of Futures Markets*, 17(7), 781–796.
- Ali, R., & Afzal, M. (2012). Impact of global financial crisis on stock markets: Evidence from Pakistan and India. *Journal of Business Management and Economics*. 3(7), 275-282.
- Alizadeh, A., & Nomikos, N. (2004). A markov regime switching approach for hedging stock indices. *The Journal of Futures Market*, 24(7), 649-674.
- Anshuman, R., & Goswami, R. (2000). Day of the week effects on the bombay stock exchange. Research Paper Presented in UTI Capital Market Conference Proceedings, 1-33.
- Awang, N., Azizan, N. A., Ibrahim, I., & Said R. M. (2014). Hedging effectiveness of stock index futures market: An analysis on malaysia and singapore futures markets. Research Paper Presented in International Conference on Economics, Management and Development Proceedings, 24-34.
- Barua, S. K. (1981). The short-run price behaviour of securities: Some evidence on efficiency of indian capital market. *Vikalpa*, 16(2), 93-100.
- Bhaduri, S. N., & Durai, S. R. (2007). Optimal hedge ratio and hedging effectiveness of stock index futures: Evidence from India. *NSE Research Paper*. India: NSE.
- Bhargava, V., & Malhotra, D. (2007). Determining the optimal hedge ratio: Evidence from cotton and soybean markets. *Journal of Business and Economic Studies*, 13(1), 38-57.
- Bose, S. (2006). The Indian derivatives market revisited. *ICRA Bulletin: Money and Finance*, 81-112.
- Brooks, C., Cerny, A., & Miffre, J. (2012). Optimal hedging with higher moments. *The Journal of Futures Markets*, 32(10), 909-944.
- Butterworth, D., & Holmes, P. (2001). The hedging effectiveness of stock index futures: Evidence for the FTSE-100 and FTSE-mid250 indexes traded in the UK. *Applied Financial Economics*, 11, 57-68.
- Carlton, D. (1984). Futures markets: Their purpose, their history, their successes and failures. *The Journal of Futures Markets*, 4(3), 237-271.

- Castelino, M. G. (1992). Hedge effectiveness: Basis risk and minimum-variance hedging. *The Journal of Futures Markets*, 20(1), 89-103.
- Chan, L., & Lien, D. (2001). Cash Settlement and Price Discovery in Futures Market. *Quarterly Journal of Business and Economics*, 40 (3/4), 65-77.
- Chang, C. Y., Lai, J. Y., & Chuang I. Y. (2010). Futures hedging effectiveness under the segmentation of bear/bull energy markets. *Energy Economics*, 32, 442-449.
- Chang, E., Chou, R. Y., & Nelling, E. (2000). Market volatility and the demand for hedging in stock index futures. *The Journal of Futures Markets*, 20(2), 105-125.
- Chaudhuri, S. K. (1991). Short-run behaviour of industrial share price indices: An empirical investigation. *Prajnan*, 22(2), 169-183.
- Ping, C. (1996). A random-walk or color-chaos on the stock market?- Time- frequency analysis of S & P indexes. *Studies in Nonlinear Dynamics & Econometrics*, 1(2), 87-103.
- Chen, C.-C., & Tsay, W.-J. (2011). A markov regime-switching arma approach for hedging stock indices. *The Journal of Futures Market*, 31(2), 165-191.
- Chen, S.-S., Lee, C.-F., & Shrestha, K. (2004). An empirical analysis of the relationship between the hedge ratio and hedging horizon: A simultaneous estimation of the short- and long-run hedge ratios. *The Journal of Futures Markets*, 24(4), 359-386.
- Chen, S. Y., Lin, C. C., Chou, P. H., & Hwang, D. Y. (2002). A comparison of hedge effectiveness and price discovery between TAIEX TAIEX index futures and SGX MSCI Taiwan index futures. *Review of Pacific Basin Financial Markets and Policies*, 5(2), 277-300.
- Chen, S.-S., Lee, C.-F., & Shrestha, K. (2001). On a mean-generalized semivariance approach to determining the hedge ratio. *The Journal of Futures Markets*, 21(6), 581-598.
- Cox, C. C. (1976). Futures trading and market information. *The Journal of Political Economy*, 84(6), 1215-1237.
- Crowder, W. J., & Phengpis, C. (2005). Stability of the S&P 500 futures market efficiency conditions. *Applied Financial Economics*, 15, 855-866.
- Diagler, R. T., & Wiley, M. K. (1999). The impact of trader type on the futures volatility-volume relation. *The Journal of Finance*, 54(6) 2297-2316.
- Dimson, E., & Mussavian, M. (1998). A brief history of market efficiency. *European Financial Management*, 4(1), 91-104.
- Ederington, L. H. (1979). The hedging performance of the new futures markets. *The Journal of Finance*, 34(1), 157-170.
- Evans, T. (2006). Efficiency tests of the U.K. financial futures markets and the impact of electronic trading systems. *Applied Financial Economics*, 16, 1273-1283.
- Fama, E. F. (1965). The behavior of stock-market prices. *The Journal of Business*, 38(1), 34-105.
- Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance*, 25(2), 383-417.
- Figlewski, S. (1984). Hedging performance and basis risk in stock index futures. *The Journal of Finance*, 39(3), 657-669.
- Floros, C., & Vougas, D. V. (2004). Hedge Ratio in Greek Stock Index Futures Market. *Applied Financial Economics*, 14, 1125-1136.
- Floros, C., & Vougas, D. V. (2006). Hedging effectiveness in greek stock index futures market, 1999-2001. *International Research Journal of Finance and Economics*, 5, 7-18.
- Garbade, K. D., & Silber, W. L. (1983). Price movement and price discovery in futures and cash markets. *The Review of Economics and Statistics*, 65(2), 289-297.
- Goudarzi, H., & Ramanarayanan, C. S. (2011). Modeling asymmetric volatility in the Indian stock market. *International Journal of Business and Management*, 6(3), 221-231.
- Gupta, K., & Singh, B. (2006a). Random walk and indian equity futures market. *ICFAI Journal of Derivatives Market*, 3(3), 23-42.
- Gupta, K., & Singh, B. (2006b). Investigating the price discovery efficiency of Indian equity futures market. *PARADIGM*, 10(2), 33-45.
- Gupta, K., & Singh, B. (2009). Estimating the optimal hedge ratio in Indian equity futures market. *Journal of Financial Risk Management*, 6 (3 & 4), 38-98.
- Gupta, O. P. (1985). *Behaviour of share prices in India: A test of market efficiency*. National Publications, New Delhi.
- Harris, R. D. F., & Shen, J. (2003). Robust estimation of the optimal hedge ratio. *Journal of Futures Markets*, 23(8), 799-816.

- Hatemi-J, A., & Roca, E. (2006). Calculating the optimal hedge ratio: Constant, time varying and the Kalman Filter approach. *Applied Economics Letters*, 13(5), 293-299.
- Holmes, P. (1995). Ex ante hedge ratios and the hedging effectiveness of the FTSE-100 stock index futures contracts. *Applied Economics Letters*, 2, 56-59.
- In, F., & Kim, S. (2006). The hedge ratio and the empirical relationship between the stock and futures markets: A new approach using wavelet analysis. *The Journal of Business*, 79(2), 799-820.
- Johnson, L. (1960). The theory of hedging and speculation in commodity futures. *Review of Economic Studies*, 27, 139-151.
- Joshi, P. (2012). Financial crisis and volatility behaviour of stock markets of Asia. *TIMS - QUEST*, 2(2).
- Juhl, T., Kawaller, I. G., & Koch, P. D. (2012). The effect of the hedge horizon on optimal hedge size and effectiveness when prices are cointegrated. *The Journal of Futures Markets*, 32(9), 837-876.
- Kamara, A. (1982). Issues in futures markets: A survey. *The Journal of Futures Markets*, 2(3), 261-294.
- Kamara, A., & Siegel, A. F. (1987). Optimal hedging in futures markets with multiple delivery specifications. *The Journal of Finance*, 42(4), 1007-1021.
- Kamath R. R. et al., (1998). Return distribution and the day-of-the-week effects in the stock exchange of Thailand. *Journal of Economics and Finance*, 22(2-3), 97-106.
- Karpoff, J. M. (1987). The relation between price changes and trading volume: A survey. *Journal of Financial and Quantitative Analysis*, 22(1), 109-126.
- Kendall, M. G., & Hill, B. A. (1953). The analysis of economic time series part I. prices. *Journal of Royal Statistical Society*, 96, 11-25.
- Kenourgios, D., Samitas, A., & Drosos, P. (2008). Hedge ratio estimation and hedging effectiveness: the case of the S&P 500 stock index futures contract. *International Journal of Risk Assessment and Management*, 9(1/2), 121-134.
- Kofman, P., & Patrick, M. (2005). Structurally sound dynamic index futures hedging. *The Journal of Futures Markets*, 25(12), 1173-1202.
- Kroner, K. F., & Sultan, J. (1993). Time-varying distributions and dynamics hedging with foreign currency futures. *The Journal of Financial and Quantitative Analysis*, 28(4), 535-551.
- Kumar S. S. S. (2012). "Financial Derivatives", Edition 5, PHI Learning Private Limited, 1-28.
- Kadapakkam, P. R., & Kumar, U. (2013). Impact of Liquidity on the Futures-Cash Basis: Evidence from the Indian Market. *Journal of Futures Markets*, 33(3), 266-298.
- Lee, H. T. and Yoder, J. K. (2007). A Bivariate Markov Regime Switching GARCH Approach to Estimate Time Varying Minimum Variance Hedge Ratios. *Applied Economics*, 39, 1253-1265.
- Lien, D. (2005). A Note on the Superiority of the OLS Hedge Ratio. *The Journal of Futures Market*, 25 (11), 1121-1126.
- Lien, D., & Luo, X. (1994). Multiperiod Hedging in the Presence of Conditional Heteroskedasticity. *The Journal of Futures Markets*, 14(8), 927-955.
- Longin, F., & Solnik, B. (2001). Extreme correlation of international equity markets. *Journal of Finance*, 56, 649-676.
- Mangala, D., & Mittal, R. K. (2005). Efficiency of Indian stock market: An evidence of day-of-the-week effect. *Gyan – A Bi-Annual Journal of Management & Technology*, 1(1), 3-8.
- Marisetty, V. B. (2003). Measuring productive efficiency of stock exchanges using price adjustment coefficients. *International Review of Finance*, 4(1-2), 79-99.
- Mishra, B. (1999). Presence of friday effect in Indian stock market. *Paradigm*, 3(2), 57-64.
- Moolman, H. C. (2004). An asymmetric econometric model of the South African stock market. Ph. D thesis submitted to faculty of economics and management science at University of Pretoria, 1-195.
- Monoyios, M., & Sarno, L. (2002). Mean reversion in stock index futures markets: A nonlinear analysis. *The Journal of Futures Markets*, 22(4), 285-314.
- Moschini, G., & Myers, R. J. (2002). Testing for constant hedge ratios in commodity markets: A multivariate GARCH approach. *Journal of Empirical Finance*, 9, 589-603.
- Myers, R. J. (1991). Estimating time-varying optimal hedge ratios on futures markets. *The Journal of Futures Markets*, 20(1), 73-87.
- Nath, G. C. (2002). Long memory and Indian stock market – An empirical evidence. Research Paper Presented in UTI Capital Market Conference Proceedings, 1-20.
- Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica*, 59, 347-370.

- Neuberger, A. (1999). Hedging long-term exposures with multiple short-term futures contracts. *The Review of Financial Studies*, 12(3), 429-459.
- Pant, B., & Bishnoi, R. T. (2001). Testing random walk hypothesis for Indian stock market indices. Research Paper Presented in UTI Capital Market Conference Proceedings, 1-15.
- Park, T. H., & Switzer, L. N. (1995). Time-varying distributions and the optimal hedge ratios for stock index futures. *Applied Financial Economics*, 5, 131-137.
- Pattarin, F., & Ferretti, R. (2004). The Mib30 index and futures relationship: econometric analysis and implications for hedging. *Applied Financial Economics*, 14, 1281-1289.
- Penning, M. E., & Meulenberg, M. T. G. (1997). The Journal of Futures Market, 17(5), 599-615. John Wiley & Sons, Inc.
- Pradhan, K. C. (2011). The hedging effectiveness of stock index futures: Evidence for the S&P CNX nifty index traded in India. *South East European Journal of Economics & Business*, 6(1), 111-123.
- Rao, N. S. V. D., & Thakur, S. (2008). Optimal hedge ratio and hedge efficiency: An empirical investigation of hedging in Indian derivatives market. Downloaded from <https://www.soa.org/library/monographs/other-monographs/2008/april/mono-2008-mas08-1-thakur.pdf> on January 21, 2014.
- Rao, K. N. (1988). Stock market efficiency: Indian experience," Proceedings of National Seminars on Indian Securities Markets: Thrust and Challenges, March 24-26, University of Delhi, 1988: New Delhi.
- Ranjan, R., & Padhye, A. (2000). Market anomalies in emerging markets: Revisiting the calendar effect in stock prices. ICICI Research Centre. Org., 1-19.
- Reddy, S. Y. (1997). Efficiency of Indian stock markets: An empirical analysis of weak-form EMH of the BSE. Research Paper Presented in UTI Capital Market Conference Proceedings, 91-115.
- Sharma, J. L. (1983). Efficient capital markets and random character of stock price behaviour in developing economy. *Indian Journal of Economics*, 63, 395-419.
- Stein, J. L. (1961). The simultaneous determination of spot and futures prices. *The American Economic Review*, 51(5), 1012-1025.
- Stevenson, A. R., & Bear, M. R. (1970). Commodity futures: Trends or random walks?. *The Journal of Finance*, 25(1), 65-81.
- Telser, L. G. (1981). Why there are organised futures markets. *Journal of Law and Economics*, 24(1), 1-22.
- Theobald, M., & Yallup, P. (2001). Mean reversion and basis dynamics. *The Journal of Futures Markets*, 21(9), 797-818.
- Theobald, M., & Yallup, P. (1997). Hedging Ratios and Cash/Futures Market Linkages. *The Journal of Futures Markets*, 17(1), 101-115.
- Thomas, S. (2006). Interdependence and dynamic linkages between S&P CNX Nifty futures and spot market: With specific reference to volatility, expiration effects and price discovery mechanism. PhD Thesis, Department of Management Studies, IIT Madras.
- Working, H. (1953). Futures trading and hedging. *American Economic Review*, 43, 314-343.
- Working, H. (1962). New concepts concerning futures markets and prices. *The American Economic Review*, 52(3), 431-459.
- Yang, M. J., & Lai, Y.-C. (2009). An out-of-sample comparative analysis of hedging performance of stock index futures: Dynamic versus static hedging. *Applied Financial Economics*, 19, 1059-1072.
- Zeng, T. (2001). Mean reversion and the comovement of equilibrium spot and futures prices: Implications from alternative data-generating processes. *The Journal of Futures Markets*, 21(8), 769-796.