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Can Crude Oil Futures be the Good Hedging Tool for Tyre Equities? Evidence from India

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ABSTRACT

This article examines the cross-hedging performance of crude futures against the tyre equity futures to hedge the tyre equity stocks. Three multivariate conditional volatility models, namely constant conditional correlation (CCC), dynamic conditional correlation (DCC) and diagonal BEKK are applied. Using the conditional covariance and variance from the MGARCH estimates, the optimal hedge ratios (OHRs) are computed. The results of this study show that the volatility spillover exists between the returns of crude oil futures and tyre equity. However, for tyre equities, the best cross hedge is tyre equity futures rather than crude futures. All the MGARCH estimates show better hedging possibility with tyre equity futures, particularly MRF futures.

Keywords: Constant Conditional Correlation, Crude Future, Dynamic Conditional Correlation, Diagonal BEKK, Tyre Equity, Tyre Equity Futures JEL Classifications: G21; G30

1. INTRODUCTION

The tyre industry in India contributes 3% for manufacturing GDP and 0.5% for the total GDP. The growth of this industry is more than the automobile industry which is considered as the mother for tyre industry. Presently, India is a marginal player in the world tyre market, but opportunities are tremendous because of the economies of scale, increasing income level of the people and easy access to core raw material rubber (Ghosh et al., 2011). With these strong fundamentals, we believe that the investor's interest in tyre equities is very high to earn a good amount of dividend and capital appreciation. However, on the other hand, a couple of studies have mentioned volatile raw material price pressure as well. For example, Meher et al. 2020; Daddikar and Rajgopal, (2016); Kansara, (2018); Shyam, (2019) have studied the impact of volatile crude oil price and synthetic rubber price on the performance of tyre manufacturing equities in India. The increased

cross border movements of goods and services have increased volatility in Indian equity market (Pinto et al., 2020; Kumar et al., 2020; Bagchi, 2017; Pandey and Vipul, 2018; Bolar et al., 2017; Hawaldar, 2018; 2016). In a volatile market, investors will look for a hedging tool to minimize the risk of loss for their portfolio. The future derivative with an active market and great volume will be the right tool to hedge the risk portfolio. However, from the Indian tyre equity perspective, a couple of large-cap tyre equities have direct futures and many other medium or small-cap are not traded in the futures and options market. This paper investigates the possibility of a cross hedge for tyre equity stocks in India using crude oil futures (Hawaldar et al., 2017a; 2017b; Iqbal, 2015; 2014).

Cross hedge with commodity futures for equity and vice versa has become the subject of interest today with many academicians and practitioners (Iqbal, 2011; Wang and Lee, 2016; Mallikarjunappa and Iqbal, 2003). Crude oil or other energy futures are the actively

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traded derivatives in several economies and cross hedge with these instruments are widely examined by many researchers. For example, Batten et al. (2017; 2019) stated that the areas of stock and energy sector integrations are critical to managing the risk. Xu (2020) found a negative correlation between the crude oil and the equity returns in the global portfolio of equities. A study by Singh and Sharma (2018) states that for variables crude oil and Sensex, the long-run equilibrium relationship is evident during and pre-crisis phase. Chunhachinda et al. (2018) studied that for Latin American stocks, commodity hedging will be more effective to reduce the portfolio risk but these are more expensive strategies. Olson et al. (2018) studied that the oil and gas equity index was the most effective cross hedge for energy stocks; Abul and Sadorsky (2015) studies the possibility of cross hedge for equity using oil, bond and gold futures. The chance for the cross hedge of equities in the US with energy commodities during the stock market crisis is very high (Junttila et al., 2018). Ahmad et al. (2018) cited a couple of examples for a cross hedge of clean energy equities with crude oil futures and their study revealed that crude oil future is the second-best asset to hedge the clean energy equities. Dutta (2018) claim that equity hedging using oil futures is common. A studies by Meher et al., (2021); Kumar and Maheswaran, (2013); Iqbal and Mallikarjunappa, (2011; 2010) found evidence of return and volatility effects of the oil market on the Indian manufacturing sector. Further, Kansara (2018) in his article in Business line stated that the tyre stocks skid on rising oil prices. To narrate from the above cited studies, the manufacturing industries performance is affected by the volatile oil price and many studies have shown the relationship between oil price and equity market movements. Couple of studies have examined the possibility of cross hedge with crude for equities. However, the study on hedging strategies for Indian tyre equities is not covered so far in the academic literatures. Hence, the possibility of a cross hedge for Indian tyre equities with crude futures or available tyre futures have become the purpose of this empirical study.

Traditionally, the OLS method was used in many studies to compute the minimum variance hedge ratio, but the constant variance and covariance assumption of this model was strongly criticised by many academicians and practitioners in the area of statistics and econometrics. Hence, to compute the minimum variance hedge ratio, researchers today are widely using conditional covariance and variance from the family of multivariate GARCH.

2. CROSS HEDGING: MILESTONES IN METHODOLOGY AND THE PRESENT STATUS

Pioneering studies on hedging and cross hedging by (Johnson, 1960; Ederington, 1979; Miller, 1985; Miller and Luke, 1986) have applied the linear OLS method to estimate the optimal hedge ratio. Grant and Eaker (1989) have used the OLS method to compare the cross hedge effectiveness of different agricultural commodities. Benet (1990) has employed the OLS method to examine the possibility of cross hedge using commodity futures to minimise foreign exchange risk. Braga and Martin (1990)

employed Anderson's revised OLS technique to examine the feasibility of cross hedge for Soybean meal price with Soybean futures. This was continued for a period of 15-20 years, where researchers were using linear OLS regression of changes in the price of cash asset on changes in the price of futures (Kumar et al., 2018; Iqbal and Mallikarjunappa, 2009; 2007). Thereby the beta coefficient (constant slope) of the regression equation will become the optimal hedge ratio. Nelson and Plsser (1982) stated that the macroeconomic time series will depict serial correlation and the predictions of these series using OLS are useless. Hence, to overcome this problem, Benninga et al. (1983) suggested the use of the log return series in the regression model to avoid spurious constants in hedging. Dahlgran (2000) and Kim et al. (2015) have used log return series to compute the hedge ratio using the OLS method. The general form of the OLS regression is shown in the following equation. In the following equation, the TE, is the logged returns of the tyre equity spot prices and CF, is log-returns of crude oil futures prices with maturity T:

$$\log TE_t - \log TE_{t-1} = a + b \left(\log CF_{t,T} - \log CF_{t-1,T} \right) + \varepsilon_t \quad (2.1)$$

Where b in the above equation is the estimated minimum variance hedge ratio.

However, Eq. (2.1) ignores the lagged values of future and cash return series which leads to serially correlated errors. Chang et al. (2011) claim that the financial asset variance and covariance are time-varying. Baillie and Myers (1991) states that the covariance of spot and futures prices are time-varying. In addition, Adams and Gerner (2012) opined that the OLS approach does not capture time-varying conditional volatility. Thus, the recent studies in the field of hedge ratio estimation have employed and suggested to use of the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model of (Bollerslev, 1986; Engle, 1982). For example, Abul and Sadorsky (2015) concluded that to hedge stock price with oil, the hedge ratio using the Asymmetric Dynamic Conditional Correlations (ADCC) model from the family of MGARCH is most effective. Ahmad et al. (2018) have applied MGARCH family models (DCC, ADCC and GO- GARCH) to estimate the time-varying optimal hedge ratios for clean energy equities. Chunhachinda et al. (2018) use the DCC - GARCH model to find the dynamic correlations between commodities and international equity portfolios. Cifarelli and Paladino (2015); Kim and Park (2016) uses bivariate GARCH models to estimate the time-varying conditional correlation. Sharma and Rodriguez (2019) have used the DCC GARCH model to analyse the hedging role of crude oil in the equity market of the United States. The asymmetric Power Arch (APARCH) model was adopted by Bagchi (2017) to analyse the relationship between crude oil price volatility and BSE Sensex. Pandey and Vipul (2018) uses the multivariate GARCH model BEKK to examine the volatility spillover from crude oil to the BRICS stock market.

The purpose of this research is two-fold. Former, we estimate three MGARCH models, namely CCC, DCC and diagonal BEKK for the returns on spot tyre equity prices with two tyre equity futures and crude oil futures prices. Later, we calculate the Optimal Hedge Ratios (OHRs) for effective hedging strategies.

3. ECONOMETRIC MODELS

3.1. Multivariate Conditional Volatility Models

The CCC model of Bollerslev (1990) assumes constant conditional correlations, while the DCC model of Engle (2002) and the BEKK model of Engle and Kroner (1995) accommodate dynamic conditional correlations. Consider the multivariate GARCH model CCC of Bollerslev (1990).

$$y_t = E(y_t \varsigma F_{t-1}) + e_t \tag{3.1}$$

$$\operatorname{Var}(\varepsilon_t F_{t-1}) = \Omega_t$$

Where F_{t-1} is the - area quantified by all the available information till time t–1 and Ω_t is the conditional covariance matrix, which is positive definite and symmetric.

$$\Omega_{t} = \begin{pmatrix} \sigma_{CF,t} & 0 \\ 0 & \boldsymbol{\delta}_{TE,t} \end{pmatrix} \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \begin{pmatrix} \sigma_{CF,t} & 0 \\ 0 & \sigma_{TE,t} \end{pmatrix}$$
(3.2)
$$\Omega = \begin{pmatrix} \sigma_{CF,t}^{2} & \rho \cdot \sigma_{CF,t} \cdot \sigma_{TE,t} \\ \rho \cdot \sigma_{CF,t} \cdot \sigma_{TE,t} & \sigma_{TE,t}^{2} \end{pmatrix}$$

 Ω_{i} has a particular decomposition of three matrices. The first and third matrix in Eq. 3.1 is diagonal matrices, where the diagonal elements are given by the conditional standard deviations of the logged returns of the crude future (CF) and tyre equity (TE) price series. The second matrix is the conditional correlation matrix, where the element ρ in the matrix is a conditional correlation between the return series of crude future and tyre equity. The first element in the resultant matrix of the decomposed matrices is the conditional variance of the crude future return series and the second diagonal element is the variance of the tyre equity return series. The off-diagonal elements in the resultant matrix are the rho times the conditional standard deviations of the two-return series. The $\sigma_{CF,t}^{2}$ and $\sigma_{TE,t}^{2}$ in Ω_{i} matrix are given by Eq. (3.3), they are the univariate GARCH (1,1) specifications.

$$\sigma_{CF,t}^{2} = \alpha_{CF} + \alpha \epsilon_{CF,t-1}^{2} + \beta_{CF} \sigma_{CF,t-1}^{2}$$
(3.3)

$$\sigma_{TE,t}^{2} = \alpha_{TE} + \alpha \in \mathcal{T}_{TE,t-1}^{2} + \beta_{TE} \sigma_{TE,t-1}^{2}$$

The CCC model assumes that conditional correlation ρ is constant over time. Engle (2002) extended the CCC MGARCH to accommodate the dynamic correlation within the model. For the conditional covariance matrix in Eq. (3.2).

The covariance matrix
$$\Omega_t = D_t R_t D_t$$
 (3.4)

The D_t , R_t , D_t in Eq. (3.4) are the decomposed matrices of covariance matrix Ω_t . The D_t and D_t are the diagonal matrices, where the conditional standard deviations of the logged returns of the crude future (CF) and tyre equity (TE) price series are vectors. The conditional standard deviations are given by Eq. (3.3), which are the univariate GARCH (1,1) specifications. The second matrix is the dynamic conditional correlation matrix; the off-diagonal

elements in this matrix are the dynamic conditional correlation ρ_t between the return series of crude future and tyre equity. The general formation of R_t as that appeared in Engle (2002) work is presented in Eq. 3.5.

$$R_t = \left(diag\left(Q_t\right)\right)^{\frac{1}{2}} Q_t \left(diag\left(Q_t\right)\right)^{\frac{1}{2}}$$
(3.5)

$$Q_t = S(1 - \alpha - \beta) + \alpha (\varepsilon_{CF,t-1} \varepsilon_{TE,t-1}) + \beta Q_{t-1}$$
(3.6)

Where Q_t is the dynamic covariance matrix of the standardised epsilons, S is the unconditional correlations of $\varepsilon_{CF,t} \varepsilon_{TE,t}$ and $(\alpha+\beta)<1$. This implies that $Q_t > 0$, if $\alpha = \beta = 0$, Q_t in Eq. 3.6 is as same as CCC. As Q_t is conditional on the vector of standardised epsilons, Eq. 3.6 is a conditional covariance matrix, and S is the unconditional correlations of $\varepsilon_{CF,t} \varepsilon_{TE,t}$. This DCC method of estimation is a simple two-step method using the likelihood function, while the DCC is not linear (Chang et al., 2013).

An alternative time-varying conditional model used in many hedging strategy studies is the BEKK model. Chang et al. (2013) and Chang et al. (2011) opined that the positive definite conditional covariance matrices in BEKK are the attractive property in it. The general formation of BEKK multivariate GARCH (11) is presented in Eq. 3.7.

$$H_{t} = C'C + A'\epsilon_{t-1}\epsilon'_{t-1}A + B'H_{t-1}B$$
 (3.7)

Where C, A and B in the above equation are individual element of the matrices, and they are given as

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, C = \begin{bmatrix} C_{11} & 0 \\ C_{21} & C_{22} \end{bmatrix}$$

The study of Caporin and McAleer (2008; 2009) has critically compared the BEKK and DCC model of multivariate GARCH, where the diagonal version of BEKK is also discussed there in detail.

3.2. Optimal Hedge Ratios

To compute the optimal hedge ratios, we have used the conditional covariance matrix obtained from different multivariate GARCH models. Eq. 3.8. is used to compute the OHR (optimal hedge ratio) from conditional covariance for tyre equity spot with tyre equity futures and crude futures.

$$\gamma_t^* \left| \Omega_{t-1} = \frac{h_{SF,t}}{h_{F,t}} \right|$$
(3.8)

Where, h_{sF} is the conditional covariance of the spot tyre equity returns with the two tyre futures and crude futures return. The $h_{F,t}$ is the conditional variance of tyre futures and crude futures. For full derivitation of Eq. 3.8. (Chang et al., 2013; Chang et al., 2011; Tansuchat et al., 2010).

4. DATA

The daily closing prices of selected tyre equities, two nearby tyre equity futures and nearby crude futures (that is the futures contract

for which the maturity is very nearby to the present date) are used in this empirical study. 10 listed tyre manufacturing companies equities are selected based on their trade volume in NSE (National Stock Exchange) India. The selected companies are Apollo, Balakrishna, Ceat, Goodyear, Govind, JK Tyres, Krypton, MRF, PTL and TVS. After adjustment for missing values, the 3167 price observations from June 21, 2005 to September 8, 2020 are obtained from the official websites of NSE India and MCX India. However, the tyre equity futures daily observations were available from November 1, 2010 hence, the 2138 price observations till September 8, 2020 are obtained from the official website of NSE India. The logged returns futures prices and select tyre equity

prices are computed using the log function $r_{ji,t} = \ln(\frac{P_{ij,t}}{P_{ij,t-1}})$, where

 $P_{ii,t}$ and $P_{ii,t-1}$ are the closing prices of crude futures and tyre equity returns for days *t* and *t*-, respectively.

Table 1 shows the descriptive statistics for the prices and logged returns of crude futures tyre equity futures and the selected tyre equities. The mean returns of futures and spot tyre equities are very low, but the corresponding standard deviations of returns are much higher. The presence of fat tails is evident from the very high kurtosis for all the return series. The negative skewness statistics for Apollo, Balakrishna, Crude futures, JK tyresPTL MRF futures and Apollo futures indicates the extreme losses (longer left tail). The right tail or the gain is evident from the positive skewness statistics in Ceat, Goodyear, Govind, Krypton and TVS return series. The Jarque-Bera statistics of

Table 1: Descriptive statistics

all the return series signify that the series are not normally distributed.

The Augmented Dickey-Fuller (ADF) unit root tests for the price level series except for JK tyres in Table 2 are not statistically significant at 1% level. So, they are not stationary or they contain a unit root. However, all the return series of selected tyre equity, tyre futures and crude futures are stationary and hence are I(1).

Table 3 presents the computed Pearson correlation coefficients of the closing prices of crude futures and the spot tyre equity. Except for Goodyear and JK tyres, the prices of other tyre equities are negatively correlated with crude futures price. Rubber is the core raw material used in the production of tyres. The Indian tyre industry is depending on supplies from the natural rubber and synthetic rubber sector. (Misurelli and Cantrell, 1997) stated that the final products of crude namely butadiene, styrene and acrylonitrile are the core ingredients for manufacturing synthetic rubber. Moreover, (Kansara, 2018) stated in a business paper that Indian tyre stocks are skidding on rising crude prices. In such situations, hedging a tyre equity portfolio with crude futures may serve the risk management purpose. An investor, who is long with tyre equity, may take a short position with crude futures and vice versa. Alternatively, the cross hedge with other tyre equity futures is also an option. The equity prices of Apollo, Balakrishna, Ceat, Goodyear and TVS are highly positively correlated with MRF futures prices and the equity prices of Govind JK tyre and Krypton are

Panel a: tyre stock and crude oil future returns									
Returns	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera		
Apollo	-0.00025	0.18	-2.24	0.05	-30.81	1418.46	264885034.26		
Balakrishna	0.00019	0.18	-1.64	0.04	-19.79	726.02	69188609.91		
Ceat	0.00072	0.26	-0.15	0.03	0.88	10.58	7994.12		
Crude	0.00002	0.22	-0.33	0.02	-0.16	22.73	51387.67		
Goodyear	0.00081	0.22	-0.21	0.03	0.74	12.61	12464.38		
Govind	-0.00058	0.29	-0.36	0.04	0.36	7.43	2658.22		
JK Tyre	-0.00018	0.17	-1.45	0.04	-14.44	521.74	35618675.14		
Krypton	-0.00043	0.57	-0.40	0.04	0.65	16.49	24221.97		
MRF	0.00100	0.18	-0.38	0.02	-0.22	27.45	78907.92		
PTL	0.00013	0.41	-1.59	0.05	-11.64	359.25	16818358.02		
TVS	0.00096	0.25	-0.17	0.03	0.74	9.37	5648.80		
Apollo Futures	0.00021	0.11	-0.28	0.03	-0.87	11.19	6249.10		
MRF futures	0.00085	0.11	-0.16	0.02	-0.07	8.33	2529.52		
		Panel	b: tyre stock and o	erude oil future p	orices				
Prices	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera		
Apollo	145.13	401.40	15.36	88.01	0.397	2.08	195.42		
Balakrishna	682.97	2494.60	114.30	405.34	0.906	4.07	585.82		
Ceat	567.50	2003.35	31.70	547.02	0.750	2.29	363.30		
Crude	3910.80	7201.00	1289.00	1069.93	0.516	2.62	159.72		
Goodyear	467.44	1274.05	55.15	316.56	0.608	2.23	273.73		
Govind	17.05	53.70	0.87	9.34	0.476	3.14	122.34		
JK Tyre	125.26	680.20	30.25	73.27	3.825	22.86	59773.12		
Krypton	20.02	98.55	6.19	13.00	2.599	11.20	12441.74		
MRF	27319.20	80821.00	1537.95	24815.11	0.615	1.83	381.33		
PTL	45.90	170.90	6.50	33.50	1.745	5.08	2176.02		
TVS	1182.77	4213.45	46.00	1246.62	0.776	2.11	423.90		
Apollo Futures	157.42	299.55	46.40	68.16	0.06	1.78	134.59		
MRF futures	37817.45	81202.70	5559.45	23477.97	0.09	1.56	186.91		

Those Brindented Diene, I dher test for dhirt toot
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Panel a: tyre stock and crude oil future prices									
Prices	t - Statistic		P-value						
		1% level	5% level	10% level					
Apollo	-2.45	-3.43	-2.86	-2.57	0.13				
Balakrishna	-2.02	-3.43	-2.86	-2.57	0.28				
Ceat	-1.07	-3.43	-2.86	-2.57	0.73				
Crude	-2.21	-3.43	-2.86	-2.57	0.20				
Goodyear	-0.95	-3.43	-2.86	-2.57	0.77				
Govind	-2.68	-3.43	-2.86	-2.57	0.08				
JK Tyre	-4.01	-3.43	-2.86	-2.57	0.00				
Krypton	-2.91	-3.43	-2.86	-2.57	0.04				
MRF	-0.58	-3.43	-2.86	-2.57	0.87				
PTL	-3.15	-3.43	-2.86	-2.57	0.02				
TVS	-1.12	-3.43	-2.86	-2.57	0.71				
Apollo Futures	-1.60	-3.43	-2.86	-2.57	0.48				
MRF Futures	-1.02	-3.43	-2.86	-2.57	0.74				

Panel D: tyre stock and crude on luture returns									
Returns	t-statistic		P-value						
		1% level	5% level	10% level					
Apollo	-21.71	-3.43	-2.86	-2.57	0.000				
Balakrishna	-92.20	-3.43	-2.86	-2.57	0.000				
Ceat	-49.34	-3.43	-2.86	-2.57	0.000				
Crude	-51.44	-3.43	-2.86	-2.57	0.000				
Goodyear	-48.26	-3.43	-2.86	-2.57	0.000				
Govind	-46.11	-3.43	-2.86	-2.57	0.000				
JK Tyre	-48.65	-3.43	-2.86	-2.57	0.000				
Krypton	59.78	-3.43	-2.86	-2.57	0.000				
MRF	-48.71	-3.43	-2.86	-2.57	0.000				
PTL	-71.96	-3.43	-2.86	-2.57	0.000				
TVS	-51.42	-3.43	-2.86	-2.57	0.000				
Apollo Futures	-46.24	-3.43	-2.86	-2.57	0.001				
MRF Futures	-21.88	-3.43	-2.86	-2.57	0.000				

Entries in bold indicate that the null hypothesis is rejected at the 1% level

Table 3: Correlation between crude futures and tyre equity price and return series

Tyre equity	Crude futures		MRF equ	uity futures	Apollo equity futures		
	Price series	Return series	Price series	Return series	Price series	Return series	
Apollo	-0.21	0.041	0.83	0.57	1.000	0.99	
Balakrishna	-0.30	0.047	0.88	0.16	0.787	0.16	
Ceat	-0.18	0.054	0.92	0.51	0.906	0.49	
Goodyear	0.04	0.049	0.96	0.39	0.837	0.38	
Govind	-0.14	0.015	-0.19	0.27	0.147	0.23	
JK Tyre	0.26	0.033	-0.01	0.30	0.334	0.32	
Krypton	-0.21	0.049	-0.50	0.05	-0.352	0.06	
MRF	-0.10	0.030	1.00	0.99	0.833	0.56	
PTL	-0.28	0.025	0.26	0.18	0.323	0.17	
TVS	-0.23	0.056	0.84	0.32	0.850	0.32	

Entries in bold indicate that the correlation values are significant at the 5% level

negatively correlated. Similarly, the correlation of Balakrishna, Ceat, Goodyear, MRF and TVS equity prices are highly positive with Apollo futures.

Figure 1 presents the line graph of crude futures, tyre futures and selected tyre equity prices. Apollo, Balakrishna, Ceat, Goodyear, MRF and TVS equity prices move in the same direction. But these price line charts are in a slightly opposite direction to the crude futures price graph, suggesting they are negatively correlated. Hawaldar et al., (2017) and Hawaldar and Kumar (2017) stated that the global oil sector was in recession during the period from 2014 till 2016, the tyre equity and tyre futures in Figure 1 show upward trend during this oil price crisis period. Figure 2 shows

the price line chart of crude futures and selected tyre equity returns. This depicts volatility clustering in the series. Volatility clustering is evident in Ceat, Goodyear, Govind, Krypton, MRF, TVS, MRF futures, Apollo futures and crude futures price series. The periods of high volatility are followed by periods of relatively high volatility and vice versa.

5. EMPIRICAL RESULTS AND INTERPRETATION

The multivariate conditional volatility models in this study are estimated with help of STATA 15 and EViews 10 packages for

Figure 1: Tyre equity spot, tyre futures and crude futures prices





Figure 2: The logarithm of daily tyre equity spot, tyre futures and crude futures returns

Table 4: CCC estimates

Panel a: MRF equity future									
Tyre equity	ARCH	GARCH	Total	CCC	Log-likelihood	AIC			
APOLLO	0.10	0.10	0.21	0.57	10955.01	-10.24			
Balakrishna	0.06	0.85	0.92	0.32	10890.91	-10.18			
CEAT	0.08	0.84	0.92	0.52	10902.71	-10.19			
Goodyear	0.08	0.82	0.89	0.35	11168.00	-10.44			
GOVIND	0.07	0.85	0.92	0.25	9618.95	-8.99			
JK TYRE	0.08	0.83	0.91	0.48	10631.42	-9.94			
Krypton	0.07	0.84	0.91	0.05	9471.02	-8.85			
MŔF	0.06	0.82	0.88	0.99	15094.62	-14.11			
PTL	0.08	0.83	0.91	0.19	10128.79	-9.45			
TVS	0.07	0.87	0.94	0.29	10752.05	-10.04			
		Pane	el b: Apollo equity fu	ture					
Tyre equity	ARCH	GARCH	Total	CCC	Log-likelihood	AIC			
APOLLO	0.06	0.84	0.90	0.99	14252.19	-13.32			
Balakrishna	0.07	0.83	0.90	0.29	10198.24	-9.53			
CEAT	0.10	0.85	0.94	0.53	10225.60	-9.56			
Goodyear	0.08	0.86	0.93	0.38	10458.25	-9.78			
GOVIND	0.08	0.86	0.93	0.24	8948.22	-8.36			
JK TYRE	0.08	0.85	0.93	0.32	9741.73	-9.11			
Krypton	0.07	0.86	0.93	0.06	8837.57	-8.26			
MRF	0.07	0.86	0.94	0.56	10954.59	-10.24			
PTL	0.07	0.86	0.93	0.16	9452.229	-8.84			
TVS	0.06	0.89	0.95	0.30	10076.76	-9.42			
		Pa	nel c: Crude oil futu	re					
Tyre equity	ARCH	GARCH	TOTAL	CCC	Log-likelihood	AIC			
APOLLO	0.10	0.89	0.99	0.037	14976.38	-9.45			
Balakrishna	0.11	0.89	1.00	0.041	15313.83	-9.67			
CEAT	0.11	0.89	1.00	0.028	14971.98	-9.45			
Goodyear	0.11	0.88	0.99	0.026	15550.3	-9.82			
GOVIND	0.10	0.89	0.98	0.041	13686.08	-8.64			
JK TYRE	0.11	0.89	1.00	0.004	14813.94	-8.63			
Krypton	0.10	0.88	0.98	0.003	13705.98	-9.43			
MRF	0.11	0.89	1.00	-0.012	15855.96	-10.01			
PTL	0.11	0.88	0.99	0.044	14199.54	-8.96			
TVS	0.11	0.89	0.99	0.019	14953.85	-9.44			

Entries in bold indicate that the estimates are significant at the 5% level

econometric analysis. Table 4 presents the CCC estimations for the tyre equity return series versus MRF equity future, Apollo equity future and crude future return series in pane a, b and c respectively. The ARCH (α) and GARCH (β) estimates of conditional variance for selected tyre equity returns with MRF equity futures, Apollo equity futures and crude futures are statistically significant at the level of 5%. The ARCH estimates are low (less than 0.11), and the GARCH estimates are high and close to one (greater than 0.89). In the case of the tyre equity cash market and futures market, the long-run persistence is close to one. This is the indication of a long memory process, where the shock in the volatility series leads to future volatility for a long period of time. Further, the $(\alpha + \beta < 1)$, for both tyre equity cash and futures markets, which satisfies the second movement and log condition to prove the QMLE to be consistent and asymptotically normal (McAleer et al., 2007). The CCC estimates between the volatility of all selected tyre equity returns and MRF equity futures returns are statistically significant at 5%. Similarly, the CCC estimates between the volatility of selected tyre equity returns and Apollo equity futures return. The CCC estimates for the volatility of tyre equities of Balakrishna and PTL with crude futures are statistically significant with the lowest CCC values of 0.041 and

Table 5: DCC estimates

0.044 respectively. The CCC estimates between the volatility of cash and futures returns of MRF tyres and Apollo tyres are close to one that is 0.99 for both. The CCC estimates for the shocks to the volatility of Balakrishna, Ceat, Goodyear, Govind, JK tyres and TVS equity returns with the MRF and Apollo futures returns are greater than 0.24. However, the conditional correlations for the volatility of Krypton and PTL with all the three futures returns are less than 0.20. Therefore, the chance of cross hedge for the tyre equity with available tyre equity futures is more suitable than crude oil futures.

Table 5 presents the DCC estimates of the selected tyre equities returns with MRF futures, Apollo futures and crude oil futures respectively in panel a, b and c. In panel parameters of DCC estimates, lambda1 ($\hat{\rho}$ 1) and lambda2 ($\hat{\rho}$ 2) are significant at 5% level for the return series of MRF, Ceat, Apollo, JK tyres, TVS, PTL and Govind with MRF futures return series. Hence, for these return series, the time-invariant conditional correlation hypothesis is not empirically supported. Lambda 1 value for Govind at 0.06 is greatest in the panel, which indicates the short-run persistence from the shocks on the time-varying conditional correlations. Further, the largest

Panel a: MRF equity future								
Tyre equity	ARCH	GARCH	Total	lambda1	lambda2	log-likelihood		
Balakrishna	0.09	0.24	0.33	0.00	0.99	9654.80		
MRF	0.13	0.16	0.30	0.05	0.02	14576.6		
CEAT	0.37	0.15	0.52	0.01	0.99	7488.032		
APOLLO	0.67	1.08	1.75	0.01	0.98	10568.57		
Goodyear	0.27	0.72	0.99	0.04	0.16	10703.75		
JK TYRE	1.02	0.05	1.07	0.00	0.93	9452.681		
TVS	0.28	0.48	0.75	0.01	0.91	10277.56		
PTL	0.78	0.20	0.98	0.05	0.62	9452.681		
Krypton	0.23	0.70	0.92	0.01	0.89	9234.847		
GOVIND	0.11	0.75	0.87	0.06	0.60	9319.641		
		Panel b: Apo	llo equity future					
Tyre equity	ARCH	GARCH	TOTAL	lambda1	lambda2	log-likelihood		
Balakrishna	0.15	0.17	0.32	0.00	0.99	7117.45		
MRF	0.25	0.28	0.53	0.02	0.97	10552.47		
CEAT	0.31	0.32	0.63	0.06	0.38	7488.032		
APOLLO	0.67	1.08	1.75	0.01	0.98	10568.57		
Goodyear	0.25	0.73	0.98	0.01	0.58	10063.08		
JK TYRE	1.04	0.03	1.07	0.00	0.95	9151.628		
TVS	0.33	0.06	0.39	0.06	0.53	6918.356		
PTL	0.78	0.20	0.98	0.05	0.62	9452.681		
Krypton	0.23	0.70	0.92	0.01	0.89	9234.847		
GOVIND	0.11	0.75	0.87	0.06	0.60	9319.641		
		Panel c: Ci	rude oil future					
Tyre equity	ARCH	GARCH	TOTAL	lambda1	lambda2	log-likelihood		
Balakrishna	0.11	0.23	0.34	0.01	0.98	8665.34		
MRF	0.55	0.13	0.68	0.01	0.76	14736.64		
CEAT	0.10	0.94	1.04	0.00	0.99	13984.60		
APOLLO	1.17	0.08	1.25	0.04	0.47	13367.57		
Goodyear	0.43	0.49	0.92	0.01	0.42	14548.66		
JK TYRE	0.94	0.04	0.98	0.01	0.75	13658.30		
TVS	0.42	0.36	0.78	0.02	0.64	14005.07		
PTL	0.75	0.23	0.98	0.01	0.64	9343.17		
Krypton	0.30	0.61	0.91	0.00	0.99	12937.75		
GOVIND	0.17	0.75	0.92	0.01	0.41	12988.01		

Entries in bold indicate that the estimates are significant at the 5% level

Panel a: MRF equity future								
Tyre equity		С		Α	В	Log-likelihood	AIC	
APOLLO	1.72E-06	0.032	7.01E-07	0.186	0.981 0.986	10920.56	-10.21	
Balakrishna	3.16E-05	0.126	1.46E-04	0.289	0.928	10839.51	-10.13	
CEAT	3.46E-06	0.058	4.23E-06	0.223	0.974	10885.03	-10.17	
Goodyear	1.71E-05	0.078	1.92E-05	0.254	0.969	11140.81	-10.41	
GOVIND	2.07E-05	0.082	1.04E-04	0.307	0.936	9608.348	-8.98	
JK TYRE	7.87E-06	0.079	2.03E-05	0.328 0.261	0.917	10566	-9.87	
Krypton	2.19E-05	0.090	0.000331	0.303	0.948	9453.073	-8.83	
MRF	-1.21E-07	0.043	1.69E-07	0.204	0.980	15041.75	-14.06	
PTL	2.88E-05	0.128	1.98E-04	0.209	0.980	10100.77	-9.44	
TVS	1.43E-05	0.062	7.57E-06	0.232	0.959	10744.81	-10.94	
		Panel	b: Apollo equity	futures	0.903			
Tyre equity		C	or ipono equity	A	B	log-likelihood	AIC	
APOLLO	6.28E-08	0.041	-3.98E-08	0.203	0.981	14226.15	-13.31	
				0.203	0.981			
Balakrishna	6.24E-05	0.122	1.61E-04	0.283	0.922	10168.26	-9.5	
CEAT	2.52E-06	0.055	3.95E-06	0.429 0.226	0.727 0.976	10207.17	-9.54	
Goodyear	1.62E-05	0.061	1.30E-05	0.243 0.233	0.969	10448.88	-9.77	
GOVIND	3.18E-05	0.080	1.00E-04	0.254	0.949	8935.94	-8.35	
JK TYRE	6.52E-06	0.068	1.44E-05	0.257	0.967	9923.774	-9.3	
Krypton	3.23E-05	0.093	3.41E-04	0.215	0.949	8820.184	-8.24	
MRF	1.42E-06	0.038	2.08E-06	0.189	0.983	10918.96	-10.21	
PTL	3.62E-05	0.118	1.84E-04	0.205	0.953	9434.642	-8.82	
TVS	1.77E-05	0.056	7.98E-06	0.222	0.965	10060.12	-9.4	
		Pan	el c: Crude oil fu	tures				
Tyre equity		С		Α	В	log-likelihood	AIC	
APOLLO	1.00E-05	0.10	0.000173	0.290	0.950	14961.87	-9.44	
Balakrishna	0.00040	0.01	0.001171	0.327 0.334	0.821 0.936	10206.83	-6.44	
CEAT	1.04E-05	0.08	3.15E-05	0.025 0.296	0.960 0.951	14943.95	-9.43	
Goodyear	1.09E-05	0.12	5.37E-05	0.280 0.281	0.943 0.953	15513.00	-9.79	
GOVIND	9.56E-06	0.10	0.000331	0.431 0.280	0.861 0.951	13660.81	-8.62	
JK TYRE	9.73E-06	0.11	0.000132	0.374 0.287 0.282	0.827	14785.9	-9.33	
Krypton	9.73E-06	0.12	0.000382	0.382 0.267 0.453	0.850	13666.2	-8.63	
MRF	1.16E-05	0.07	1.76E-05	0.304	0.950	15828.55	-9.99	
PTL	1.02E-05	0.16	0.000265	0.267	0.955	14161.31	-8.94	
TVS	1.28E-05	0.07	7.09E-06	0.301 0.232	0.946 0.970	14917.98	-9.42	

 Table 6: Diagonal BEKK estimates

Entries in bold indicate that the estimates are significant at the 5% level

Figure 3: Optimal hedge ratios based in alternative MGARCH estimates



Figure 3: Optimal hedge ratios based in alternative MGARCH estimates (Continued)







sum of lambda 1 and lambda 2 of Ceat 1.00 (0.01+0.99) indicates the lengthy long-run persistence from the shocks to the conditional correlation. In panel b of Table 5, the lambda 1 and lambda 2 of MRF, Ceat, Apollo, TVS, PTL and Govind are statistically significant at 5% level. Hence the hypothesis of time-invariant conditional correlation from the shocks is not empirically supported for these series. The lambda at 0.06 of Ceat, TVS and Govind indicates the greatest short-run persistence from the shocks to the time-varying conditional correlations. While the total of lambda1 and lambda 2 of MRF at 0.99 (0.02+0.97) is highest in panel b, this proves the lengthy long rum persistence of shocks on the conditional correlation. The last panel in the Table shows the DCC estimates between the crude future returns and selected tyre equity returns. The lambda1 and lambda 2 of the volatility of TVS and PTL return series with crude futures return series at statistically significant. Therefore, the time-invariant conditional correlation assumption is not empirically supported for these series. The highest ladmbda2 value at 0.02 for TVS indicates the largest short-run persistence of the disturbances on the dynamic conditional correlations. The highest lambda 2 value of 0.99 for Ceat and Krypton indicates the longest long run persistence from the disturbances to the conditional correlations.

The estimates of diagonal BEKK and seven parameters are shown in Table 6. The coefficients for conditional variances, conditional covariances, the arch and the GARCH effects for selected tyre equity return with MRF future, Apollo future and crude future are presented in panel a, b and c respectively. The ARCH and GARCH effects for all estimates in Table seven are statistically significant and the sums of these effects are close to one. This gives evidence of volatility spillover between the return series of MRF futures, Apollo futures and crude futures with the selected tyre equities. A and B are the elements of diagonal matrices, they prove the presence of strong GARCH effects and weak ARCH effects. In panel a, the estimates for the covariances are statistically significant for all except Apollo and PTL tyre equity. The estimates of covariances are significant for all tyre equities in panel b, while in panel c only for Balakrishna tyre equity estimate of covariance is not significant. The dynamic covariations in shocks are the indications of these significant results.

Table 7 presents the optimal hedge ratios for selected tyre equities based on different MGARCH estimates. OHR based CCC, DCC and BEKK estimates are shown in panel a, aand c respectively. The average OHR values for Apollo and MRF equity are very high (>0.95) in the 1st and second columns of all the panels, indicating the possibility of an effective direct hedge. The crosshedge possibility for other tyre stock is affective with tyre equity futures rather than crude futures. In all the 3 panels, the average

Panel a: Optimal hedge ratio using DCC estimates								
Tyre Equity_Apo	llo Futures	OHR	Tyre Equity_MRF Futures	OHR	Tyre Equity_Crude Futures	OHR		
Apollo		0.975	Apollo	0.799	Apollo	0.081		
Balakrishna		0.246	Balakrishna	0.379	Balakrishna	0.039		
Ceat		0.516	Ceat	0.711	Ceat	-0.046		
Goodyear		0.271	Goodyear	0.373	Goodyear	0.037		
Govind		0.370	Govind	0.539	Govind	0.041		
JK Tyre		0.544	JK Tyre	0.720	JK Tyre	0.048		
Krypton		0.095	Krypton	0.125	Krypton	0.037		
MRF		0.393	MRF	0.959	MRF	0.005		
PTL		0.197	PTL	0.339	PTL	0.017		
TVS		0.276	TVS	0.374	TVS	0.047		
		Pa	nel b: Optimal hedge ratio using	g DCC estin	lates			
Tyre Equity_Apo	llo Futures	OHR	Tyre Equity_MRF Futures	OHR	Tyre Equity_Crude Futures	OHR		
Apollo		0.979	Apollo	0.769	Apollo	0.147		
Balakrishna		0.344	Balakrishna	0.467	Balakrishna	0.117		
Ceat		0.578	Ceat	0.744	Ceat	0.136		
Goodyear		0.335	Goodyear	0.443	Goodyear	0.137		
Govind		0.433	Govind	0.582	Govind	0.163		
JK Tyre		0.581	JK Tyres	0.689	JK Tyre	0.127		
Krypton		0.180	Krypton	0.180	Krypton	0.175		
MRF		0.436	MRF	0.964	MRF	0.086		
PTL		0.287	PTL	0.393	PTL	0.147		
TVS		0.891	TVS	0.432	TVS	0.125		
		Panel c:	Optimal hedge ratio using diag	onal BEKK	estimates			
Tyre Equity_Apo	llo Futures	OHR	Tyre Equity_MRF Futures	OHR	Tyre Equity_Crude Futures	OHR		
Apollo		0.972	Apollo	0.719	Apollo	0.014		
Balakrishna		0.068	Balakrishna	0.112	Balakrishna	0.000		
Ceat		0.457	Ceat	0.612	Ceat	0.014		
Goodyear		0.177	Goodyear	0.223	Goodyear	0.023		
Govind		0.188	Govind	0.287	Govind	0.018		
JK Tyre		0.373	JK Tyre	0.445	JK Tyre	0.009		
Krypton		0.031	Krypton	0.039	Krypton	0.024		
MRF		0.348	MRF	0.955	MRF	0.002		
PTL		0.064	PTL	0.109	PTL	-0.003		
TVS		0.192	TVS	0.253	TVS	0.024		

Table 7: Alternative hedging strategies

OHRs with MRF futures are greater than the average OHRs with Apollo futures, suggesting the affective cross hedge with MRF futures rather than Apollo futures. The highest average OHR for the cross hedge is 0.720 for JK tyres with MRF futures and 0.612 for Ceat based on CCC and BEKK estimates respectively. Figure 3 shows the computed time-varying OHRs based on alternative multivariate GARCH estimates.

6. CONCLUSION

This study has analysed the possibility of a cross hedge for selected Indian tyre equities with crude oil futures and two tyre equity futures. Multivariate GARCH models, namely CCC, DCC and diagonal BEKK are estimated between the above-mentioned spot and futures return series. Optimal hedge ratios are computed using the conditional covariance matrices of the estimated CCC, DCC and diagonal BEKK models. In the past, the price of crude has influenced the equity price of tyre companies in India.

The results of the daily observation from June 21, 2005 to September 8, 2020 for the crude oil futures and selected tyre equity returns showed that the volatility spillover exists between these variables. However, the conditional volatility models showed better cross hedge possibility with tyre futures. For MRF and Apollo tyres, a direct hedge is more effective, while for other selected equities the MRF futures is the best underlying for cross hedge. All the selected tyre equities showed a positive correlation with MRF futures, hence, in short with MRF futures to protect the long tyre equity and vice versa are suggested.

REFERENCES

- Abul, S., Sadorsky, P. (2015), Hedging emerging market stock prices with oil, gold, VIX, and bonds: A comparison between DCC, ADCC and GO-GARCH. IEnergy Economics, 54, 235-247.
- Adams, Z., Gerner, M. (2012), Cross hedging jet-fuel price exposure. Energy Economics, 34(5), 1301-1309.
- Ahmad, W., Sadorsky, P., Sharma, A. (2018), Optimal hedge ratios for clean energy equities. Economic Modelling, 72, 278-295.
- Bagchi, B. (2017), Volatility spillovers between crude oil price and stock markets: Evidence from BRIC countries. International Journal of Emerging Markets, 12(2), 352-365.
- Baillie, R.T., Myers, R.J. (1991), Bivariate garch estimation of the optimal commodity futures Hedge. Journal of Applied Econometrics, 6, 109-124.
- Batten, J.A., Kinateder, H., Szilagyi, P.G., Wagner, N.F. (2017), Can stock market investors hedge energy risk? evidence from Asia. Energy Economics, 66(2017), 559-570.
- Batten, J.A., Kinateder, H., Szilagyi, P.G., Wagner, N.F. (2019), Timevarying energy and stock market integration in Asia. Energy Economics, 80, 777-792.
- Benet, B.A. (1990), Commodity futures cross hedging of foreignexchange exposure. The Journal of Futures Markets, 10(3), 287-306.
- Benninga, S., Eldor, R., Zilcha, I. (1983), Optimal hedging in the futures market under price uncertainty. Economics Letters, 13(2-3), 141-145.
- Bolar, S., Pinto, P., Hawaldar, I.T. (2017). Semi-monthly effect in stock returns: New evidence from Bombay stock exchange. Investment Management and Financial Innovations, 14(3), 160-172.
- Bollerslev, T. (1986), Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31, 307-327.

- Bollerslev, T. (1990), Modelling the coherence in short run normal exchange rates: A mutivariate generalized ARCH model. The Review of Economic Studies, 72, 498-505.
- Braga, F.S., Martin, L.J. (1990), Out of sample effectiveness of a joint commodity and currency hedge: The case of soybean meal in Italy. Journal of Futures Markets, 10(3), 229-245.
- Caporin, M., McAleer, M. (2008), A Scientific Classification of Volatility Models. Available from: https://www.ssrn.com/abstract=1314231.
- Caporin, M., McAleer, M. (2009), A scientific classification of volatility models. Journal of Economic Surveys, 24(1), 192-195.
- Chang, C., Mcaleer, M., Tansuchat, R. (2011), Crude oil hedging strategies using dynamic multivariate GARCH. Energy Economics, 33(5), 912-923.
- Chang, C.L., González-Serrano, L., Jimenez-Martin, J.A. (2013), Currency hedging strategies using dynamic multivariate GARCH. Mathematics and Computers in Simulation, 94, 164-182.
- Chunhachinda, P., De Boyrie, M.E., Pavlova, I. (2018), Measuring the hedging effectiveness of commodities. Finance Research Letters, 30, 201-207.
- Cifarelli, G., Paladino, G. (2015), A dynamic model of hedging and speculation in the commodity futures markets. Journal of Financial Markets, 25, 1-15.
- Daddikar, P.V., Rajgopal, M. (2016), Commodity price volatility and firm value an emprirical study of Indian ture industry. ELK Asia Pacific Journal of Social Science, 3(1), 1-25.
- Dahlgran, R.A. (2000), Cross-hedging the cottonseed crush: A case study. Agribusiness, 16(2), 141-158.
- Dutta, A. (2018), Oil and energy sector stock markets: An analysis of implied volatility indexes. Journal of Multinational Financial Management, 44, 61-68.
- Ederington, L.H. (1979), The hedging performance of the new futures markets. The Journal of Finance, 34(1), 157-170.
- Engle, R. (2002), Dynamic conditional correlation a simple class of multivariate GARCH models. Journal of Business and Economic Statistics, 20, 339-350.
- Engle, R.F. (1982), Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica, 50(4), 987-1007.
- Engle, R.F., Kroner, K.F. (1995), Multivariate simultaneous generalized arch. Econometric Theory, 11(1), 122-150.
- Ghosh, A., Ray, S., Ponniah, P., Dwibedy, S. (2011), Indian Tyre Industry: An ICRA Perspective, Gurgaon, India.
- Grant, D., Eaker, M. (1989), Complex hedges: how well do they work? The Journal of Futures Markets, 9(1), 15-27.
- Hawaldar, I.T. (2016), The reaction of Bahrain bourse to announcement of annual financial results. International Review of Business Research Papers, 12(1), 64-75.
- Hawaldar, I.T. (2018), The reaction of stock prices to earnings announcements. Asian Journal of Multidimensional Research, 7(9), 282-293.
- Hawaldar, I.T., Kumar, A. (2017), Impact of financial and oil price crisis on the financial performance of selected banks in Bahrain. International Journal of Economic Research, 14(1), 83-96.
- Hawaldar, I.T., Rohit, B., Pinto, P. (2017b), Testing of weak form of efficient market hypothesis: Evidence from the Bahrain bourse. Investment Management and Financial Innovations, 14(2), 376-385.
- Hawaldar, I.T., Rohit, B., Pinto, P., Rajesha, T.M. (2017), The impact of oil price crisis on financial performance of commercial banks in Bahrain. Banks and Bank Systems, 12(4), 4-16.
- Hawaldar, I.T., Shakila, B., Pinto, P. (2017a), Empirical testing of month of the year effect on selected commercial banks and services sector companies listed on Bahrain Bourse. International Journal of Economics and Financial Issues, 7(2), 426-436.

- Iqbal, T.H. (2011), Relevance of capital asset pricing model a review. Journal on Banking Financial Services and Insurance Research, 1(2), 85-97.
- Iqbal, T.H. (2014), Seasonal analysis of abnormal returns after quarterly earnings announcements. International Journal of Accounting and Financial Reporting, 4(2), 501-519.
- Iqbal, T.H. (2015), Empirical testing of capital asset pricing model on Bahrain bourse. Asian Journal of Finance and Accounting, 7(2), 107-119.
- Iqbal, T.H., Mallikarjunappa, T. (2007), Market reaction to earnings information: An empirical study. AIMS International Journal of Management, 1(2), 153-167.
- Iqbal, T.H., Mallikarjunappa, T. (2009), Indian stock market reaction to the quarterly earnings information. Indian Journal of Finance, 3(7), 43-50.
- Iqbal, T.H., Mallikarjunappa, T. (2010), A study of efficiency of the Indian stock market. Indian Journal of Finance, 4(5), 32-38.
- Iqbal, T.H., Mallikarjunappa, T. (2011), Efficiency of Stock Market: A Study of Stock Price Responses to Earnings Announcements. Germany: LAP Lambert Academic Publishing Company.
- Johnson, L.L. (1960), The theory of hedging and speculation in commodity futures. The Review of Economic Studies, 27(3), 139-151.
- Junttila, J., Pesonen, J., Raatikainen, J. (2018), Commodity market based hedging against stock market risk in times of financial crisis: The case of crude oil and gold. Journal of International Financial Markets, Institutions and Money, 8(1), 5-46.
- Kansara, P. (2018), Tyre Stocks Skid on Rising Oil Prices. The Hindu Business Line. p1-7. Avaialble from: https://www. thehindubusinessline.com/markets/tyre-stocks-skid-on-rising-oilprices/article23952660.ece
- Kim, M.J., Park, S.Y. (2016), Optimal conditional hedge ratio: A simple shrinkage estimation approach. Journal of Empirical Finance, 38, 139-156.
- Kim, S.W., Brorsen, B.W., Yoon, B.S. (2015), Cross hedging winter canola. Journal of Agricultural and Applied Economics, 47(4), 462-481.
- Kumar, A., Soni, R., Hawaldar, I.T., Vyas, M., Yadav, V. (2020), The testing of efficient market hypotheses: A study of Indian pharmaceutical industry. International Journal of Economics and Financial Issues, 10(3), 208-216.
- Kumar, D., Maheswaran, S. (2013), Correlation transmission between crude oil and Indian markets. South Asian Journal of Global Business Research, 2(2), 211-229.
- Kumar, K.R.N., Hawaldar, I.T., and Mallikarjunappa, T. (2018), Windows of opportunity and seasoned equity offerings: An empirical study.

Cogent Economics and Finance, 6(1), 1-18.

- Mallikarjunappa, T., Iqbal, T.H. (2003), Stock price reactions to earnings announcement. Journal of IAMD and IUCBER, 26(1), 53-60.
- McAleer, M., Chan, F., Marinova, D. (2007), An econometric analysis of asymmetric volatility: theory and application of patents. Journal of Econometrics, 139, 258-284.
- Miller, S.E. (1980), Beef price hedging opportunities for food service institutions. Journal of Food Distribution Research, 11, 29-34.
- Miller, S.E. (1985), Simple and multiple cross-hedging of millfeeds. The Journal of Futures Markets, 5(1), 21–28.
- Misurelli, D., Cantrell, R. (1997), Industry and Trade Summary Synthetic Rubber. Washington, DC. Available from: https://www.usitc.gov/ publications/docs/pubs/industry_trade_summaries/pub3014.pdf
- Nelson, C.R., Plsser, C.I. (1982), Trends and random walks in macro economic time series: some evidence and implications. Journal of Monetary Economics, 10, 139-162.
- Olson, E., Vivian, A., Wohar, M.E. (2018), What is a better cross-hedge for energy: Equities or other commodities ? Global Finance Journal, 42, 3.
- Pandey, V., Vipul, V. (2018), Volatility spillover from crude oil and gold to BRICS equity markets. Journal of Economic Studies, 45(2), 426-440.
- Pinto, P., Hawaldar, I.T, Guruprasad, K., Rohit, B., Spulbar, C., Birau, R., Stanciu, C.V. (2020), The impact of risk anomalies on the pharmaceutical sector of the Indian stock market: A comparative analysis between pharmaceutical, FMCG and IT companies. Revista de Chimie Journal, 71(2), 58-63.
- Sharma, S., Rodriguez, I. (2019), The diminishing hedging role of crude oil: Evidence from time varying financialization. Journal of Multinational Financial Management, 52-53, 100593.
- Shyam, A. (2019), Lower Oil Prices Could Put Tyre Companies on the Fast Track. The Economic Times. p3-5. Available from: https://economictimes.indiatimes.com/markets/stocks/news/ lower-oil-prices-could-put-tyre-companies-on-the-fast-track/ articleshow/67376148.cm
- Singh, N.P., Sharma, S. (2018), Phase-wise analysis of dynamic relationship among gold, crude oil, US dollar and stock market. Journal of Advances in Management Research, 15(4), 480-499.
- Tansuchat, R., Chang, C.L., McAleer, M. (2010), Crude oil hedging strategies using dynamic multivariate GARCH. Science Direct, 33(5), 1-33.
- Wang, K.M., Lee, Y.M. (2016), Hedging exchange rate risk in the gold market: A panel data analysis. Journal of Multinational Financial Management, 35, 1-23.
- Xu, H. (2020), Improved diversification through a mix of oil and equities. Research in Finance, 26, 113-126.