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Volatility spillover between Gold Spot & future market in India: An Experiment with Multi commodity Exchange

A.Saha[1*], S.Chakraborty[2], G. Mitra[3]

[1]Dept. of Commerce, Bhairab Ganguly College, Kolkata, India
[2] Dept. of Research & studies, The Institute of Cost Accountants of India, Kolkata, India
[3]Dept. of Business Administration, The University of Burdwan, Burdwan, India

[*]*Corresponding Author: Amitava saha_mail.amitavasaha@gmail.com. Tel.: +91-94333-83213*

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Abstract— In economics spillover effects[i] are economic events in one context that occur because something else in a seemingly unrelated context. When more information about someone generates more information about people related to her and that information helps to eliminate asymmetries in information, then the spillover effects are positive. Spillover from disequilibrium in one market may influence effective demand in other market. In the present initiative we venture to investigate whether the volatility in the spot price have a spill over effect on futures price or vice-versa. As India is one of the largest market markets for gold and growing affluence is driving growth in demand, we focus on Gold spot and future market. We have collected daily data from MCX for the period from 1 st April 2008 to 31 st March 2018. Our basic objective is to investigate the spill over effect of spot market volatility on futures prices volatility or vice versa. In order to complete our experiment we have done descriptive statistics, unit root test, ARCH test, GARCH test on our sample data. Having completed our experiments and obtaining results on measurement of price volatility in both segments of the market we take further initiatives to run exponential GARCH (Nelson and Cao, 1991) and threshold GARCH (Zakoian,1994) models. The reasons behind our model selection are in the pursuit of usefulness in asset pricing Exponential GARCH (EGARCH). Threshold GARCH (TGARCH) is different from Jagannathan-Runkel GARCH (1993) only in one parameter. In TGARCH model specification is on conditional standard deviation instead of conditional variance. Our TGARCH has captured asymmetric effects of positive and negative shocks of the gold futures market in India. We are confident that our research contributes towards greater understanding of (i) direction of spill over effect and (ii) asset pricing and leverage effects in the gold futures market. The results of our experiment provided evidence that effect of negative shock have less effective than positive shocks. This result is quite contradictory to Barreto & Ramesh (2018) and Srinivasan & Ibrahim (2012). Besides the study results shows that spilllover of certain information takes place from future price to spot price. Our result is similar to Barreto & Ramesh (2018) and Mahalik et al (2009). However, unlike these two research papers our result claims spilllover of certain information takes place from spot market to future market. This is quite identical to the findings of Srinivasan & Ibrahim (2012).

Keywords— *Spillover effect, Gold Future, Price volatility, GARCH (1,1), EGARCH, TGARCH.*

I. INTRODUCTION

India is one of the largest market markets for gold and growing affluence is driving growth in demand. Gold has a central role in the country's culture, considered a store of value, a symbol of wealth and status and a fundamental part of many rituals. Among the country's rural population, a deep affinity for gold goes hand in hand with practical consideration of the portability and security of jewellery as an investment[ii].

The past two decades have seen a radical change in the world economy. Stock market volatility and currency weakness improve demand of gold in many emerging market. According to International Monetary Fund (IMF) gold play an important part in the Central bank's foreign exchange (FX) reserves. The world gold council's aim is to make a framework for gold mining companies which provide confidence to investors, supply chain participants and consumers that their gold has been performing responsibly.
India is one of the largest markets for gold. In 2017 and onwards investors added gold into their portfolio as an asset because it is traded through the exchanges. Exchanges give the guarantee that the contract should honored at the end of the contract. It creates the demand for gold.

II. RELATED WORK

Day and Lewis (1997) examined the relation between changes in initial margin requirements and the volatility of the crude oil futures market. Daily closing prices for call options on crude oil futures were taken from New York Mercantile Exchange for the period from November 14, 1986 to March 18, 1991. Mean-reverting diffusion process and Granger causality tests were applied. Changes in margin policy do not affect subsequent market volatility. Granger causality tests suggests that the chain of causation may run from volatility of the crude oil futures markets to initial margin requirements.

Mahalik, Acharya and Babu (2009) studied the price discovery process and volatility spilllover effect in futures and spot commodity markets. For their study they took daily data of Agriculture, Energy, and Metal and Aggregate commodity index of MCX from 12th June2005 to 31st December2008. After applying Johansen Co integration Test, VECM, and EGARCH they found that except Metal market all other markets serves the Price discovery function. No Co integrating relationship exists between Metal Spot and Future Market. Volatility spilllover effect transcends from future to spot.

Ge, Wang and Ahn (2010) studied the integration of China's cotton market with the international market especially the U.S. market. Weekly prices obtained from the ZCE in China (www.czce.com.cn) and the ICE futures U.S. (www.theice.com) over the period from December 1, 2004 to December 25, 2008. After applying econometric tools like ADF test, PP test, Co-integration, Error Correction models (ECMs) with Generalized Autoregressive Conditional Heteroskedasticity (GARCH), Granger Causality test they found Bidirectional Causality confirms the long-run relationship between these two major cotton futures markets. Presence of ARCH/GARCH effects in both price series and joining in World Trade Organization and China's exchange rate reform had important impacts on these futures markets.

Sehgal, Rajput and Dua (2012) studied the relationships between futures trading activity and spot market volatility for agricultural commodities. Daily closing spot and futures prices of seven commodities namely guar seeds, turmeric, soybean, black pepper, barley, Maize and castor seed traded on NCDEX were taken for the period from April 2004 to March 2012. ADF test, Phillips-Perron test, Hodrick-Prescott filter (HP filter) test, GARCH model and Granger causality tests were applied and they conclude that unexpected futures trading volume is Granger causing spot price volatility and are significant for five agricultural commodities like Guarseed, Turmeric, Soybean, Maize and Castor Seed. In case of Pepper the effect of spot market volatility on futures trading and for Barley no causality is revealed either from future to spot or Vice-Versa.

Salisu and Fasanya (2012) examined basic volatility models for capturing the nature and significance of fluctuations in oil price. Daily oil price (OP) data collected from the work book of Thomson Reuters over the period from 04/01/2000–20/03/2012. After applying ARCH Lagrangian Multiplier (ARCHLM) test, symmetric models AR(1)-GARCH(1,1), AR(1)-GARCH-M(1,1) and asymmetric models AR(1)-TGARCH(1,1), AR(1)-EGARCH(1,1) they conclude that Oil price was most volatile during the global financial crises. The asymmetric GARCH models appear superior to the symmetric ones in dealing with oil price volatility. This finding indicates an evidence of leverage effects in the oil market and ignoring these effects in oil price modelling will lead to serious bases and misleading results.

Bilgin, Gozgor and Karabulut (2015) analysed the impact of volatility in the world energy price on aggregate economic activity in an unbalanced panel data framework for 10 developing Asian countries: Bangladesh, People Republic of China, India, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, Turkey and Vietnam. They framed Panel data based on the period from 1970 to 2010 in Vietnam and for remaining nine developing economies. Their period of observation was 51 years from 1960 to2010. The frequency of the data is annual. Data of the world energy price in monthly frequency are available from 1960 to present at the database of the Global Economic Monitor (GEM) Commodities of the World Bank Group. They obtained the world energy price data from the World Bank and that is why the beginning date of the empirical analysis is 1960. They Also used the data of the Penn World Tables (version 7.1).Autoregressive Conditional Heteroskedasticity (ARCH), GARCH (1,1) model and Dynamic panel data[iii] estimations showed that the world energy price volatility is negatively associated with the aggregate economic activity in the panel data framework. Using the common correlated effects panel estimation techniques, they also systematically examined uncertain transmission channel of the world energy price volatility on the aggregate economic activity in each economy and obtain the most impressive negative effects in Turkey, People Republic of China and India respectively.

Gakhar (2016) examined the impact of financial derivatives (futures and options) on the underlying market volatility and awareness and perception of investors about future of derivatives market in India. He collected data for the period from January 1, 1997 to February 5, 2015. Various indices like CNX S&P Nifty Index daily closing prices, Nifty Junior Index, S&P 500 Index and Index Futures near month contracts daily closing prices from June 12, 2001 to February 5, 2015 were taken. 522 filled in questionnaires have been analyzed in this study. After using AR (1)-GARCH (1, 1)

model and Structural Equation Model they concluded that volatility had been reduced in the spot market after the introduction of derivatives.

Haugom and Ray (2017) analysed the relationship between liquidity, volatility and return distributions for the crude oil futures market. More than 10 years of high-frequency transaction level data for the front month Brent Crude oil futures contracts traded at the Intercontinental Exchange (ICE) were taken for the period from January 3, 2006 to January 31, 2016, for 2564 trading days. Quintile regression[iv] method had been applied for the study. Increase in trade size decreases volatility significantly, especially at the tails, resulting in an inverse "smile" or a "frown".

So far our knowledge no single study has been done yet to check the volatility spill over on the Indian gold market.

In this study we investigate whether the volatility in the gold spot price have a spill over effect on futures price or vice-versa.

III. METHODOLOGY

We used daily data of gold spot and futures prices from Multi commodity Exchange of India Limited's website for the period from 1st April 2008 to 31st March 2018 for our study. Total of 2726 observations are to be consider here.

In order to satisfy our objective we have applied Descriptive statistics to see the normality of the data series. Here we have applied Augmented Dickey-Fuller (ADF) test to see the stationarity of the data series. We have applied Autoregressive Conditional Heteroskedasticity (ARCH) model developed by Prof. Robert F. Engle (1982) to estimate the riskiness of the asset at a certain period of time and understand the behavior of the conditional variance of the series.

Mean and variance equation of ARCH (q) model are as follows:

$$Y_t = a + \beta' X_t + u_t$$

$u_t / \Omega_{t-1} \sim iidN(0, h_t)$ here, Ω is the information set

$$h_t = \gamma_0 + \sum_{j=1}^{q} \gamma_j u_{t-j}^2$$

According to Engle (1995) ARCH specification looked more like a moving average specification than an auto regression. This result established a new idea where a lagged conditional variance term includes as auto regressive terms. This is nothing but Generalized Autoregressive Conditional Heteroskedasticity (GARCH)[v]. Here we have applied GARCH (1,1) model developed by Bollerslev (1986) to see how variance scaling parameter depends on past value of the shocks (captured by lagged squared residual terms) and on past value of itself (captured by lagged variance terms).

Mean and variance equation of GARCH (p,q) model are as follows:

$$Y_t = a + \beta' X_t + u_t$$

$$u_t / \Omega_{t-1} \sim iidN(0, h_t)$$

$$h_t = \gamma_0 + \sum_{i=1}^{p} \delta_i h_{t-i} + \sum_{j=1}^{q} \gamma_j u_{t-j}^2$$

Having completed our experiment and obtaining results on movement of price volatility in both segments of the market we take further apply (Exponential GARCH) E-GARCH(1,1) model developed by Nelson(1991) which allows the testing of asymmetries and to see the leverage effect exponential instead of quadratic and estimate the conditional variance.

Here mean equation follows the AR(1) process.

The variance equation of this model is given by;

$$\log(h_t) = \gamma + \sum_{j=1}^{q} \zeta_j \left| u_{t-j} / \sqrt{h_{t-j}} \right| + \sum_{j=1}^{q} \xi_j u_{t-j} / \sqrt{h_{t-j}} + \sum_{i=1}^{p} \delta_i \log($$

Where, $\gamma, \zeta s, \xi s and \delta s$ are parameters to be estimated.

We have also applied (Threshold GARCH) T-GARCH(1,1) introduced by Zakoian (1990) which is very much similar to GJR model developed by Glosten, Jaganathan and Runkle(1993), different only instead of variance used standard deviation in the specification to see the asymmetries in terms of negative and positive shocks.

Here mean equation follows the AR(1) process.

The conditional variance equation is given by:

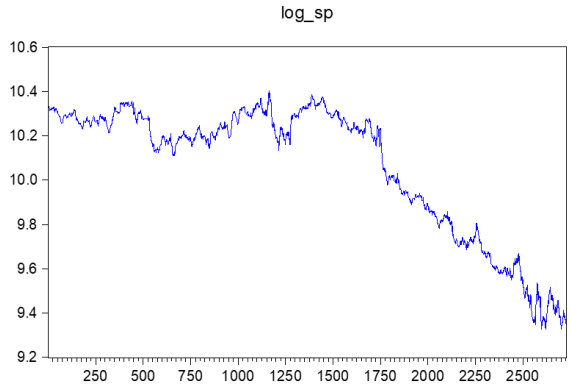
$$h_t = \gamma_0 + \gamma u_{t-1}^2 + \vartheta u_{t-1}^2 d_{t-1} + \delta h_{t-1}$$

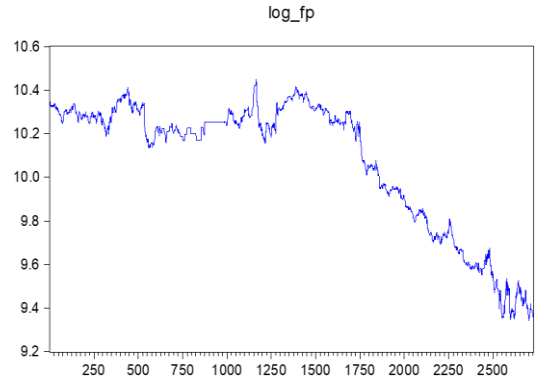
IV. RESULTS AND DISCUSSION

Graphical Presentation of Price series

We should first study the basic statistics of the data series. We used log transformation to reduce the scatter ness of both the data series. Following graphs of raw data of the price series shows in Exhibit 1

Exhibit 1: Graphical presentation of raw data of spot and futures price series





It is indicate from the above that there is no trend in any of the price series and it implies all the price series are non stationary.

V. DESCRIPTIVE TEST STATISTICS

We have study normality of the data series through descriptive test shows in Exhibit 2.

Exhibit 2: Descriptive statistics on spot and futures prices

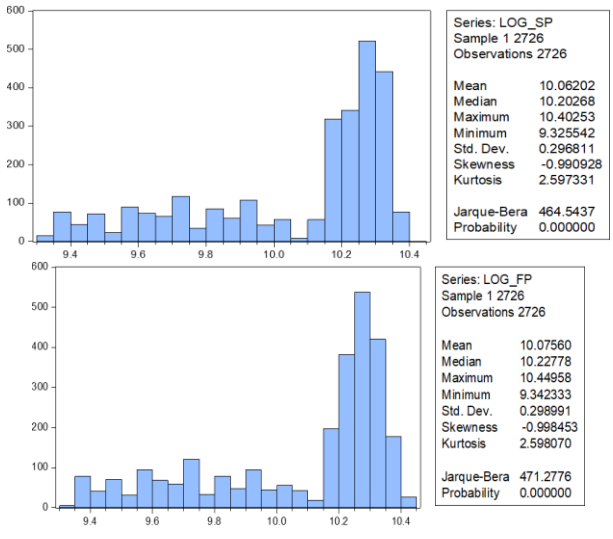


Exhibit 2 displays a summary for gold spot price series where mean is 10.06202. The Std. Dev. is 0.296811. Histogram displays that the sample has negative skewness at -0.990928 which indicate the longer tail towards the left. Jarque-Bera indicates that spot price returns are not normally distributed. Kurtosis values of 2.597331 indicate a high peak. The same results also shown in case of gold futures price series where mean is 10.07560. The Std. Dev. is 0.298991. Histogram displays that the sample has negative skewness at -0.998453 which indicate the longer tail towards the left. Jarque-Bera indicates that spot price returns are not normally distributed. Kurtosis value of 2.598070 indicates a high peak.

Unit root test

In our present study we have apply Augmented Dickey-Fuller (ADF) test to check the stationarity of the data series shows in Exhibit 3 and Exhibit 4.

Exhibit 3: ADF test statistics (Intercept)

Variables	At Level				At 1st difference			
	Test Statistic	Critical Value (1%)	Critical Value (5%)	Prob.	Test Statistic	Critical Value (1%)	Critical Value (5%)	Prob.
LOG_FP	0.594132	-3.433586	-2.862856	0.9896	-49.80194	-3.433591	-2.862858	0.00001
LOG_SP	0.586100	-3.433589	-2.862857	0.9894	-52.83622	-3.433597	-2.862861	0.00001

Exhibit 4: ADF test statistics (Intercept and trend)

Variables	At Level				At 1st difference			
	Test Statistic	Critical Value (1%)	Critical Value (5%)	Prob.	Test Statistic	Critical Value (1%)	Critical Value (5%)	Prob.
LOG_FP	-1.223645	-3.962872	-3.412171	0.9047	-49.83447	-3.962879	-3.412175	0.0000
LOG_SP	-1.204304	-3.962877	-3.412174	0.9086	-52.87133	-3.962887	-3.412179	0.0000

It is observed from Exhibit 3 that in case of intercept the computed test statistics value of futures price series is 0.594132 with p-value 0.9896 and spot price series is 0.586100 with p-value 0.9894 ,which is greater than or lies to the right of all critical values. Hence we accept the null hypothesis and conclude that log_fp and log_sp has a unit root. It is observed that the result of unit root test for the first difference of both the series in case of intercept shows computed test statistics value is lower than or lies to the left side of all critical values. This implies that both the series at first difference form is stationary.

In case of Exhibit 4 the same result as above shows for intercept and trend. Here also both the series has a unit root at level and the first difference form of the series are stationary.

ARCH test

Conventional econometric analysis views the variance of the disturbance terms constant over time that implies the homoscedasticity. Here we have applied ARCH test to understand the behavior of the conditional variance of the series to estimate the riskiness of the price return at a certain period of time. It is shown in Exhibit 5 below.

Exhibit 5: Heteroskedasticity Test ARCH

Price	Spot Price	Futures Price
Observations	2724	2724
F-statistic	111.1352	33.46428
Obs*R-squared	106.8541	33.08215
Prob. F(1,2722)	0.0000	0.0000
Prob. Chi-square(1)	0.0000	0.0000

It is observed from the ARCH test that $T.R^2$ statistic or Obs*R-squared value is 106.8541 with p-value 0.0000 in case of spot price series and 33.08215 with p-value 0.0000 in case of futures price series. It implies that we reject the null hypothesis of homoscedasticity and conclude that ARCH (1) effect are present in the spot price series as well as in the futures price series.

GARCH test

Now we have apply GARCH(1,1) model to see how the variance scaling parameter depends both on past value of the shocks, which are captured by the lagged squared residual terms and on past value of itself. It is shown in Exhibit 6 below.

Exhibit 6: GARCH (1,1) Result

Equations	Spot Price	Futures Price
Mean Equation		
C	-0.005009 (0.3319)	-0.004082 (0.4772)
Variance Equation		
C	2.02E-06 (0.0000)	8.48E-07 (0.0000)
RESID(-1)^2	0.095835 (0.0000)	0.045727 (0.0000)
GARCH(-1)	0.883525 (0.0000)	0.948310 (0.0000)

P-values are given in parenthesis

The above observation indicates the coefficients on the lagged squared residuals (0.095835) and lagged conditional variance (0.883525) for spot price series and the coefficients on the lagged squared residuals (0.045727) and lagged conditional variance (0.948310) for futures price series. The sums of these two are very close to unity with highly significant p-values for both the price series. Here we conclude that the volatility shocks are quite persistent in both the price series.

T-GARCH test

Now we have applied T-GARCH (1, 1) model to capture the asymmetries in terms of negative and positive shocks. It is shown in Exhibit 7 below.

Exhibit 7: T-GARCH (1, 1) Result

Equations	Spot Price	Futures Price
Mean Equation		
C	-0.007778 (0.1307)	-0.004670 (0.4021)
Variance Equation		
C	1.97E-06 (0.0000)	9.08E-07 (0.0000)
RESID(-1)^2	0.117119 (0.0000)	0.053836 (0.0000)
RESID(-1)^2*(RESID(-1)<0)	-0.044259 (0.0004)	-0.017912 (0.0007)
GARCH(-1)	0.885584 (0.0000)	0.948336 (0.0000)

P-values are given in parenthesis

It is observed from the above that asymmetry term RESID (-1)^2*(RESID(-1)<0) term is negative and statistically significant in case of both spot and futures price series.So no asymmetry present in both the price series implies that negative shocks that is bad news has no impact on next period conditional variance and positive shocks that is good news have a little impact due to negligible coefficient value for both spot and futures price series.

E-GARCH test

Now we have applied E-GARCH to see the leverage effect exponential instead of quadratic because the left hand side is the log of variance series. It is shown in Exhibit 8 below.

Exhibit 8: E-GARCH (1, 1) Result

Equations	Spot Price	Futures Price
Mean Equation		
C	-0.014192 (0.0000)	-0.010177 (0.0000)
Variance Equation		
γ	-0.362355 (0.0000)	-0.241512 (0.0000)

ζ	0.184132 (0.0000)	0.099814 (0.0000)
ξ	0.023279 (0.0067)	0.026195 (0.0000)
δ	0.975604 (0.0000)	0.981065 (0.0000)

P-values are given in parenthesis

It is observed from the above that coefficient value of C (5) ξ that is RESID(-1)/@SQRT(GARCH(-1)) is positive and significant in case of both the price series. Since δ is significant, this implies that downward movement in gold spot and futures price volatility followed by higher volatility than an upward movement of the same magnitude. So the result $\xi > 0$, implies that the negative shocks (bad news) generate less volatility than positive shocks (good news). Here investors are liable to suffer from positive news in comparison to the negative news.

In the above exhibit 8 coefficient value of C(5) ξ is 0.023279 with p-value 0.0067 in spot price series is lesser than coefficient value of C(4) ζ that is 0.099814 with p-value 0.0000 in futures price series. So we conclude that volatility spillover takes place from future market to spot market.

Besides, the above results also state that coefficient value of C(5) ξ is 0.026195 with p-value 0.0000 in futures price series is lesser than coefficient value of C(4) ζ that is 0.184132 with p-value 0.0000 in spot price series which implies that volatility spillover takes place from spot market to future market.

Here we apply wald test to cheek whether any short run causality running from independent variable to dependent variable. The test result is shown in Exhibit 9 below.

Exhibit 9: Wald test Result

Price	Spot Price	Futures Price
F-statistic	47948.45	116995.4
Chi-square	143845.3	350986.3
Probability of F-statistic	0.0000	0.0000
Probability of Chi-square	0.0000	0.0000

It is observed from the above table that p-value at chi-square is highly significant for both spot and futures price return. Here we reject the null hypothesis and accept the alternative hypothesis implies that short run causality exits between independent and dependent variable.

Here we also apply ARCH LM test to see the presence the heteroskedasticity in the price series. It is shown in Exhibit 10 below.

Exhibit 10: ARCH LM test results

Price	Spot Price	Futures Price
Observations	2724	2724
F-statistic	4.398411	7.349034
Obs*R-squared	4.394542	7.334631
Prob. F(1,2722)	0.0361	0.0068
Prob. Chi-square(1)	0.0361	0.0068

It is observed from the above that $T.R^2$ statistic or Obs*R-squared is 4.394542 with p-value 0.0361 in case of spot price returns and 7.334631 with p-value 0.0068 in case of futures price returns which are significant. It implies that heteroskedasticity observed over different periods are autocorrelated. It indicates volatility clustering present in the data series.

VI. CONCLUSION AND FUTURE SCOPE

The results of our experiment provided evidence that effect of negative shock have less effective than positive shocks. This result is quite contradictory to Barreto & Ramesh (2018) and Srinivasan & Ibrahim (2012). Besides the study results shows that spilllover of certain information takes place from future price to spot price. Our result is similar to Barreto & Ramesh (2018) and Mahalik et al (2009). However, unlike these two research papers our result claims spilllover of certain information takes place from spot market to future market. This is quite identical to the findings of Srinivasan & Ibrahim (2012).

Our study is confined to gold spot and future market only with reference to MCX. Daily data over 10 years is an acceptable size. However, similar data from other exchanges in India could make the study more robust and acceptable.

Different authors like Srinivasan & Ibrahim (2012) have used ECM*-EGARCH method for their research. We have not used it. Study could be made intertemportal and / or inter country. Comparative study could be done with respect to other metals of the bullion market like silver, copper etc. Studies could be helpful not only for future researchers but for professionals too.

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Authors Profile

Mr. A.Saha pursed Bachelor of Commerce from University of Calcutta, Calcutta in 1998 and Master of Commerce from University of Calcutta in year 2000. He also pursed Master of Business Administration from University of Calcutta in the year 2013. He is currently pursuing Ph.D. from Dept. of Business Administration, University of Burdwan under the supervision of Prof. Gautam Mitra and currently working as Assistant Professor in Department of Commmerce, Bhairab Ganguly College since 1st December,2016.

Ms. S.Chakraborty completed her ph.D. under the supervision of Prof. Gautam Mitra from University of Burdwan. She is currently working as an Additional director, Dept. of Research & Studies,The Institute of Cost Accountants of India.

Prof. G. Mitra obtained his ph.D degree in commerce from University of Calcutta and supervised seven ph.D. scolar so far. He is a fellow member of Institute of Chartered Accountants of India, and associate member of Institute of Cost Accountants of India, He is also member of The Econometric Society of India, The Operation Research Society of India, Bangiya Arthaneeti parishad, Indian Accounting Association, Indian Accounting Association Research Foundation.

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i.Excellent flower garden in the neighbor has a spillover effect on peers. Neither it is dependence (captured by regression) nor it is causality (captured by granger causality). It has its own uniqueness.

ii. The ancient law- giver Manu decreed that gold ornaments should be worn for important ceremonies and occasions

iii. Dynamic panel data describes the case where a lag of the dependent variable is used as repressor: $y_{it} = \alpha + \beta' X_{it} + \gamma y_{it-1} + u_{it}$,

The presence of the lagged dependent variable violates strict exogeneity, that is, endogeneity may occur. The fixed effect estimator and the first differences estimator both rely on the assumption of strict exogeneity. Hence, if is believed to be correlated with one of the independent variables, an alternative estimation technique must be used.

iv. Quantile regression is the extension of linear regression and we use it when the conditions of linear regressions are not applicable. This method of least squares results in estimates of the conditional mean of the response variables given certain values of the predictor variables. It aims at estimating either the conditional median or other quintiles of the response variables.

v. The main advantage of the GARCH model is that it has much less parameters and performs better than ARCH model.

