



## Rational Bubble Testing On Commodity Market Of India

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**ABSTRACT:** In finance, the valuation is one of the most important attributes of any asset. Valuation of any asset or commodities is often impacted by assets price bubble. When there is any evidence of presence of bubble in the market in relation to any security, stock, commodity or any assets, it generally drives the price of assets in upward or downward direction in short term or sometimes it even manipulates the actual price of any assets and gives the investor or market player wrong information about the assets which can cause huge loss to the investor.

This study is conducted empirically on the six commodities namely cotton, CPO, gold, Silver, Crude oil, Zinc from 2004 to 2016 in order to detect the presence of Commodity price bubble in that period. In the domain of investment, finance spotting (identification) of any unusual deviation and movement of asset prices in an uneven manner over a relatively short span of time is very crucial. This study extends Caspi, Itamar's study in 2013, Bikramaditya Ghosh in 2016 using three advanced form of augmented dickey fuller Test. Earlier the study is conducted in stock but not in the commodity. So this study tries to investigate its validity in Indian commodity industry. This study will also through an interesting aspect of commodity market along with spotting of herding behavior during the pre-global crisis, during global crisis and during the recovery phase till now. The major limitation of study is that only six commodities are studied under fixed effect.

**Keywords:** Commodity, Bubble Test, ADF series, Coupling, Valuation

**JEL Classification Code:** C5, C12, C15, C22, Q02

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### I. INTRODUCTION

Commodity trading is an emerging growth engine which can lead the world from limited opportunities to unlimited avenues to tap the economic opportunities. Commodity trading provides an ideal asset allocation, also help the hedge against inflation and buy a piece of global demand growth. Commodities today include agriculture goods, Precious metals, Base metals, petrochemical and energy the get traded in commodity exchange.

While engaging in commodity trading participants usually use fundamental and technical analysis to make their trades. The smart commodity-trading player will use both analysis to determine his/her actions.

When we talk in context of bubble, its formation and burst behavioural finance holds a greater degree of importance. There are two important notion regarding bubble formation and collapsing in behavioural finance. In behavioural finance first comes the herding. In herding, a group of people follows either a financial guru, or any eminent fund manager. As a result of such blind following and overconfidence, investor or market players takes their decision based on their leader and own guts instead of calculation based decision. End result of such decision is very fatal as it creates social distortion because of wrong judgement and formation of general opinion. In other words, we can say that such irrational behaviour are clear signals of error due to cognitive bias. However their quantification become more important, as the prediction of future in relation to such incidents saves the public money entering and exiting the bourses at the crucial point of time.

### II. REVIEW OF LITERATURE

A study was conducted by (Fama, 1965) in this context, which stated that in accordance with the theory of efficient market hypothesis there is no phenomena or event named as bubble. As per Though Fama no bubble can exist. But as the time passes with the increase in the study and interest of the researcher in this field during past four decade had had raised criticism against it and proved such claim false. If we go more backward in history there is one more similar study done by (Keynes, 1936) much way before Fama's study, he predicted and stated about existence of bubble and provides rationality for the same with the irrationality of investor when they are trading or dealing in stock market. One more study which was given by (Evans, 1991) which tells about

the theory of periodically collapsing bubble. As more people start, doing study on bubble as a result more arguments starts among different research scholar. In case of the study which was conducted by (Brunnermeier & Abreru, 2003) he stated that bubbles emerges, but not on irrationality when dealing in stock market, it occurs as a result of wrong pricing or false pricing of assets. One similar thing which is observed among all the above mentioned study is that none of them had investigated the reason for the formation of bubble nor they investigated about the time of bubble formation in the market when it becomes evident or its presence can be felt in the market to everybody. With the increase in momentum and curiosity to know more about bubble and its related attributes in different verticals some researcher like (Jarrow, Protter, & Shimbo, 2007), they all state that derivatives can be used in detecting bubble by using it against the underlying assets. Major shortfall or shortcoming in this study, which was exposing the study towards arguments and criticism was that the researcher has restriction on boundaries and lack of empirical evidence support for such claim. During the period of 1980s the first bubble test was administered which was named as “variance bounds tests”. This test was administered and constructed by (Shiller, Leroy, & Porter, 1980). In this test calculation for prediction of the rational value of stock is done in accordance to the present value of the dividend which is already paid to the holder.

In this test if output shows that the rational price is less than the actual price then there is presence of bubble is there and it indicates that prices are not realistic. But there is also some criticism against this test which was raised by (Flavin, 1983) and (Kleidon, 1986). They both stated that there is presence of some biasness towards terminal value and small sample which hampers, dilutes and raise question against the reliability of the study. As time passes more test was done on bubble testing by using different tools. One among this was a test which was conducted by (Diba & Grossman, 1988) they make use of stationarity as a tool for bubble detection and based upon future value. It takes into consideration expected future stock price, future dividend and some unobserved variable. Although this study was again criticized and questioned by (Gürkaynak, 2008), it was clearly evident that when the data sets were large in number and spread over a vast period of time, the outcome will be more accurate. In 1987, West introduced unique equation named ARIMA. As compare to other methods his methods was relatively simple method and easy to interpret. In this method he regressed current stock price on lagged dividend by making use of discount rate and it leads to generation new equation named ARIMA as output of study. But then also two gaps were highlighted in this area by Gürkaynak. He states that only past dividends are taken into consideration and non-stationary cannot be detected with high precision even if it is present. In accordance to Gürkaynak the model should be linear in nature but as the log dividend are taken into consideration for the study as a result model is coming out non-linear. Moreover when this model was used by Ma and Kanas by taking into consideration data set of long period from US capital market over a century, the result of forecasting the stock price were reasonably good with high degree of accuracy. In 1993 study done by S Hall and M Sola was unique in itself. For the first time (HALL & SOLA, 1993) introduced the check of stationarity in this area of study and moreover they also extended the augmented dickey fuller test in order to check whether there is some presence of stationary pattern in the stock prices or the stock prices are tending towards mild explosive pattern. All other test which were conducted in the similar domain were not generating effective and reliable result in short run but they are effectively predicting the past bubble with greater degree of accuracy and reliability. (Phillips, Wu, & Yu, 2011) had introduced new test named as “supremum ADF or SADF test” to determine bubble with greater degree of accuracy. They all extended this study further and in year 2013 they all came up with generalized SADF for efficient bubble prediction which was more accurate, reliable and efficient as compared to all other tools of bubble detection. Moreover in the same direction (Taipalus, 2012) used unit root test and its rolling version i.e. RADF with the help of Monte Carlo simulation on the US stock market data, where he came to conclusion that there is presence high signals of bubble which is coming up well before 12 months. (Sornette, 2009) had combined the conventional rational theory of finance with the behavioural theory in order to study and analyse the two collapses in Chinese stock exchange market indexes i.e. SSE and SZSE within the time period starting from year 2005 to year 2009 by making use of LPPL i.e. Log-periodic power law. However this toll was amended by (Sornette & Zhou 2010) to incorporate the fundamental economic factors in 2006 such as interest rate, spreads, exchange rate and historical volatility which helps in defining the proof of herding. (Caspi, 2013) extended both hall and sola model and Katja Taipalus model further and effectively come up with new model. He used standard ADF, rolling window ADF, Supremum ADF (SADF) and Generalized SADF where rejection of null hypothesis in every case means and create evidence or the empirical proof of the existence of an asset price bubble. Similarly (Korkos, 2014) also conducted the study and used GSADF and RADF model to test it in US capital market and found that there was trace of bubble, both collapse and on-going. (Ghosh, 2016) conducted the same type of study as of Caspi and extend it and do the in-depth analysis of CNX – nifty. He conducted four test using ADF, max RADF, SADF and GSADF. Result were again similar which means that entire test fails to reject null hypothesis, therefore it states an empirical proof that there is presence of asset price bubble in CNX nifty and similar was the result when this study was further extended by (Jain, 2016) on BSE BANKEX. All the above mentioned researcher

have conducted study in bubble detection in the past using standard ADF, rolling window ADF, Supremum ADF (SADF) and Generalized SADF but none of them has conducted this study in commodity market.

Now next the researcher will talk about studies conducted in commodity market. As per (LORD, 1991) conducted research on storable commodities. He states that demand function are represented by the error correction mechanism and expected price in the stock demand relationship are generated by the rational expectation process. As his root mean square was low, it states that model provides more efficient forecast and allows some scope for key behavioural relationship in commodity market. Furthermore the researcher will talk about the Theory and evidence for default premiums in commodity market. As per (Bailey & NG, 1990) look for the evidence of non-performance risk in precious metal future prices. They found that the default premium changes associated with many individual events. Moreover they more emphasis on considering ex ante cost of non-performance should be considered as important factor while dealing with pricing of the commodity contracts. (Caballero, Farhi, & Gourinchas, 2008) states that crisis has its origin in global asset scarcity which results in large capital inflows for United States. In first phase the crash create shortage of assets in the world economy which leads to creation of bubble in the commodity market, majorly impacting oil market. But in the final phase slowdown worked reverse and tighten the commodity market condition and which finally leads to destroying the commodity bubble.

In accordance with (Beck, 2001) created a model of an autoregressive conditional heteroscedastic price variance process from a generalization of Muth's rational expectation model. Test were conducted on the model for both storable and non-storable commodity prices. It shows that correlated price variance process exists only for the storable commodities not for the non-storable commodities. But there were little evidence that the storable commodities have more asymmetric price distribution than non-storable commodities. As (Kawai, 1983) studies about the price volatility of storable commodities. He first focus on agents who sells commodities in absence or presence of opportunities for future contracting. He also states that future market has another important facility of reducing price fluctuation by distributing demand and supply. He states that it was possible to stabilize but the authorities need to quite cautious in implementing this scheme as gives unanticipated shocks in inventory holding.

(Jovanovic, 2013) performs a test on for the presence of bubble in the price of exhaustible resources. The test on consumable exhaustible resources bears some peculiar features. First feature is, it is easier for the bubble to form in such resources and second is bubble detection is also quite simpler i.e. it only requires asset to consumption ratio rise over the period of time. The only limitation of this test is that it does not apply to all non-reproducible assets. As per (Zhang, Yao, & He, 2012) conducted the research to obtain reasonable and reliable forecast method for detecting and measuring volatility in crude oil prices. The researcher in this paper evaluates the single regime GARCH and two regime Markov Regime switching GARCH model for crude oil prices volatility. They found that linear single regime GARCH model overall performs better than the other three non-linear GARCH type models in Value at risk (VaR) forecast.

In accordance with (Aslan, Yozgatligil, & Iyigun, 2016) conducted the research to find the temporal cluster for several commodity prices using the threshold nonlinear autoregressive Models. The major focus was on improving current knowledge about the dynamics of co-moving and can serve as a basis for multivariate time series analysis. Cluster were formed in according to similarity between their data generating mechanism rather than comparing patterns or similarities. They conducted the simulation study to assess the effectiveness of the mention clustering approach and then they presented the results for both the simulated and real data sets. (Saitone & Sexton, 2007) conducted the study on speculative bubble in Agriculture. The analysis is applied to US alpaca industry where prices of breeding stock are much higher than in Peru. The study was conducted to check whether prices are supported by market fundamentals or not. Finally they found out that sign of bubble in prices of alpaca stock in US.

As per (Tahir & Riaz, 1997) conducted study to test the integration of agriculture commodity market. The researcher's study focuses on market for cotton, wheat and rice. The researcher want to test for short run and long run integration. The researcher found that integration was possible only in long run. The researcher defines that small market takes time to fully adjust themselves to the price shocks originated or created in central or dominated markets. As per (Dasgupta, 2004) conducted a research to prove that allegation against future market in India "that it distorts the spot market price and creates artificial scarcity by allowing unnecessary hoarding". The researcher found that there is co-movement in future prices, production decision and inventory decision. The study also states that future price elasticity of inventory is inversely related to carrying cost which means that if any one does hoarding, it will lead to increase on carrying cost which will discourage hoarding.

As per (Areal, Balcombe, & Rapsomanikis, 2014) conducted the researcher to find out whether food prices spikes are generated by forces of demand and supply or by the speculation. The researcher found that few food commodities exhibited bubble behaviour during 2008 food prices. One major thing they concluded that such explosive behaviour are short lived. Moreover market condition sometimes tend to impact the effect of

speculation on prices. They conducted another research in 2013. These researcher apply GSADF test for identifying bubble in food, beverages, agricultural raw material etc. between 1980-2012. The tests identify presence of bubble in some commodities within food markets. As per (Nakajima & Hamori, 2012) conducted research in for testing rational bubble in commodity market. Their paper revealed that there is no bubble in commodity market under the assumption that there is stationarity in convenience yield and real prices of the product. Moreover they interpret with these finding that these price fluctuation are caused due to high elasticity in income. They also states that these prices reflect the fundamental values of these commodities. (Varadi, 2012) had conducted the research in order to investigate for the evidence and impact of speculation on volatility of commodity prices in Indian commodity market. The researcher through study was able to find that speculation has played higher degree of role in bubble formulation in commodity market during the global crisis in India.

The entire paper and researcher which are mentioned above had conducted the research in understanding bubble, its detection, to know market fundamentals of commodity market and presence of bubble? Etc. All studies are done either in Oil prices or natural gas or agriculture products. All researcher have try to identify price elasticity, market efficiency on commodity. But none of them have conducted a comprehensive study including all the dimension of commodity market. As a result it does not reveal the true picture of market fundamentals, its elasticity etc.

### **Need of Study**

The gap in which the study is undertaken is identified while reviewing is that there is the absence of study on all the four verticals which are Bullion, Energy, Base metals, Agriculture in the commodity market. Moreover, majorly study was done in the US, china etc., but very few studies were conducted in Indian commodity market.

These are the responsible factors which drive the study to bridge the gap and conduct bubble testing in commodity market in Indian context to check the presence of bubble if present, which will help the audience to know about the market fundamentals of Indian Commodity market.

## **III. RESEARCH METHDOLOGY**

### **Problem Statement**

The studies and researches which are conducted in past ranging from the 1990s till date stated that there are trends and pattern of price escalation observed in the capital market (stocks and commodity). Some of the studies mentioned the herding behavior is one of the factor responsible for price escalation in the commodity market which in turn leads to bubble formulation. However, there is the absence of study on all the four verticals of commodity market in relation to bubble detection.

### **Objective**

- To detect the bubble if any in the Indian commodity market for the period of 12 years (01/04/2004-31/03/2016).
- To trace the evidence of herding behaviour if present in Indian commodity market.

### **Data Collection And Sampling Technique**

In order to achieve an objective of this research, the study includes the data, which was collected from MCX website. The data set is for 12 years starting from 01/04/2004 to 31/03/2016.

The number of observation in the dataset is 17107 samples, which are a relatively huge chunk of data and will provide better accuracy in the result.

The frequency of the data set is daily data spread across period of 12 years.

The basis of selection for the commodity is the contribution of each commodity in terms of traded contracts to their respective index. The benchmark was taken as 25% of total index traded contracts. Only six commodities in all verticals cross the benchmark and are considered in the study.

### **Methodology Used For Analysis**

#### **Equation:**

The time series analysis will be done using following equation:

$$y(t) = \mu + \delta y(t-1) + \sum_{i=1}^p \phi_i \Delta y(t-i) + \varepsilon(t)$$

Where

Y(t) is defined as closing price of each commodity

$\mu$  is Intercept

p is the maximum number of lags to be considered in the study

$\phi$  is defined as a differentiated lag coefficient for the lags which is denoted by symbol "T"

$\epsilon$  is a term used to define error

These variables are borrowed from a similar type of study which was conducted by Itamar Caspi, Bikramaditya Ghosh in the similar condition for testing the presence of a bubble in the market.

Every dataset constitutes range of tiny samples from 77 to 143 in each window of the sample.

### Scope of the Study

The Study majorly focuses on detection and identification of bubble (if found) in particular commodity and based on the output of each test, the study will conclude for the entire market. The study has selected six commodities in total from all four vertical. These products are Zinc, Gold, Silver, Crude oil, Cotton and CPO. The researcher will take closing price of each commodity and run the four test namely ADF, RADF, SADF and GSADF. The time of study is 12 years (01/04/2004 to 31/03/2016)

### Hypotheses Formulation

H0:  $\delta = 1$ ; Unit Root

Ha:  $\delta > 1$ ; No unit root

Here, H0 defines that the time series which is linear stochastic in nature has a unit root which means that nature of time series is non stationary. On the other side, Ha defines or states that linear stochastic time series is stationary in nature our benchmark value of P is 5%. In case if the P value is less than 5%, Null Hypothesis (H0) is rejected and study can conclude or say that there is possible evidence or trace of a price bubble in the market. While if the P value is more than 5%, Null Hypothesis (H0) is accepted and study can conclude or state that there is no proof or evidence to state the presence of price bubble.

### Limitation of Study

There is various dimension to this study which could be added and extends this study using different variable. However, this study focuses on limited commodity from different segments of market and additionally, there was also Time resource constraint to the study. It cannot be generalized for all periodas it focuses on from 2004 to 2016 and finally, the "Effect" considered in study is fixed.

### Data Interpretation

#### 1. Agro Commodity

##### A) Cotton

Test	T-statistic	Window size	Confidence level	Probability	Occurrence
ADF	-15.80104	77	95%	0.00%	100.00%
maxRADF	-2.805014	77	95%	0.00%	100.00%
SADF	-7.613051	77	95%	0.00%	100.00%
GSADF	-2.792536	77	95%	0.00%	100.00%

Observation: 1282 and Table 1 Table: 1

Source: Eviews analysis

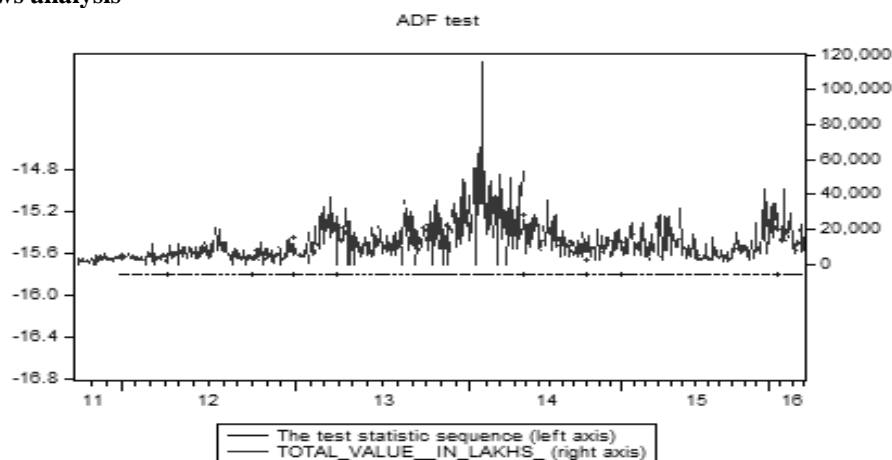


Fig: 1 Source: Eviews analysis

In the loop first comes the ADF test(Fig 1). It is primary test which tells us about the stationarity nature of time series. The probability of this test is showing zero. As probability is Zero which leads to 100% occurrence level. As P-value is low then benchmark level of 5%, so therefore we reject the null hypothesis. As a result we can say that there is no unit root in price time series of cotton commodity. Moreover in this test T-statistic value for the cotton commodity is 15% which hints towards impact on momentum of cotton prices in commodity market. Along with it shows a negative sign of T-statistic's value, which denotes that price of cotton, may fall sharply before the bubble bursts.

Now the question raises regarding this test is its accuracy and why is the impact factor (T-statistic) is high, is this model robust enough to answer the study objective?

In order to answer this question and check the robustness of the model, we will run the cotton price time series on maxRADF test.

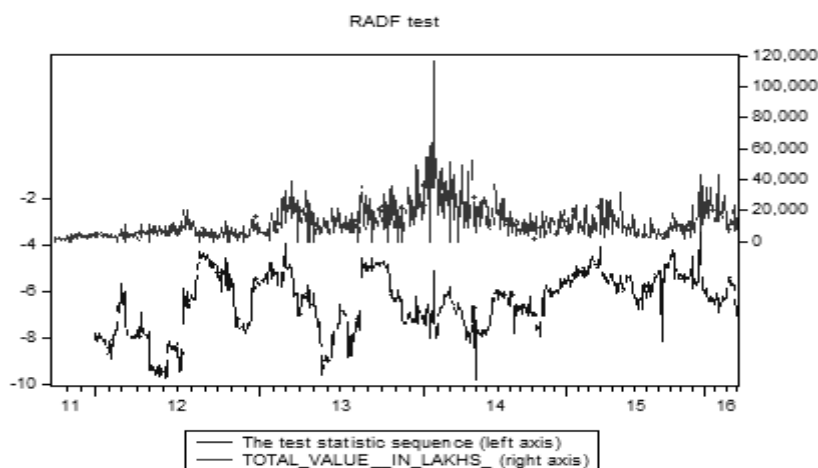


Fig: 2 Source: Eviews analysis

As it is evident from test output that T-statistic has substantially reduced from 15% in ADF to 2% in max RADF (Fig 2) which reflects more optimum impact on cotton price movement. Moreover the probability is at zero percent. As a result the occurrence level is 100%. In accordance with our benchmark level, the probability is below than 5% in stationarity test. Therefore from this output we can infer and state that our null hypothesis is rejected i.e. price time series (Total Value) of Cotton taken under the study has no unit root. As result it confirms the presence of Stationarity in time series which may leads to presence of bubble. Now the Question rises, can impact factor i.e. T-statistic can be reduced more and can this model be more optimized to improve the accuracy level. Therefore, in the loop we will move to next test in stationarity series which is SADF.

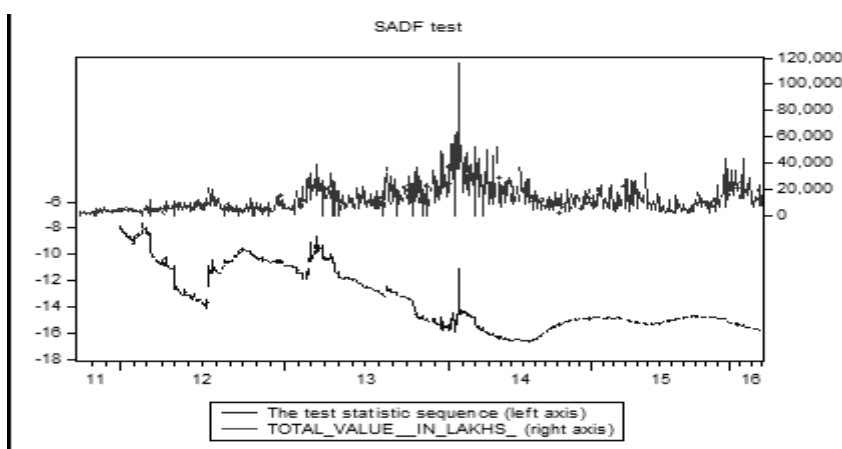


Fig: 3Source: Eviews analysis

As per SADF (Fig 3) output the probability and the occurrence level are same i.e. 0 and 100% respectively. But the impact factor on price momentum i.e. T-statistic has increased marginally from 2% to 7%. But the sign of T-statistic is still negative which denotes downside movement of price of commodity just before the bubble burst. In other words, it has negative bubble. The T-statistic (impact factor of commodity price movement) may have raised because of any cognitive error like herding, biasness etc. in the time series. In order to validate the T-statistic and arrive at final probability, we will run the last test in the loop which is named as GSADF test to check the presence of unit root in time series.

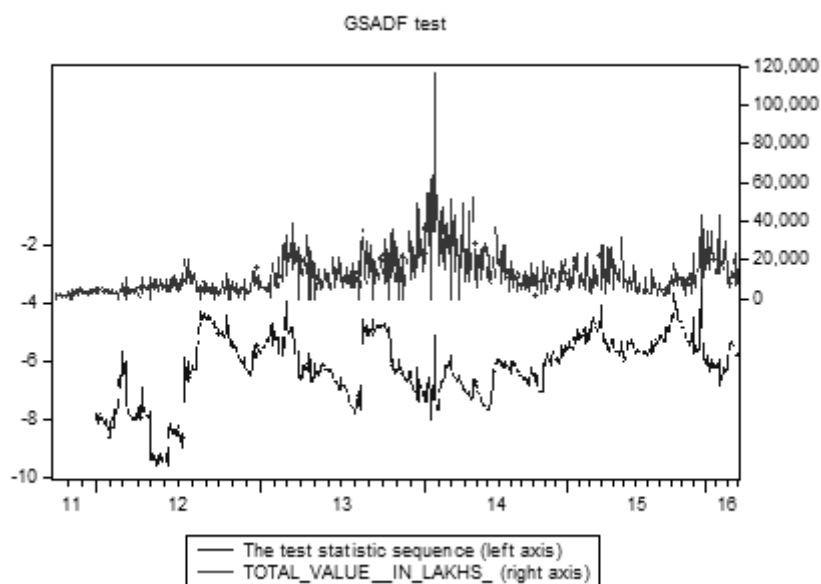


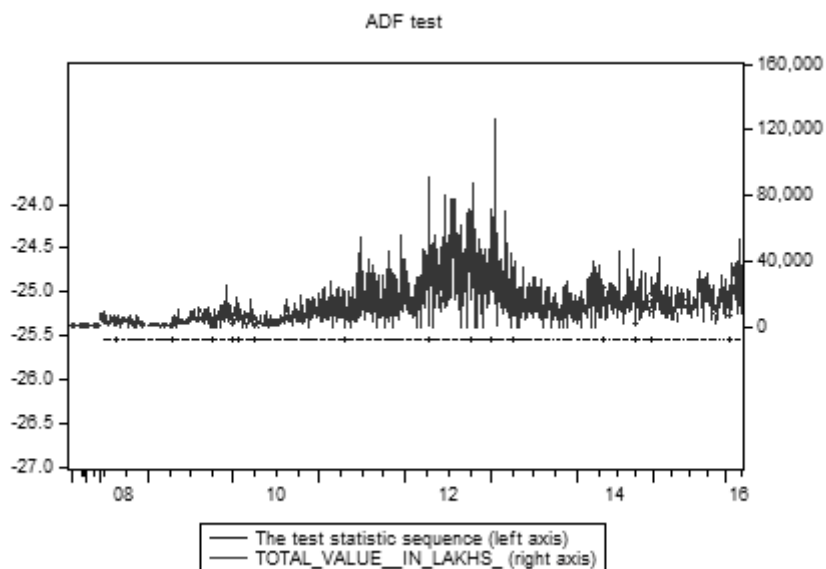
Fig: 4 Source: Eviews analysis

Now as per GSADF (Fig 4) the T-statistic (Impact factor) come down again to 2%. Here also probability and occurrence level are 0% and 100% as they were in all other test. As a result H0 is also rejected as per GSADF probability. Therefore, it confirms the absence of unit root in cotton price time series and states the positive signal of bubble in cotton prices.

**B) CPO**

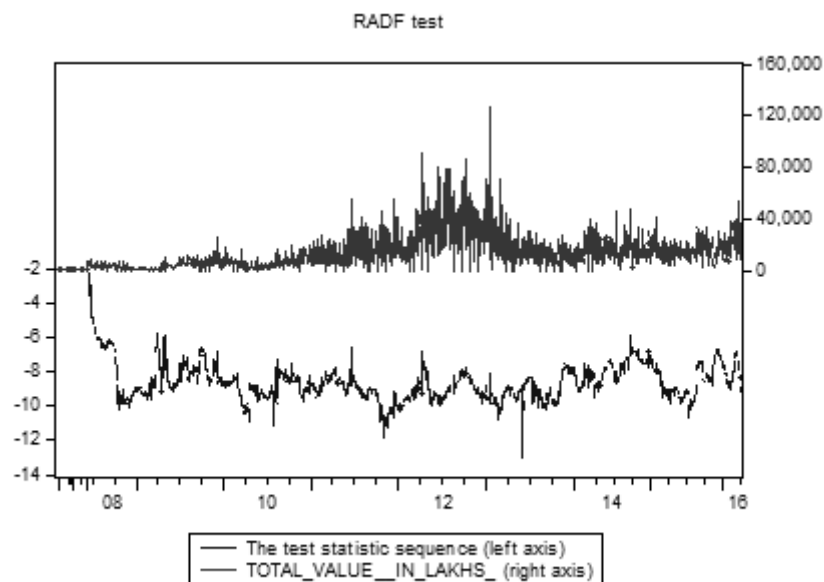
Test	T-statistic	Window Size	Confidence level	Probability	Occurrence
ADF	-25.55112	112	95%	0.00%	100.00%
maxRADF	-2.331599	112	95%	0.00%	100.00%
SADF	-2.331599	112	95%	0.00%	100.00%
GSADF	-2.331599	112	95%	0.00%	100.00%

Observation: 2401 Table:2  
Source: Eviews analysis



**Fig: 5 Source: Eviews analysis**

First we start with the output of CPO commodity with ADFtest(Fig 5). Its probability is coming zero, so we can say that occurrence level is 100%. As P-value is low then benchmark level of 5%, so we reject the null hypothesis, which means there is no unit root in time series. Next we move to T-statistic which is the impact factor on commodity price and tell us the momentum of bubble. In CPO commodity output is reflecting 25% which hints towards substantially impact on momentum of price of CPO commodity. Furthermore the negative sign of T-statistic denotes that price of CPO might fall substantially before the bubble bursts. Now the question raises regarding this test is its accuracy and why is the impact factor (T-statistic) is high, is this model robust enough to answer the study objective? In order to answer this question and check the robustness of the model, we will run the CPO price time series on maxRADF test.



**Fig: 6 Source: Eviews analysis**

As it is evident from test output that T-statistic has substantially reduced from 25% in ADF to 2% in max RADF(Fig 6)while probability is same which is zero. Therefore, occurrence level is 100%. In this test also null hypothesis is rejected as P-value is less than benchmark level. From this we can infer and state that price



time series (Total Value) of CPO taken under the study has no unit root. It confirms presence of Stationarity in time series which may leads to presence of bubble. Now the Question rises, can impact factor i.e. T-statistic can be reduced more and can this model be more optimized to improve the accuracy level. Therefore, in the loop we will move to next test in stationarity series which is SADF. Therefore, we move to next test in series, which is SADF.

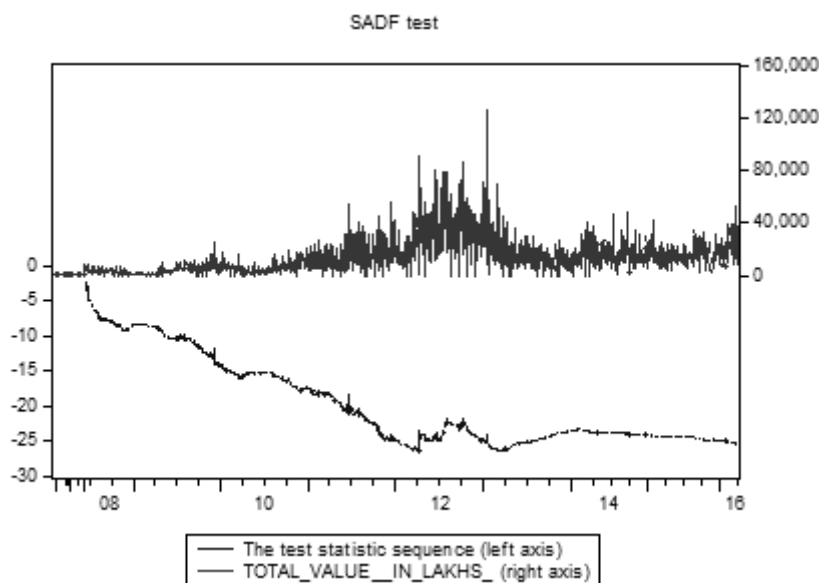


Fig: 7 Source: Eviews analysis

As per SADFtest(Fig 7) output, the probability and occurrence level are same and coincide the other test i.e. 0 and 100% respectively. Moreover, T-statistic has maintained the status quo at 2% and sign of T-statistic is still negative which denotes downside movement of price of commodity at time of bubble burst. In other words, it has negative bubble. The T-statistic has maintained the status quo because the model may have reached to the optimum impact factor and probability level. In order to validate the T-statistic and arrive at final probability, we will run the last test in the loop which is named as GSADF test to check the presence of unit root in time series.

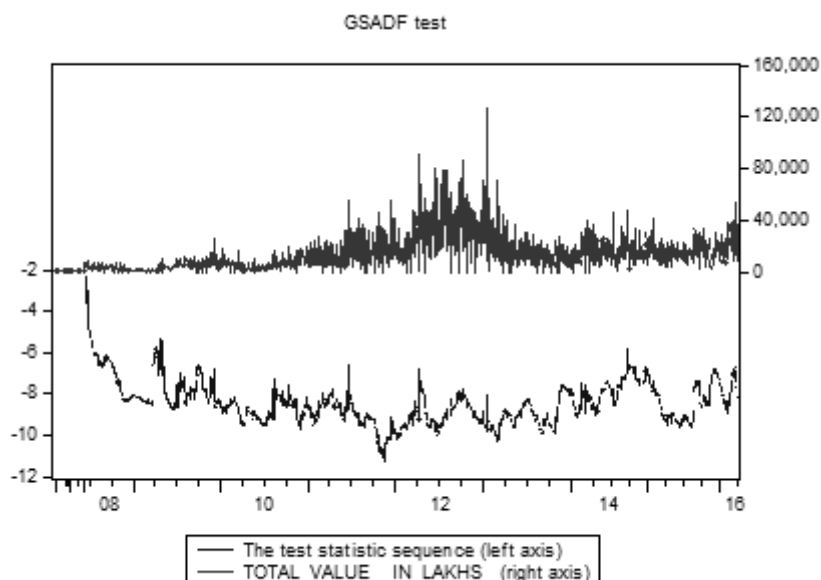


Fig: 8 Source: Eviews analysis

When the GSADF(Fig 8) test was conducted on CPO commodity, the T-statistic was still the same. In other words, it is maintaining the status quo from max RADF to GSADF. Here also probability and occurrence level are 0% and 100% respectively as they were in all other test. As in this test also our P-value is less than

benchmark level H0 is rejected as per GSADF probability. Therefore, it confirms the absence of unit root in time series and states the positive signal of bubble in CPO commodity of Agro sector in commodity market.

2. Energy

A) Crude Oil

Test	T-statistic	Window Size	Confidence level	Probability	Occurrence
ADF	-36.09642	137	95%	0.00%	100.00%
maxRADF	-5.159143	137	95%	0.00%	100.00%
SADF	-7.725777	137	95%	0.00%	100.00%
GSADF	-5.159143	137	95%	0.00%	100.00%

Observation: 3319 Table: 3

Source: Eviews analysis

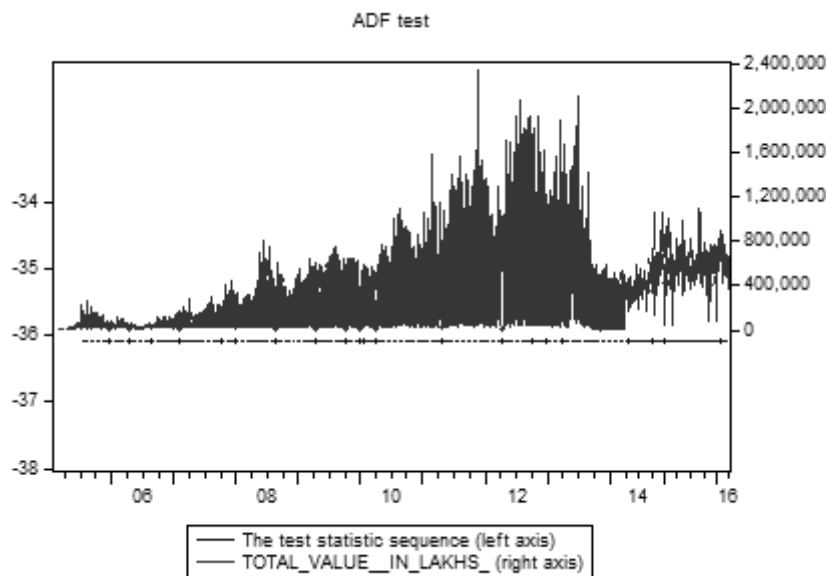
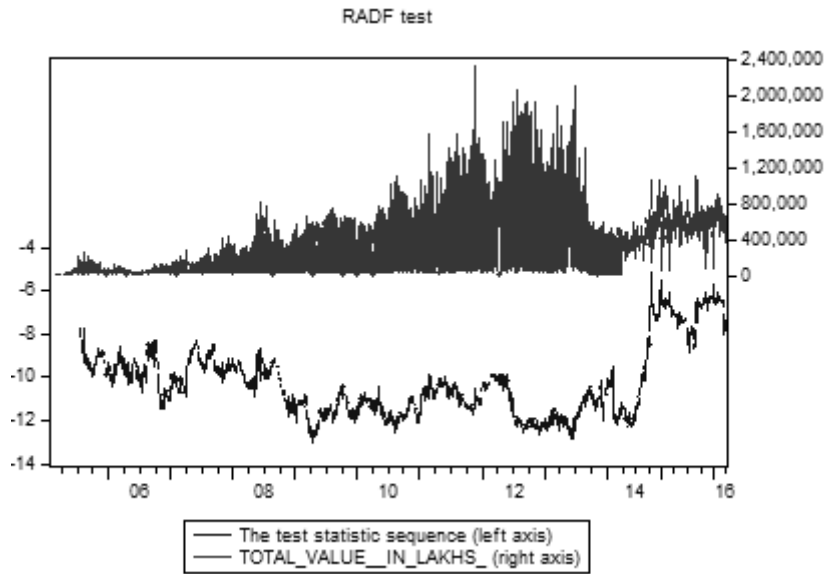


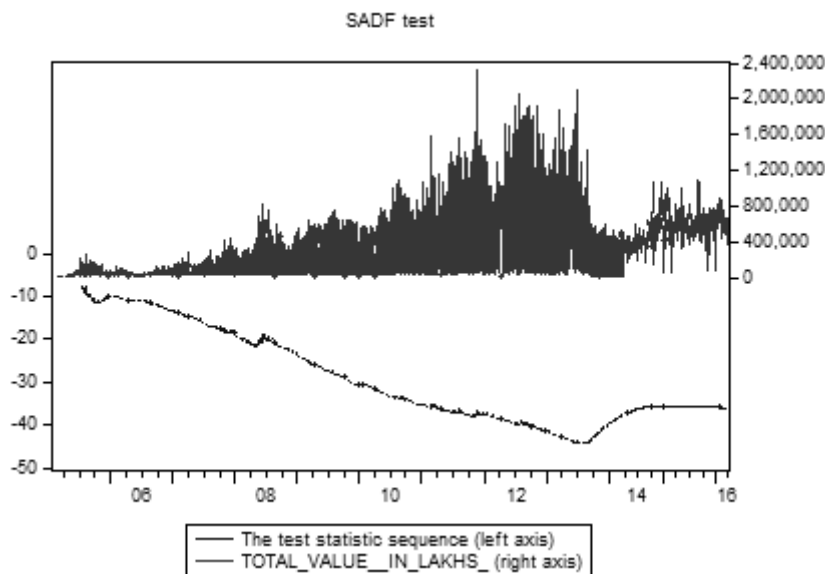
Fig: 9 Source: Eviews analysis

Now we move to next domain in commodity market which is Energy sector. In this domain study is conducted on crude oil. First we start with the output of Crude oil commodity with ADF test(Fig 9). The probability of this test is showing zero. As probability is Zero which leads to 100% occurrence level. As P-value is low then benchmark level of 5%, so therefore we reject the null hypothesis. As a result we can say that there is no unit root in time series. Moreover in this test T-statistic value for the crude oil commodity is 36% which hints towards high impact on momentum of crude oil prices in commodity market. Along with it shows a negative sign of T-statistic's value, which denotes that price of crude oil, may fall sharply before the bubble bursts. Now the question raises regarding this test is its accuracy and why is the impact factor (T-statistic) is high, is this model robust enough to answer the study objective? In order to answer this question, we will further run analysis of this time series with maxRADF test.



**Fig: 10 Source: Eviews analysis**

According to output of maxRADF test(Fig 10), it is evident that T-statistic i.e. impact factor of bubble movement and commodity price has substantially reduced from 36% in ADF to 5% in max RADF while probability is same which is zero percent. Therefore, occurrence level is 100%. In this test also coincide with other output. Therefore, we reject the null hypothesis which means price time series (Total Value) of Crude oil under the study has no unit root. It confirms presence of Stationarity in time series which may leads to presence of bubble. Now the Question rises, can T-statistic can be reduced more and more accuracy be achieved. Therefore we move to next test in series which is SADF.



**Fig: 11 Source: Eviews analysis**

In SADF(Fig 11) the probability and occurrence level are same i.e. 0 and 100% respectively. But the impact factor on price and bubble momentum i.e. T-statistic has increased marginally from 5% to 7%. But the sign of T-statistic is still negative which denotes and confirms the downside movement of price of commodity and bubble in the commodity at time of bubble burst. In other words, it has negative bubble. The T-statistic may have raised because of any cognitive error like herding, biasness etc. in the time series. In order to validate the T-statistic and arrive at final probability, we will run the last test in the loop which is named as GSADF test to check the presence of unit root in time series.

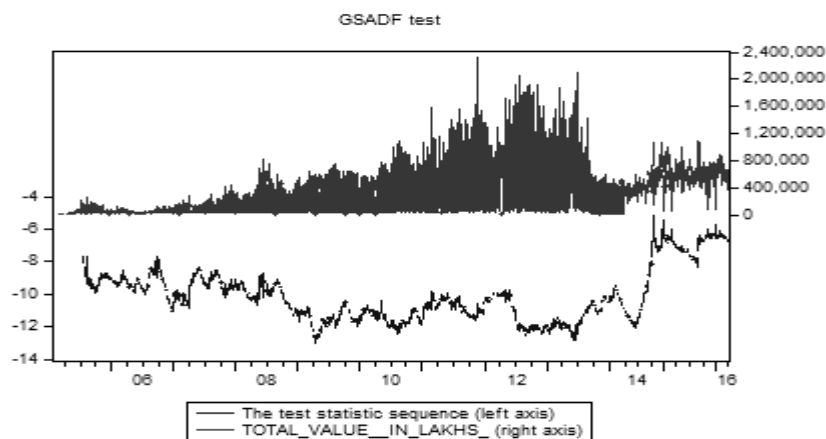


Fig: 12 Source: Eviews analysis

Now as per GSADF(Fig 12) the T-statistic (Impact factor) come down again to 5%. Here also probability and occurrence level are 0% and 100% as they were in all other test. As a result H0 is also rejected as per GSADF probability and occurrence level. Therefore, it confirms the absence of unit root in time series and states the positive signal of bubble in crude oil prices.

### 3) BULLION

#### A) Gold

Test	T-statistic	Window Size	Confidence level	Probability	Occurrence
ADF	-309396	143	95%	0.00%	100.00%
maxRADF	-6.132724	143	95%	0.00%	100.00%
SADF	-9.938822	143	95%	0.00%	100.00%
GSADF	-5.988948	143	95%	0.00%	100.00%

Observation: 3566 Table: 4

Source: Eviews analysis

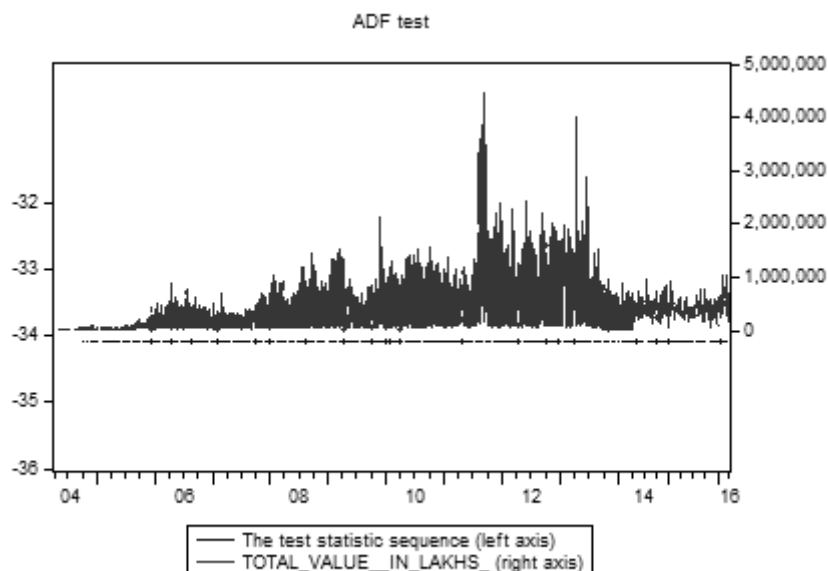


Fig: 13 Source: Eviews analysis

First we start the analysis of Gold commodity with ADF test. As per ADF (Fig 13)output the probability is coming zero. From this probability level we can infer that occurrence level is 100%. As P-value is low then benchmark level of 5%, so therefore we reject the null hypothesis. As a result we can say that there is

no unit root in time series. In addition to it the T-statistic i.e. impact factor on bubble momentum and price movement is 34% which hints towards substantially impact on price movement of gold prices in commodity market. Besides the value, sign is also an important determinant. As per T-statistic of ADF for gold commodity is negative. The negative sign of T-statistic denotes that price of gold might fall substantially before the bubble. Now the question raises regarding this test is it's accurate and why is the T-statistic is high, is this model robust enough to answer the study objective? In order to answer this question and check the robustness of the model, we will run the Gold price time series on maxRADF test.

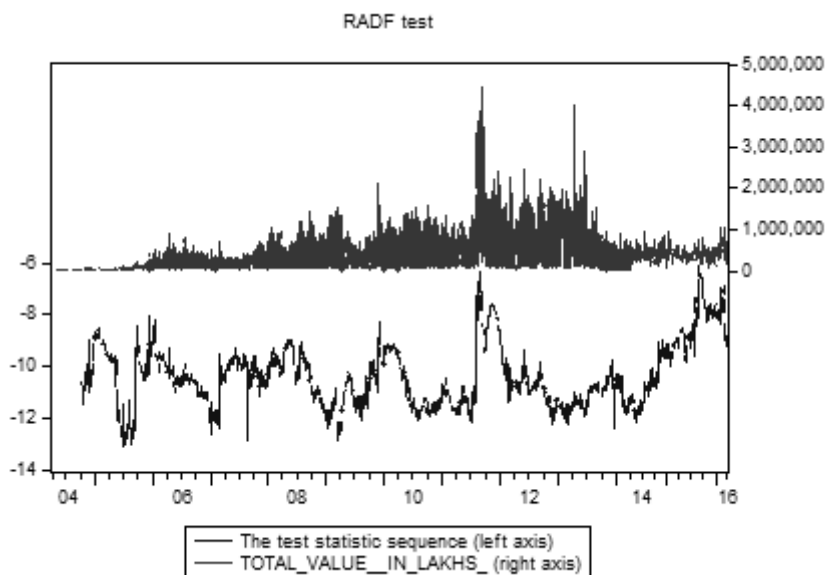


Fig: 14 Source: Eviews analysis

As per the output of maxRADF test(Fig 14), it is evident that T-statistic has substantially reduced from 34% in ADF to 6% in max RADF while probability is same which zero percentage is. So from this probability level we can infer that the occurrence level is 100%. Moreover, the result of this test also coincide with other output and rejects the null hypothesis which means price time series (Total Value) of Gold taken under the study has no unit root. It confirms presence of Stationarity in time series which may leads to presence of bubble. Now the Question rises, can T-statistic can be reduced more and more accuracy be achieved. Therefore, we move to next test in series which is SADF.

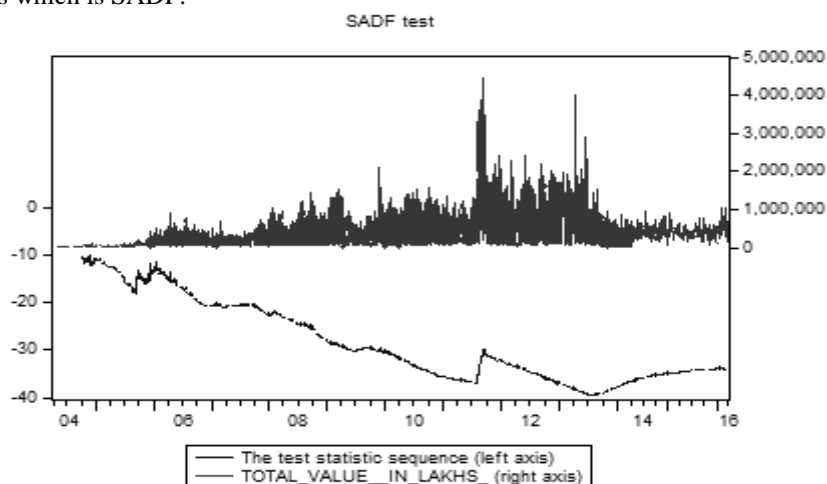


Fig: 15 Source: Eviews analysis

In SADF(Fig 15)the probability and occurrence level are same i.e. 0 and 100% respectively. But the impact factor on price and bubble momentum i.e. T-statistic has increased marginally from 6% to 9%. But the sign of T-statistic is still negative which denotes and confirms the downside movement of price of commodity and bubble in the commodity at time of bubble burst. In other words, it has negative bubble. The T-statistic may have raised because of any cognitive error like herding, biasness etc. in the time series. In order to validate the

T-statistic and arrive at final probability, we will run the last test in the loop which is named as GSADF test to check the presence of unit root in time series.

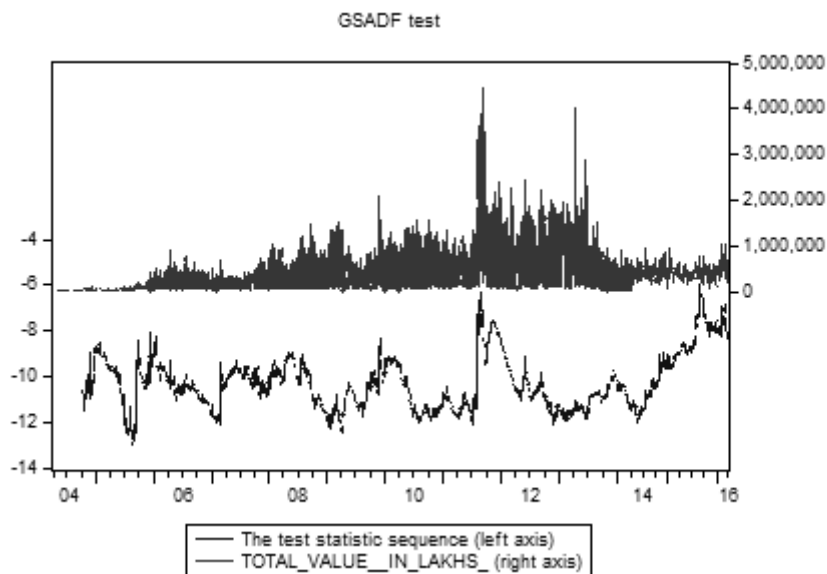


Fig: 16 Source: Eviews analysis

Now as per GSADF(Fig 16) T-statistic come down again to 5%. Here also probability and occurrence level are 0% and 100% as they were in all other test in the study. Therefore, H0 is also rejected as per GSADF probability and occurrence level. So, it confirms the absence of unit root in time series and states the positive signal of bubble in Gold prices in the commodity market.

**B) Silver**

Test	T-statistic	Window Size	Confidence level	Probability	Occurrence
ADF	-28.70902	143	95%	0.00%	100.00%
maxRADF	-6.408062	143	95%	0.00%	100.00%
SADF	-7.490858	143	95%	0.00%	100.00%
GSADF	-6.408062	143	95%	0.00%	100.00%

Observation: 3566 Table: 5

Source: Eviews analysis

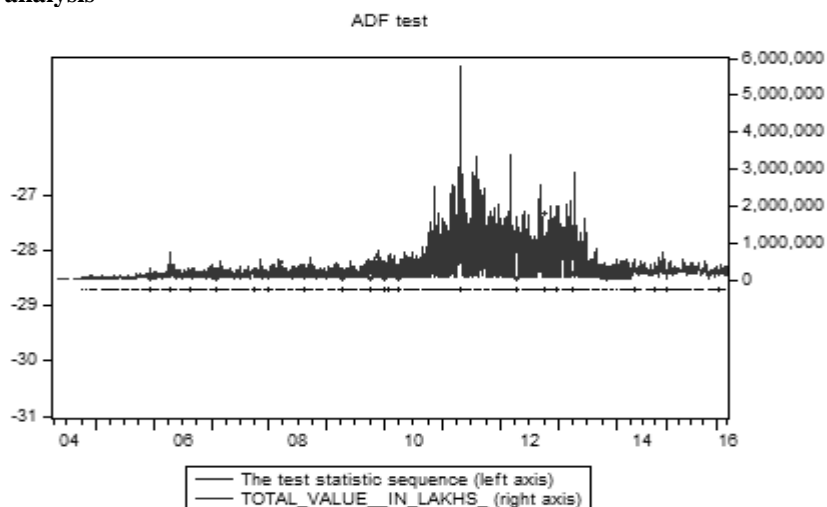


Fig: 17 Source: Eviews analysis

Now we start the analysis of silver commodity with ADF test(Fig 17). As per ADF output the probability is coming zero. From this probability level we can infer that occurrence level is 100%. As P-value is low then benchmark level of 5%, so therefore we reject the null hypothesis. As a result we can say that there is no unit root in time series. In addition to it the T-statistic i.e. impact factor on bubble momentum and price movement is 28% which hints towards substantially impact on price movement of silver prices in commodity market. Besides the value sign is also an important determinant. As per T-statistic of ADF for silver commodity is negative. The negative sign of T-statistic denotes that price of gold might fall substantially before the bubble. Now the question raises regarding this test is its accuracy and why is the T-statistic is high, is this model robust enough to answer the study objective? In order to answer these questions, we will further run analysis of this time series with maxRADF test.

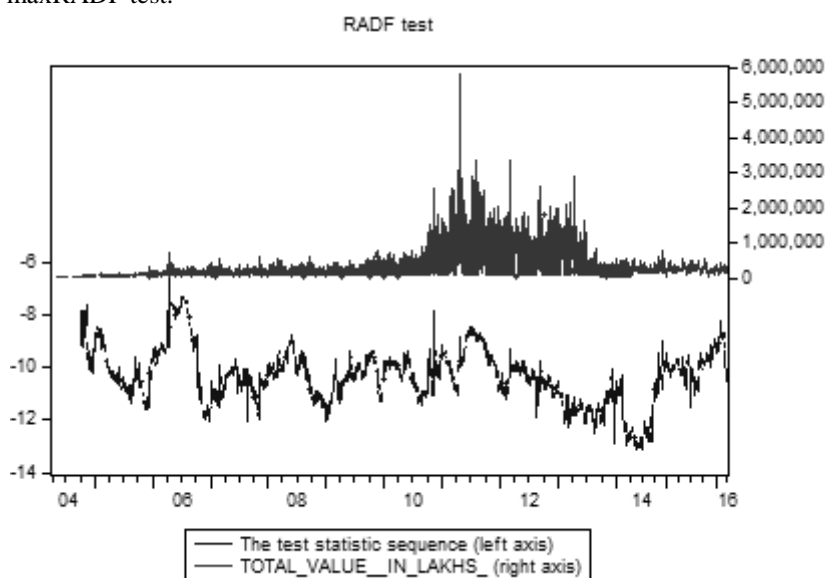


Fig: 18 Source: Eviews analysis

As per the output of maxRADF test(Fig 18), it is evident that T-statistic has substantially reduced from 28% in ADF to 6% in max RADF while probability is same which zero percentage is. So from this probability level we can infer that the occurrence level is 100%. Moreover, the result of this test also coincide with other output and rejects the null hypothesis. Therefore we can state that price (Total Value) of silver has no unit root. It confirms presence of Stationarity in time series which may leads to presence of bubble. Now the Question rises, can T-statistic can be reduced more and more accuracy be achieved. Therefore, we move to next test in series which is SADF.

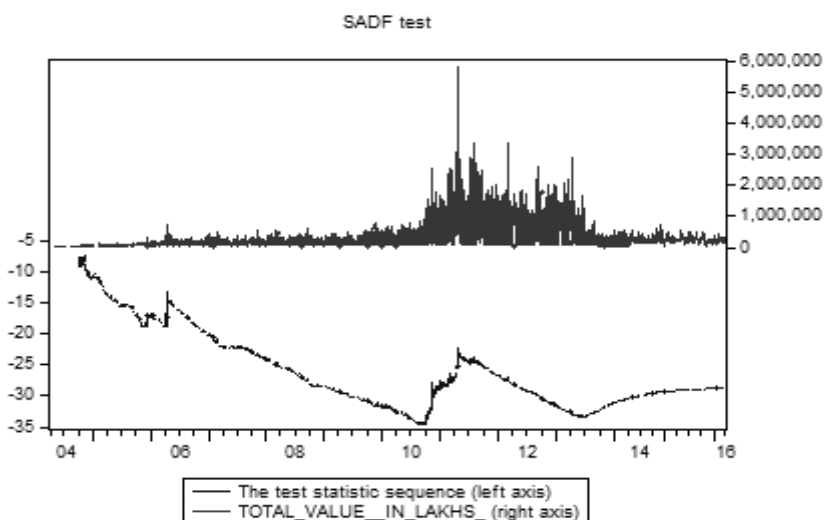


Fig: 19 Source: Eviews analysis

In accordance with the output of SADF(Fig 19) the probability and occurrence level are same i.e. 0 and 100% respectively. But T-statistic has increased marginally from 6% to 7%. But the sign of T-statistic is still negative which denotes and confirms the downside movement of price of commodity at time of bubble. In other words, it has negative bubble. The T-statistic may have raised because of any cognitive error like herding, biasness etc. in the time series. In order to validate the T-statistic and arrive at final probability, we will run the last test named GSADF test to check the presence of unit root in time series.

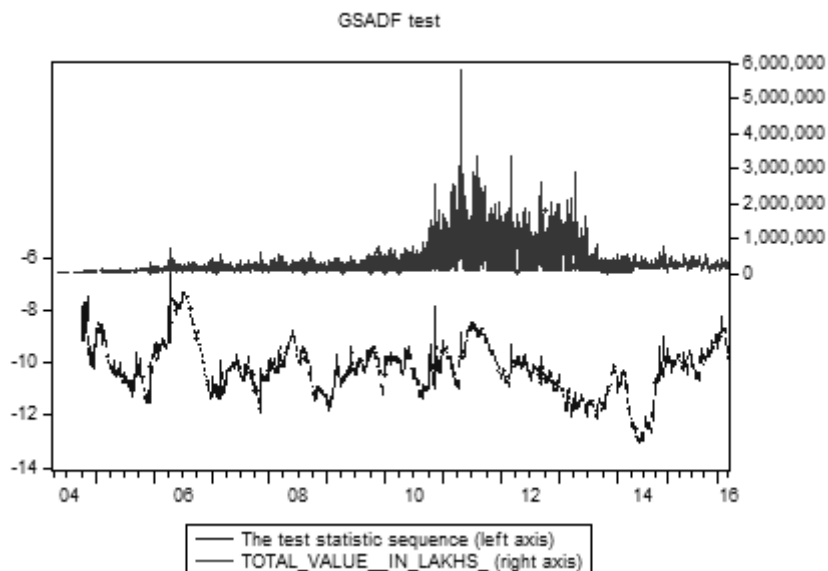


Fig: 20 Source: Eviews analysis

Now as per GSADF(Fig 20) T-statistic (Impact factor) come down again to 6%. Here also probability and occurrence level are 0% and 100% as they were in all other test in the study. Therefore, H0 is also rejected as per GSADF probability and occurrence level. So, it confirms the absence of unit root in time series and states the positive signal of bubble in Silver prices in the commodity market.

4) METAL

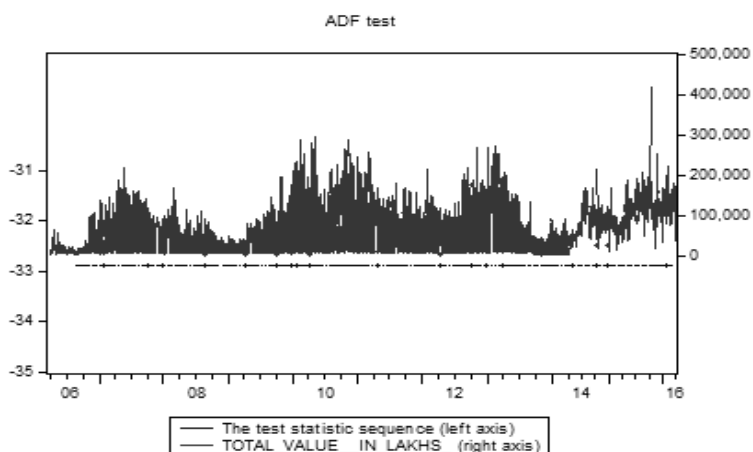
A) Zinc

Test	T-statistic	Window Size	Confidence level	Probability	Occurrence
ADF	-32.87759	128	95%	0.00%	100.00%
MaxRADF	-2.851271	128	95%	0.00%	100.00%
SADF	-4.727894	128	95%	0.00%	100.00%
GSADF	-2.851271	128	95%	0.00%	100.00%

Observation: 2973 Table: 6

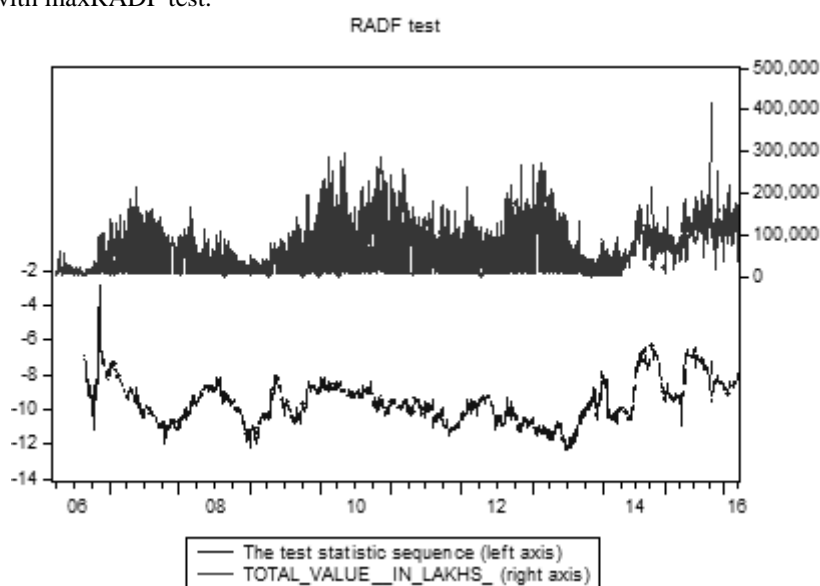
Source: Eviews analysis





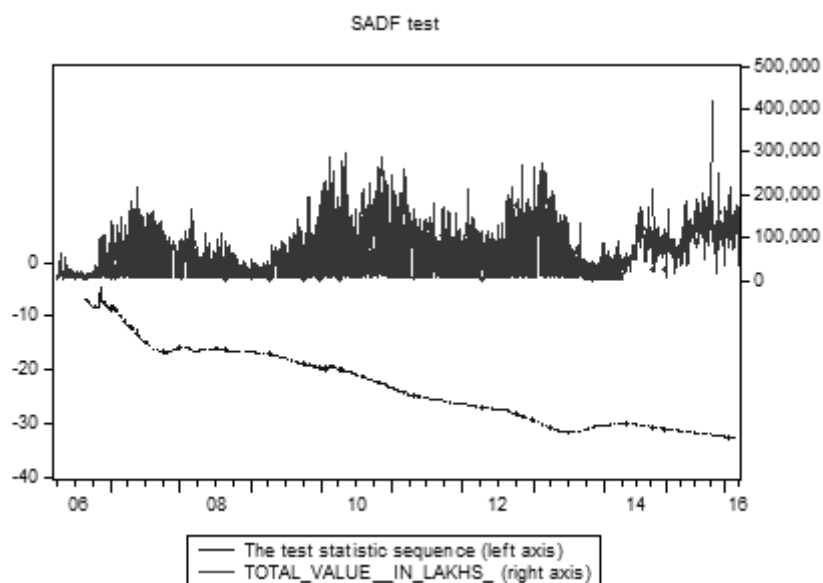
**Fig: 21 Source: Eviews analysis**

Now we start the analysis of Zinc commodity with ADF test(Fig 21). As per ADF output the probability is coming zero. From this probability level we can infer that occurrence level is 100%. As P-value is low then benchmark level of 5%, so therefore we reject the null hypothesis. As a result we can say that there is no unit root in time series. In addition to it the T-statistic i.e. impact factor on bubble momentum and price movement is 32% which hints towards substantially impact on movement of Zinc prices in commodity market. Besides the value sign is also an important determinant. As per T-statistic of ADF for Zinc commodity is negative. The negative sign of T-statistic denotes that price of zinc might fall substantially before the bubble burst. Now the question raises regarding this test is its accuracy and why is the T-statistic is high, is this model robust enough to answer the study objective? In order to answer these questions, we will further run analysis of this time series with maxRADF test.



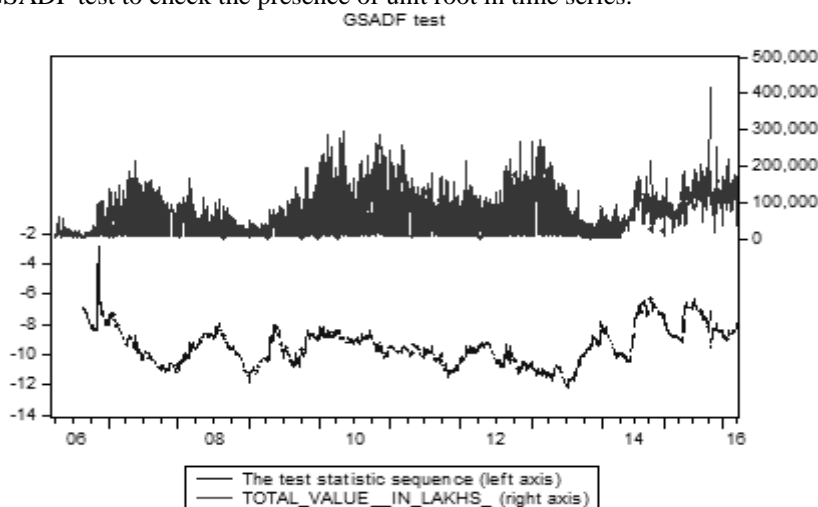
**Fig: 22 Source: Eviews analysis**

As per the output of maxRADF test(Fig 22), it is evident that T-statistic has substantially reduced from 32% in ADF to 2% in max RADF while probability is same which zero percentage is. So from this probability level we can infer that the occurrence level is 100%. Moreover, the result of this test also coincide with other output and rejects the null hypothesis. Therefore, we can state that price time series (Total Value) of Zinc taken under the study has no unit root. It confirms presence of Stationary in time series which may leads to presence of bubble. Now the Question rises, can T-statistic can be reduced more and more accuracy be achieved. Therefore, we move to next test in series which is SADF.



**Fig: 23 Source: Eviews analysis**

In accordance with the output of SADF(Fig 23) the probability and occurrence level are same i.e. 0 and 100% respectively. But T-statistic has increased marginally from 2% to 4%. But the sign of T-statistic is still negative which denotes and confirms the downside movement of price of commodity at time of bubble burst. In other words, it has negative bubble. The T-statistic may have raised because of any cognitive error like herding, biasness etc. in the time series. In order to validate the T-statistic and arrive at final probability, we will run the last test named GSADF test to check the presence of unit root in time series.



**Fig: 24 Source: Eviews analysis**

Now as per GSADF (Fig 24)T-statistic (Impact factor) come down again to 2%. Here also probability and occurrence level are 0% and 100% as they were in all other test in the study. Therefore, H0 is also rejected as per GSADF probability and occurrence level. So, it confirms the absence of unit root in time series and states the positive signal of bubble in Zinc prices in the commodity market.

#### IV. FINDINGS AND CONCLUSION

After conducting ADF to GSADF test for all six commodities on the basis of their output and graphs. The voyage of such steps is strive for higher perfection and accuracy. In all test P-value is less then benchmark level of 5% which results in rejection of Null Hypothesis i.e. time series has a unit root. In other words it can be inferred that as P-value less than significance level which results and give empirical evidence of presence of stationary in the time series.From this outcome, we can say that there is evidence and possible trace of fraudulent activity which may be due to cognitive error, herding or any other loop hole. As a resultsit provides

us an empirical evidence of presence of Commodity price bubble in all six commodities during the period from 2004 to 2016 considered under the study.

Thus it may be concluded and infer that Cotton, CPO, Crude oil, Gold, Silver, Zinc as a commodity has some flaws or deficiency in the structure or any other fundamental factors which are not allowing the assets to reflect its true price and leads to formation of Commodity price bubble.

**So in order to conclude we can infer from the study and states that:**

- As the P-value is less than benchmark level of 5% researcher rejects the Null Hypothesis and concludes that time series has a unit root. Therefore there was possible trace of bubble across all the six commodities.
- The volume of trade also may impact the prices of commodities which are gold, crude oil and silver.
- The test shows some symmetry in T-statistic movement in all commodity except CPO which hints towards some possible negative activities in commodity market.
- This study also reveals an important factor in spotting Commodity price bubble along with spotting of herding behaviour during the Prior to global crisis. During global crisis, post the financial cyclones and during the recovery phase extended till now.
- It also spotted the possible movement of bubble which is downwards owing to the negative sign of T-statistic.
- Owing to the possible herding behaviour and complex market structure there is possibility of coupling of commodity with commodities in other exchange.

## V. RESEARCH IMPLICATIONS

In accordance of the study which was done by Garber (2000) in relation to bubble. He states that the bubble can't be explained with the help of price movement of the economic assets which cannot be justified by rational valuation theories, one more similar study was conducted by Barlevy in his paper titled "Economic Theory and Assets Bubble" in year 2007. The paper majorly discusses about economic theory in relation to occurrence of asset price bubble. In addition to it also explains that bubble may be termed as the phase of the assets when the prices of the assets are in a uniface manner and it exceeds the valuation of assets largely in short of time. This study focuses on Indian commodity market, which is an ideal example of weak efficient economy, wrong decisional judgement, inadequate financial literacy, distortion of information. So it's considered as an appropriate place to study market in terms of financial breaks, Cognitive error owing to the nascent stage of market. As a result, it becomes the necessity of the situation that we should conduct an in-depth investigation on such an important aspect of Indian economy and its market.

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