ANALYSIS OF FRACTAL PATTERNS IN THE PRICES OF AGRO –BASED COMMODITIES

Neha Sam, Vidhi Vashishth, Yukti

In affiliation with

Department of Mathematics, Jesus and Mary College, University of Delhi, New Delhi-110021

ABSTRACT

This paper aims to investigate whether commodity markets follow a pattern with respect to prices and if they do, then whether this could be determined by using basic fractal theory and determination of Hurst exponent. The determination of Hurst exponent will help us to classify the time series as persistent or anti persistent i.e. how strong is the tendency of the time series to revert to its long term mean value.
This result would thus lead us to understand if prices in the commodity market could be remotely predicted. Hence this fractal analysis can be used to determine the characteristics of the prices in an agro based economy.

Keywords: Prices; Pattern; Fractal theory

1. Introduction

When we talk of patterns with respect to economic variables, the *concept of memory* comes to play instinctively. As per *the Concept of Dynamic Memory in Economics by Valentina V. Tarasova and Vasily E. Tarasov* " the concept of memory is considered from the standpoint of economic models in the framework of continuous time approach". With this approach in mind we have attempted to investigate if prices in the Indian Agro-Based Commodity Market tend to show this behavior of possessing a long term memory. The investigation in this paper is streamlined towards the *market for onions* in the National Capital Delhi region. [1]
On an average, the last few years have seen fluctuations and volatilities in all sectors of the Indian Economy, this includes some notable price variations in the commodity market. For an agro-based economy like India even slightest changes in the agro based commodity market can prove to be detrimental to the country's growth. Amongst all the agro-based products *onions* nevertheless have shown a high degree of instability in prices. Hence a study on onion prices in the Indian Economy might lead to a good insight of whether the market in general can be remotely predicted.
The paper is inspired by Fractal Market Hypothesis (FMH) which analyses the daily
randomness of the market, and to understand the same, the Hurst Exponent approach has been used.
This paper would unfold a suitable algorithm to find the Hurst exponent using statistical methods, specifically linear regression and time series analysis, wherein time is the independent variable and price of the commodity considered, is dependent. The reason why time series analysis is chosen, is

because of the tendency of a time series to regress strongly to its mean. A statistical measure chosen to classify time series is the Hurst exponent.[2]

2. Background

2.1 Characteristics of the Indian Commodity Market

Trading of commodities in India has a long history. Weather conditions unique to India play a major role in determining the price variations provided that commodities in the Indian market are traded in bulk. Production of soft commodities like agricultural products have always been influenced by external factors which include farming patterns which are driven by production profits.

2.2 Role of agriculture in the Indian Economy

It is quite evident that India has always been an agriculturally driven economy with an enormous section of its GDP being derived from agriculture and allied activities. Politically speaking a lot of emphasis is laid upon policies that are directly targeted towards the welfare of the agriculture sector. Hence such policy actions might as well be crucially decisive of the course of governance of the country. With this aspect in mind if a pattern is found to exist then this could lead to path breaking developments in the formulation of new policies for the sector.

2.3 Fractal Patterns and Fractal Market Hypothesis

A fractal is a never ending pattern that is self similar. These fractal patterns have been used in previous studies to dictate that financial markets follow such repeatable, cyclical fractal-like patterns. Based on the belief that history repeats itself, the Fractal Market Hypothesis focuses on the price movements of assets. Through the course of this research, if a similar fractal like pattern is found to persist in the specified commodity market then the hypothesis which previously was known to be applicable for financial markets only, will find a new domain of existence.[3]

2.4 Onion as a representative of the agro-based commodity market

India is the second largest producer of onions after China. In India, onion is more than just a vegetable. Apart from being a diet staple and hoarder's favourite, onion prices are often used as an indicator of inflation – and the attendant anger aimed at the government in charge. Moreover onion prices have always been a mystery as recent reports have suggested that onion prices have risen despite increased production which makes it relevant for research as it can be studied (to some extent) independent of external factors. [4]

3. Methodology

3.1 Hurst Exponent

In order to investigate the existence of any such patterns in the agro based commodity market we have used the Hurst Exponent approach. The *Hurst Exponent (H)* can be used to quantify the character of randomness exhibited in a time series via an autocorrelation measurement.

$0 < H < 0.5$ represents negative autocorrelations between variables

$H = 0.5$ represents a process that is purely random

$0.5 < H < 1$ represents positive autocorrelations and the persistence of definite patterns.

Autocorrelation function can be obtained by $C=2^{2H-1}-1$, which is used to describe the influence of the present on the future. The *Fractal Dimension* can also be calculated from Hurst exponent by using the simple relation $D=2-H$, which is a statistical quantity that gives an indication of how completely a fractal appears to fill space, as one zooms down to finer and finer scales. [2][25]

3.2 Data Collection

Onion prices for the years 2013- 2017. The data set has been derived from the official website of the Consumer Affairs Department of the Government of India. The daily retail prices for Delhi for the month of July, August and September were observed and analysed. [26][27]

3.3 Method: Determination of Hurst Exponent by Monofractal Analysis

1. Split the time series of size N into disjoint subsets of time intervals $T_a(a=1,...,A)$ of size n.
2. Calculate mean of values of the commodity in each of these subsets denoted by xmean(a) . Also each value to the corresponding time value is represented by x_i_a, i=1,...,n.
3. The cumulative deviation x_k_a (k=1,...,n) is calculated for each Ta.
4. Range r_a = max (x_k_a, k=1,...,n) - min(x_k_a,k=1,...,n)
5. S_a= standard deviation for each T_a
6. (R/S)(n)= average of ra/sa for a=1,...,A.

   Then on applying linear regression to the equation

   $\log(R/S)= \log c + H\log n,(c=\text{constant})$

   the value of H, Hurst exponent is estimated.[25]

4. Results and Analysis

4.1 Data

Fig 1 is the price graph of daily retail prices(in Rs. per kg) of onions in Delhi from the year 2013-2017 for the months of July, August and September.
X- axis represents the time period and y-axis represents the price per kg in INR.

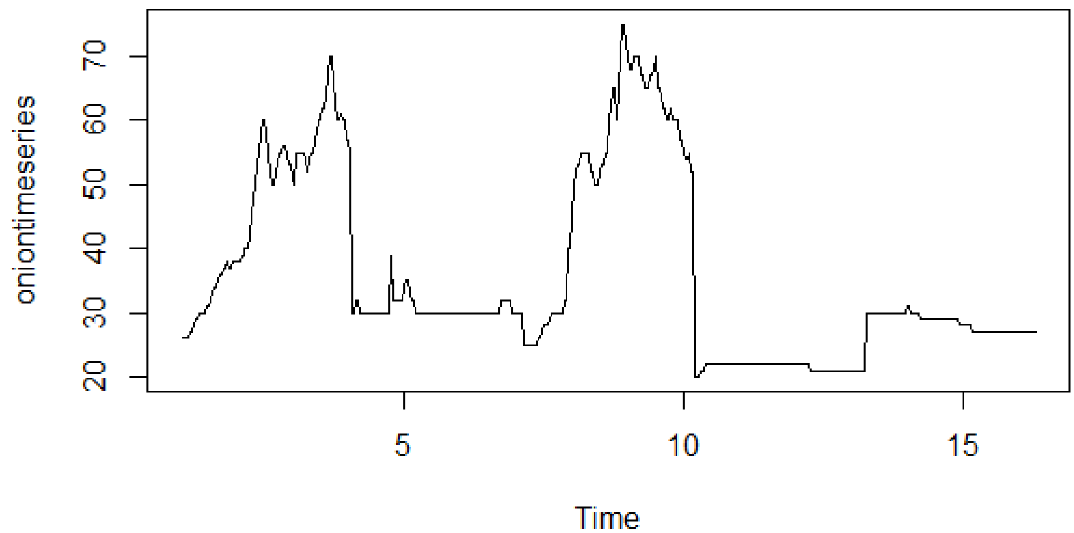


Fig 1

4.2 Monofractal Analysis Results

Table 1

Year	Value of Hurst exponent(H)	$C=2^{2H-1}-1$ (Autocorrelation function)	D=2-H (Dimension)
2013	0.8096	0.5360	1.1904
2014	0.5028	0.0039	1.4972
2015	0.6175	0.1769	1.3825
2016	0.5281	0.0397	1.4719
2017	0.8018	0.5195	1.1982

Table 1 lists the Hurst exponent values for each year from 2013-17. It also lists the autocorrelation function value and fractal dimension for each year.
Since the Hurst Exponent for each year is greater than 0.5, therefore the variations are not completely random and can be predicted in short terms. The variations show fractal characteristic.

The following are the linear regression graphs for each year for determining Hurst Exponent:

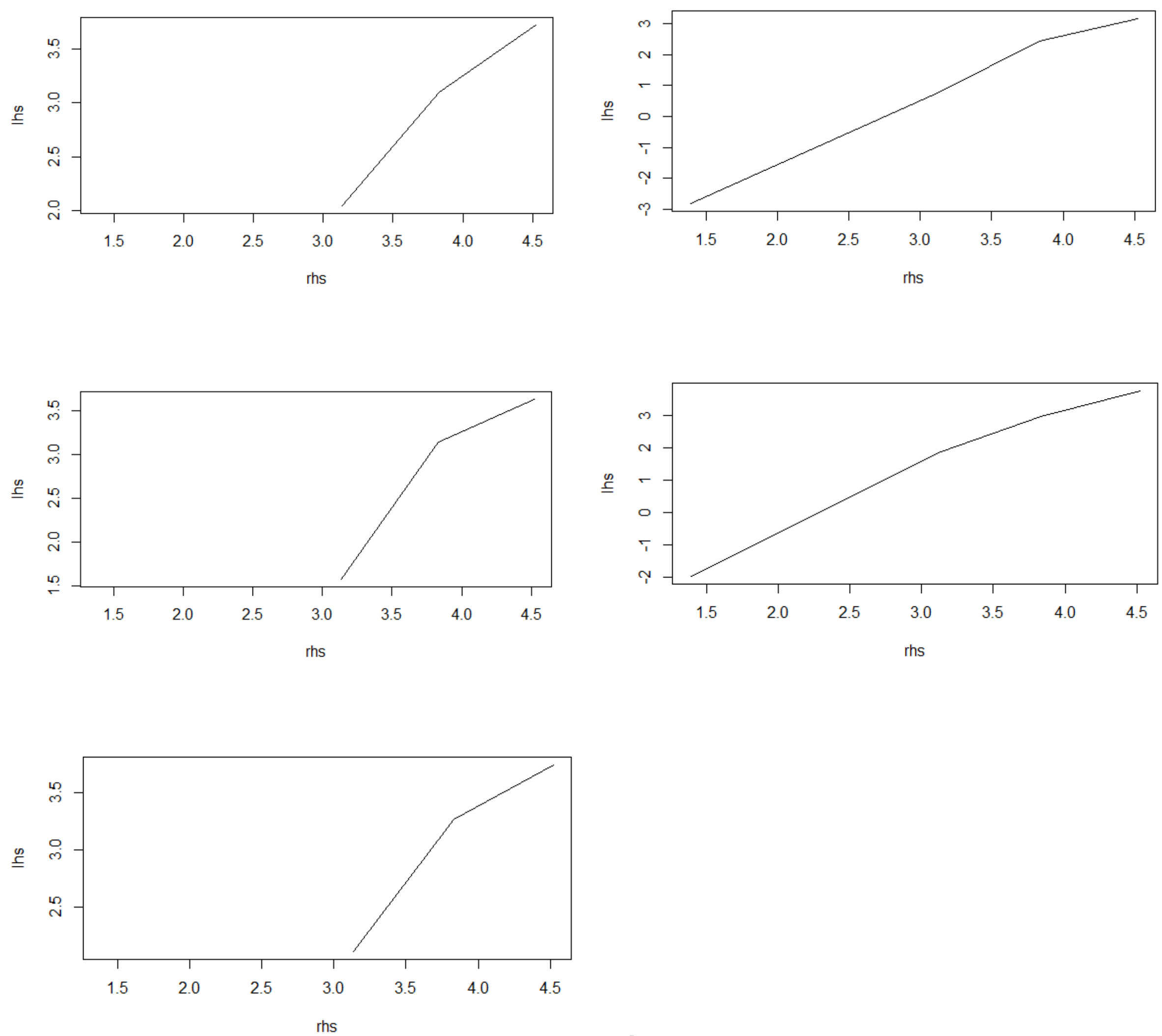
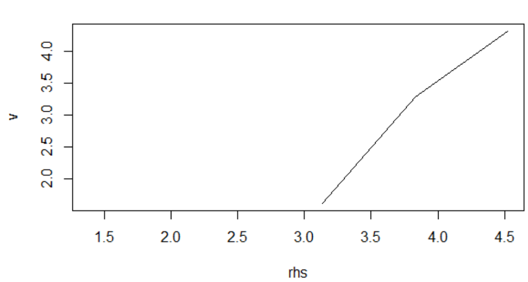
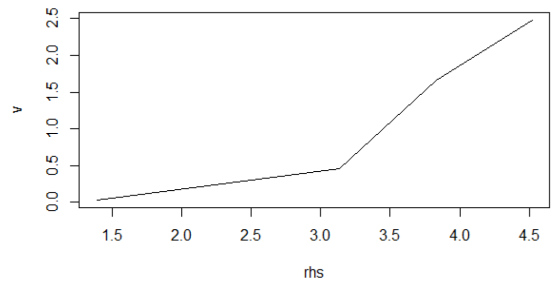
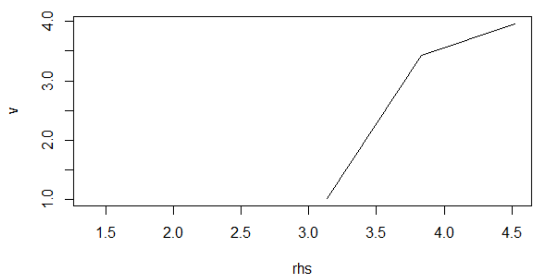


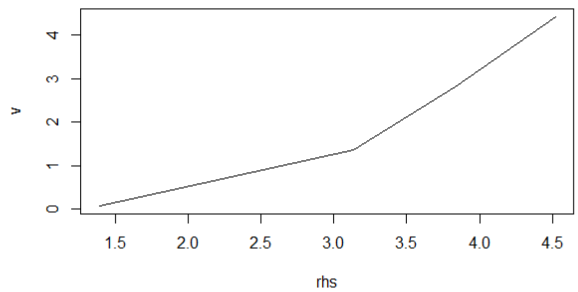
Fig 2

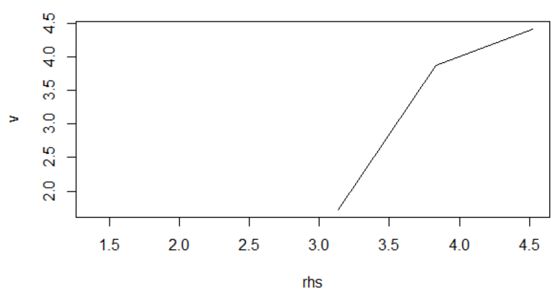
The following are V_n versus log(n) graphs for each year:











Since the V_n versus log(n) graphs for all the years are upward sloping, therefore the time series is persistent in nature. [25]

Conclusions

By the values of the Hurst Exponent derived for onions for the year 2013-17 for the months of July, August and September it is evident that the prices exhibit fractal characteristics. Therefore, the retail onion prices series is *Monofractal*.
It can be observed that the fractal dimensions calculated are fractional in nature unlike the usual dimensions which are natural numbers.
We also conclude that the time series of the onion prices is persistent in nature and the prices can be remotely predicted .This may or may not be generalized to the other agro based commodities of the Indian Market but this fractal analysis can be used to determine the characteristics of the prices in an agro based economy. Lastly, this result could be of benefit to the policymakers of India while drafting policies targeted towards the agriculture sector.

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