Chaotic Trend Possibility in the Gold Market

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Abstract: In this study, the International market gold prices over the last 31 years were analyzed for trends by five different methods, linear trend analysis, ARMA analysis, Rescaled range analysis, attractor reconstruction and maximal Lyapunov Exponent, detrended fluctuation analysis. Unfortunately not all methods give consistent results. The linear analysis reveals three regions with different trends. This is not supported by the rescaled range or detrended fluctuation analysis results. The maximal Lyapunov exponent calculation reveals chaotic behavior. The detrended fluctuation analysis reveals behavior close to brown noise. This is not corroborated by the rescaled range analysis, which indicates anti persistent behavior. The ARMA model implies first differencing that indicates a strong underlying linear trend.

Combining these results, one probable explanation is that the strong linear trend, (also corroborated by ARMA analysis) affects the rescaled range calculation, because of its dependence on extreme values. The detrended fluctuation analysis removes this trend and reveals brown noise. This is consistent with a maximal positive Lyapunov exponent. Hence, we have a linear trend plus brown noise and neither of these two effects is dominant.

Keywords: Dynamical systems, Gold Markets, Lyapunov exponents, Nonlinear Time Series Analysis.

1. Introduction

The goal of this paper is to provide a practical and accessible example for linear and nonlinear time series modeling. As a case study Gold prices in International markets between January 2, 1973 and March 31, 2011 is chosen. This field of study has been chosen for two main reasons. First, up-to-date data are available and it is free to download from international agencies. Second, Gold prices had

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important effects on international monetary system which is explained in Section two. In section three, time series definition and its key features are explained such as trend, seasonality. In section four, one dimensional time series analysis of ARIMA and its components are explained. Section five is arranged for non linear time series analysis methods and linear and non linear time series analysis results are given. Gold has been the foundation of monetary systems for centuries. To illustrate the importance of Gold in monetary systems over the last century, one could start with the end of the British Gold Standard in 1914 to permit inflationary financing of World War I. As with all monetary inflations, it resulted in a buildup of debt as the public borrowed in order to spend money before loss of its purchasing power, with a view to repaying borrowings with currency after relative loss of its purchasing power. The end of monetary inflation in 1921 brought a return to stability for the UK and US. In 1929, collapse of overpriced equity markets resulted in deflation of consumer demand and depression. The cure for this came in 1935 by devaluing the paper money thus raising the paper money price of Gold. To restore stability and to avoid giving a message in favor of possible further inflation of the World Monetary Base, Foreign Exchange Rates were then fixed against Gold and the US Dollar was made convertible into Gold at a set price. The 1935 was ratified at Bretton Woods in 1944. Integrity of the US Dollar was guaranteed by the right of non-US Central Banks to convert their US Dollars to Gold if they feared that the purchasing power of the Dollar could be devalued through excess creation of money. However, in 1968 this arrangement was informally, and in 1971 formally, ended. The World Monetary system came off the US Gold Standard to permit inflationary financing which led directly to the Great Inflation of the 1970's and which, as usual, touched off a resurgence in debt. The 1970's Great Inflation of money ended in 1981, resulting in falling interest rates and strengthening bond and equity prices[1,2].

2. Nonlinear Time Series Analysis

Chaos occurs from the nonlinear evolution of systems. Chaotic dynamical systems are ubiquitous in nature such as the tornado, stock market, turbulence, and weather. Firstly, phase space reconstruction is necessary to understand that whether time series has chaotic behaviors or not[3,4,5].

The most striking feature of chaos is the limit of unpredictability of its future. This feature is usually called as the "sensitive dependence on initial conditions" or referring to the Lorenz models behavior, "butterfly effect. In this section, we will look at the details of nonlinear time series analysis by using mutual information, embedding dimension, maximal Lyapunov exponents, detrended fluctuation analysis and rescaled range analysis[6,7].

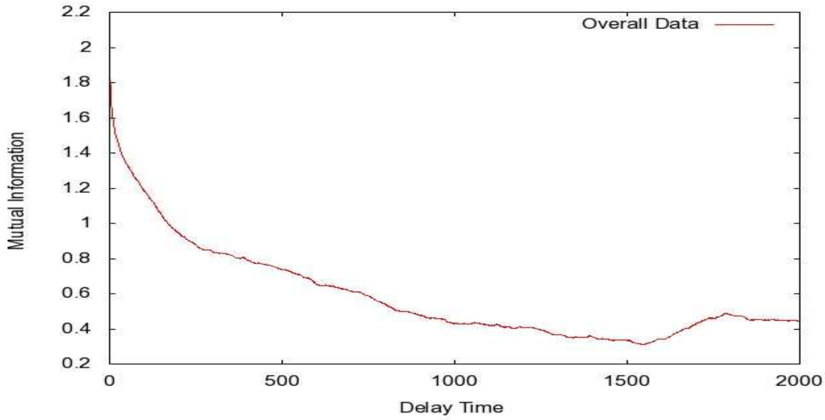

Fig. 1. Mutual Information of Overall Data

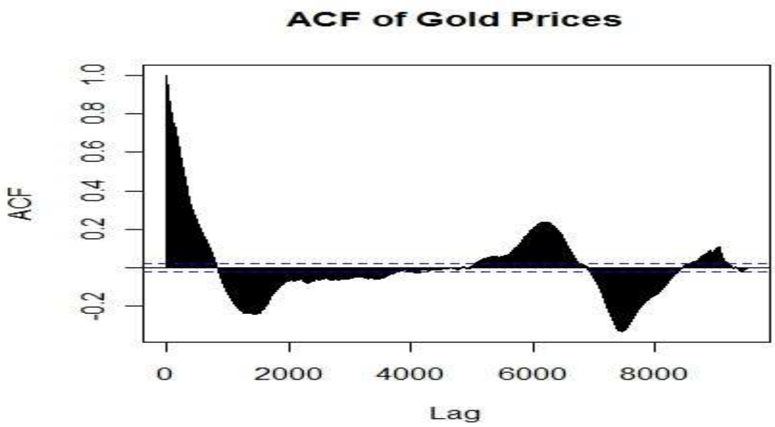

Fig. 2. Autocorrelation function of Gold prices (ACF vs. Lag)

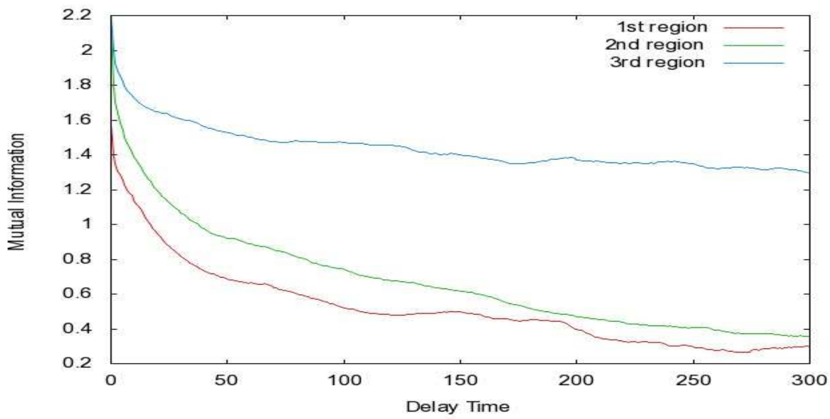

Fig. 3. Mutual Information of Each Region and Overall Data

In order to reconstruct phase space delay time should be found and to find delay time there are basically two methods which are mutual information and autocorrelation function.
As implied in Figure delay time of overall data is nearly 1500. Delay time is expected to be small as far as possible. As second method the calculation of autocorrelation functions were made with R Project statistics package program and also figures were drawn with this program. Figure shows autocorrelation ACF vs. lag and in this figure from first value to nearly 1000th value the ACF rapidly decreases and reaches zero. According to this figure delay time is nearly 1000. After that value it fluctuates between -0.2 and 0.2.The lags do not fall within their standard errors for this reason it is not white noise[8,9].
In each method delay times are too high to evaluate data as a whole. For this reason each region's mutual information was drawn one by one. Delay time chosen from average mutual information is more reliable because it also takes into account possible nonlinearity. For this reason as shown in Figure delay time of each region are calculated and plotted with mutual information method only. Moreover, they are found different from each other. First region's delay time is 100. For second delay time is calculated as 300 and for third region 60.

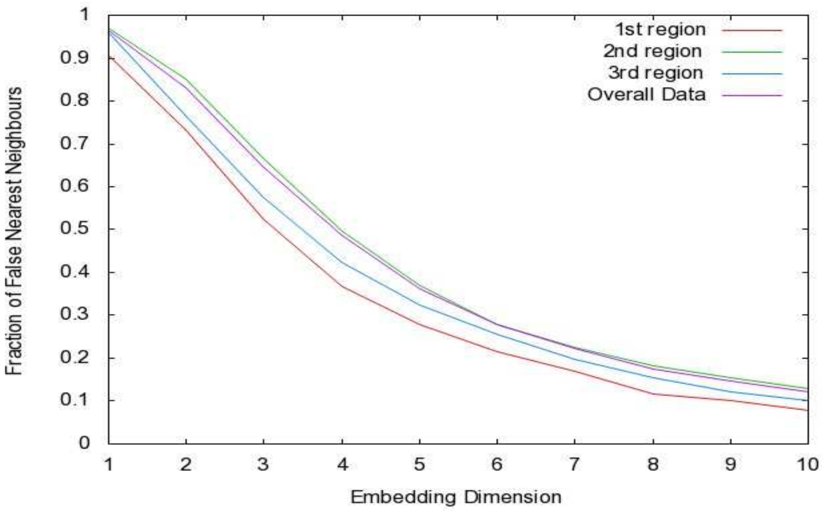

Fig. 4. FNN vs. Embedding Dimension of Each Region and Overall Data

After determining delay times embedding dimensions should be found. To find a satisfactory value for the embedding dimension, false nearest neighbors' method provides a good estimate. After finding delay time for overall data and for each region the fraction of false nearest neighbors are calculated. In Figure14 and the fraction of false nearest neighbors versus embedding dimension are plotted.
Although each regions delay times and trend behaviors' are different from each other, their embedding dimensions are nearly same. All regions embedding dimension graphs' are stabilizing after 8 dimensions.

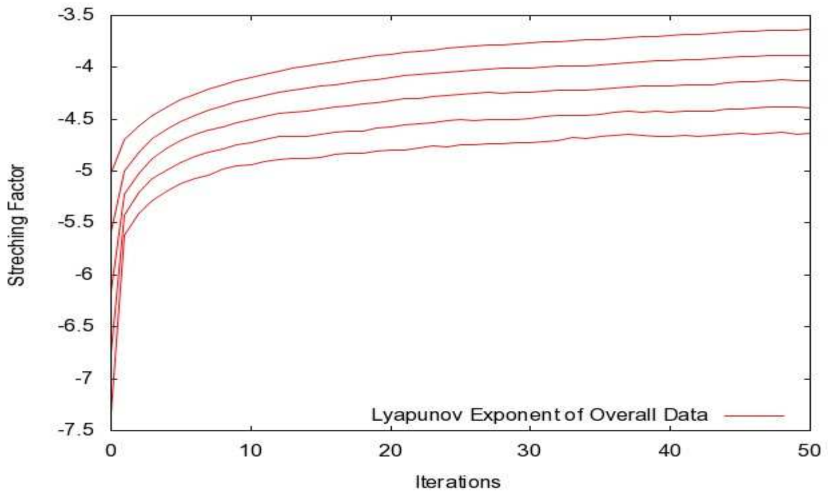

Fig. 6. Lyapunov exponents of Overall Data

The Lyapunov exponents are invariants of the dynamics. The maximal Lyapunov exponents are estimated with the use of TISEAN package and coded as the lyap_k routine. With the fit function of Gnuplot each region's slopes are calculated.1st region's Lyapunov exponent is 0.0308149, in 2nd is 0.0308149, in 3rd is 0.0255495 and Lyapunov exponent of overall data is 0.0175337.As a conclusion a positive Lyapunov exponent is indicated from Gold prices. All Lyapunov exponents are positive on this account they are not stable fixed points .Moreover, they are not equal to ∞. Consequently, they do not indicate random noise. However, they are positive and this shows that this time series is chaotic with a predictibility horizon of approximately 30.

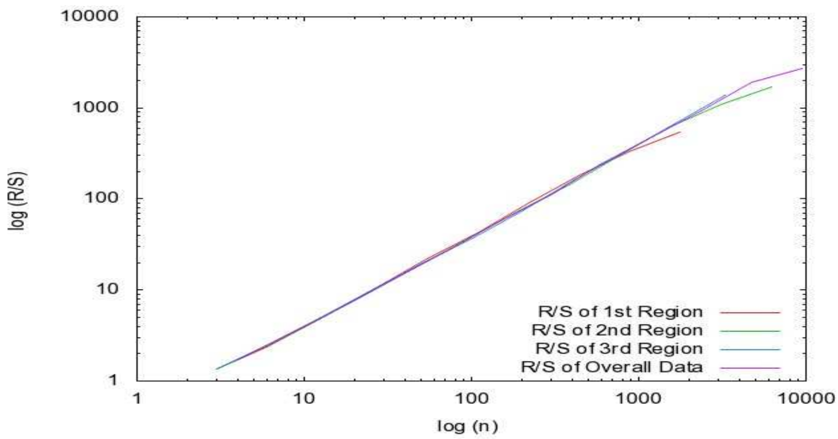

Fig. 7. R/S Analysis of Overall Data and Three Regions

In order to calculate Hurst exponent for each region and overall data Gnuplot and its fit function were used. For each region the Hurst exponent is calculated and the exponents are found to be very close to each other. In the graph below, 1st region's R/S slope is 0.315411 and for 2nd region is 0.285779, for 3rd is 0.285779 and for overall data is 0.305127. If R/S slope was 0.5 it will be random series but it is positive and less than 0.5. Therefore, we consistently observe anti persistent behavior. There is a linear overall trend, as indicated by the first differencing plus noise. The positive Lyapunov exponent indicates that the noise is broadband.

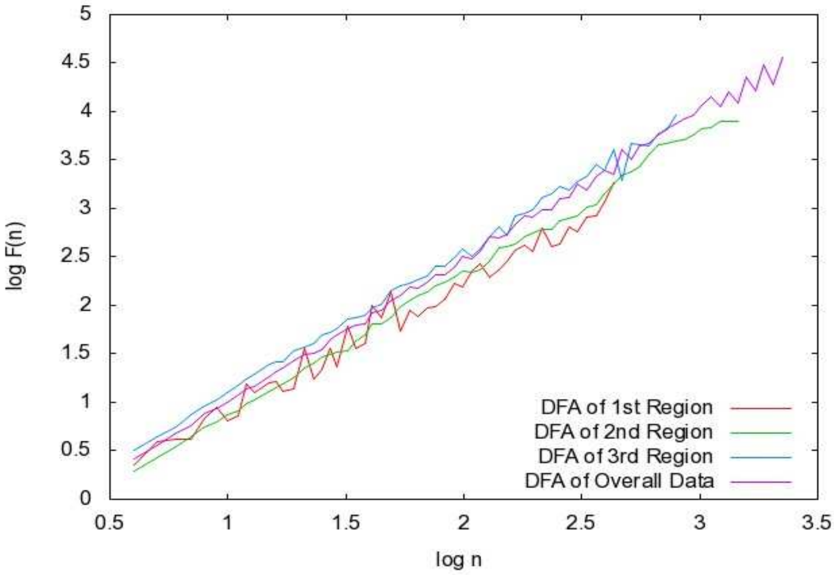

Fig. 8. Log n of Overall Data and Three Regions

As shown in Figure each regions' DFA behavior is very similar to the others .Slopes are calculated with Gnuplot' s fit function and they are found as that 1st region is 1.3136, for 2nd region is 1.45522, 3rd region is 1.46538 and for overall data is 1.4911. As explained in chapter 5 if the slope of DFA is 1.5 it is shows random walk model. All regions especially DFA slope of overall data is nearly 1.5 and it shows random walk model.

3. Conclusions

In this study, the International market gold prices over the last 31 years were analyzed for trends by five different methods, linear trend analysis, ARMA analysis, Rescaled range analysis, attractor reconstruction and maximal Lyapunov Exponent, Detrended fluctuation analysis. Unfortunately not all methods give consistent results. The linear analysis reveals three regions with different trends. This is not supported by the rescaled range or detrended fluctuation analysis results. The maximal Lyapunov exponent calculation reveals chaotic behavior. The detrended fluctuation analysis reveals behavior close to brown noise. This is not corroborated by the rescaled range analysis, which indicates anti persistent behavior. The ARMA model implies first differencing.

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