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Is There Chaos in Inflation Data?

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Abstract

Economic indicators are snippets of financial and economic data published regularly by governmental agencies and the private sector. An exchange rate represents the value of one currency in another and it fluctuates over time. ForEx rates are affected by many highly correlated economic, political and even psychological factors. It was observed that changes in the exchange rate are related to news in the fundamentals which cover Inflation for the country concerned. In a series of work, we investigated and confirmed the chaotic property of ForEx Rates of several countries. In this perspective, we concentrate on nonlinear data analysis of inflation data of nine countries. We find existence of chaos in inflation data for some countries.

Keywords

Inflation, Surrogate Method, Lyapunov Exponent, Chaos

1. Introduction

An exchange rate represents the value of one currency in another. An exchange rate between two currencies fluctuates over time. Foreign exchange (ForEx) rates are amongst the most important economic indices in the international monetary markets. It was observed that changes in the exchange rate are related to news in the fundamentals. Set of fundamentals covers: inflation for the country concerned, money supply for the country under scrutiny, Money Market Rate etc. In a series of work (2007, 2012, 2013), we investigated and confirmed the chaotic property of Foreign Exchange Rates of several countries [1]-[4]. Chaotic processes are characterized by positive Lyapunov Exponent (LE)s and we calculated LEs from ForEx data.

Economic indicators are snippets of financial and economic data published regularly by governmental agencies and the private sector. Here we introduce CPI as defined below for measuring inflation.

Consumer Price Index (CPI): Measures the average price level paid by urban consumers (80% of the population in major currency countries) for a fixed basket of goods and services. It reports price changes in over 200 categories. The CPI also includes various user fees and taxes directly associated with the prices of specific goods and services [5].

In this work we have collected data of some of these indicators from year 2000 to 2013 of the above few important indicators. Figures plotted from this data indicate that ForEx is closely related to other indicators. Our main focus is to explore the nature of dependence of CPI on ForEx rate. We like to address the specific question: Is CPI data also chaotic as with other indicator, it influences ForEx whose fluctuation is already found to be chaotic.

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Little work was attempted in this direction. Guastello (1995) showed low-dimensional chaos for US inflation rates during the 1948-1995 era with Lyapunov dimensionality 1.5. He also confirmed that although there was short time linear prediction of inflation rates, the global picture was, nonetheless, chaotic [6]. In another study (2001) he stressed the presence of chaotic attractors for inflation rate in the US [7]. Results from linear and nonlinear analyses provide overwhelming evidence in support of the nonstationarity of the inflation rate in Africa [8]. We like to study this situation for some EU countries, as well as some other countries having its own ForEx rate. Obviously, we are not attempting any analysis of justification of Euro. Our analysis will be confined to understand the economic indicators, particularly inflation data in relation to ForEx rate through data analysis.

2. Data Collection

Detailed Inflation or CPI data: The inflation rate is based upon the consumer price index (CPI). The CPI inflation rates used are on a yearly basis (compared to the same month the year before). For example, inflation for January 2013 is difference over that in January 2012 expressed as per cent. Inflation.eu [9] maintains historical data for many countries which have been used in this paper. We have collected data on monthly basis from January 2000 to September 2013 for the following countries: France, Italy, Germany, Spain, Greece, India and UK. So each country has a dataset consisting 165 data—one for each month. For Sri Lanka, data from January, 2001 to April, 2008 are available, so data points are 88 in number from Department of Census and Statistics. Government of Sri Lanka [10]. Singapore CPI data was taken from 'Time Series on Monthly CPI (2009 = 100) And Percentage Change Over Corresponding Period Of Previous Year', Government of Singapore [11].

3. Nonlinear Analysis of Inflation Data

Here we shall concentrate on detailed nonlinear data analysis of inflation data collected to get more insight of it. The basic point we like to investigate is if CPI data analysis show chaos or not. For characterizing chaos both qualitatively and quantitatively, we have to find Largest Lyapunov Exponent (LLE).

3.1. Test for Nonlinearity Using Surrogate Data Method

We follow the approach of Theiler *et al.* (1992) [12]. The surrogate signal is produced by phase-randomizing the given data. It has spectral properties similar to the given data, that is, the surrogate data sequence has the same mean, the same variance, the same autocorrelation function, and therefore the same power spectrum as the original sequence, but (nonlinear) phase relations are destroyed. Details of the method for the countries considered have been given in the previous work [1] or as used with additional noise reduction (Çoban *et al.*, 2012) [3]. We used the TSTOOL package by Parlitz *et al.* (1998) [13], under MATLAB (2008) [14] software to create surrogate data for a scalar time series. From this analysis, we got some idea about the degree of nonlinearity associated with the time series of foreign exchange data up to year 2008. We are not repeating the same analysis because we are considering the same countries and compared to our previous data, we now have 450 more points, which is only 5% of total only (from January 2008 to October 2009). But we certainly have to use the results.

3.2. Finding Lyapunov Exponent Using TSTOOL Package

Chaotic processes are characterized by positive Lyapunov Exponent (LE)s calculated following the approach of Wolf *et al.* [15], as explained in previous works [1] [2]. Again, we used the TSTOOL to find the LLE. The function used is largelyap which is an algorithm based on work by Wolf (1985), it computes the average exponential growth of the distance of neighboring orbits via the prediction error. The increase of the prediction error versus the prediction time allows an estimation of the LLE [7]. In the particular MATLAB code, largelyap, the average exponential growth of the distance of neighboring orbits is studied in a logarithmic scale, this time via prediction error p(k). Dependence of p(k) on the number of time steps may be divided into three phases. Phase I is the transient where the neighboring orbits converges to the direction corresponding to the λ the LLE. During phase II, the distance grows exponentially with exp ($\lambda\ t_k$) until it exceeds the range of validity of the linear approximation of the flow. Then phase III begins where the distance increases slower than exponentially until it decreases again due to folding in the state space. If the phase II is sufficiently long, a linear segment with slope λ appears in the p(k) versus k diagram [13]. While calculating the LLE, we have obtained the prediction error p(k) versus k diagrams as output and are given.

4. Results and Discussion

To ascertain the nonlinearity of data, we have applied surrogate methods as described in Section 3.1, we have used Theiler algorithm [12] to produce three surrogate datasets of each series. We have calculated LLE from original as well as three surrogate sets and compared the values to see how much they change in per cent. This is given in **Table 1**. For a sufficiently chaotic dataset, LL for a surrogate set would differ considerably for reasons described in Section 3.1. In this paradigm, percent deviation of LLE values in corresponding surrogate sets will indicate chaotic nature of the original data. From the results given in the **Table 1**, we find:

For Inflation data, chaotic natures of data are the following:

- Low (change < 20%): France, Germany, Spain.
- High (change < 40%): Greece, India.
- Very high ((change > 40%): Italy, Singapore, Sri Lanka and UK.

From above results, we can draw following conclusions:

- We can say that from above calculation, LLE values indicate that inflation data shows chaos. They are highly chaotic for at least four countries listed above.
- Inflation data points for very low in number. Consumer Price Index is calculated monthly, so during the period under present study (year 2000 to 2013), we have about 160 points only. But there is evidence, for many countries (say, for example India, Sri Lanka) prices fluctuate daily like in ForEx markets, but only monthly values are recorded.
- Another important aspect of inflation data is that, as this factor immediately affects people's life, they are more closely monitored by respective Governments. Even the intervention during present global recession is so acute that some reverse phenomena like deflation has taken place in many European countries. Deflation refers to fall in money prices of commodities also constitutes a serious threat to the monitory system. Inflation falling low, as seen in **Figure 1** for countries (say, for example Greece) threatens Europe' [16]. In the present study, we are interested in fluctuations of the CPI, not its absolute values. So, whether inflation is high or low is not of direct importance here, but such interventions some times in unspoken terms, makes data analysis more difficult. Particularly, these become important when we try to see CPI in relation to other economic indicators mentioned in this paper.

5. Discussion

We found chaotic nature of the inflation rate. But as pointed out earlier, experimentations with higher amount of

Table 1. Calculation of Largest Lyapunov Exponent (LLE) using TSTOOL in Mat Lab: Inflation (Monthly data, January 2000 to September 2013).

Country	Original data	surrogate set1	% change in surrogate over original	surrogate set2	% change in surrogate over original	surrogate set3	% change in surrogate over original
France	1.8	2.1	16.67	1.9	5.56	2.2	22.22
Germany	1.7	2.1	23.53	1.9	11.76	2	17.65
Greece	1.7	2.2	29.41	1.7	0	2.2	29.41
India	1.1	1.4	27.27	1.3	18.18	1.5	36.36
Italy	1.2	1.9	58.33	1.6	33.33	1.7	41.67
Singapore	0.7	1.2	71.43	1.2	71.43	0.8	14.29
Spain	1.7	1.8	5.88	1.7	0	1.9	11.76
Sri Lanka	0.6	0.8	33.33	0.4	-33.33	0.85	41.67
UK	1.3	1.9	46.15	1.5	15.38	1.4	7.69

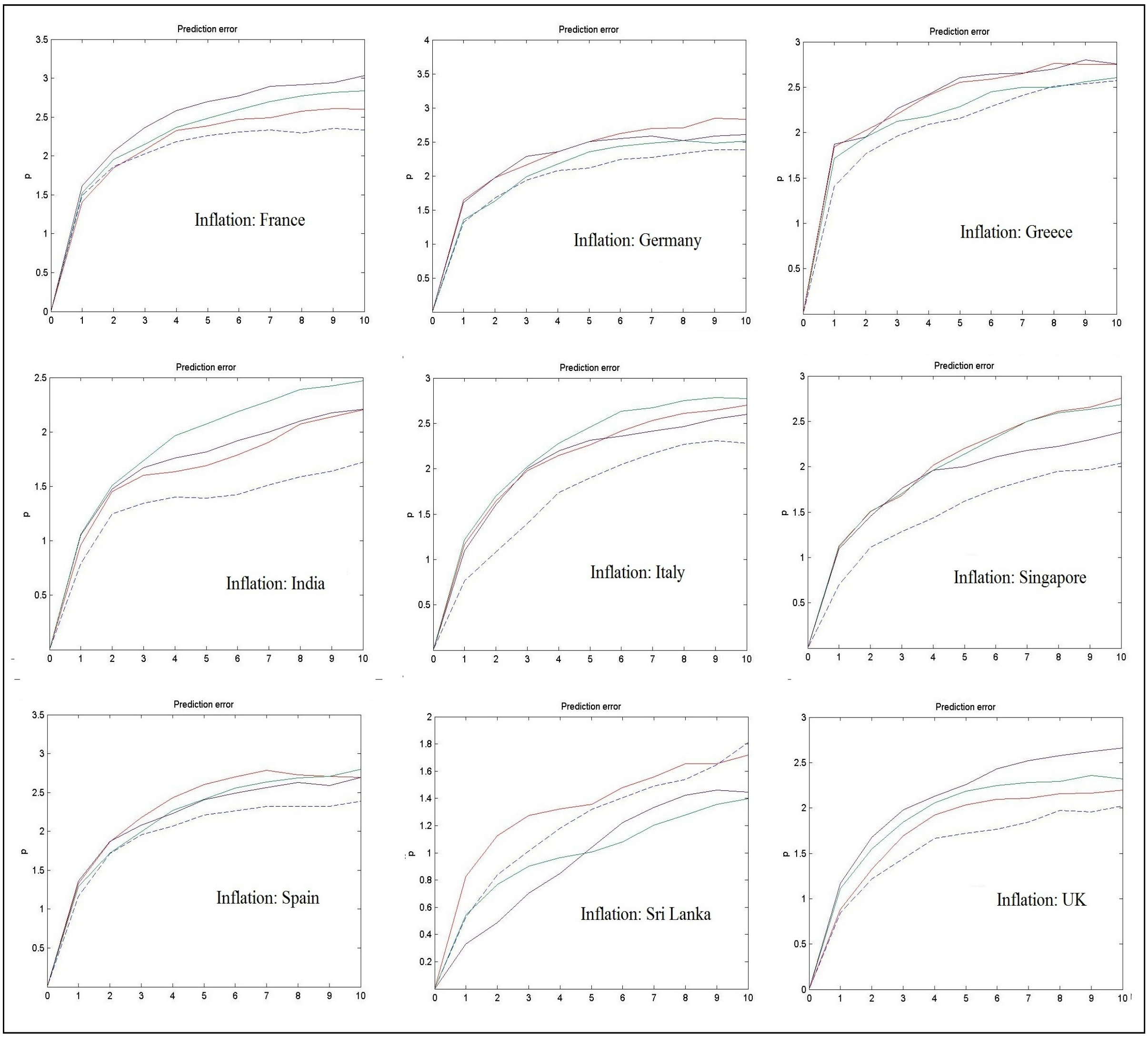

Figure 1. Plot of LLE from inflation data. Dashed line for original data and other three represents surrogate counter parts.

data have to be made. For that reason, more rigorous data collection practice has to be adopted. If we can establish at least some empirical mathematical relation of indicators towards setting up a model of a system consisting of these indicators, we can investigate important parameters controlling the system. These issues deserve more thoughtful studies which will have far reaching effect to handle the system for the benefit of citizens.

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