International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2018, 8(3), 17-22.

Forecasting of Sudan Inflation Rates using ARIMA Model

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ABSTRACT

This study forecasted the inflation rates in Sudan. Annual time series data for the period 1970-2016 has been used in the analysis, by using Box-Jenkins method and ARIMA model. Data were obtained from Central Bureau of Statistics in Sudan. The results showed that, there is a convergence between predictive values and actual values during the period (1970-2016). Hence, there inflation rates in Sudan will increase in the coming years (2017-2026).

Keywords: Inflation, Box-Jenkins, ARIMA, Model, Forecasting
JEL Classifications: E17, E31

1. INTRODUCTION

Inflation is one of the economic problems facing most economies in both developing and developed countries; it is a monetary phenomenon and means a continuous rise in the overall level of prices.

Economists use the term inflation to describe a situation in which the economy's overall price level is rising. The inflation rate is the percentage change in some measure of the price level from one period to the next (Mankiw, 2015). Inflation expectations appear reasonably well anchored and both inflation expectation and actual inflation remain within a range consistent with price stability. In this context raising inflation objective would likely entail much greater cost than benefits. Inflation would be higher and probably more volatile under such a policy, undermining confidence and the ability of firms and households to make longer-term plans, while squandering the Fed's hard-won inflation credibility. Inflation expectations would also likely become significantly less stable, and risk premiums in asset markets- including inflation risk premiums would rise (quoted from Ascari and Sbordone, 2014).

Sudan economy is currently going sever economic crisis. It is experiencing a staggering rate of inflation associated many macroeconomics problems such as higher exchange rate, debt overhang, adverse balance of payment rates and high unemployment rates (Abdulrahman et al., 2016).

The ARIMA model divides the pattern of time series into three components: The autoregressive component (p), the differencing component (d), and the moving average component (q). The objective of this study is to forecast Sudan inflation rate by using box-Jenkins and ARIMA method. Data were obtained from Central Bureau of Statistic for the period 1970-2016.

The rest of this research is organized as follows. Section (2) briefly reviews the literature, while Section (3) discusses the data and methodology. The results and conclusion remarks are given in Sections (4 and 5) respectively. The study posed one research question: Can ARIMA models forecasts in Inflation Rates in Sudan?

2. LITERATURE REVIEW

Schofield and Bowler 2011, differentiate between three concepts; inflation, deflation, and disinflation. Inflation is rising prices, deflation falling prices and disinflation is where price increases slow down. They discussed that, within the inflation world a nominal frame of reference looks at investments in terms of cash paid without taking into account the loss of purchasing power. So if an item costs €1 today, with 2% inflation it will cost €1.02 by the end of the year. Alternatively they said that at the end of the year, €1 will only buy 0.98 of the item.

Theoretically inflation is a monetary phenomenon; it may also be demand pull, cost push or imported inflation. The quantity theory of money is used to explain inflation as monetary phenomenon, however, inflation determinants also include; exchange rate, foreign inflation, external deficit, government deficit, financing, cost of finance, etc. Therefore, inflation is basically affected by various factors that represent economic fundamentals which interact to shape the domestic and foreign imbalances (Abdalla, 2010).

With respect to financial crises, Caprio and Honohan (2005) reported that, Inflation remained surprisingly low despite the crises and, in some cases, fell even lower afterward. In East Asia, inflation traditionally had been low and remained in single digits in almost all cases during the crisis. The exception was Indonesia, where inflation jumped to more than 50% after the large devaluation. However, Indonesian inflation fell back to about 6% in 2003 and 2004. Latin America historically had high inflation, with inflationary spurts, and the associated inflation tax on depositors was often used to finance governments and clean up bank balance sheets. However, in a break with history, Latin American inflation dropped sharply in the 1990s. Most Latin American emerging-market borrowers, which often had experienced three- or even four-digit inflation at the beginning of the 1990s, dropped to single-digit inflation in 2000, despite their crises. The crises in Argentina and Uruguay that began in 2001 were associated with large real devaluations and inflation that rose to the 20–30% range, but by 2004 their inflation returned to single digits. The crisis in the Dominican Republic that began in 2003 was associated with an even sharper rise in inflation, but after July 2004 inflation was largely halted by a sharp appreciation of the peso.

The notion of money creation by the state was associated with hyperinflation and utterly rejected as "printing money." Recurrent examples like the hyperinflation in Zimbabwe did not help this perception. An alternative view of the cause of inflation is that it is not the public issue of money in itself that is the problem, but issuing it in an unbalanced way so that consumer demand is not matched by material wealth in the production of goods and services. Parguez and Seccareccia see this as the cause of the pre-war German hyperinflation (2000. p. 107). In the case of Zimbabwe this was clearly a failed state whose productive system had collapsed. Its hyperinflation and debased money was arguably as much a reflection as a cause of its predicament. The fact that through history public authorities have created and circulated money without necessarily incurring inflationary consequences is ignored as, too, is the historical evidence of disastrous activities by banks. In the privatized world of private good, public bad, the public sector has been forced to meet expenditure by borrowing from commercially created and circulated money.

According to previous literature, inflation rate between 2 consecutive years is calculated as follow:

$$\text{Inflation Rate} = \frac{P2 - P1}{P1} * 100$$

Where:

P2: Price level in current year,

P1: Price level in previous year

Suppose the price level for year 2017 is 125 and for 2016 is 60. So inflation rate is equal 100*(125−60)÷60 = 108.3

3. DATA AND METHODOLOGY

The data of the study obtained from Central Bureau of Statistics (CBS), consists of annual data on Sudan inflation rates and consumer prices for the period 1970-2016. We use ARIMA model for forecast one period a head of the series by applying Box-Jenkins approach. An ARIMA is a generalization of an ARIMA model. The model is generally referred to as ARIMA (p, d, q) model, where p, d and q are integers greater than or equal zero and refer to the order of autoregressive integrated and moving average aspects.

The Box-ARIMA model is a combination of the AR (autoregressive) and MA (moving average) model as follows:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \ldots + \beta_p Y_{t-p} - \alpha_1 U_{t-1} - \alpha_2 U_{t-2} - \ldots - \alpha_q U_{t-q} + U_t$$

The Box-Jenkins methodology is a five step process for identifying, selective and Assessing conditional means models.

4. RESULTS AND DISCUSSION

The ARIMA methodology is summarized in four stages in which the most appropriate model is selected for evaluation in the time series model, the stages are:

Phase I: The first stage: Stability analysis: It checks the stability of the time series, and if it is unstable, conversions are applied. So it is necessary to make it stable. The first step in model identification is to ensure the process is stationary. Stationarity can be checked with a Dickey-Fuller test. Any non-significant value under model assumptions suggests the process is non-stationary. The process must be converted to a stationary process to proceed, and this is accomplished by the differencing the time series using a lag in the variable as well as removing any seasonality effects. The lagged values used to difference the time series will constitute the "d" order.

Phase II: Appreciation ARIMA Model: C5 estimates at each iteration

Iteration	SSE	Parameters		
0	107.889	0.100	0.100	0.109
1	82.926	−0.050	0.249	0.037
2	78.668	0.056	0.399	0.031
3	73.938	0.149	0.549	0.026
4	68.185	0.216	0.699	0.021
5	60.740	0.239	0.849	0.016
6	53.430	0.195	0.999	0.010
7	48.100	0.045	0.995	0.005
8	45.672	−0.105	0.987	0.002

9	45.442	−0.179	0.980	0.001
10	45.412	−0.184	0.982	0.003
11	45.411	−0.185	0.981	0.003

During which the parameters of the standard model are estimated.

Phase III: Personal examination. Unable to reduce sum of squares any further

Final estimates of parameters

Type	Coef	SE Coef	T	P
AR 1	−0.1854	0.1616	−1.15	0.258
MA 1	0.9813	0.1108	8.86	0.000
Constant	0.00263	0.01380	0.19	0.850

The estimation procedure involves using the model with p, d and q orders to fit the actual time series. We allow the software to fit the historical time series, while the user checks that there is no significant signal from the errors using an ACF for the error residuals, and that estimated parameters for the autoregressive or moving average components are significant.

Differencing: 2 regular differences:

Number of observations: Original series 44, after differencing 42

Residuals: SS = 43.9248 (backforecasts excluded)

MS = 1.1263 DF = 39

Modified Box-Pierce (Ljung-Box) Chi-square statistic

Lag	12	24	36	48
Chi-square	15.8	27.7	44.2	*
DF	9	21	33	*
P-value	0.071	0.149	0.093	*

4.1. Autocorrelation Function: C5

Lag	ACF	T	LBQ
1	0.278932	1.85	3.66
2	−0.098820	−0.61	4.13
3	−0.056868	−0.35	4.29
4	−0.041604	−0.25	4.38
5	0.189663	1.16	6.25
6	0.045797	0.27	6.36
7	−0.045688	−0.27	6.47
8	−0.082017	−0.48	6.85
9	−0.188582	−1.11	8.91
10	−0.076739	−0.44	9.26
11	0.040891	0.23	9.36

4.2. Partial Autocorrelation Function: C5

Lag	PACF	T
1	0.278932	1.85
2	−0.191524	−1.27
3	0.033091	0.22
4	−0.058133	−0.39
5	0.240930	1.60
6	−0.127272	−0.84
7	0.051438	0.34
8	−0.116694	−0.77
9	−0.116318	−0.77
10	−0.056424	−0.37
11	0.057406	0.38

During which the model is checked for relevance to the given time series and when it is not convenient we return to the 2nd stage, otherwise we move to Phase IV.

Phase IV: Forecasting

After a model is assured to be stationary, and fitted such that there is no information in the residuals, we can proceed to forecasting. Forecasting assesses the performance of the model against real data. There is an option to split the time series into two parts, using the first part to fit the model and the second half to check model performance. Usually the utility of a specific model or the utility of several classes of models to fit actual data can be assessed by minimizing a value such as root mean square.

4.3. Forecasts from Period 47

Period	Forecast	95% limits	
		Lower	Upper Actual
48	−0.70691	−2.78740	1.37359
49	−0.78925	−3.49731	1.91881
50	−0.84960	−4.12177	2.42257
51	−0.91140	−4.67350	2.85069
52	−0.97031	−5.18118	3.24056
53	−1.02713	−5.65668	3.60243
54	−1.08171	−6.10779	3.94438
55	−1.13407	−6.53958	4.27144
56	−1.18422	−6.95561	4.58717
57	−1.23215	−7.35849	4.89418

Note that the model is AR (1,2,1)

Forecasts from period 10

Period	Forecast	95% limits	
		Lower	Upper actual
11	−0.395426	−0.405136	−0.385717
12	−0.409659	−0.419565	−0.399753
13	−0.424044	−0.433952	−0.414135
14	−0.438400	−0.448310	−0.428489
15	−0.452761	−0.462672	−0.442850
16	−0.467121	−0.477033	−0.457209
17	−0.481482	−0.491395	−0.471569
18	−0.495842	−0.505756	−0.485929
19	−0.510203	−0.520117	−0.500289
20	−0.524563	−0.534479	−0.514648

- If the model hypotheses are validated and the latter is statistically acceptable, the observed phenomenon can be predicted.
- Based on the proposed model, the forecast that is calculated is only a short-term forecast and is not valid for long periods.
- This study specifically examined the use of ARIMA forecasting and tested its ability to create accurate baselines. Specifically, as a retrospective.
- Secondary data analysis using Inflation Rates in Sudan surveillance system this study examined the use of ARIMA model.

- Models and its ability to create accurate baselines for use in inflation rates in Sudan.

5. CONCLUSION REMARKS

By applying the inflation chain in Sudan, the following conclusions are drawn:

- Sudan's time series of inflation has an increasing general trend, which means it is not static. We create the natural logarithm and convert it into a stable time series.
- We observe that the time series is unstable. We create the first difference and convert it into a stable time series by taking the second difference.
- We note that the time series is unstable. We took the second difference and the chain became stable.
- We find the auto correlation function and the partial auto correlation.
- From the auto correlation function we note that the coefficient of MA = 1.
- From the partial auto correlation function we note that the coefficient of AR = 1 and degree of difference = 2
- Check the residue properties in the model ARIMA (1, 2, and 1), P > 0.05 and go beyond the testing phase and diagnosis.
- The ideal model for inflation forecasting in Sudan is ARIMA (1, 2, and 1).
- There is a convergence between predictive values and actual values during the period (1970-2016).
- There is an increase in inflation in Sudan in the coming years (2017-2026).

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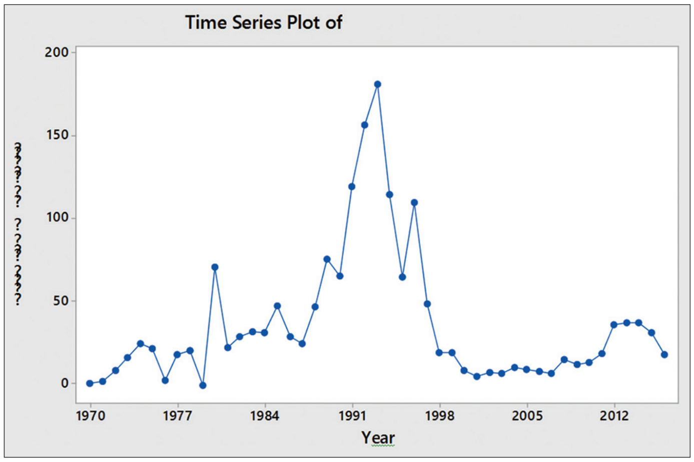
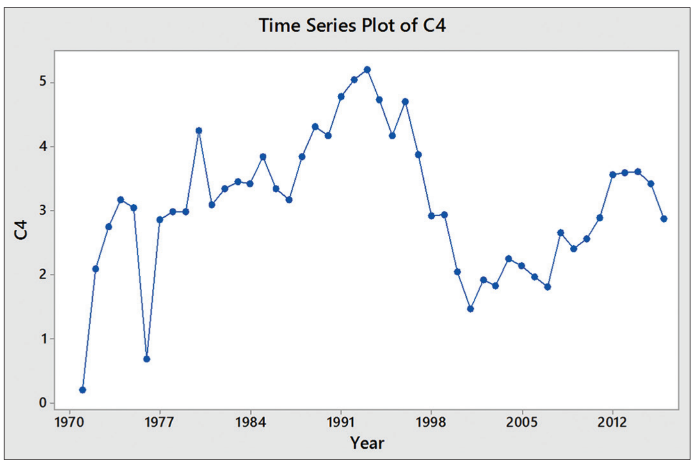
APPENDICES

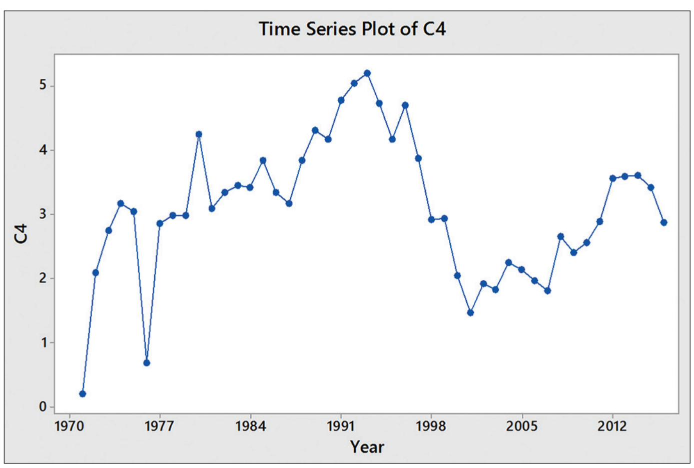
A.1: Time series plot of inflation



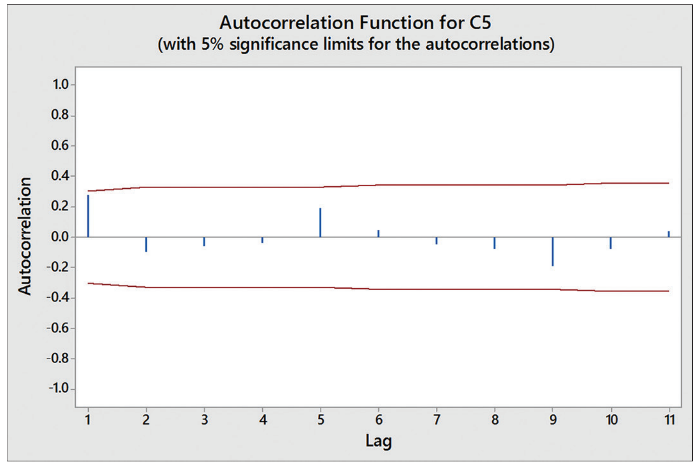
A.2: Time series plot of C4



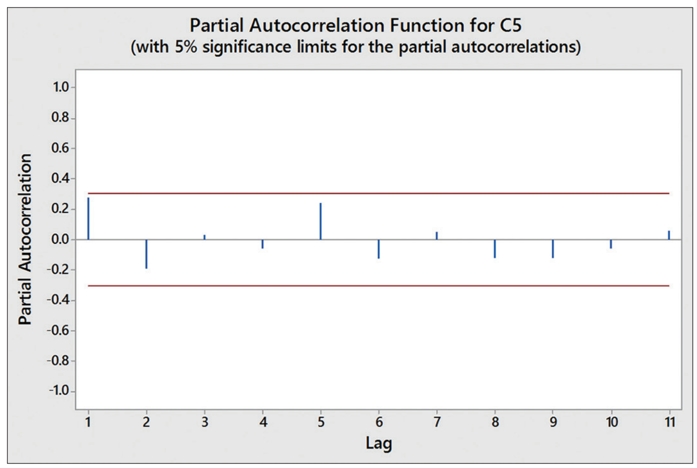
A.3: Time series plot of C4



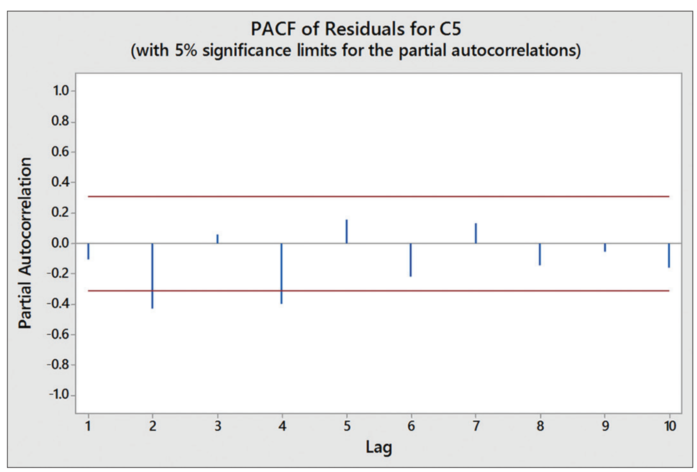
A.4: Autocorrelation function



A.5: Partial autocorrelation

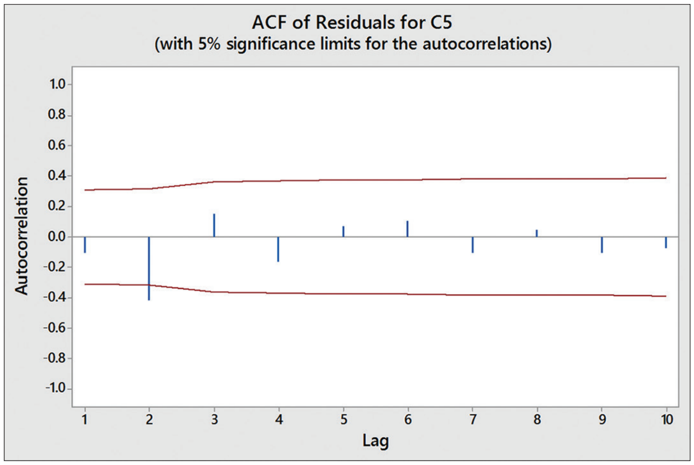


A.6: PACF



APPENDICES

A.7: ACF



A.8: Inflation rates in Sudan

Year	Inflation rate	Year	Inflation rate	Year	Inflation rate
2000	7.76	1985	47.17	1970	0
2001	4.4	1986	28.35	1971	1.23
2002	6.9	1987	24.05	1972	8.15
2003	6.25	1988	46.67	1973	15.76
2004	9.52	1989	75.3	1974	24.08
2005	8.59	1990	65.3	1975	21.1
2006	7.2	1991	119.05	1976	1.99
2007	6.21	1992	156.69	1977	17.52
2008	14.3	1993	181.47	1978	19.98
2009	11.24	1994	114.5	1979	-1.04
2010	12.98	1995	64.55	1980	70.79
2011	18.08	1996	109.84	1981	22.02
2012	35.6	1997	48.39	1982	28.43
2013	36.52	1998	18.73	1983	31.66
2014	36.9	1999	18.89	1984	30.75
2015	30.7				
2016	17.8				

Source: CBS