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DAILY CHINESE YUAN – NIGERIAN NAIRA EXCHANGE RATES SARIMA MODELLING

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ABSTRACT

A 179-point realization of daily exchange rates of the Chinese Yuan and the Nigerian Naira spanning from 18th October 2015 and 13th April 2016 is analyzed by seasonal autoregressive integrated moving average (SARIMA) methods. The time plot shows an initial downward trend up to the middle of December 2015 and then an upward trend from then onwards. This means that prior to the middle of December 2015 the Naira was relatively appreciating before it started depreciating relatively. The series is adjudged as non-stationary by the Augmented Dickey Fuller Test. A seven-point (i.e. seasonal) differencing of the series yields a series which, though adjudged stationary, still exhibits seasonality and therefore could not said to be stationary. A further (non-seasonal) differencing is done to achieve stationarity. The autocorrelation structure of the resultant series suggests the possibility of some SARIMA models. These include a SARIMA$(0,1,1)x(0,1,1)_{12}$ and a SARIMA$(0,1,0)x(0,1,1)_{12}$. Comparison on the basis of the information criteria AIC, Schwarz criterion and Hannan-Quinn criterion shows that the former model is the superior. It is as well observed that its residuals are white noise. Forecasting and simulation of these rates may be done on its basis.

Keywords: *Chinese Yuan, Nigerian Naira, SARIMA Modelling*

INTRODUCTION

Of recent the Nigerian President Muhammadu Buhari paid a visit to China and it is being conjectured that the purpose of his visit was to discuss the possibility of a currency swap between the Chinese Yuan (CNY) and the Nigerian Naira (NGN). If this is true then it would mean that transactions of all kinds between the two governments will be in terms of the exchange rates of the two currencies. This implies that demand for US dollars through Nigerian banks for trade transactions between both countries shall reduce. Preference shall be given to the Yuan (Clement, 2016). Nigeria can do business with China using the Yuan and China can do business with Nigeria using the Naira. Nigerians hope that this will augur well for their economy which is currently experiencing a downturn. Whatever trade transactions between China and Nigeria will affect and be affected by the exchange rates between CNY and NGN.

This work is therefore aimed at modelling the daily exchange rates of the two currencies. Because of its importance, exchange rates modelling has engaged the attention of many researchers a few of whom are Erdemliogu *et al.* (2012), Chong *et al.* (2002) and Ari and Unal (2016). These authors focussed on volatility modelling by members of the Garch family. Some others are Li *et al.* (2007) who applied regularized least squares regression to model the exchange rates of the British pound (GPB) and United States Dollar (USD), Martinez and Gaw (2013) who modelled the Philippine-USD exchange rates as an ARIMA (1,1, 2) and Urrutia *et al.* (2015) who fitted an ARIMA(0,1,0) to quarterly exchange rates of the Philippine relative to the USD. Moreover, Appiah and Adetunde (2011) proposed the use of an ARIMA (1,1,1) in forecasting Ghana cedi / USD exchange rates and Osarumwese and Waziri (2013) used an ARIMA(0,1,1) to model Nigerian Naira (NGN) and USD exchange rates. In this work we shall use the seasonal autoregressive integrated moving average (SARIMA) approach for the modelling. Application of the SARIMA approach on foreign exchange rates has had a measure of success in recent times. Etuk (2013, 2014) and Etuk and Bazinzi (2015) have successfully applied SARIMA modelling on foreign exchange rates.

MATERIALS AND METHODS

Data

The data analyzed herein are 179 Chinese Yuan (CNY)/Nigerian Naira (NGN) daily exchange rates from 18th October 2015 to 13th April, 2016. For out-of-sample comparison of data with forecasts a further set of 8 values from 14th April to 21st April, 2016 are used. The website from which data were read is www.exchangerates.org.uk/CNY-NGN-exchange-rate-history.html accessed on the 14th April, 2016 and 24th June 2016 for the out-of-sample data. They are to be interpreted as the amount of NGN in one CNY.

Sarima Modelling

Box and Jenkins (1976) defined a SARIMA (p,d,q)x(P,D,Q)$_s$ model as

$$A(L)\Phi(L^s)\nabla_s^D\nabla^d X_t = B(L)\Theta(L^s)\varepsilon_t \qquad (1)$$

where X_t is the value of the time series at time t, A(L) the autoregressive (AR) operator which is a polynomial of degree p in L, B(L) the moving average (MA) operator which is a polynomial of degree q in L, Φ(L) is the seasonal AR operator which is a polynomial of degree P in L, Θ(L) is the seasonal MA operator which is a polynomial of degree Q in L, L is the backshift operator defined by $L^kX_t = X_{t-k}$, ∇ is the non-seasonal differencing operator, ∇_s is the seasonal differencing operator , s is the seasonality period and $\{\varepsilon_t\}$ is a white noise process. The parameter s may be suggestive directly from knowledge of the seasonal nature of the series. It is often enough to select the differencing orders d and D such that they sum up to at most 2 for the data to be stationary. The augmented Dickey Fuller (ADF) Test shall be used to test for data stationarity. The AR orders p and P are usually estimated by the non-seasonal and the seasonal cut-off lags for the partial autocorrelation functions (PACF) while their MA counter parts q and Q are estimated by the non-seasonal and the seasonal cut-off lags of the autocorrelation function (ACF) respectively.

Model estimation shall be by the least squares procedure. Model selection shall be by the Akaike Information criterion (AIC) (Akaike, 1974), Schwarz criterion (SC) (Schwarz, 1978) and Hannan-Quinn criterion (HQ) (Hannan and Quinn, 1979). Diagnostic checking shall be done by examining the time plot of the model residuals. Granted model adequacy the residuals should be uncorrelated.

RESULTS AND DISCUSSION

The time plot of the series shows an initial overall downward trend up to the third week of December 2015 followed by an overall upward trend. This means that prior to the third week of December 2015 the Naira was relatively appreciating and then depreciating up to April 2016. This series cannot be stationary since its mean level is clearly not constant. This suspicion is upheld by the ADF test as follows: the test statistic value is -1.69 and the 1%, 5% and the 10% critical values are respectively -3.47, -2.88 and -2.58. This calls for a differencing of the rates. Initial a seven-day differencing is done under the hypothesis of a seasonal component of weekly periodicity. The time plot of the differences in Figure 2 reveals a slight positive trend.

The ADF test with a statistic value of -3.68 certifies the differences as stationary. However the correlogram of Figure 3 seems to contradict a stationarity hypothesis.

A further but non-seasonal differencing yields a series with an overall horizontal trend (See Figure 4). The correlogram of Figure 5 shows that his series may be considered as stationary. Suggestive by the autocorrelation structure shown by the ACF and the PACF are some SARIMA models which include a SARIMA(0,1,1)x$(0,1,1)_7$ and a SARIMA(0,1,0)x$(0,1,1)_7$. These models have been estimated and the estimation summaries are displayed in Tables 1 and 2 respectively. Clearly the latter model is the less adequate model as evident from the values of the information criteria: AIC, SC and HQ, and even the R^2.

That means that the moving average model

$$X_t = \varepsilon_t - 0.2754\varepsilon_{t-t} - 0.9488\varepsilon_{t-7} + 0.2620\varepsilon_{t-8} \qquad (2)$$

$$(\pm 0.0744) \quad (\pm 0.0170) \quad (\pm 0.0720)$$

where $\{X_t\}$ is the difference of the seasonal difference series , is the better model proposed for the forecasting and simulation of the exchange rates. Its adequacy is not in doubt. Its residuals are uncorrelated (See Figure 6). Besides out-of-sample forecasts and observations agree very closely as evident from Table 3 results.

CONCLUSION

It may be concluded that model (2) which is a SARIMA(0,1,1)x$(0,1,1)_7$ model may be used to forecast the daily CNY/NGN exchange rate series. Its adequacy has been demonstrated by some residual analysis as evident in Figure 6. A close agreement is observed between the out-of-sample observations and the forecasts in Table 3. It then may be possible on the basis of our results to make forecasts and simulations for planning and management purposes.

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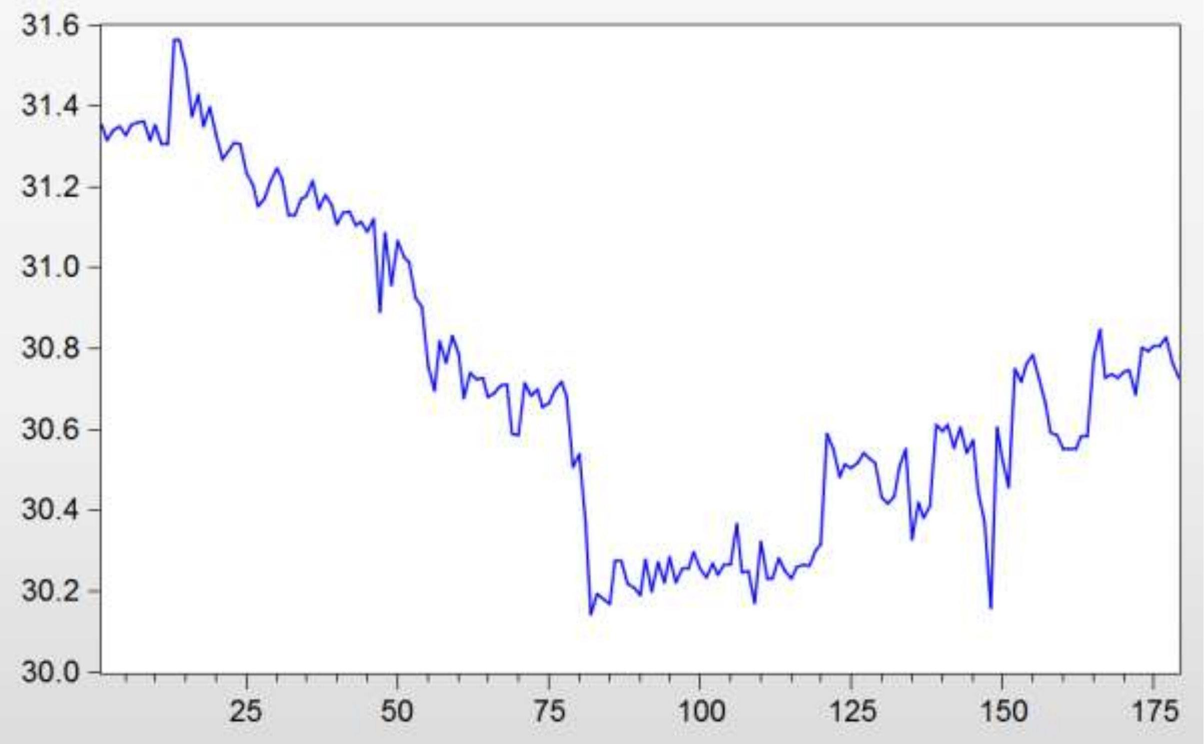


FIGURE 1: TIME PLOT OF THE EXCHANGE RATES

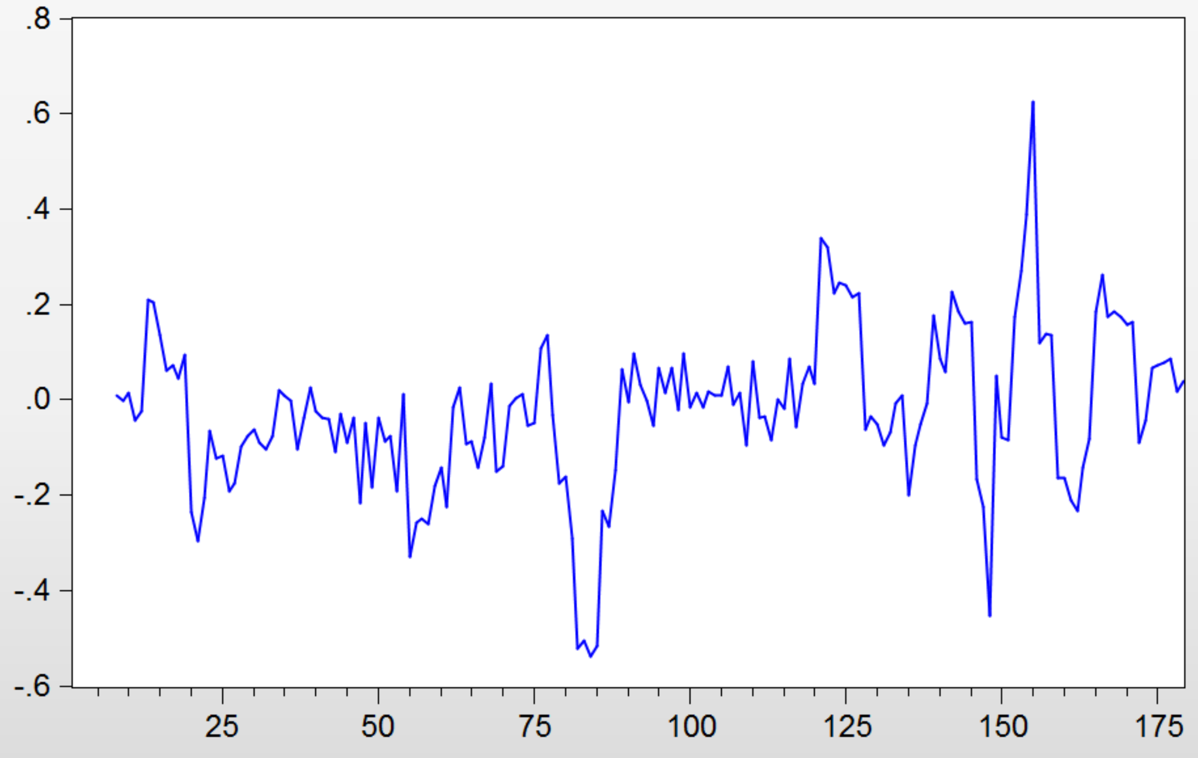
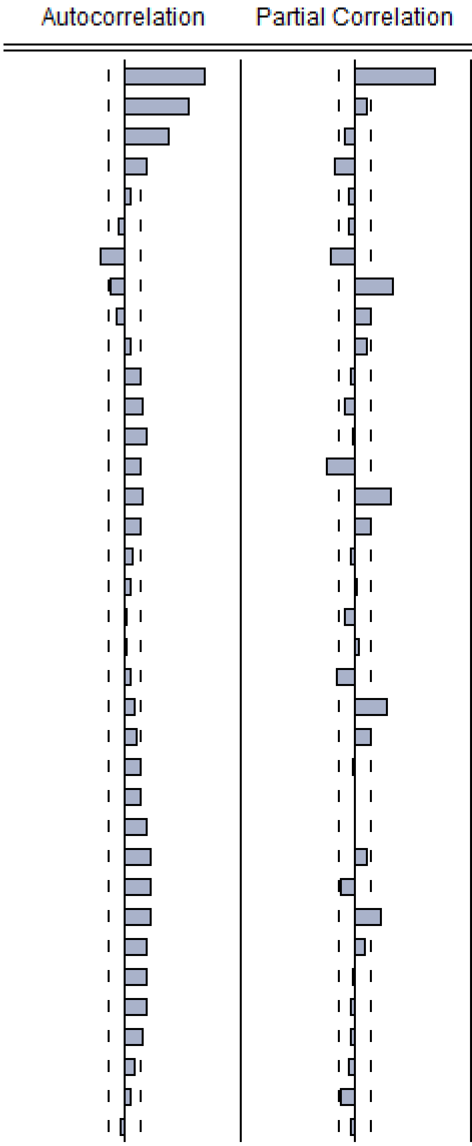


FIGURE 2: TIME PLOT OF SEASONAL DIFFERENCES



	AC	PAC	Q-Stat	Prob
1	0.722	0.722	91.225	0.000
2	0.569	0.100	148.25	0.000
3	0.396	-0.097	176.04	0.000
4	0.201	-0.176	183.27	0.000
5	0.060	-0.064	183.92	0.000
6	-0.063	-0.064	184.63	0.000
7	-0.228	-0.218	194.05	0.000
8	-0.137	0.341	197.45	0.000
9	-0.066	0.151	198.25	0.000
10	0.043	0.109	198.60	0.000
11	0.134	-0.028	201.93	0.000
12	0.164	-0.088	206.96	0.000
13	0.197	-0.012	214.29	0.000
14	0.150	-0.250	218.56	0.000
15	0.169	0.315	223.98	0.000
16	0.152	0.136	228.42	0.000
17	0.074	-0.031	229.47	0.000
18	0.046	0.015	229.89	0.000
19	0.024	-0.089	230.00	0.000
20	0.022	0.041	230.10	0.000
21	0.064	-0.165	230.90	0.000
22	0.084	0.288	232.32	0.000
23	0.107	0.136	234.62	0.000
24	0.145	-0.017	238.85	0.000
25	0.151	0.002	243.49	0.000
26	0.205	0.007	252.08	0.000
27	0.224	0.112	262.47	0.000
28	0.240	-0.124	274.45	0.000
29	0.230	0.233	285.50	0.000
30	0.204	0.085	294.25	0.000
31	0.204	-0.021	303.11	0.000
32	0.190	-0.025	310.85	0.000
33	0.156	-0.027	316.10	0.000
34	0.091	-0.054	317.91	0.000
35	0.051	-0.123	318.48	0.000
36	-0.034	-0.036	318.74	0.000

FIGURE 3: CORRELOGRAM OF THE SEASONAL DIFFERENCES

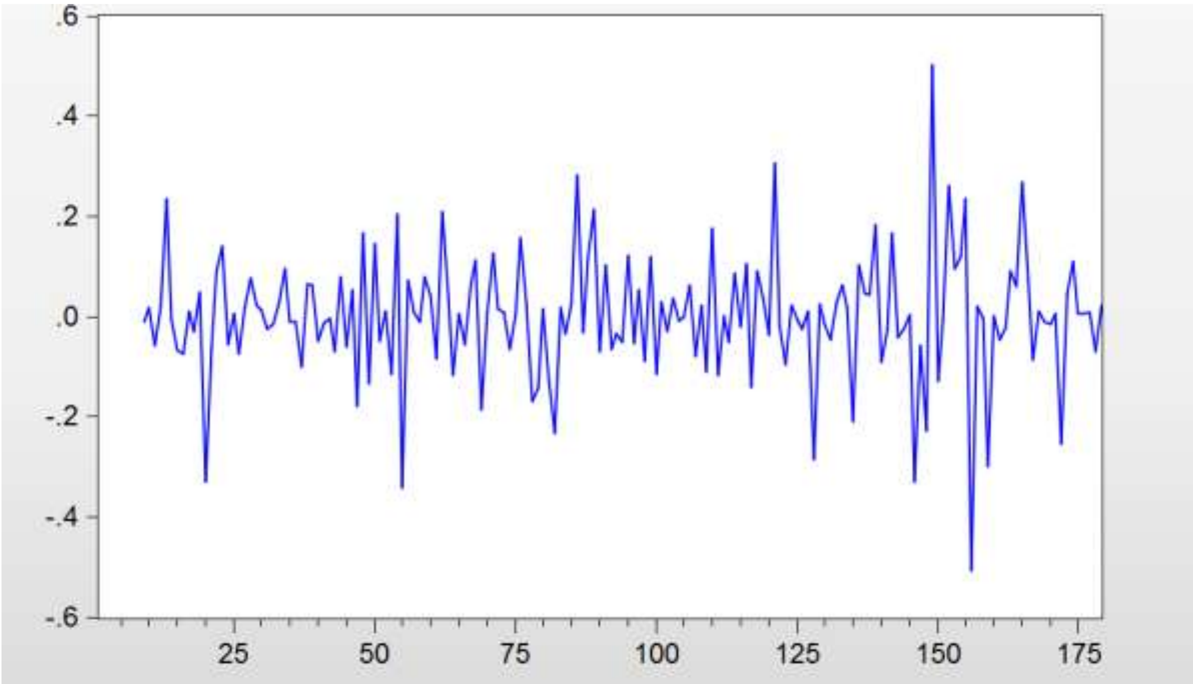


FIGURE 4: TIME PLOT OF DIFFERENCE OF THE SEASONAL DIFFERENCES

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.225	-0.225	8.8029	0.003
		2	0.034	-0.017	9.0098	0.011
		3	0.040	0.047	9.2950	0.026
		4	-0.097	-0.081	10.946	0.027
		5	-0.036	-0.081	11.173	0.048
		6	0.079	0.058	12.285	0.056
		7	-0.460	-0.451	50.482	0.000
		8	0.032	-0.221	50.668	0.000
		9	-0.069	-0.165	51.542	0.000
		10	0.033	-0.018	51.745	0.000
		11	0.108	0.040	53.918	0.000
		12	-0.002	-0.037	53.919	0.000
		13	0.143	0.193	57.772	0.000
		14	-0.117	-0.362	60.369	0.000
		15	0.067	-0.166	61.230	0.000
		16	0.114	0.002	63.704	0.000
		17	-0.090	-0.041	65.270	0.000
		18	-0.009	0.063	65.285	0.000
		19	-0.037	-0.068	65.557	0.000
		20	-0.079	0.135	66.786	0.000
		21	0.030	-0.319	66.964	0.000
		22	-0.004	-0.155	66.967	0.000
		23	-0.027	0.001	67.109	0.000
		24	0.045	-0.033	67.515	0.000
		25	-0.080	-0.021	68.812	0.000
		26	0.063	-0.123	69.615	0.000
		27	0.010	0.116	69.633	0.000
		28	0.053	-0.250	70.218	0.000
		29	0.029	-0.095	70.396	0.000
		30	-0.052	0.005	70.954	0.000
		31	0.037	0.006	71.245	0.000
		32	0.032	0.023	71.458	0.000
		33	0.054	0.049	72.091	0.000
		34	-0.052	0.110	72.684	0.000
		35	0.083	0.022	74.173	0.000
		36	-0.077	-0.015	75.481	0.000

FIGURE 5: CORRELOGRAM OF THE DIFFERENCE OF THE SEASONAL DIFFERENCES

TABLE 1: ESTIMATION OF THE SARIMA $(0,1,1)X(0,1,1)_7$ MODEL

Dependent Variable: DSDCYNG
Method: Least Squares
Date: 04/15/16 Time: 07:36
Sample (adjusted): 9 179
Included observations: 171 after adjustments
Convergence achieved after 9 iterations
MA Backcast: 1 8

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(1)	-0.275399	0.074449	-3.699157	0.0003
MA(7)	-0.948784	0.016961	-55.93903	0.0000
MA(8)	0.262004	0.072011	3.638390	0.0004

R-squared	0.539972	Mean dependent var	0.000175
Adjusted R-squared	0.534496	S.D. dependent var	0.124293
S.E. of regression	0.084802	Akaike info criterion	-2.079599
Sum squared resid	1.208162	Schwarz criterion	-2.024482
Log likelihood	180.8057	Hannan-Quinn criter.	-2.057235
Durbin-Watson stat	2.007343		

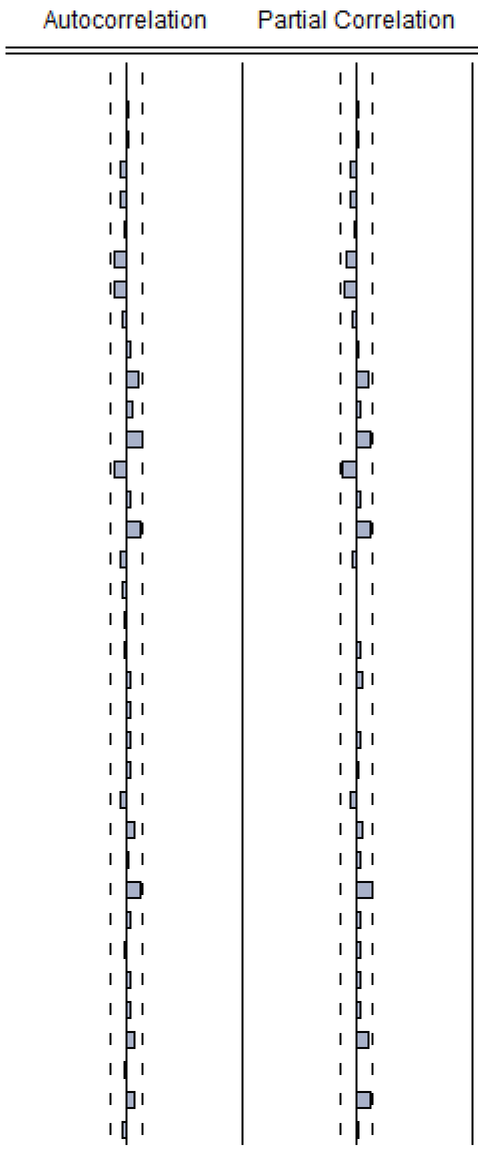
TABLE 2: ESTIMATION OF THE SARIMA $(0,1,0)X(0,1,1)_7$ MODEL

Dependent Variable: DSDCYNG
Method: Least Squares
Date: 04/15/16 Time: 07:40
Sample (adjusted): 9 179
Included observations: 171 after adjustments
Convergence achieved after 5 iterations
MA Backcast: 2 8

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(7)	-0.948441	0.015915	-59.59449	0.0000

R-squared	0.503990	Mean dependent var	0.000175
Adjusted R-squared	0.503990	S.D. dependent var	0.124293
S.E. of regression	0.087537	Akaike info criterion	-2.027681
Sum squared resid	1.302662	Schwarz criterion	-2.009309
Log likelihood	174.3667	Hannan-Quinn criter.	-2.020226
Durbin-Watson stat	2.527810		

Inverted MA Roots	.99	.62-.78i	.62+.78i	-.22-.97i
	-.22+.97i	-.89+.43i	-.89-.43i	



	AC	PAC	Q-Stat	Prob
1	-0.005	-0.005	0.0041	
2	0.018	0.018	0.0599	
3	0.015	0.015	0.0989	
4	-0.059	-0.059	0.7115	0.399
5	-0.064	-0.065	1.4338	0.488
6	-0.018	-0.017	1.4926	0.684
7	-0.100	-0.097	3.2894	0.511
8	-0.100	-0.104	5.0931	0.405
9	-0.028	-0.036	5.2374	0.514
10	0.026	0.024	5.3587	0.616
11	0.111	0.103	7.6223	0.471
12	0.044	0.025	7.9797	0.536
13	0.134	0.117	11.342	0.332
14	-0.107	-0.124	13.498	0.262
15	0.039	0.027	13.786	0.315
16	0.117	0.125	16.414	0.228
17	-0.052	-0.029	16.936	0.260
18	-0.025	-0.003	17.056	0.316
19	-0.018	0.001	17.116	0.378
20	-0.017	0.037	17.174	0.443
21	0.029	0.043	17.344	0.500
22	0.030	0.006	17.524	0.554
23	0.032	0.040	17.724	0.606
24	0.029	0.024	17.894	0.656
25	-0.063	-0.052	18.699	0.664
26	0.072	0.055	19.751	0.657
27	0.016	0.028	19.803	0.708
28	0.128	0.134	23.166	0.568
29	0.027	0.025	23.321	0.615
30	-0.022	0.027	23.424	0.662
31	0.027	0.033	23.579	0.704
32	0.039	0.033	23.905	0.734
33	0.069	0.104	24.914	0.729
34	-0.015	-0.008	24.961	0.769
35	0.080	0.127	26.365	0.747
36	-0.031	0.012	26.577	0.778

FIGURE 6: CORRELOGRAM OF THE SARIMA $(0,1,1)X(0,1,1)_7$ MODEL RESIDUALS

TABLE 3: OUT-OF-SAMPLE COMPARISON OF OBSERVATIONS AND FORECASTS

Days	Observations	Forecasts
14TH APRIL 2016	30.7017	30.6353
15TH APRIL 2016	30.7376	30.7505
16TH APRIL 2016	30.7334	30.7516
17TH APRIL 2016	30.7352	30.7607
18TH APRIL 2016	30.7459	30.8047
19TH APRIL 2016	30.8167	30.7956
20TH APRIL 2016	30.7375	30.7628
21ST APRIL 2016	30.6993	30.6183