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Intervention Analysis of Daily Yuan-Naira Exchange Rates

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ABSTRACT

Time series of daily Chinese Yuan – Nigerian Naira exchange rates from 1 May 2016 to 28 October 2016 shows a very slight negative trend until 20 June 2016 after which there is an abrupt increase and then a fairly level trend. This calls for intervention. The pre-intervention data displays a negative slope and it is non-stationary. Its first difference has an overall horizontal trend and is adjudged as stationary. Following its autocorrelation structure an MA (2) is fitted to these first differences of the pre-intervention data. The residuals of this ARIMA(0,1,2) model follow a Gaussian distribution with mean zero and this is an indication of model adequacy. Differences between the forecasts of this model and the observations in the post-intervention period are used to estimate the intervention transfer function. The coefficients of this function are significant and the intervention forecasts closely agree with the corresponding observations. Therefore the intervention effect is significant. The fitted intervention model is hoped to be a basis for managing this situation and possibly helping to proffer a due solution.

Keywords: Yuan, Naira, exchange rates, intervention analysis

INTRODUCTION

A look at daily exchange rates of the Chinese Yuan and the Nigerian Naira from May to October 2016 shows an abrupt jump from ₦30.30 on 20 June through ₦31.03 on 21 June to ₦42.90 on 22 June and even higher from that point further with a fairly horizontal trend. This calls for intervention analysis to ascertain whether the current economic recession, which is the speculated reason, has a significant effect on the exchange rates. The Yuan is becoming more interesting to Nigeria following a move by the Buhari-led Nigerian Government to attract international economic collaboration from the Chinese Government.

Etuk (2016) has modelled the Yuan/Naira exchange rates as a SARIMA $(0,1,1)x(0,1,1)_{12}$. He used a realization spanning from 18th October 2015 to 13th April 2016 from the same source as the data used herein. In this work our attention is focussed on the proposal and the fitting of an intervention model for the Yuan/Naira exchange rates which might be useful for finding a solution to the problem of relative Naira depreciation.

After the introduction of ARIMA intervention analysis by Box and Tiao (1975) researchers have engaged themselves with its application on a variety of time series. A few of such cases are mentioned hereunder. Naraya and Considine (1989) modelled the impact of price changes on ridership in a transit system. Gilmour *et al.* (2006) studied the effect of an abrupt change in heroin availability in Australia in 2001. Chung *et al.* (2009) used intervention analysis to account for a financial crisis in China. Changes in heart rates of cows after receiving audio and environmental/physiological cues have been described by Anderson *et al.* (2010) using this technique. Bried and Ervin (2011) studied the impact of vegetation removal on the counts of dragonflies. The impact of an announcement to change the contract unit has on the price premium of non-genetically modified soybeans at the Tokyo Grain Exchange was examined by Aruga (2014). Mosugu and Anieting (2016) have proposed and fitted an intervention model for US Dollar / Nigerian Naira exchange rates.

MATERIALS AND METHODS

Data

The data for this work are 181 daily Yuan – Naira exchange rates from 1 May to 28 October 2016 from the website www.exchangerates.org.uk/CNY-NGN-exchange-rate-history.html . This website was accessed for this purpose on 29th October 2016. These data are read as the amounts of Naira in one Yuan.

Arima Modelling

Box and Jenkins (1976) defined an autoregressive moving average model of order p and q (designated ARMA(p, q)) as

$$X_t = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \dots + \alpha_p X_{t-p} + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \cdots + \beta_q \varepsilon_{t-q} + \varepsilon_t \quad (1)$$

where $\{X_t\}$ is a stationary time series, $\{\varepsilon_t\}$ is a white noise process, the α's and β's are constants such that model (1) is stationary as well as invertible.

If $\{X_t\}$ is non-stationary, Box and Jenkins (1976) proposed that differencing of the series up to an appropriate order might make it stationary. Let $\nabla^d X_t$ be the d^{th} difference of X_t. If d is the minimum positive integer such that $\{\nabla^d X_t\}$ is stationary then a replacement of $\{X_t\}$ by $\{\nabla^d X_t\}$ in (1) yields an autoregressive integrated moving average model of order p, d and q, designated ARIMA(p, d, q), in $\{X_t\}$.

The unit-root test for stationarity may be done using the Augmented Dickey Fuller (ADF) Test. The orders p and q are usually estimated by the cut-off lags of the partial autocorrelation function (PACF) and the autocorrelation function (ACF) respectively after which estimation of the α's and β's may be done by the least squares or the maximum likelihood procedure. Contending models could be chosen for adequacy using the Akaike's Information Criterion (AIC).

Intervention Modelling

An ARIMA (p,d,q) model may be written from model (1) as

$$\Phi(L)\nabla^d X_t = \Theta(L)\varepsilon_t \quad (2)$$

where $\Phi(L) = 1 - \alpha_1 L - \alpha_2 L^2 - \dots - \alpha_p L^p$ and $\Theta(L) = 1 + \beta_1 L + \beta_2 L^2 + \dots + \beta_q L^q$ and $L^k X_t = X_{t-k}$ and $\nabla = 1-L$.

Let T be the intervention point of the series $\{X_t\}$. The pre-intervention part of the series is modelled by an ARIMA model. That is, the pre-intervention part of the series is given by

$$X_t = \frac{\Theta(L)\varepsilon_t}{(1-L)^d \Phi(L)} \quad (3)$$

Forecasts of the post-intervention series are obtained on the basis of model (3). Difference between these forecasts and the corresponding observed data are modelled using the transfer function

$$Z_t = \frac{c(1)(1-c(2)^{t+1})}{(1-c(2))} \qquad (4)$$

where c(1) and c(2) may be estimated by the least squares or the maximum likelihood approach.

The overall intervention model is given by

$$Y_t = \frac{\Phi(L)\varepsilon_t}{(1-L)^d\Phi(L)} + I_t Z_t \qquad (5)$$

where $I_t = 0$, $t < T$ and $I_t = 1$, $t \geq T$. (Box and Tiao, 1975), (The Pennsylvania State University, 2016)

RESULTS AND DISCUSSION

The time plot of the entire realization of the series in Figure 1 shows a fairly horizontal trend and an abrupt vertical rise and then a fairly flat trend. The abrupt rise, which is seen as a perturbation, occurred on June 21. This point is regarded as the intervention point T; that is, T = 51. The pre-intervention part of the series has a slight negative trend (See Figure 2) and, with an ADF statistic value of -2.15 and the 1%, 5% and 10% critical values of -3.57, -2.92 and -2.60 respectively, is adjudged non-stationary. First differencing is enough to make it of a horizontal trend (See figure 3). Also, with an ADF statistic value of-7.02, it is adjudged stationary. The correlogram of these first differences in Figure 4 shows significant spikes at lag 2 on both the ACF and the PACF. Of the entertained ARMA (2,2), AR(2) and an MA(2) models, on the basis of AIC the MA(2) is found the most adequate and fitted to the first differences. This MA (2) model has residuals which may be regarded as normally distributed at 1% level of significance (See figure 5). Hence the model is adequate. The least squares based pre-intervention model as estimated in Table 1 is given by

$$(1-L)X_t = (1 - 0.4415L^2)\varepsilon_t \qquad (6)$$

where X_t is the Yuan/Naira exchange rate on day t. Forecasts of the post-intervention data on the basis of model (6) were obtained. The difference Z_t of these forecasts with the original observations for the post-intervention part of the series are modelled as estimated in Table 4 by

Z_t = 1.7172(1-.8970^(t+1))/(1-.8970), t > 52 (7)

The statistical significance of the coefficients c (1) and c (2) is noteworthy. This is an indication of the significance of the overall intervention.

Hence, by combining (6) and (7), the overall intervention model is

$$X_t = \frac{(1-4415L^2)\,\varepsilon_t}{(1-L)} + I_t Z_t \quad (8)$$

A plot of this intervention model and the corresponding observations in figure 6 shows a very close agreement between the two.

CONCLUSION

The intervention model given by (7) and (8) clearly captures the adverse effect of economic recession on the Yuan/Naira exchange rates to Nigeria. It is hoped it shall be of use to work out a management process for intervention by the nation with the relatively ailing economy especially vis-a-vis the trade relationship between the two countries.

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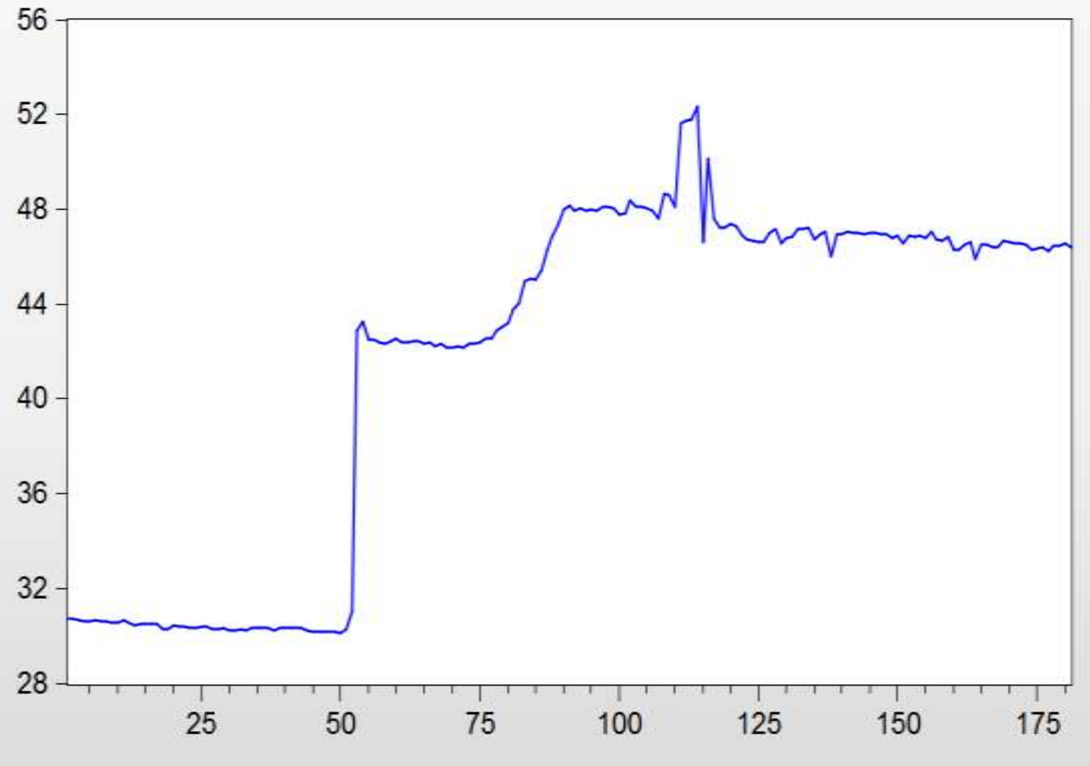

FIGURE 1: DAILY YUAN/NAIRA EXCHANGE RATES

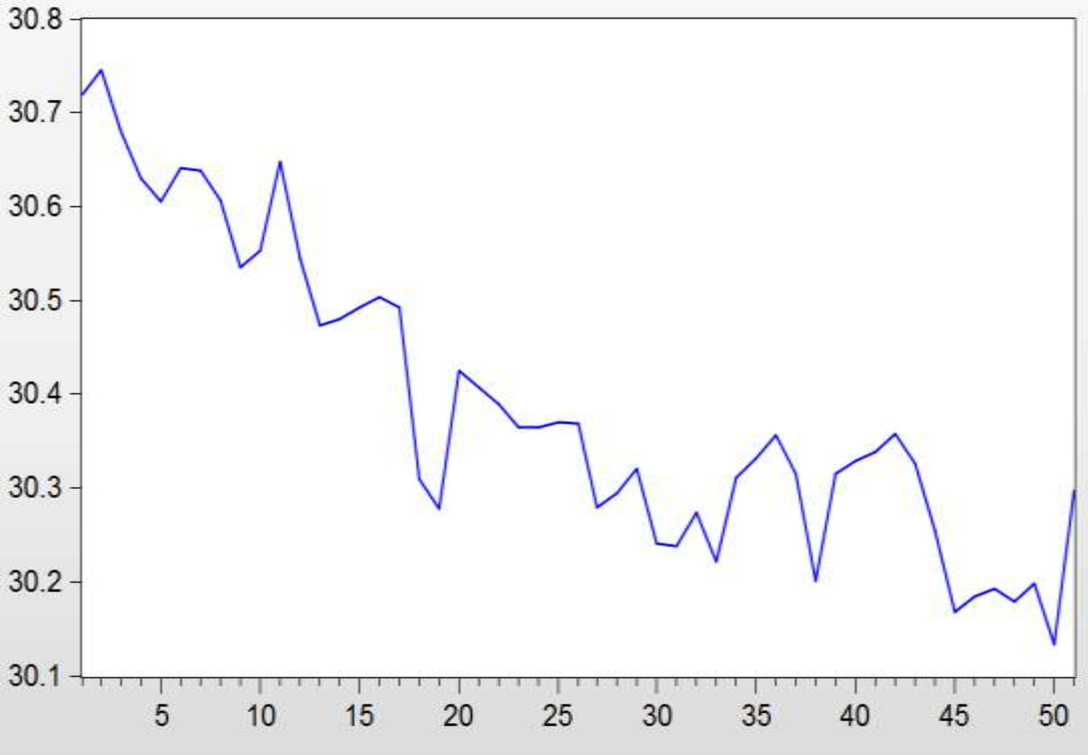

FIGURE 2: PRE-INTERVENTION YUAN/NAIRA EXCHANGE RATES

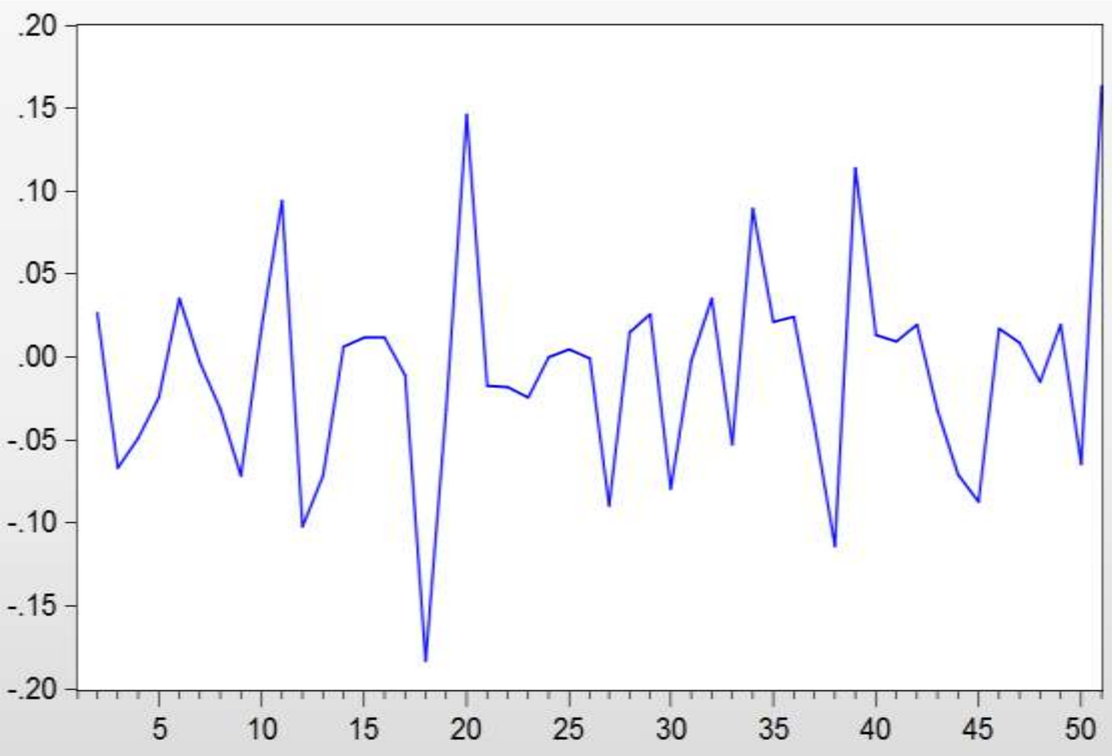

FIGURE 3: DIFFERENCE OF PRE-INTERVENTION DATA

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.113	-0.113	0.6815	0.409
		2	-0.316	-0.333	6.0835	0.048
		3	-0.039	-0.142	6.1690	0.104
		4	-0.019	-0.180	6.1895	0.185
		5	0.219	0.146	8.9561	0.111
		6	-0.006	-0.006	8.9583	0.176
		7	-0.226	-0.128	12.051	0.099
		8	-0.070	-0.139	12.358	0.136
		9	0.196	0.087	14.787	0.097
		10	0.003	-0.084	14.787	0.140
		11	-0.103	-0.076	15.490	0.161
		12	0.096	0.130	16.122	0.186
		13	-0.137	-0.132	17.445	0.180
		14	0.136	0.099	18.789	0.173
		15	0.183	0.163	21.283	0.128
		16	-0.222	-0.053	25.049	0.069
		17	0.015	0.055	25.065	0.093
		18	-0.006	-0.043	25.068	0.123
		19	0.111	0.163	26.109	0.127
		20	0.099	0.079	26.963	0.136
		21	-0.151	-0.016	28.998	0.114
		22	-0.046	0.104	29.198	0.139
		23	0.038	0.004	29.335	0.169
		24	-0.101	-0.284	30.357	0.173

Figure 4: Correlogram of Differences to the Pre-Intervention Data

Table 1: Estimation of the Arima (0,1,2) Model fitted to Pre-Intervention Data

Dependent Variable: DACYNN
Method: Least Squares
Date: 12/14/16 Time: 17:20
Sample (adjusted): 2 51
Included observations: 50 after adjustments
Convergence achieved after 6 iterations
MA Backcast: 0 1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(2)	-0.441532	0.138719	-3.182923	0.0025

R-squared	0.112757	Mean dependent var	-0.008430
Adjusted R-squared	0.112757	S.D. dependent var	0.063354
S.E. of regression	0.059675	Akaike info criterion	-2.780008
Sum squared resid	0.174494	Schwarz criterion	-2.741768
Log likelihood	70.50020	Hannan-Quinn criter.	-2.765446
Durbin-Watson stat	1.973078		

Inverted MA Roots	.66	-.66

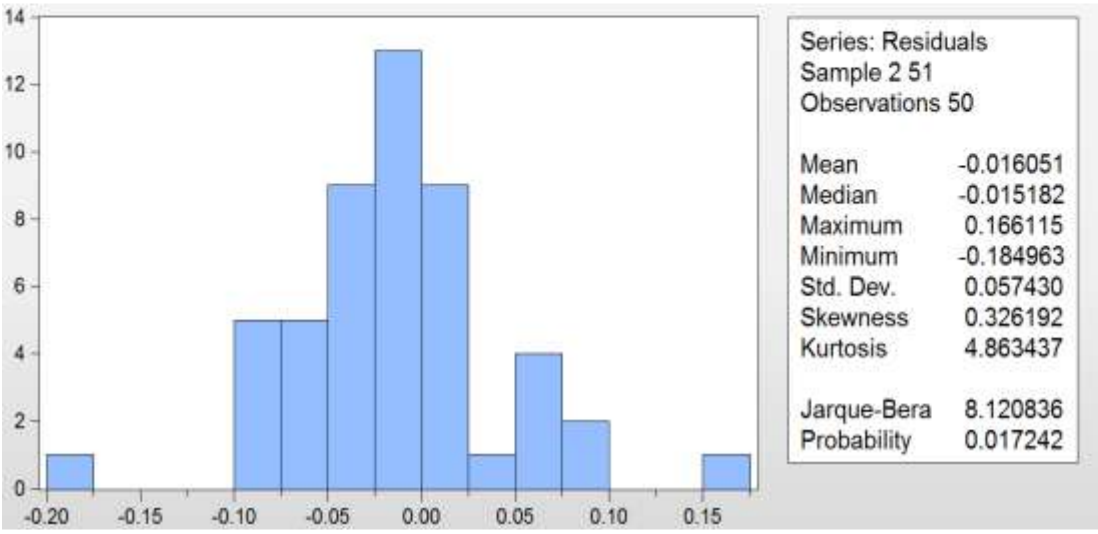

Figure 5: Histogram of Residuals of the ARIMA (0,1,2) Model of Pre-Intervention Data

Table 2: Estimation of the Post-Intervention Model

Dependent Variable: DIFF
Method: Least Squares
Date: 12/14/16 Time: 21:55
Sample: 52 181
Included observations: 130
Convergence achieved after 11 iterations
DIFF=C(1)*(1-C(2)^(T-50))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.717246	0.132740	12.93695	0.0000
C(2)	0.896959	0.008405	106.7210	0.0000

R-squared	0.434555	Mean dependent var	15.76421
Adjusted R-squared	0.430138	S.D. dependent var	2.612638
S.E. of regression	1.972260	Akaike info criterion	4.211502
Sum squared resid	497.8955	Schwarz criterion	4.255618
Log likelihood	-271.7476	Hannan-Quinn criter.	4.229428
Durbin-Watson stat	0.393637