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Intervention Analysis of Daily Moroccan Dirham/Nigerian Naira Exchange Rates

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ABSTRACT:
Daily Moroccan Dirham (MAD)/Nigerian Naira (NGN) exchange rates, from 12th March 2017 to 4th September 2017, show an abrupt jump on 4th August, 2017. This work is an attempt to model the series using an ARIMA intervention model. The pre-intervention rates are adjudged non-stationary by the Augmented Dickey Fuller test necessitating differencing. The first differences are adjudged stationary. An MA(1) model is fitted to them. Forecasts on the basis of this model for the post-intervention period are obtained and their differences from their actual observation counterparts are modeled to produce the transfer function. The intervention forecasts agree closely with the actual post-intervention forecast which is indicative of model adequacy. Hence the intervention model may be used in the management of the rates.
Keywords: *Moroccan Dirham (MAD), Nigerian Naira (NGN), exchange rates, ARIMA intervention model*

INTRODUCTION
The Dirham (MAD) is the official currency of Morocco and is issued by Bank Al-Maghrib, the Central Bank of Morocco. Its daily exchange rates with the Nigerian Naira (NGN) are the subject of this research work. The realization analyzed in this work starts from 12th March to 4th September, 2017. A sudden jump in the quantity of the NGN per MAD was noticed on 4th August, 2017 and ever since there is no drop in the relative value of the MAD. This is an intervention problem. This work is an attempt to model this relationship using the ARIMA approach proposed by Box and Tiao (1975). This approach has been extensively and successfully applied by many researchers. For example, Tiwari *et al.* (2014) showed that following treatment of symptoms the temperament and character of obsessive compulsive disorder patients ameliorated. Min (2008) showed that the 9-21 Earthquakes in 1999 and the Severe Acute Respiratory Syndrome of 2003 reduced tourism demand in Japan. Sabiruzzaman and Razzaque (2014) have constructed an intervention model for the share index of banks in Bangladesh. Aruga (2014) inferred that an announcement from Tokyo Grain Exchange affected the price premium for non-genetically modified soybeans. Chung *et al.* (2009) have concluded that China's manufacturing is temporarily affected by a financial tsunami caused by a subprime mortgage crisis triggered in the United States of America. Okereke *et al.* (2016) have observed that the National Economic and Empowerment Strategy (NEEDS) in Nigeria had a temporary effect on inflation. Amadi and Etuk (2017) studied the daily exchange rates of the Euro and NGN with a view to fitting an intervention model to them. Etuk and Eleki (2017) constructed an intervention odel for exchange rates of the NGN and the Central African Franc. This is to mention a few.

MATERIALS AND METHOD

Data

The data analyzed herein are daily MAD/NGN exchange rates from 12th March to 4th September 2017 retrieved from the website www.exchangerates.org.uk/MAD-NGN-exchange-rate-history.html accessed 5th September 2017. To be read as the amount of NGN per MAD, they are listed in the appendix.

Intervention Modeling

Suppose that a time series $\{X_t\}$ encounters an intervention at t=T. Box and Tiao (1975) proposed that an ARIMA(p, d, q) be fitted to the pre-intervention series and forecasts be obtained on its basis for the post-intervention period. Let this pre-intervention ARIMA model be

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

It may be written as

$$A(L)(1-L)^p X_t = B(L)\varepsilon_t \quad (2)$$

where $A(L) = \sum_{i=0}^{p} \alpha_i L^i$ and $B(L) = \sum_{i=0}^{q} \beta_i L^i$, $\alpha_0 = \beta_0 = 1$, and L is the backward shift operator defined by $L^k \varepsilon_t = \varepsilon_{t-k}$, $\{\varepsilon_t\}$ is a white noise process and the α's and β's are constants such that for stationarity and invertibility the zeros of A(L) and B(L) must be outside the unit circle respectively. .

Suppose that the post-intervention forecasts be F_t, for $t \geq T$ and $Z_t = X_t - F_t$, $t \geq T$. Z_t may be modeled by

$$Z_t = \frac{[1-c(2)^\wedge(t-T+1)]}{(1-c(2))} \quad \text{(The Pennsylvania State University, 2016)} \quad (3)$$

The final intervention model is given by

$$Y_t = \frac{B(L)\varepsilon_t}{A(L)(1-L)^p} + I_t Z_t \quad (4)$$

Where $I_t = 1$, $t \geq T$, zero elsewhere.

Computer Package: Eviews 10 was used for all computational work of this research.

RESULTS AND DISCUSSION

The time plots of the rates in Figure 1 and Figure 2 show a pre-intervention series with a slightly positive trend. The intervention point is 4th August 2017. This pre-intervention series is adjudged as non-stationary by the Augmented Dickey Fuller (ADF) Test of Table 1. Differencing gets rid of the non-stationarity of the series (See Figure 3 and Table 2). Going by the autocorrelation structure of the differences shown in Figure 4, an MA(1) estimated in Table 3 is fitted to it. It is given by

$$(1-L)X_t = \varepsilon_t - 0.8751\varepsilon_{t-1} \quad (5)$$

The autocorrelation structure of the residuals shown in Figure 5 is indicative of the adequacy of the model (5), virtually all autocorrelations being non-significant. The noise component of the intervention model is therefore

$$N_t = \frac{(1-0.8751L)\varepsilon_t}{(1-L)} \quad (6)$$

Post-intervention forecasts F_t were made on the basis of model (5). According to (3) as estimated in Table 4,

$$Z_t = \frac{5.364974[1-(-0.080806)^{t-147}]}{1.080806}, \ t > 147 \quad (7)$$

Combining (6) and (7), the intervention model is given by

$$Y_t = N_t + I_t Z_t \quad (8)$$

where $I_t = 1$, $t > 147$, zero elsewhere. The intervention model is shown in Figure 6 to closely agree with the post-intervention data.

CONLUSION

It may be concluded that model (8) is an adequate intervention model that may be used to describe the rise in the amount of NGN per MAD after 4th August 2017 due to Nigerian Economic recession. This model may be used to address this situation.

REFERENCES

Amadi, E. and Etuk, E. (2017). Statistical Intervention Analysis of Daily Quantities of Naira per Euro due to Nigerian Economic Recession. World Wide Journal of Multidisciplinary Research and Development, 3(9): 122-126.

Aruga, K. (2014). An intervention analysis on the Tokyo Grain Exchange non-genetically modified and conventional soybean futures markets. Cogent Economics & Finance, 2(1): http://dx.doi.org/10.1080/23322039.2014.918854

Box, G. E, P. and Tiao, G. C. (1975). Intervention Analysis with applications to economic and environmental problems. Journal of American Statistical Association, 70: 70-79.

Etuk, E. H. and Eleki, A. G. (2017). Arima Intervention Analysis of Monthly Xaf-Ngn Exchange Rates Occassioned by Nigerian Economic Recession. Noble International Journal of Economics and Financial research, 2(4): 76-81.

Chung, R. C. P., Ip, W. H. and Chan, S. L. (2009). An ARIMA-Intervention Analysis Model for the Financial Crisis in China's Manufacturing Industry. Internationall Journal of Engineering Business Management, 1(1): 15-18.

Sabiruzzaman, M. D. and Razzaque, M. A. (2014). Intervention analysis of share index data for banks and other financial institutions in Bangladesh. Journal of Financial Management & Analysis, 27(2): 20-28.

The Pennsylvania State University. (2016). "Welcome to STAT 510! Applied Time Series Analysis Lecture Notes. Lesson 10: Intervention Analysis." Department of Statistics Online Program. www.onlinecourses.science.psu.edu/stat510/accessed 9th November 2016.

Tiwari, R., Ram, D. and Srivastava, M. (2014). Temperament and Charater Profile in Obsessive Compulsive Order (OCD): A Pre and Post Intervention Analysis. International Journal of School and Cognitive Psychology, 1(2): http://dx.doi.org/10.4172/2469-9837.1000106

Min, J. C. H. (2008). Forecasting Japanese tourism demand in Taiwan using an intervention analysis. International Journal of Culture, Tourism and Hospitality Research, 2(3): 197-216.

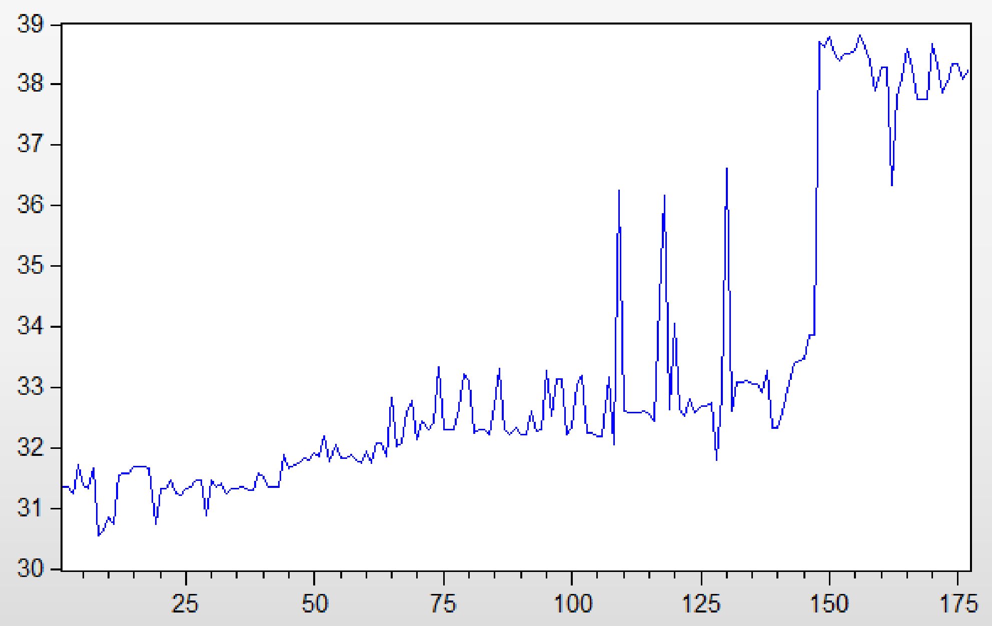


FIGURE 1: DAILY MAD/NGN EXCHANGE RATES

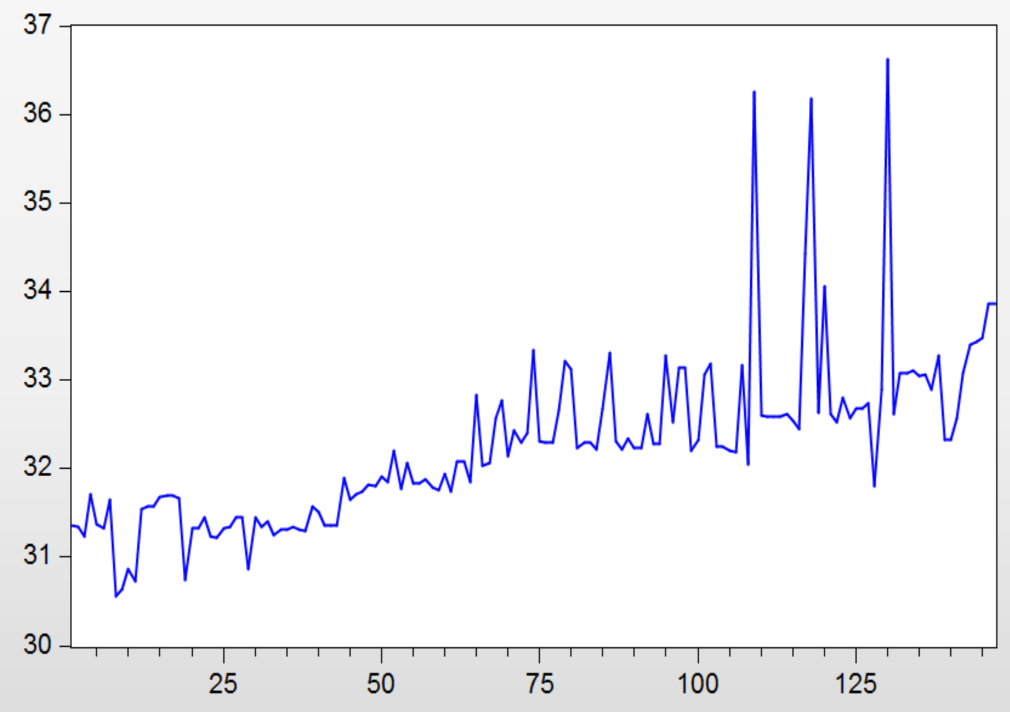


FIGURE 2: PRE-INTERVENTION EXCHANGE RATES

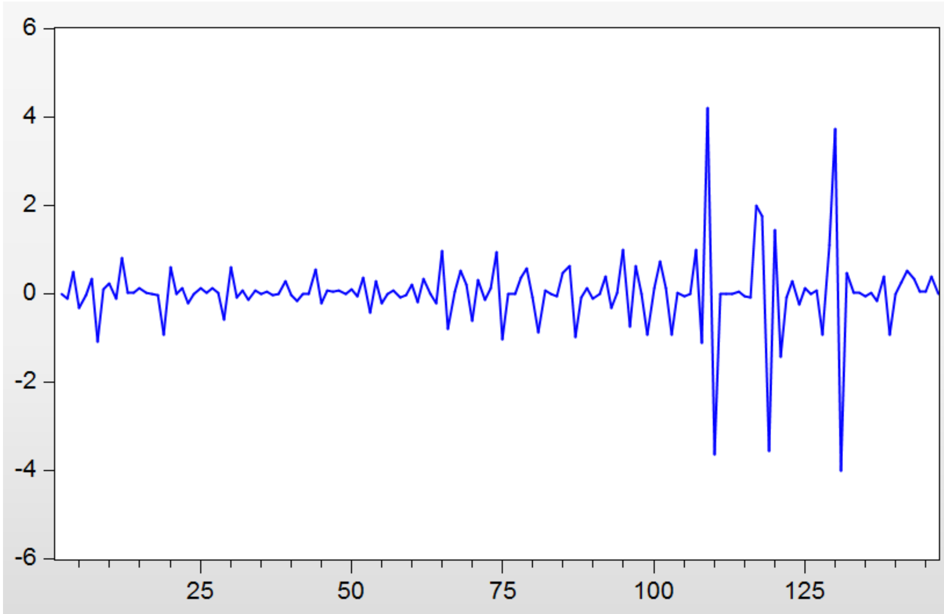


FIGURE 3: DIFFERENCE OF PRE-INTERVENTION RATES

TABLE 1: Stationary Test for the Pre-intervention exchange rates

Null Hypothesis: MDNN has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.739529	0.0699
Test critical values:	1% level	-3.476143	
	5% level	-2.881541	
	10% level	-2.577514	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MDNN)
Method: Least Squares
Date: 11/20/17 Time: 19:10
Sample (adjusted): 4 147
Included observations: 144 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MDNN(-1)	-0.210153	0.076711	-2.739529	0.0070
D(MDNN(-1))	-0.474703	0.093913	-5.054735	0.0000
D(MDNN(-2))	-0.230787	0.082932	-2.782831	0.0061
C	6.808873	2.473919	2.752262	0.0067

R-squared	0.330899	Mean dependent var	0.018242
Adjusted R-squared	0.316561	S.D. dependent var	0.870277
S.E. of regression	0.719461	Akaike info criterion	2.206756
Sum squared resid	72.46736	Schwarz criterion	2.289250
Log likelihood	-154.8864	Hannan-Quinn criter.	2.240277
F-statistic	23.07867	Durbin-Watson stat	2.041928
Prob(F-statistic)	0.000000		

TABLE 2: stationary test for difference of Pre-intervention data

Null Hypothesis: DMDNN has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.94158	0.0000
Test critical values:	1% level	-3.476143	
	5% level	-2.881541	
	10% level	-2.577514	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DMDNN)
Method: Least Squares
Date: 11/20/17 Time: 19:17
Sample (adjusted): 4 147
Included observations: 144 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DMDNN(-1)	-1.920291	0.137738	-13.94158	0.0000
D(DMDNN(-1))	0.304134	0.080282	3.788318	0.0002
C	0.033493	0.061363	0.545820	0.5861

R-squared	0.760643	Mean dependent var	0.000773
Adjusted R-squared	0.757248	S.D. dependent var	1.493550
S.E. of regression	0.735870	Akaike info criterion	2.245086
Sum squared resid	76.35214	Schwarz criterion	2.306958
Log likelihood	-158.6462	Hannan-Quinn criter.	2.270227
F-statistic	224.0393	Durbin-Watson stat	2.090098
Prob(F-statistic)	0.000000		

TABLE 3: Estimation of the Intervention transfer function

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.472	-0.472	33.263	0.000
		2	-0.013	-0.304	33.287	0.000
		3	0.043	-0.154	33.562	0.000
		4	-0.080	-0.188	34.534	0.000
		5	0.029	-0.149	34.661	0.000
		6	0.000	-0.122	34.661	0.000
		7	-0.062	-0.192	35.252	0.000
		8	0.022	-0.204	35.325	0.000
		9	0.150	0.039	38.882	0.000
		10	-0.202	-0.149	45.339	0.000
		11	-0.000	-0.278	45.339	0.000
		12	0.184	-0.046	50.769	0.000
		13	-0.060	0.046	51.347	0.000
		14	-0.031	-0.018	51.502	0.000
		15	-0.054	-0.140	51.975	0.000
		16	0.061	-0.029	52.593	0.000
		17	0.012	0.009	52.615	0.000
		18	0.035	0.078	52.820	0.000
		19	-0.132	-0.021	55.774	0.000
		20	-0.030	-0.211	55.931	0.000
		21	0.266	0.095	68.149	0.000
		22	-0.276	-0.081	81.414	0.000
		23	0.195	0.134	88.063	0.000
		24	-0.080	0.033	89.193	0.000
		25	-0.007	-0.030	89.201	0.000
		26	0.004	-0.058	89.204	0.000
		27	-0.047	-0.048	89.604	0.000
		28	0.021	-0.002	89.682	0.000
		29	0.090	0.041	91.186	0.000
		30	-0.054	-0.092	91.732	0.000
		31	-0.074	-0.061	92.762	0.000
		32	0.078	-0.010	93.916	0.000
		33	0.004	0.001	93.919	0.000
		34	-0.078	-0.159	95.088	0.000
		35	0.144	0.013	99.152	0.000
		36	-0.108	0.017	101.44	0.000

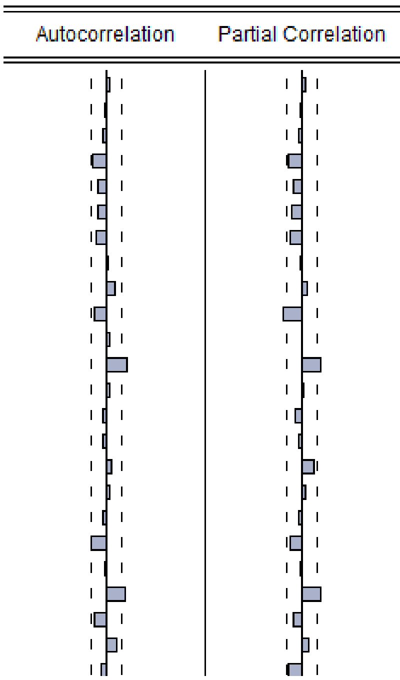
FIGURE 4: Correlogram of difference of Pre-Intervention Data

Dependent Variable: DMDNN
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 11/20/17 Time: 19:26
Sample: 2 147
Included observations: 146
Convergence achieved after 18 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MA(1)	-0.875050	0.041286	-21.19478	0.0000
SIGMASQ	0.443337	0.017614	25.17020	0.0000

R-squared	0.402461	Mean dependent var	0.017163
Adjusted R-squared	0.398311	S.D. dependent var	0.864323
S.E. of regression	0.670444	Akaike info criterion	2.061790
Sum squared resid	64.72725	Schwarz criterion	2.102661
Log likelihood	-148.5106	Hannan-Quinn criter.	2.078397
Durbin-Watson stat	1.894041		

Inverted MA Roots .88



	AC	PAC	Q-Stat	Prob
1	0.026	0.026	0.0984	
2	-0.021	-0.022	0.1671	0.683
3	-0.040	-0.039	0.4059	0.816
4	-0.143	-0.142	3.5311	0.317
5	-0.093	-0.090	4.8571	0.302
6	-0.097	-0.106	6.3165	0.277
7	-0.101	-0.121	7.8992	0.246
8	0.017	-0.020	7.9444	0.338
9	0.093	0.051	9.3201	0.316
10	-0.132	-0.190	12.094	0.208
11	0.040	-0.008	12.355	0.262
12	0.212	0.192	19.628	0.051
13	0.028	0.012	19.753	0.072
14	-0.039	-0.082	20.009	0.095
15	-0.047	-0.029	20.381	0.119
16	0.049	0.115	20.773	0.144
17	0.030	0.039	20.928	0.181
18	-0.048	-0.033	21.317	0.212
19	-0.161	-0.118	25.753	0.106
20	-0.010	-0.024	25.769	0.137
21	0.193	0.202	32.225	0.041
22	-0.122	-0.093	34.825	0.030
23	0.101	0.079	36.630	0.026
24	-0.054	-0.141	37.142	0.031

Figure 5: Correlogram of the Pre-intervention arima(0,1,1) residuals

Dependent Variable: Z
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/01/18 Time: 03:49
Sample: 148 177
Included observations: 30
Convergence achieved after 0 iterations
Coefficient covariance computed using outer product of gradients
Z = C(1)*(1-C(2)^(T-147))/(1-C(2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	5.364974	0.477884	11.22651	0.0000
C(2)	-0.080806	0.097623	-0.827740	0.4148

R-squared	0.026635	Mean dependent var	4.976160
Adjusted R-squared	-0.008128	S.D. dependent var	0.481985
S.E. of regression	0.483940	Akaike info criterion	1.450628
Sum squared resid	6.557536	Schwarz criterion	1.544041
Log likelihood	-19.75942	Hannan-Quinn criter.	1.480512
Durbin-Watson stat	1.376140		

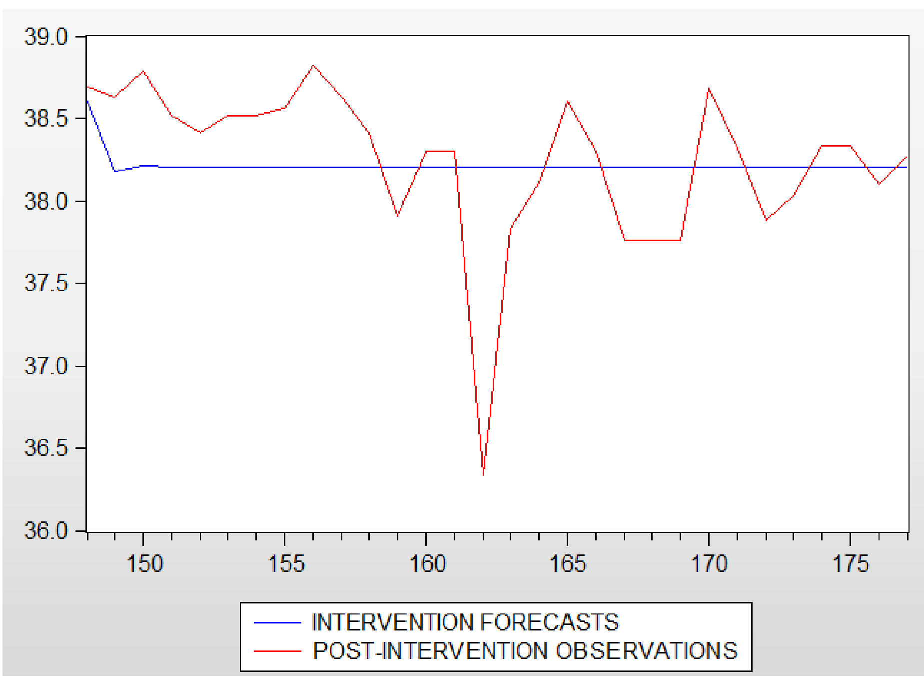


FIGURE 6: POST-INTERVENTION DATA AND FORECASTS

APPENDIX

Data

March, 2017 (from 12th)

31.3547 31.3450 31.2337 31.7127 31.3758 31.3351 31.6563 30.5532 30.6393 30.8634 30.7352 31.5427 31.5666 31.5668 31.6792 31.6932 31.6932 31.6635 30.7404 31.3351

April, 2017

31.3351 31.4507 31.2319 31.2135 31.3336 31.3399 31.4491 31.4522 30.8682 31.4520 31.3481 31.4084 31.2516 31.3129 31.3129 31.3454 31.3094 31.2918 31.5682 31.5178 31.3510 31.3510 31.3510 31.8903 31.6559 31.7098 31.7407 31.8187 31.8110 31.9051

May, 2017

31.8523 32.2006 31.7745 32.0584 31.8320 31.8320 31.8877 31.7913 31,7521 31.9464 31.7370 32.0788 32.0788 31.8524 32.8248 32.0315 32.0688 32.5742 32.7647 32.1379 32.4274 32.2915 32.4059 33.3372 32.3028 32.2956 32.2956 32.6589 33.2217 33.1207 32.2404

June, 2017

32.3018 32.2919 32.2143 32.6797 33.3036 32.3088 32.2221 32.3349 32.2287 32.2285 322.6139 32.2766 32.2850 33.2752 32.5247 33.1460 33.1459 32.2091 32.3289 33.0621 33.1880 32.2413 32.2508 32.1953 32.1946 33.1760 32.0455 36.2505 32.6063 32.5857

July, 2017

32.5857 32.5857 32.6184 32.5420 32.4503 34.4303 36.1849 32.6274 34,0603 32.6234 32.5280 32.8051 32.5648 32.6838 32.6838 32.7468 31.8048 32.8944 36.6202 32.6097 33.0799 33.0801 33.1024 33.0462 33.0614 32.8985 33.2725 32.3315 32.3315 32.5731 33.0764

August, 2017

33.3968 33.4373 33.4796 33.8605 33.8605 38.6945 38.6261 38.7866 38.5147 38.4134 38.5134 38.5134 38.5601 38.8260 38.6312 38.4122 37.9127 38.2993 38.2992 36.3305 37.8270 38.1062 38.6073 38.3025 37.7626 37.7627 37.7593 38.6868 38.3146 37.8789 38.0295

September, 2017

38.3383 38.3383 38.0965 38.2700