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Modeling of Nigerian Foreign Exchange (Naira/1.0$) Using Disbursement Data (1981-2010)

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Abstracts:
The study aimed at developing a model that best describe foreign exchange disbursement data. The data was obtained from CBN statistically Bulletin 2012. Time series technique of ARIMA was used to model the data. The Time series plot of the data shows that the data has a trend which it is not stationary. ADF and KPSS were employed to test for stationarity of the data which revealed that data is non-stationary at levels but became stationary after the first difference. The residual ACF and PACF suggest mixed process (ARMA) is appropriate. Several models were developed and tested and of all the models developed ARIMA (2,1,2) was the best fit in terms of coefficients significant and information criterion (Akaike, Hann-Quin and Schwartz). The model was then recommended for the forecast disbursement of Nigerians foreign exchange which will help policy makers in the economic sector to foresee the likely disbursement of the Foreign Exchange

Keywords: *ARMA, Disbursement, Foreign exchange, Model Residual, Series, Stationary*

1. Introduction

No any country worldwide lives in an absolute economic independent. The economies of the world are interrelated in one way or the other be it in terms of import, export, Forex, foreign direct investment and many more. In most economic relation that exist between countries. Foreign exchange plays an important role. The price (value) of foreign currency in terms of local currency is actually very important in understanding the growth of all the countries. Strong evidence abounds on strong alignment between exchange rate and growth of per capita output in developing nations (Isard, 2007).

Most emerging economies adopted the main two exchange rate regimes with the purpose of gaining domestic and international balance. Nations economic strength is measured as the sum of exchange rate and budget indices. Exchange rate is the value of foreign currency in relation to local currency, while budget a prepared and approved financial statement (Nzotta, 2004). Therefore, country's foreign exchange and budget can aid in slowing or accelerating the walking growth progress and development. Jinghan (1997) and Paul (1996) opined that factors that stimulates demand and supply in Forex market are equally responsible for change in exchange rate.

1.1. Historical Background

Changes in the economy and structural shifts in production are the key factors that brought about the evolution of foreign exchange market in the Nigerian economy. Private sectors and commercial banks earned and held foreign exchange by acting as local agents. During which agricultural export was the main source of foreign exchange receipt.

A comprehensive exchange rate came in bear in Nigeria around 1982, despite that the foreign exchange was deficient in yielding an adequate means of foreign exchange alleviation in line with requirement of internal balance. These resultant shortfalls brought about the introduction of what is called as Second tier of Foreign Exchange Market (SFEM) in 1986; through which market forces dictates exchange rate and budget allocation. In 1989, the scope of the exchange rate bureau was broadened. Yet another reform was introduced in 1994 due to volatility in the exchange market, which include official pegging of the Naira exchange rate, centralization in the central Bank of Nigeria (CBN), restriction on Bureau De Change, the reaffirmation of the illegality of parallel market, discontinuation and bills of payment. The introduction of an Autonomous Foreign Exchange Market (AFEM) brought about the liberalization of the foreign exchange market in 1995 by the CBN. In October 1999, the foreign exchange witness yet another liberalization with the introduction of Inter-Bank Foreign Exchange Market (IFEM).

2. Review of Related Literature

In a study of 56 developing countries in sub-Saharan countries, Thomas (1997) found out that foreign exchange was negatively correlated to private sector investment. Jayarama (1996) opines that macroeconomic and private investment are significantly related but inversely to variation in the real exchange rate and private investment in his study of six pacific countries. Duncan et al. (1999) was of the opinion that although variations in the real exchange rate is reasonably signifies instability in major economic variable such as fluctuation in inflation and productivity and in the fiscal and monetary policy in general

Nwankwo (2014), in a study of naira to US-dollars exchange rates observed that AR (1) was the best model for the exchange rate. The rate of growth of the per capita output is being influenced significantly by exchange rate alignment (Ismail, 2007). Onasanya, Olarenwaju and Adeniji (2013) in a study to forecast the exchange rate between naira and US dollars using time domain model observed that ARIMA (1,2,1) was the best model that explains the series. Etuk (2014) uses seasonal ARIMA model for the period 2012-2013 to forecast naira British pounds' exchange rate. He reveals that the series exhibit downward trend and that the seasonal variation is better explained by ARIMA (1,1,1) model. Appiah and Adetunde (2011) conducted a study on Ghana cedi's and US-dollars exchange rate; the findings reveals that the rate ARIMA (1,1,1) best fits and predicts the series.

Ette Harrison (1998), opined that exchange rate has a negative trend between 2004 and 2007 and was stable in 2008. M.K Newaz (2008) made a comparison on the performance of time series models for forecasting exchange rate for the period of 1985 – 2006. Found out that ARIMA model provides a better forecasting of exchange rate than some other techniques.

3. Materials and Methodology

The data for the study was obtained from central bank statistical (CBN) bulletin from 1981-2012. The study employed Box-Jenkins (1997) methods; which entails four basic steps as follows:

i. Identification
ii. Estimation
iii. Diagnostic checking and
iv. Forecasting or prediction

3.1. Model Identification

To determine an appropriate structure and order of the model that fit a particular data, the following are utilized: we observe the ACF and PACF graph of data and look out for the following characteristics such as; does the ACF decays exponentially to zero, or cut off at a given lag, or does the PACF cut off at a given lag or decay exponentially or neither the ACF nor PACF decay or cut off at a given lag. If the ACF decays exponentially, we suspect an AR-process, and MA-process when if cut off at a particular lag or ARMA when neither the ACF nor PACF decay or cut off at a given lag. One can use Dickey-Fuller, Augmented Dickey-Fuller (ADF) (1979), KPSS and other test to test for stationarity of the data.

Autocorrelation function (ACF)

The sample estimate of auto covariance of lag h is

$$g_h = i/n \sum_{t=1}^{n-h} (y_t - \bar{y})\,(y_{t+h} - \bar{y}) \quad h= 0, 1, 2, \ldots, n-1 \qquad (3.1)$$

Consequently, the sample estimates of autocorrelation of lag h is

$r_h = g_h / g_0$

Where a graph of r_h against h is called a correlogram

Partial autocorrelation function (PACF)

Partial autocorrelation coefficient at lag k is defined as

$$\emptyset_{kk} = \rho_k - \sum_{j=1}^{k-1} \emptyset_{k-1,}\, j\rho_{k-j} \Big/ 1 - \sum_{j=1}^{k-1} \emptyset_{k-1,}\, j\rho_{k-j} \qquad (3.2)$$

$\{\emptyset_{kj} = \emptyset_{k-1,j} - \emptyset_{kk}\emptyset_{k-1,k-j}$ for j- 1, 2, 3, . . . , k-1}

3.2. Model Estimation

Once identification is attend, the next thing is to fit the parametric model for the stationary process (differenced): AR(p), MA(q) or ARIMA (p, d, q) to the data. Which involves: estimation of the parameter of the model identified, and determination of the order of the selected model. This could require an iterative process to select the best fit model using information criterion like: AIC, SIC, and BIC and MSE.

- First order autoregressive model (AR (1))

First Order AR (1) process, satisfies the following difference equation

$X_t - \alpha X_t = \varepsilon_t$ or

$$X_t = \alpha X_t - \varepsilon_t \qquad (3.3)$$

Where α is constant and ε_t is a stationary purely random process

Then, an AR (p):

$$X_t = \alpha_o + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \ldots .\alpha_q X_{t-p} \qquad (3.4)$$

MA(q)

A moving average process of order q is giving as:

$X_t = \beta_o + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ \dots . \beta_q \varepsilon_{t-q}$ (3.5)
Where $\beta_o, \beta_{1,} \ . \ . \ . \ . \ \beta_{t-q}$ are constants and ε_t is a stationary purely random process
In backshift operator we have:

$$X_t = b(B) \ \varepsilon_t$$

- Mixed Process (ARMA)

Both AR and MA provide a useful description for large number of real life process; combining the two will provide a more generalized model.
Therefore, an ARMA model satisfies the equation of the form
$X_t + \alpha_o + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \ \dots . \alpha_q X_{t-p} = \beta_o + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ \dots . \beta_q \varepsilon_{t-q}$
Where ε_t is a stationary purely random process, and ($\alpha_o, \alpha_{1,} \dots . \alpha_{p,} \beta_o, \beta_{1,} . . .?\beta_q$ are constants.
In backshift operator, we have
$\theta(B) X_t = b(B) \ \varepsilon_t$ (3.6)

3.2.1. Akaike's Information Criterion
Proposed by Akaike, is an attempt to select a good approximating model for inference based on the principle of parsimony. AIC proposes the use of the relative entropy, or the Kull back –Leibler (KL) information as a fundamental basis for model selection. A suitable estimator of the relative K-L information is used and involves two terms. The first term is a measure of lack of model fit, while the second is a "penalty" for increasing the size of the model, assuring parsimony in the number of parameters. The AIC criterion to be minimized is
AIC (n) = log ($^2 q$) + $2n/T$ (3.7)
n is the dimension of the model and $\delta$is the maximum likelihood estimate of the white noise variance, and T is the sample size. (Olatunji and Bello, 2013)

3.2.2. Schwarz's Bayesian Information Criterion
Proposed by Schwarz was derived in a Bayesian context and is "dimension consistent" in that it attempts to consistently estimate the dimension of the true model. It assumes a true model exists in the set of candidate models, therefore requires a large sample size to be effective. The BIC Criterion to be minimized is
BIC (n) = log ($^2 q$) +$n log \ (T)/T$ (3.8)
n is the dimension of the model, $\delta$and is the maximum likelihood of estimate of the white noise variance, and T is the sample size. (Olatunji and Bello, 2013)

3.2.3. Hannan – Quinn Criterion
Proposed by Hannan and Quinn was derived from the low of the iteration logarithm, it is
HQ (n)= log ($\delta^2 q$) + $2n log T/T$ (3.9)
Where n is the dimensionality of the model, $\delta$is the maximum likelihood of estimate of the white noise variance, and T is the sample size. Hannan and Rissanen later replaced the term log (n) with log n to speed up the convergence. (Olatunji and Bello, 2013)

- Diagnostic Checking

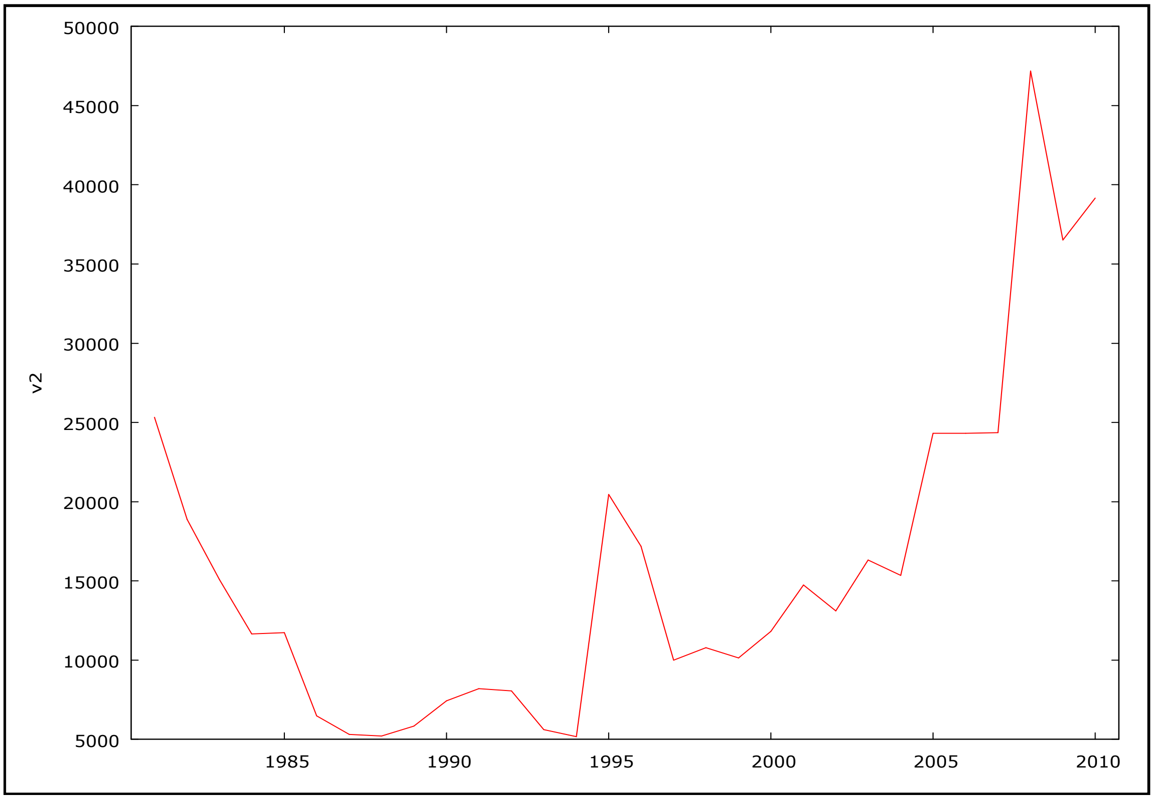
Having identified and fitted the appropriate model, the adequacy of the model so fitted is examined through: normality, ACF and PACF of the residual of the model.

- Forecasting/Prediction

The last thing is to make forecast using the model established. The will make forecast for the period 2012-2015.

4.1. Results and Discussion
Foreign exchange disbursement data for naira against US Dollar was obtained from the central bank statistical bulletin (CBN) or 1982-2010. ARIMA model used to identify the model that best fit the series, and employ some diagnostic test to assess the adequacy of the model chosen.

4.2. Graphical Presentation of the Series



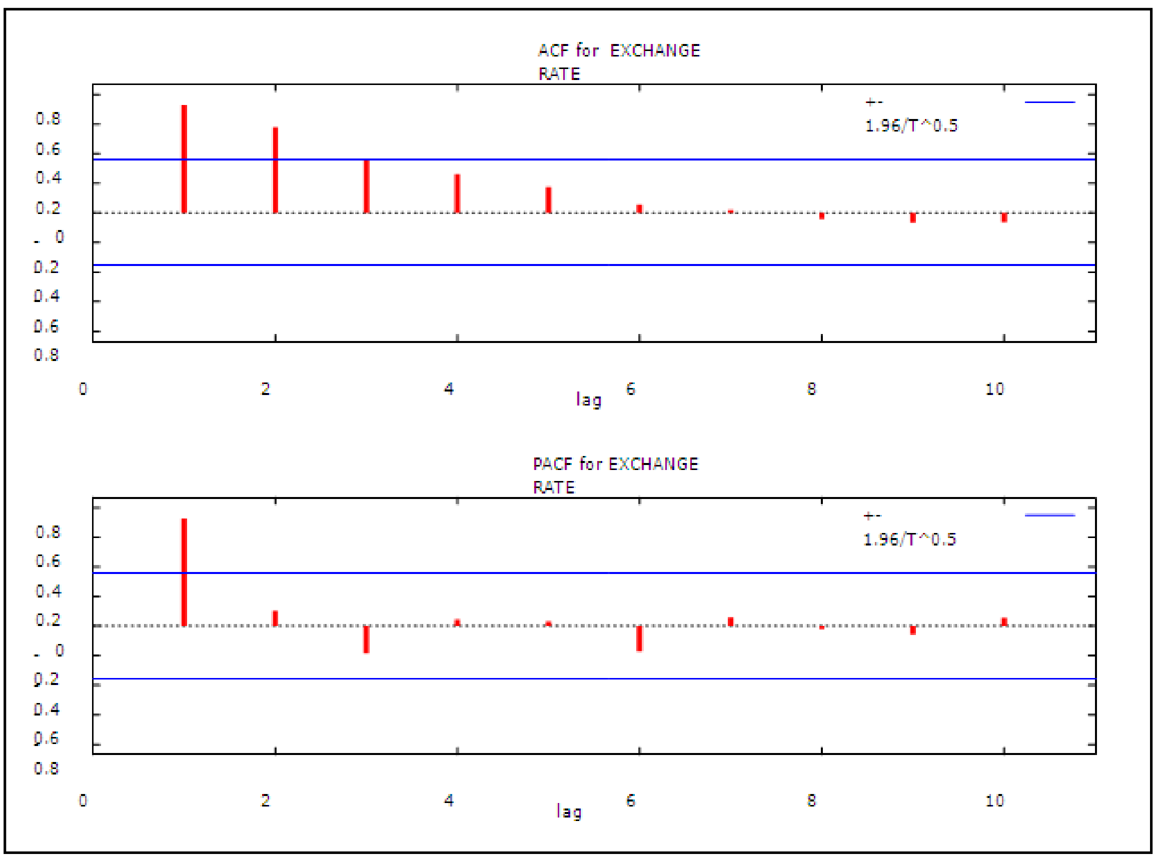


Figure 1: time series plot for the disbursement data for exchange rate at levels
The plot revealed that the mean of the series increases with time, hence making the series non-stationary

4.3. ACF and PACF of the Series at Level

Having observed from the plot that the mean varies with time, we plot the ACF and PACF to further examine the behaviour of the series. ACF dies geometrically, while the PACF cut off at lag 1. This further confirmed that the series is not stationary, hence the need to difference the series.

4.4. Unit Root Test (Test of Stationarity)

Augmented Dickey Fuller (ADF) and KPSS tests was used to check for the stationarity of the exchange rate series. The ADF test statistic test the hypothesis that the series is not stationary against the alternative that the series is stationary.

Test	At level	Critical values	First differenced	p-value
ADF	-3.39315	0.05223	-4.63741	0.00078
KPSS	0.0678053	0.216	0.3852	0.0032

Table 1: ADF and KPSS test

From the table above the results revealed that ADF test statistic of -3.39315, with p-value of 0.05223 which is greater than 0.05 and 0.01. Hence, we don't reject the null hypothesis that the series is not stationary at 0.05 and 0.01 level of significance.
Similarly, KPSS test statistic has a value of 0.0678053 and p-value of 0.216; but became stationary after the first differenced.

4.5. Model Selection

The series was differenced once to achieve stationary. We proceeded to identify the order of the Autoregressive and Moving Average terms (p and q). The tools deployed in selecting the best model were Akaike, Schwarz and Hann-Quinn information criterion

<u>4.5.1. ARIMA Models</u>

Model	AIC	SIC	HQC
ARIMA (1,1,1)	574.7817	580.1105	576.4108
ARIMA (2,1,1)	572.3114*	578.9724*	574.3477*
ARIMA (2,1,2)	573.1374	581.1306	575.5810
ARIMA (2,1,3)	574.8007	584.1261	577.6516
ARIMA (3,1,1)	574.2397	582.2329	576.6833

Table 2

From the table above it is obvious that ARIMA (2,1,1) has the smallest AIC, SIC and HQC. Hence, it is the best model

4.6. Model Estimation

Having selected the best model in terms of AIC, SIC and HQC; we then estimated the parameters of the selected model.
ARIMA, using observations 1983-2010 (T = 28)
Dependent variable: (1-L) d_Exchangerate
Standard errors based on Hessian

	Coefficient	Std. Error	z-stat	p-value	
const	256.432	61.3049	4.1829	0.00003	***
phi_1	-0.544363	0.17805	-3.0574	0.00223	***
phi_2	-0.442346	0.193129	-2.2904	0.02200	**
theta_1	-1	0.11738	-8.5193	<0.00001	***
, * Means significance at 1% and 5% respectively					

Mean dependent var	324.3389		S.D. dependent var	10202.51
Mean of innovations	617.8518		S.D. of innovations	5054.714
Log-likelihood	-281.1557		Akaike criterion	572.3114
Schwarz criterion	578.9724		Hannan-Quinn	574.3477

Table 3: Estimated Models

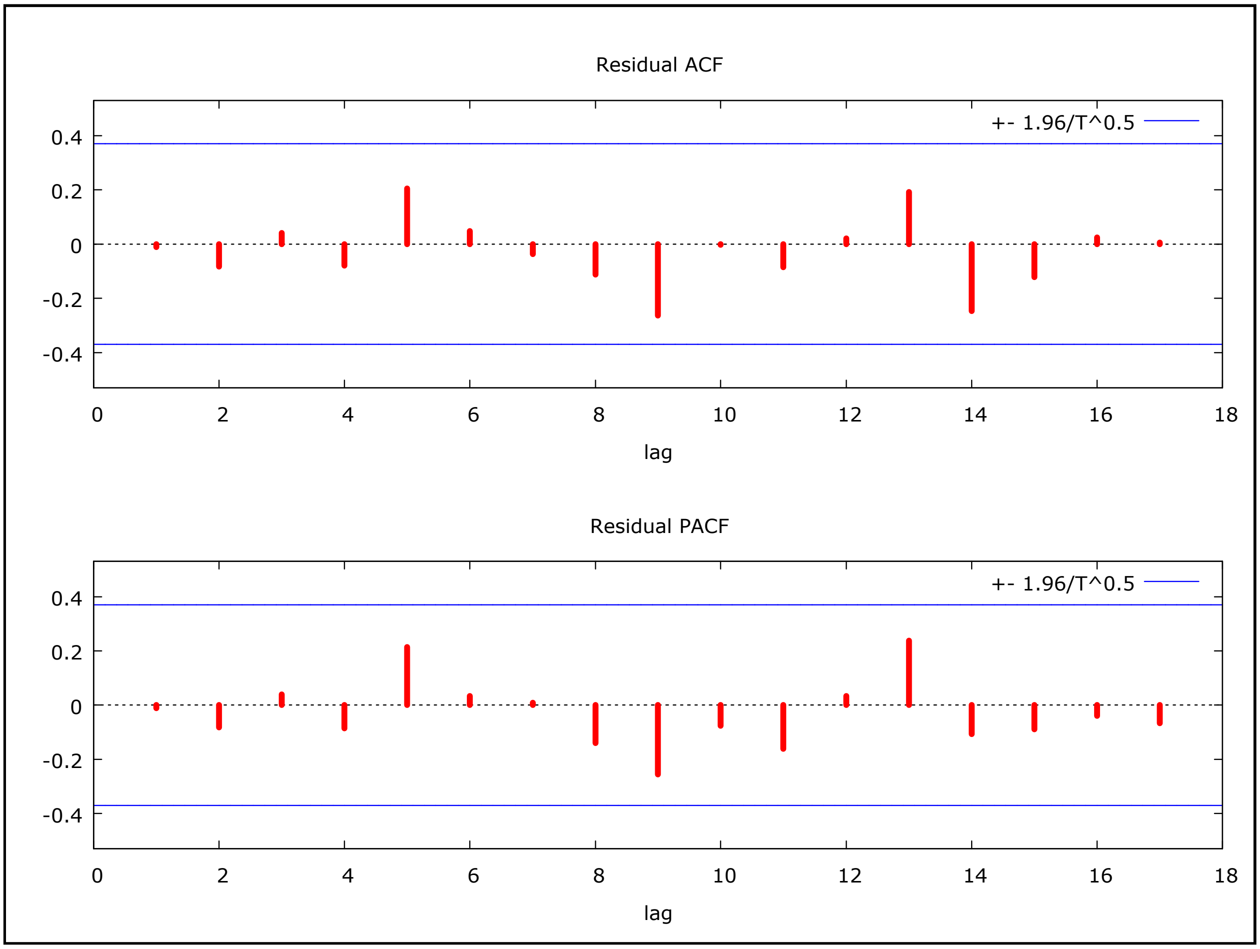


Figure 2: ACF and PACF of the residuals of ARIMA (2,1,1) model
The plots show that the model is free of serial correlation

5. Summary and Conclusion

The study aimed at developing a model that best describe the disbursement of Nigerians foreign exchange (Naira/$1.0). The plot of the series revealed that Disbursement has been increasing overs the year's understudy. The series was non stationary at levels as the case with most financial data with ADF and KPSS test -3.39315 (0.05223) and 0.0678053(0.22), but became stationary after first differenced as equally indicated -4.65741 (0.00078) and 0.3852 (0.0322). The ACF and PACF analysis shows a mixed process is appropriate. (ARIMA). ARIMA (1,1,1), ARIMA (2,1,1), ARIMA (2,1,2), ARIMA (2,1,3), and ARIMA (3,1,1) fitted and of all the model fitted ARIMA (2,1,1) happens to be the best fit in terms of Information Criterion (Akaike, Hann-Quin and Swartz). The residual of model was subjected to examination and revealed that they are normally distributed and are free of serial correlation.

The study recommends the ARIMA (2,1,1), for forecasting disbursement of Nigerians Foreign Exchange

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