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Sarima Modeling of Nigerian Food Consumer Price Indices

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ABSTRACT

The study is an attempt to model Nigerian Food Consumer Price Indices (NFCPI) data extracted from the Central Bank of Nigeria (CBN) website starting from January, 2003 to November, 2014. The data variables for the study were examined using basic time series concept such as time plot and stationary test. It was observed that there exists seasonality in the trend of the variable. However, test for serial correlogram was conducted using correlogram of the residuals after which the variables were estimated using SARIMA model and a Multiplicative Seasonal Autoregressive Integrated Moving Average (SARIMA) (0, 1, 0) x $(1, 1, 1)_{12}$ was fitted to the time series variable. The correlogram of the residual model estimation were examined. Since virtually all correlations are zero, the (SARIMA) (0, 1, 0) x $(1, 1, 1)_{12}$ model of NFCPI is adequate.

INTRODUCTION

Food plays a very important role in our lives. Everyone eat food to survive. As a result of that we are affected to some extent by the slightest little change in the price of food stuff. Thus, change in food prices has a considerable effect on one's consumption.

Consumer price index can be defined as a statistical estimate of the level of prices of goods and services brought for consumption purposes by households. It is the general measure of the level of increase in the cost of living that occurs in the economy and its effect on the standard of the living of the people.

The importance of Consumer Price Indices to a country like Nigeria cannot be over-emphasized, because it is used in computing the value of salary and wages. Furthermore, this is one of the frequently used statistics in identifying the period of inflation and deflation. Inflation can be seen as a major economic crisis in a developing economic and therefore, fighting inflation as well as keeping prices of food stable is one of the major objectives of Government agency like Central Bank of Nigeria (CBN).

The negative consequences of inflation can also cause reduction in the national currency which could likely worsen social conditions and living standards of the people. Increase in prices can also bring about uncertainty that can make domestic and foreign investors unwilling to invest in the country's economy (Adams et al, 2014).

Moreover, increase in price deteriorates the country in terms of trade by making local consumer goods more costly in Nigeria. Thus, a good monetary policy relied largely on the capacity of economists and statisticians to develop a reliable model that can help understand the ongoing economic situation and as well predict future development (Adams *et al.,* 2014).

Therefore, it will serve as basis to provide a scientific ground for observing, monitoring, modelling and also forecasting Consumer Price Indices in order to guide investors, business planners, marketers, policy makers and time series analyst. This research therefore, seeks to fit Seasonal Autoregressive Integrated Moving Average Model (SARIMA) to monthly data of Nigerian Food Consumer Price Indices from (2003 - 2014).

LITERATURE REVIEW

Box and Jenkins (1976) developed the SARIMA model as an extension of (ARIMA) model, which has been previously proposed; specifically explain this movement in seasonal time series. SARIMA modelling has been proven to be successful, few authors had written widely on the theoretical properties as well as the practical applications of SARIMA models, while also highlighting its relative benefits (Etuk and Igbudu, 2013).

Recently, there has been a growing interest in SARIMA model; this is because many real life time series have seasonal natures. Box and Jenkins (1976) projected that such time series could be modelled using SARIMA models. Some of the seasonal time series that have been modelled by SARIMA techniques are rainfall, inflation, microwave transmission, temperature, electricity and foreign exchange rate (Etuk & Ojekudo, 2014). Furthermore, (Etuk *et al.,* 2014) suggested that it has been demonstrated that for intrinsically seasonal series SARIMA models outdo the ordinary

Autoregressive Integrated Moving Average (ARIMA) model

Some numbers of studies using the application of SARIMA modeling of Nigerian Food Consumer Price Indices have been investigated, among which are Etuk (2012), used Seasonal ARIMA model to Nigerian Consumer Price Index data from March 1963 to December 2003, the results reveal a seasonality of lag 12 and a seasonal MA component to the model. The PACF indicate no spike in the early lags (1, 2, 3,...) revealing a non-seasonal MA component. It was however proposed to be a (0, 1, 1)x $(0, 1, 1)_{12}$ seasonal model and it is seasonal. SARIMA model, (0, 1, 1) x $(0, 1, 1)_{12}$, is fitted to the series. A visual assessment of the actual and the fitted time plots reveals a close accord between the two.

Okorie (2015), investigating consumer price index data of Nigeria for 1996 to 2013 extracted from the Central Bank of Nigeria (CBN) website. The time series approach adopted was descriptive statistics which shows inter alia, neither fallen below 21.19 nor rises above 152.29 within the sample period. SARIMA model adopted shows that SARIMA (1, 2, 1)$(0, 0, 1)_{12}$ is the best fit to the data under the investigation. Forecasts were also made using the model and the difference between the two average of the forecast, and the observed consumer price index value was tested at 5% level of significance. The results show there is no significant difference between the two means of the forecast.

Akhter (2013) forecasted short-term inflation rate of Bangladesh using monthly Consumer Price Indices from January, 2000 – December, 2012. The paper employs seasonal ARIMA models proposed by Box et al (1994). Because of the presence of structural break in the Consumer Price Indices, the study use data value from September 2009 - December 2012. And it reveal a seasonal ARIMA (1, 1, 1)$(1, 0, 1)_{12}$ model was confirmed. The forecast result reveals high rate of inflation within the forecast period.

MATERIALS AND METHODS

The data for this study are monthly Nigerian Food Consumer Price Indices from 2003 to 2014 obtainable from the website of the Central Bank of Nigeria (www.cbn.gov.ng). Econometric views (reviews) software version 7.0 was used to construct the

SARIMA model.

Seasonal ARIMA Model
According to Etuk (2012), a time series variable are said to be seasonal of certain order if there exists a tendency for the time series to show periodic behavior within a certain time interval. However, such time series variable could be said to follow a multiplicative $((\rho,d,q) \times (\rho, D, Q)_s)$ and seasonal ARIMA model can be written as:

$$A(B)\Phi(B^s)\nabla^d\nabla^D X_t = B(B)\Theta(B^s)\varepsilon_t \quad (1.0)$$

The non-seasonal component is defined:

$$AR: \varphi(B) = 1 - \varphi_1(B) - \ldots\ldots - \varphi_p B^p \quad (1.1)$$

$$MA: \Theta(B) = 1 + \Theta_1(B) + \ldots\ldots + \Theta q(B^q) \quad (1.2)$$

The seasonal components of the model are as thus:

$$\text{Seasonal AR}: \varphi(B^s) = 1 - \varphi_1(B^s) - \ldots\ldots - \varphi_p(B^{ps}) \quad (1.3)$$

$$\text{Seasonal MA}: \Theta(B^s) = 1 + \Theta_1(B^s) + \ldots\ldots + \Theta Q(B^{Qs}) \quad (1.4)$$

Note, the left hand side of equation (1.0) is the seasonal and non-seasonal AR components multiply each other whereas the right hand side of equation (1.1) represents the seasonal and non-seasonal MA components multiplying each other.

ESTIMATION TECHNIQUE AND PROCEDURE
The estimation technique/ procedure used are to capture the seasonality in Nigerian Food Consumer Price Indices which include Time series Plot, Unit root test, Differencing, Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF), Estimation of Model and the Residual model.

a. Time Series Plot: A time series plot could be seen as series of discrete numerical points indexed (or listed or graphed) in time line order. Time series are sequences of successive equally spaced points in a line chart. A time series plot or graph reveals the trend exhibited by the data, the seasonal and cyclic pattern.

b. Unit root test: Unit root test is a characteristics involving step by step process that evolves through time. A unit root test is done to know whether the time series variables are non-stationary using an Augmented Dickey Fuller test (ADF) Dickey and Wayne filler (1979, 1981).

c. Differencing: Differencing is often use in estimating or testing for non-stationarity of a data set which may occurs in the form of trend or seasonality or both trend and seasonality. If trend is present in the data, we may need to apply non-seasonal differencing. When both trend and seasonality are present we apply both a non-seasonal first difference and a seasonal difference.

d. Autocorrelation Function (ACF): Autocorrelation Function are usually refers to as the number of ways an observations in a time series are related to each other. It could also be seen as a serial correlation of equally spaced interval of time series between data set, it could one, two or more lags apart. It is also known as a lagged correlation.

e. Partial Autocorrelation Function (PACF): This measure the degree of association between X_t and X_{t-p} when the X– effects at other time lags 1, 2, 3,…., p-1 are removed. Furthermore, the word Partial Autocorrelation Function is similar to autocorrelation, except when estimating it, the (auto) correlations of the variable within the lag specified is partially (Box and Jenkins, 1976).

f. Estimation of the Model Selection: This deals with the estimation of SARIMA model. The estimation of the model parameter can be done by the conditional list square and maximum likelihood.

g. Examine the Residual Model: This is to show if the model seems fit.

RESULT AND DISCUSSION

The series was analyzed using the SARIMA model. A Time Plot was constructed which reveal the presence of a trend in (figure 1). In this case, a Unit Root test for stationarity is conducted using Augmented Dickey- Fuller test. The test statistic was -2.929116 with probability of 0.0445. This shows that the NFCPI series is not stationary (see table 1). As a result, there is need to construct a time series plot of the Seasonal Differencing of the NFCPI which produces a less trend (figure 2). Hence, the Seasonal Differencing is still not stationary at the first differences with probability value 0.0299 which is greater than the standard probability value 0.001 (see Table 2). Non Seasonal Differencing shows that the series has no trend and clear seasonality (figure 3). However, there is need for Unit Root test for the Difference Seasonal Differencing of the Nigerian Food Price Indices (DSDFCPI). At this point, the Difference Seasonal Differencing of Nigerian Food Consumer Price Indices (DSDNFCPI) became stationary and this clearly show that the probability value of (0.0000) which is less than the standard probability value at 0.001 level of significance while the coefficient DSDFCPI (-1) is -1.180679 with standard error (0.122158) and probability value at 0.0000.

Also, the coefficient of the Difference Differences Seasonal Differencing of Food Consumer Prices Indices (D(DSDFCPI))(-1) is 0.192334 with standard error 0.086853 with probability value 0.0286 which is evidently non significant as its value is greater than standard probability value of 0.001. Similarly, the constant co-efficient (c) is -0.127824 with standard error 0.435802 and non significant probability value 0.7698 (see Table 3).

The Correllogram of Difference Seasonal Differencing for Nigerian Food Consumer Prices Indices has a negative spike at Lag 12 revealing a seasonality of Lag 12 and a seasonal moving average component to the model. A look at the collelogram shows a proposed SARIMA (0, 1, 0) $(1, 1,1)_{12}$ seasonal model (figure 4).

That means DSDNFCPI = α_1 $DSDNFCPI_{t-12} + \beta_{12} + \varepsilon_{t-12} + \varepsilon_t$

The estimation of the model is given by DSDNFCPI = - 0.234577 $DSDNFCPI_{t-12}$ - 0.999909 $\varepsilon_{t-12} + \varepsilon_t$.

This can be written as:

DSDNFCPI + 0.234577 $DSDNFCPI_{t-12}$ + 0.999909 $\varepsilon_{t-12} = \varepsilon_t$

The model converts indices (± 0.083199) (± 0.027900) was achieved after 18 iterations.

CONCLUSION

From the result obtained, it was reveal that the Nigerian Food Consumer Price Indices follow a SARIMA $(0,1,0)(1,1,1)_{12}$ model. The model has been proven to be adequate. Although, this result seem to be in line with similarly studies carryout by Etuk (2012) on seasonal ARIMA model to Nigerian Consumer Price Index data which SARIMA$(0,1,1)(0,1,1)_{12}$ model was confirmed.

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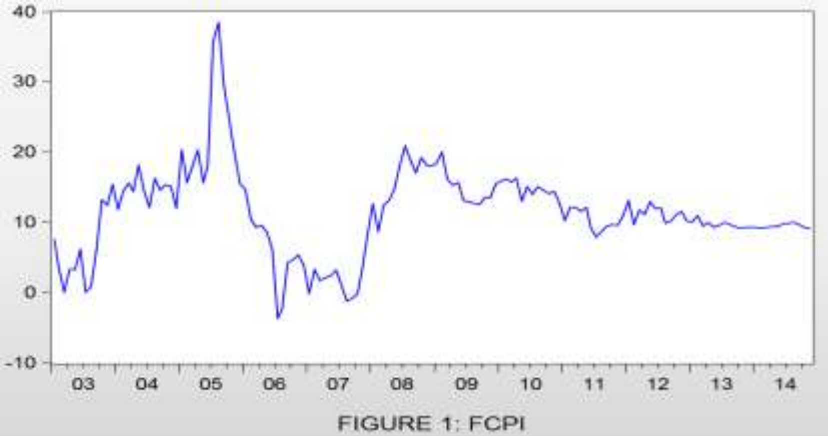


Figure 1

Table 1: Unit Root Test for Nigerian Food Consumer Price Indices

Null Hypothesis: FCPI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.929116	0.0445
Test critical values:	1% level	-3.476805	
	5% level	-2.881830	
	10% level	-2.577668	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FCPI)
Method: Least Squares
Date: 07/22/16 Time: 17:10
Sample (adjusted): 2003M02 2014M11
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FCPI(-1)	-0.114583	0.039119	-2.929116	0.0040
C	1.328414	0.513362	2.587673	0.0107

R-squared	0.057745	Mean dependent var	0.011268
Adjusted R-squared	0.051015	S.D. dependent var	3.029470
S.E. of regression	2.951185	Akaike info criterion	5.016275
Sum squared resid	1219.329	Schwarz criterion	5.057906
Log likelihood	-354.1555	Hannan-Quinn criter.	5.033192
F-statistic	8.579722	Durbin-Watson stat	1.815745
Prob(F-statistic)	0.003970		

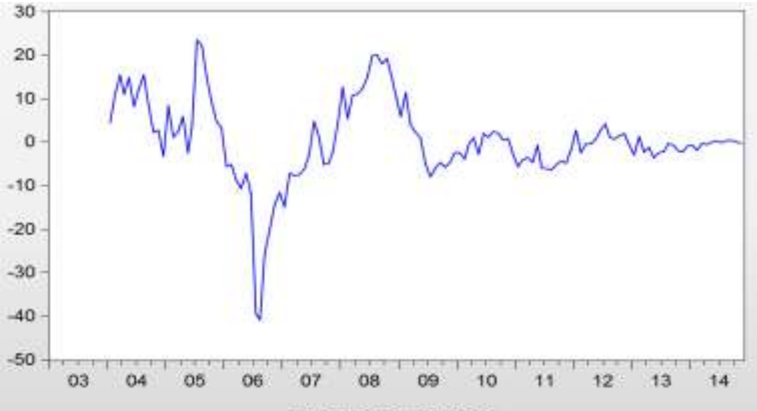


Figure 2: Time Series Plot of the Seasonal Differences of the Nigerian Food Consumer Price Indices

Table 2: Seasonal Differencing of Nigerian Food Consumer Price Indices (SDNFCPI).

Null Hypothesis: SDFCPI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.087780	0.0299
Test critical values:	1% level	-3.481217	
	5% level	-2.883753	
	10% level	-2.578694	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(SDFCPI)
Method: Least Squares
Date: 07/22/16 Time: 17:17
Sample (adjusted): 2004M02 2014M11
Included observations: 130 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SDFCPI(-1)	-0.137940	0.044673	-3.087780	0.0025
C	0.008968	0.424799	0.021112	0.9832

R-squared	0.069324	Mean dependent var	-0.035385
Adjusted R-squared	0.062053	S.D. dependent var	4.998241
S.E. of regression	4.840681	Akaike info criterion	6.007253
Sum squared resid	2999.320	Schwarz criterion	6.051369
Log likelihood	-388.4714	Hannan-Quinn criter.	6.025179
F-statistic	9.534387	Durbin-Watson stat	1.825678
Prob(F-statistic)	0.002473		

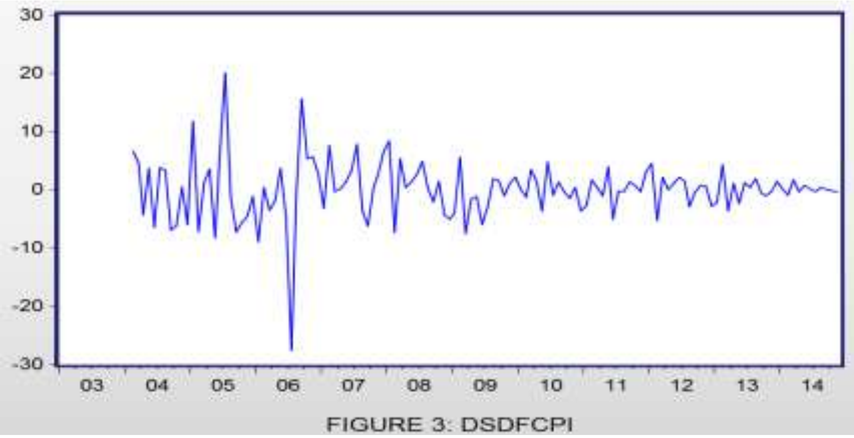


Figure 3: Time Series Plot for Non-seasonal Difference of the Seasonal Differencing of NFCPI

Table 3: Unit Root Test for Difference Seasonal Differences for Nigerian Food Consumer Price Indices (DSDFCPI).

Null Hypothesis: DSDFCPI has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

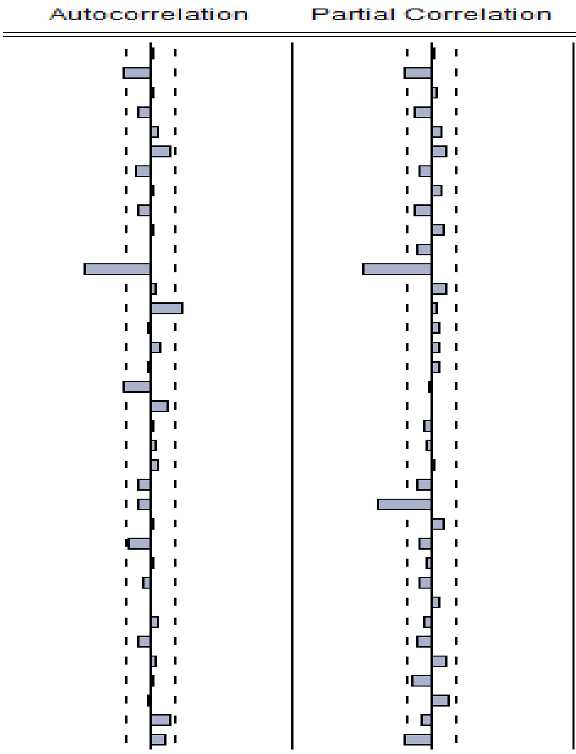
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.665141	0.0000
Test critical values:	1% level	-3.482035	
	5% level	-2.884109	
	10% level	-2.578884	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DSDFCPI)
Method: Least Squares
Date: 07/22/16 Time: 17:23
Sample (adjusted): 2004M04 2014M11
Included observations: 128 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DSDFCPI(-1)	-1.180679	0.122158	-9.665141	0.0000
D(DSDFCPI(-1))	0.192334	0.086853	2.214473	0.0286
C	-0.127824	0.435802	-0.293309	0.7698

R-squared	0.516527	Mean dependent var	-0.037500
Adjusted R-squared	0.508791	S.D. dependent var	7.033788
S.E. of regression	4.929721	Akaike info criterion	6.051600
Sum squared resid	3037.769	Schwarz criterion	6.118445
Log likelihood	-384.3024	Hannan-Quinn criter.	6.078760
F-statistic	66.77291	Durbin-Watson stat	1.978833
Prob(F-statistic)	0.000000		



	AC	PAC	Q-Stat	Prob
1	0.018	0.018	0.0413	0.839
2	-0.192	-0.193	4.9903	0.082
3	0.016	0.025	5.0261	0.170
4	-0.082	-0.125	5.9488	0.203
5	0.056	0.074	6.3847	0.271
6	0.149	0.108	9.4453	0.150
7	-0.113	-0.096	11.234	0.129
8	0.022	0.074	11.302	0.185
9	-0.082	-0.135	12.262	0.199
10	0.020	0.085	12.321	0.264
11	-0.007	-0.104	12.328	0.339
12	-0.484	-0.506	46.352	0.000
13	0.040	0.110	46.591	0.000
14	0.245	0.040	55.484	0.000
15	-0.012	0.061	55.507	0.000
16	0.076	0.055	56.370	0.000
17	-0.012	0.043	56.390	0.000
18	-0.200	-0.011	62.507	0.000
19	0.117	-0.008	64.629	0.000
20	0.017	-0.061	64.673	0.000
21	0.034	-0.033	64.856	0.000
22	0.049	0.021	65.238	0.000
23	-0.092	-0.115	66.603	0.000
24	-0.089	-0.391	67.886	0.000
25	0.017	0.093	67.934	0.000
26	-0.159	-0.088	72.086	0.000
27	0.008	-0.027	72.098	0.000
28	-0.058	-0.095	72.667	0.000
29	-0.002	0.057	72.668	0.000
30	0.049	-0.061	73.075	0.000
31	-0.084	-0.107	74.296	0.000
32	0.033	0.102	74.482	0.000
33	0.012	-0.141	74.509	0.000
34	-0.024	0.126	74.608	0.000
35	0.138	-0.068	78.041	0.000
36	0.112	-0.192	80.322	0.000

Figure 4: Correlogram of Difference Seasonal Differencing for Nigerian Food Consumer Price Indices

Table 4: Model Estimation of the Dependent Variable

Dependent Variable: DSDFCPI
Method: Least Squares
Date: 07/22/16 Time: 17:28
Sample (adjusted): 2005M02 2014M11
Included observations: 118 after adjustments
Convergence achieved after 18 iterations
MA Backcast: 2004M02 2005M01

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(12)	-0.234577	0.083199	-2.819465	0.0057
MA(12)	-0.999909	0.027900	-35.83882	0.0000

R-squared	0.690377	Mean dependent var	-0.072881
Adjusted R-squared	0.687708	S.D. dependent var	4.889591
S.E. of regression	2.732454	Akaike info criterion	4.865081
Sum squared resid	866.0913	Schwarz criterion	4.912042
Log likelihood	-285.0398	Hannan-Quinn criter.	4.884148
Durbin-Watson stat	1.690826		

Inverted AR Roots	.86+.23i	.86-.23i	.63-.63i	.63+.63i
	.23-.86i	.23+.86i	-.23+.86i	-.23-.86i
	-.63-.63i	-.63-.63i	-.86-.23i	-.86+.23i
Inverted MA Roots	1.00	.87-.50i	.87+.50i	.50+.87i
	.50-.87i	.00+1.00i	-.00-1.00i	-.50+.87i
	-.50-.87i	-.87-.50i	-.87+.50i	-1.00

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.145	0.145	2.5403	
		2	-0.191	-0.216	6.9791	
		3	-0.023	0.045	7.0422	0.008
		4	-0.030	-0.081	7.1574	0.028
		5	-0.101	-0.083	8.4252	0.038
		6	0.052	0.069	8.7689	0.067
		7	0.020	-0.046	8.8191	0.117
		8	0.019	0.053	8.8642	0.181
		9	0.017	-0.009	8.9028	0.260
		10	-0.028	-0.025	9.0054	0.342
		11	-0.179	-0.168	13.255	0.151
		12	-0.144	-0.111	16.014	0.099
		13	0.243	0.255	24.001	0.013
		14	0.161	0.021	27.527	0.006
		15	-0.026	0.030	27.622	0.010
		16	-0.019	-0.029	27.672	0.016
		17	-0.105	-0.125	29.212	0.015
		18	-0.126	-0.028	31.460	0.012
		19	0.046	0.030	31.760	0.016
		20	0.018	-0.010	31.808	0.023
		21	0.019	0.021	31.862	0.032
		22	0.004	-0.083	31.865	0.045
		23	-0.038	-0.062	32.085	0.057
		24	-0.218	-0.193	39.271	0.013
		25	-0.074	0.082	40.112	0.015
		26	0.013	-0.087	40.136	0.021
		27	0.004	-0.059	40.139	0.028
		28	-0.027	-0.092	40.257	0.037
		29	0.117	0.041	42.424	0.030
		30	-0.071	-0.091	43.242	0.033
		31	-0.136	-0.036	46.235	0.022
		32	0.047	0.058	46.604	0.027
		33	0.009	-0.082	46.619	0.036
		34	0.020	0.027	46.684	0.045
		35	0.085	-0.033	47.915	0.045
		36	0.013	-0.032	47.942	0.057

Figure 4: The Correllogram of the Residuals Model Estimation

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