Modeling Of Interest Rate In Albania With ARCH Model

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***Abstract*—In this paper we have studied the series of interest rate on deposits and its modeling. The modeling of interest rates is a challenge considering the variety of elements that characterize the financial systems.**

Based on data of the deposits interest rate for the years 1996-2015 in Albania with monthly frequency obtained by the Bank of Albania, we have realized a detailed modeling. We have used autoregressive conditional heteroskedasticity (ARCH) to evaluate the model with volatility at times.

Keywords—modeling; interest rate; times series; ARCH model

I. INTRODUCTION

Deposit is a known form of individual, companies, or wider saving investment in Albanian banking market. The banking intermediaries transfer the surplus funds from surplus units to deficient units. As in world economies, even in Albania the deposits have a significant development, especially in recent years. The banks reward individuals for the use of their funds with a rate set in advance or under contract. This is the interest rate on deposits, which is profit for depositors and cost for banks. When this interest rate increase, the deposit becomes more attractive to lenders and they increase the supply of funds, so the level of deposits increased. On the other hand, the interest rate reduction decreases the borrowing of the bank, because there are offered less funds for a lower profit. In conclusion, the relationship between deposition and their interest rate is right.

Regarding to the deposit market, in Albania, it has been developed after the 90s, but has a greater momentum in recent years. Based on the data by the respective years, obtained by the official website of the Bank of Albania, we conclude that the interest rate of deposits in 2008 has been 6.9% higher, in 2014 has been 2.1% higher, and it has a drastic reduction in November in 2015 with 1.75%. This can be primarily explained by the global crisis that affected most of the countries, which due to their substantial losses from bad loans reduced the profitability of the lenders.

Looking at the financial situation in Albania in the last ten years, the gross domestic product (GDP) was higher in 2008 and continuous to drop after 2010. The inflation rate has the highest value in 2010, but over the years it generally appears as a stable indicator. While the level of the unemployment rate is far from normal unemployment rate (4-6%) and reaches the maximum value to 16.1% in 2014.

In other years, the performance is in the range of 13-14% with minor fluctuations. While the bad loan rate has a gradual upward trend quite large, from 2.3% in 2005 to 24% in 2014.

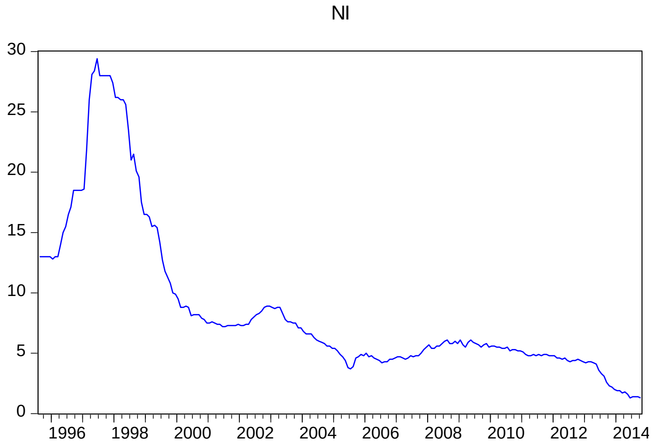

Fig. 1 *The performance graph of deposit interest rates in the years 1996-2015.*

II. LITERATURE REVIEW

Modeling interest rates is a challenge considering the variety of elements that characterize the financial systems in different countries.

One element to consider is the impact of the deposits growth rate on interest rate. In the last sixty years these rates are not well correlated with each other (Zelnick, 2014).

The way how deregulation of interest rates modifies the behavior of deposit rates in Hong Kong summed up in (James 1998):

- Increasing the level of total deposits

- Consistency in the deposit rate

- Prohibition to encroach on bank profitability

This paper suggests the studying of the deregulation of interest rates during periods of economic decline.

Other authors (Leuvenssteijn et al, 2006) have had on their focus the banking competition. In European countries, due to fierce competition, banks reduce lending interest rates. Also, they reduce interest rates on deposits to compensate the losses. Moreover, it is concluded that the response of banks to competition is immediately.

Based on a simple logic, it is thought that deposit insurance, e.g. ASD in the US, will cause a decrease in interest rates of deposits. Empirical studies (Carapelle, 2003) demonstrate there does not exist a strong relation between these two variables.

The bank deposits are the main alternatives where Albanian citizens choose to invest their savings. In Albania, there are fewer studies in this field; they are more in the form of small sections integrated into broader topics. We mention here the relationship between interest rate of deposits, inflation and business cycles (Leskaj & Kotor, 2011).

Similarly, another study supports the relationship between interest rate and deposits in Albania. It is concluded that the interest rate influence the credit rate in Albania (Sinaj. V 2015) and the model of the rate is SARIMA (Sinai & Tushaj 2015). Another modeling on deposit interest rates is carried out in the Montenegro (Steseciv, 2008). They studied the macroeconomic variables specifically related to the Montenegrin economy such as money supply, loan interest rate, market capitalization and the level of consumption.

III. Empirical Analyses

In this study we have done a detailed modeling of data of the deposit interest rate with monthly frequency for the years 1996-2015 in Albania, obtained from the bank of Albania.

A. *Stationarity*

The equations In general, the time series variables have a certain trend so they are non-stationary and should be transformed to stationary using differences. A time series is stationary if the mean, variance and autocorrelation are constant (independent of time t). We present analytically:

$$E(NI_t) = \mu$$
$$Var(NIt) = \sigma^2$$
$$cov(NI_{t+k}, NI_t) = \gamma_k$$

A useful way to determine the order of differentiation is the use of criteria of the existence of unitary series roots in the study. The order of differentation will be determined by the number of unitary roots.

We will use the DF test assuming that the residues were uncorrelated between them. If such a thing happens, we use the generalized Dickey-Fuller test, ADF(p), which is an asymptotic test to prove the existence of unitary roots.

Referring to the model:

$$\Delta Z_t = \beta_1 + \beta_2 t + \delta Z_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Z_{t-i} + u_t$$

We set up the hypotheses:

$H_0 : \delta = 0$ (equivalent to the existence of unitary roots)

The alternative hypothesis: H_1: $\delta<0$ (the time series is stationary)

If student statistics values are greater than the critical value then the basic hypothesis stands.

TABLE I. The ADF test results for IR series and IR difference

Basic Hypothesis	t-Statistic	Prob.*
NI has a unit root	0.89	0.10
d(NI) has a unit root	-21.5	0.000
Test critical values:	1% level	-3.452991
	5% level	-2.871402
	10% level	-2.572097

So, IR series is not stationary, because student statistics value is 0.89 greater than the critical values of unilateral hypothesis. Whereas the value of difference series of IR is -21.5, which is less than the critical values, consequently the basic hypothesis stands. So IR series is non-stationary and a difference is sufficient to transformi it into stationary and therefore it is called integral of first order I(1).

B. *Model Evaluation*

Referring to the criteria mentioned above, interest rate is non-stationary variabel of first order, ARIMA(p,1,q). In the previous paragraphs, we showed this series has seasonal effects, so the general form of its model is SARIMA(p,1,q)(P,D,Q)$_{12}$. The general form of this model, in the language of backwards operator, is:

$$(1-\Phi_1 B^{12} - \Phi_2 B^{24} - .... - \Phi_P B^{12P})(1-B^{12})^D (1-B)\ (1-\varphi_1 B - \varphi_2 B^2 - ... - \varphi_p B^p) TFR_t =$$
$$= (1+\Theta_1 B^{12} + \Theta_2 B^{24} + ... \Theta_Q B^{12Q})(1+\theta_1 B + ... + \theta_q B^q) u_t$$

where u_t is white noise.

The chosen model, based on the selection criteria of AIC, BIC and SBQ models, is:

MODEL FINALLY CHOSEN:

SARIMA(1,1,1)(1,0,0)

WITHOUT MEAN

The estimated model

METHOD OF ESTIMATION: EXACT MAXIMUM LIKELIHOOD

PARAMETER	ESTIMATE	STD ERROR	T RATIO	LAG
AR1 1	-.93492	0.43724E-01	-21.38	1
AR2 1	-.25420	0.70150E-01	-3.62	12
MA1 1	-.74071	0.79304E-01	-9.34	1

We use Jarque-Bera test to test the distribution of residuals. The test is given as below:

$$JB = \frac{n}{6}\left[S - \frac{(K-3)^2}{4}\right] \sim \chi_2^2$$

We build the hypothesis: $H_0 : u_i \sim N\left(\mu = 0, \sigma^2\right)$

TABLE II. THE TEST RESULTS AND THE MAIN RESIDUALS STATISTICS

TEST-STATISTICS ON RESIDUALS

MEAN= -0.0027055

ST.DEV.= 0.0021650

OF MEAN

T-VALUE= -1.2497

NORMALITY TEST= 5.092 (CHI-SQUARED(2))

SKEWNESS= -0.3414 (SE = 0.1640)

KURTOSIS= 3.2859 (SE = 0.3281)

SUM OF SQUARES= 0.2347131

DURBIN-WATSON= 2.0326

STANDARD ERROR= 0.3266309E-01

OF RESID.

MSE OF RESID.= 0.1066878E-02

C. *ARCH models*

To evaluate the model with volatility at times, there is used autoregressive conditional *heteroskedasticity* (ARCH) presented by Engle (1982). ARCH is used to model the series correlations through the square of returns assuming the conditional variance as a function of past errors and changes that occur during the time. So, ARCH to determine the today variance of dependent variable takes into account only the residuals of past periods. The expansion of ARCH model is known as the generalization of autoregressive conditional *heteroskedasticity* or GARCH model (Bollerslev 1986).

The general form of ARCH(q) model is:

$$\mathrm{NIt} = f(Z) + u_t$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-1}^2 + \cdots + \alpha_q u_{t-q}^2 \qquad (1)$$

So, the residual model variance is not constant, but conditional. It depends on the square of residuals with time delays. The maximum lag, involved in modeling, determines the order q of ARCH model.

The variables of conditional variance equation are all squared delays residuals; therefore they cannot be negative. To make sure we always have positive variance, usually all the coefficients should be non-negative. If at least one coefficient would have negative value, then the value of the conditional variance would be negative, which makes no sense. The non-negativity condition for the model (1) would be $\alpha_0 \geq 0 \ldots \alpha q \geq 0$. In general, all the coefficients for the ARCH(q) model should be non-negative: $\alpha_i \geq 0$ $\forall i = 0,1,2,\ldots q$. In fact, this is a sufficient condition but no necessary for the non-negativity of the conditional variance (stricter than necessary). ARCH models are rarely used in the last decade, because of the difficulties that were generated by:

- How to set the values of q, q is the number of included lags of the squared residuals in the model? One way is to use the tests of maximum; however it is not the best possible solution.
- The lags values of the squared residuals needed to determine the dependence on the conditional variance can be large. This would result in a very wide model of the conditional variance, which would be inappropriate.
- Limitations of non-negativity can be "violated". The more parameters included in the conditional variance equation, the more it is possible at least one of them have a negative rating.

Due to the limitations revealing by the ARCH(p) model, there was developed a natural extension of ARCH(q) model avoiding in this way the problems mentioned above. Thus was created a new econometric model known as GARCH model. This model was created by Bollerslev and Taylor in 1986.

GARCH(q;p) model is a function which conditions the current residuals variance from the square residuals to q-residuals and from the variances of p-earlier periods. The presentation in functional form is as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

We use the ARCH test on the estimated model of IR to find out if there has heteroskedasticity problems in the residuals of model, further of that conditional. Raised hypotheses in this case are:

H0: the residuals of the model do not have conditional heteroskedasticity.

There is used Fisher statistic to test the hypothesis. If it is greater than the critical value then the basic hypothesis is rejected.

TABLE III. ARCH TEST RESULTS

Heteroskedasticity Test: ARCH			
F-statistic	57.28392	Prob. F(1,216)	0.0000
Obs*R-squared	45.69568	Prob. Chi-Square(1)	0.0000

The value of Fisher statistic is 57.28 and the value of p=0000, shows the hypothesis is rejected, therefore the residuals of model “suffer” from the presence of ARCH.

The evaluated equation, GARCH(2,3), is:

Dependent Variable: NI

Method: ML - ARCH (Marquardt) - Normal distribution

Date: 01/16/16 Time: 18:39

Sample (adjusted): 1995M09 2014M10

Included observations: 230 after adjustments

Failure to improve Likelihood after 34 iterations

MA Backcast: 1995M08

Presample variance: backcast (parameter = 0.7)

GARCH=C(3)+C(4)*RESID(-1)^2+C(5)*RESID(-2)^2+C(6)*GARCH(-1) + C(7)*GARCH(-2) + C(8)*GARCH(-3)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	1.000893	0.010998	91.00993	0.0000
MA(1)	0.528553	0.111324	4.747866	0.0000
	Variance Equation			
C	5.281959	0.789090	6.693732	0.0000
RESID(-1)^2	0.254504	0.066257	3.841154	0.0001
RESID(-2)^2	0.183716	0.061919	2.967036	0.0030
GARCH(-1)	-0.726229	0.083238	-8.724714	0.0000
GARCH(-2)	-0.811020	0.034893	-23.24284	0.0000
GARCH(-3)	-0.745183	0.062460	-11.93063	0.0000

R-squared	0.993906	Mean dependent var	8.632609
Adjusted R-squared	0.993879	S.D. dependent var	6.539355
S.E. of regression	0.511620	Akaike info criterion	2.459288
Sum squared resid	59.68022	Schwarz criterion	2.578873
Log likelihood	-274.8181	Hannan-Quinn criter.	2.507526
Durbin-Watson stat	2.026379		

The graph of the evaluated model and residuals is in Appendix.

IV. Conclusions

After Based on the data by the respective years, obtained by the official website of the Bank of Albania, we conclude that the interest rate of deposits in 2008 has been 6.9% higher, in 2014 has been 2.1% higher, and it has a drastic reduction in November in 2015 with 1.75%. This can be primarily explained by the global crisis that affected most of the countries, which due to their substantial losses from bad loans reduced the profitability of the lenders.

We concluded that this time series is not stationary, but a difference is enough to transform it in a stationary series, called the first order integral I(1).

Based on the results of this study we come to the conclusion that the model of IR is SARIMA(1,1,1)(1,0,0), and the estimated model of residuals is GARCH(2,3).

References

[1] Ajibola , Arewa, "*Bank credit risk and interest rate volatility- granger causality vs. var-garch approach*", Lagos State University, Lagos, Nigeria, Faculty of Management Sciences, Accounting and Finance Department. 2013

[2] Woodford. M., *Interest and Prices:* Foundations of a Theory of Monetary Policy Princeton: Princeton University Press. 2003

[3] Hannan, T.H., and Berger, A.N. "*The Rigidity of Prices: Evidence from the Banking Industry*", American Economic Review, 81 (4), pp. 938-945. 1991

[4] Hutchison, D.E. "Retail Bank Deposit Pricing: An Intertemporal Asset Pricing Approach", Journal of Money, Credit, and Banking, 27, pp. 217-231. 1995

[5] www.bankofalbania.org

[6] http://www.hnb.hr/dub-konf/13-konferencija/galac-ivicic-dumicic.pdf

[7] http://www.bankofalbania.org/web/ABC_ja_e_normave_te_interesit_3241_1.php

[8] Sinaj & Tushaj. "Interest rate modeling for Albania." http://www.aasrc.org/aasrj/index.php/aasrj/article/view/1696

[9] Sinaj. V., "Analysis of the response rate loans in Albania by changes in interest rate" http://ekonomskiinstitut.com/al/wp-content/uploads/2014 /08/revista_nr7_v2.pdf

[10] Investopedia: Who determines interest rates? http://www.investopedia.com/ask/answers/03/112003.asp

[11] Agalliu A., 2013, "Kapitali human përballe sfidave të sistemit bankar në Shqipëri"

[12] Masson P., Bayoumi T., Samiei H., "International evidence on the determinants of private savings", South Asia Economic Journal. 2007

[13] Huizinga H., "Determinants of commercial banks interest in margins and profitability: some international evidence", World Bank Economic Review. 1999

Appendix

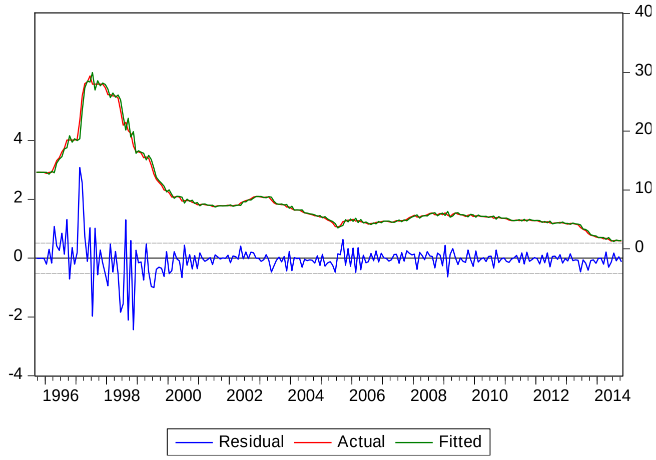

Fig. 2 *The model graph of interest rates*