Modeling the Interdependence of Consumer Loan Rates Fluctuation in Monthly among Banks by Using MGARCH and VAR

Moses Alfian Simanjuntak and Darman Mappangara

***Abstract*—This research paper aims to analyze the impact of the interest rates of customer loan fluctuation in monthly among banks. The study employed MGARCH model for volatilities (risk) and VAR model is helpful to describe interest rates and inflation shocks which are explained on the impulse response functions and variance decomposition analysis. The data is collected base on www.bi.go.id from the period January 2004 to October 2013. The study empirically find that the interest rate returns have clearly differently volatilities between banks. The best model for volatilities is MGARCH-BEKK where the log likelihood estimation is multivariate student's *t*-distribution. Private National Banks (BSN) and Regional Government Bank (BPD) interest rate returns have top two highest volatilities (risky interest rates). There are clearly exist the interdependences among interest rate return banks and inflation. Inflation has impact on banks loan in the short term (one year). The largest shock is coming from Regional Government Bank (BPD) interest rate return that influence others. Another important implication of this study shows that the return of Commercial Banks (BU) interest rate is more sensitive and it can create the largest turbulence to the other banks loan. The Central Bank (Bank Indonesia) regulation to influence stability in monetary, must fully concern to the activities of Commercial Banks (BU) and Regional Government Bank (BPD).**

***Index Terms*—Inflation, volatilities, impulse response functions, variance decomposition analysis.**

I. Introduction

Vaishali Rastogi, the Boston Consulting Group partner and managing director, told a press conference in Jakarta that the middle class in Indonesia would almost double to 141 million by 2020 and added that the nation's buying power would also rise rapidly. Rastogi said that most middle class consumers tended to buy things that could improve their quality of life. The consumption trends will also shift from essentials to products that offer facilities and comforts, such as longer lasting household appliances, electronics, cars and financial services. A rising middle class leads to a stronger and more stable economy, especially since the Indonesian economy is based on strong domestic consumption. The growth of middle class in Indonesia make banking business in consumer credit to be better. Consumer credit that banking offer include credit cards, store cards, motor (auto) finance, personal loans (installment loans), consumer lines of credit, retail loans (retail installment loans) and mortgages.

Nowadays, the integration of financial market activities and the growing level of integration in consumer banking become more important to be discussed. Evaluating time-varying conditional covariances and volatilities of consumer loan would be of major concerns to government, banking managers, and customers in order to obtain diversify risk effectively and an efficiently dynamic allocation of loans.

Regarding with the phenomenon of middle class in Indonesia would almost double to 141 million by 2020, so that its implication is to make a good prospect of banking business in consumer credit. Furthermore, this research main purpose is to analyze the interest rates of customer loan fluctuation in monthly. Diversify risk effectively that we stated above will be expressed in MGARCH model. Meanwhile, an efficiently dynamic allocation of loans can be explained by VARs model. The vector autoregression (VARs) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables [1].

Increasing financial integration of economies has resulted in a spate of studies on monetary linkages across interest rates and inflation. This paper consider also to look the shock of inflation impact on the interest rates. At least we have 2 theories of economic monetary which is explain the relationship between interest rate and inflation, as follows:

1) Robert Alexander Mundell, CC is a Nobel Prize-winning in 1999, Canadian economist. He said that fluctuation in inflation will impact directly to fluctuation in interest rate (IMF interview, September 2006).
2) In 1963, Milton Friedman said that inflation is always and everywhere a monetary phenomenon (The Economist, July 2012). That is mean that inflation also has a impact to interest rate.

II. Methodology and Data

The illustration analysis is based on MGARCH model and VARs model which are discribed as follows:

A. Multivariate Generalized Autoregressive Conditional Heteroskedasticity (MGARCH)

The System GARCH estimator is the multivariate version of GARCH estimator. System GARCH is an appropriate technique when one wants to model the variance and covariance of the error terms, generally in an autoregressive form. System GARCH allows us to choose from the most popular multivariate GARCH specifications: Constant

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Conditional Correlation, the Diagonal VECH, and (indirectly) the Diagonal BEKK [2]-[5]. The multivariate GARCH specifications are explained as follows :

a) Diagonal VECH model that Bollerslev, Engle, and Wooldridge introduced in 1988 is

$$H_t = \Omega + A \cdot \varepsilon_{t-1}\varepsilon'_{t-1} + B \cdot H_{t-1} \quad (1)$$

where the coefficient matrices *A*, *B*, and Ω are $N \times N$ symmetric matrices, and the operator " · " is the element by element (Hadamard) product. They generalized the exponentially weighted moving-average approach to propose the model.

b) Constant Conditional Correlation (CCC) is introduced by Bollerslev in 1990 [6] as

$$h_{iit} = c_i + a_i\varepsilon^2_{it-1} + d_i I^-_{it-1}\varepsilon^2_{it-1} + b_i h_{iit-1} \quad (2)$$

where

$$h_{ijt} = \rho_{ij}\sqrt{h_{iit}h_{jjt}}$$

To keep the number of volatility equations low, Bollerslev considers the special case in which the correlation coefficient is time-invariant.

c) BEKK is defined by Engle and Kroner in 1995 as:

$$H_t = \Omega\Omega' + A\varepsilon_{t-1}\varepsilon'_{t-1}A' + BH_{t-1}B' \quad (3)$$

Engle and Kroner guaranteed that the matrices form will be positive definite. This model also allows for dynamic dependence between the volatility series.

MGARCH estimation uses maximum likelihood to jointly estimate the parameters of the mean and the variance equations. The log likelihood contributions for MGARCH models are given by:

d) Multivariate normality distribution

$$l_t = -\frac{1}{2}mlog(2\pi) - \frac{1}{2}log(|H_t|) - \frac{1}{2}\varepsilon'_t H_t^{-1}\varepsilon_t \quad (4)$$

where *m* is the number of mean equations, and ε_t is the *m* vector of mean equation residuals.

e) Multivariate student's *t*-distribution

$$l_t = log\left\{\frac{\Gamma\left(\frac{v+m}{2}\right)v^{m/2}}{(v\pi)^{m/2}\Gamma\left(\frac{v}{2}\right)(v-2)^{m/2}}\right\} - \frac{1}{2}log(|H_t|) - \frac{1}{2}(v+m)log\left[1 + \frac{\varepsilon'_t H_t^{-1}\varepsilon_t}{v-2}\right] \quad (5)$$

where *v* is the estimated degree of freedom.

B. Vector Autoregressions (VARs)

The vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system [5]-[8]. The systems approach yields interesting insights and to interpret the estimated models in terms of recent work on the term structure of interest rates and inflation. The VAR designed for use with stationary series that are known to be cointegrated. Meanwhile, a vector error correction (VEC) model is a restricted VAR designed for use with nonstationary series that are known to be cointegrated in the long run [5], [9], [10].

The model of a VAR can be expressed as

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + Bx_t + \varepsilon_t \quad (6)$$

where y_t is a *k* vector of endogenous variables, x_t is a *d* vector of exogenous variables, $A_1, \ldots, A_p$ and *B* are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

The log likelihood value is computed assuming a multivariate normal (Gaussian)
distribution as:

$$l = -\frac{T}{2}\{k(1 + log2\pi) + log|\widehat{\Omega}|\} \quad (7)$$

where

$$|\widehat{\Omega}| = det\left(\frac{1}{T-p}\sum_t \hat{\varepsilon}_t\hat{\varepsilon}_t{}'\right)$$

The structural analysis will focus on the impulse response function and error decompositions. The monthly data runs from January 2004 to October 2013 are selected from website: www.bi.go.id [11] for analysis purpose. The monthly data collected are inflation and consumer loan from 5 group of banks such as State Banks/Bank Persero (BP), Regional Government Bank/Bank Pemerintah Daerah (BPD), Private National Banks/Bank Swasta Nasional (BSN), Foreign Banks and Joint Banks/Bank Asing dan Bank Campuran (BAC), and Commercial Banks/Bank Umum (BU).

III. Result

TABLE I: Statistics Descriptive

	DLNBAC	DLNBP	DLNBPD	DLNBSN	DLNBU
Mean	-0.196290	-0.251091	-0.191744	-0.318496	-0.295851
Median	-0.166205	-0.262467	-0.141143	-0.358423	-0.304044
Maximum	5.192294	5.266326	22.92291	3.083096	3.676090
Minimum	-10.38524	-5.732868	-22.27844	-10.49580	-5.917396
Std. Dev.	1.641614	1.299315	2.996700	1.500386	1.084534
Skewness	-2.105519	-0.070167	0.505714	-2.458390	-0.919902
Kurtosis	16.50388	9.527932	56.43763	19.63355	10.15320
Jarque-Bera	975.4272	207.8388	13925.94	1466.642	265.9463
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	-22.96592	-29.37764	-22.43404	-37.26406	-34.61457
Sum Sq. Dev.	312.6080	195.8333	1041.704	261.1344	136.4409
Observations	117	117	117	117	117

The empirical results are given in this section. The result from descriptive statistics in Table I, show that both returns of Private National Banks (BSN) and Commercial Banks (BU) interest rates have on average the least profitable. Regional Government Bank (BPD) interest rate return has the highest kurtosis value followed by Private National Banks (BSN) interest rate return. Kurtosis measures the peakedness or flatness of the distribution of the series. The kurtosis of the

normal distribution is 3. To model the thick tail in the residuals, we will assume that the errors follow a Student's t-distribution [12]. In general, all the interest rate return banks are not normally distributed (as evidence from *p*-value of Jarque-Bera). Some studies found that a Lagrange Multiplier (LM) test for the constant-correlation hypothesis in a multivariate GARCH model is supported by some financial data. The LM test appears to have a good power and is more robust to nonnormality [6].

The unit root test on the interest rate returns are conducted using ADF test procedure, as in Table II. The result show that the all of interest rate returns are stationary in level, I(0). If a time series has a unit root or is non-stationary, corresponding estimated results will have a spurious problem. This is because the mean and auto covariance of the non-stationary time series depend on times [1], [4], [7], [8].

The kernel density graphical presentation of the interest rate returns show that the normal distribution is not suitable for the error distribution, as in Fig. 1. The plots also give clear indications of volatility clustering, periods of high volatility (during economic crisis in 2004 and 2008 [1], [8]) and periods of calm.

TABLE II: VAR MODEL

ADF test	DLN BAC	DLN BP	DLN BPD	DLN BSN	DLN BU	D INF
t-Stat	-9.62	-10.83	-11.91	-3.42	-3.80	-8.87
Prob.*	0.00	0.00	0.00	0.01	0.00	0.00

Note: Null Hypothesis: Return has a unit root. *MacKinnon (1996) one-sided p-values. All returns have statistically significant at the 5% level.

The volatility plots show that there are exist time varying volatility among the interest rate returns, as in Fig. 2.

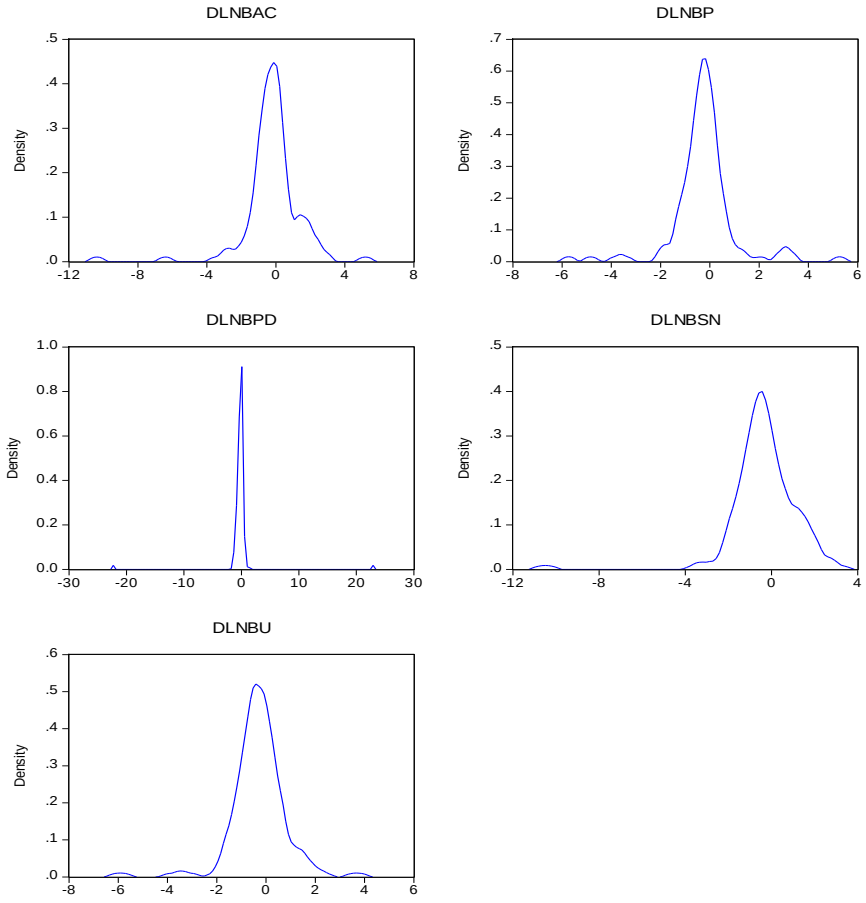

Fig. 1. Kernel density.

TABLE III: MULTIVARIATE TIME SERIES EQUATION

Covariance specification: BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)*A1 + A2*RESID(-1)*RESID(-1)*A2
M is an indefinite matrix
A1 is diagonal matrix
A2 is diagonal matrix
GARCH1 = 16.37+0.26*RESID1(-1)^2+0.21*RESID1(-2)^2
GARCH2 = 4.19+0.72*RESID2(-1)^2+0.47*RESID2(-2)^2
GARCH3 = 0.36+**0.85***RESID3(-1)^2+0.51*RESID3(-2)^2
GARCH4 = 5.81+**1.04***RESID4(-1)^2+0.63*RESID4(-2)^2
GARCH5 = 3.19+0.78*RESID5(-1)^2+0.46*RESID5(-2)^2

Note: M as constant term has not significant. A1 and A2 as squared error terms have statistically significant at the 10% level. System Residual Portmanteau Tests for Autocorrelations result is no residual autocorrelations up to lag 10. GARCH1 is a model of BAC, GARCH2 is a model of BP, GARCH3 is a model of BPD, GARCH4 is a model of BSN, and GARCH5 is a model of BU.

The conditional heteroscedasticity is directly dependent on conditional higher variance, kurtosis (> 6) and skewness [12]. Those informations show that we need volatility equation (MGARCH). Multivariate volatility model is an important tool to estimate the changing volatility as well as correlation in financial time series. MGARCH is a variance model where the error variances that we obtain will be constant. From some simulation that we have done, we can select that the best specification model is MGARCH-BEKK where the log likelihood estimation is multivariate student's t-distribution and this model is convergence also (see in Table III). Fortunely, MGARCH-BEKK model that we obtain is relatively suitable to interest rate returns due to the fluctuation terms between variances and interest rate returns

are closely at the same time (see in Fig. 2). As an example, the fluctuation terms on Var(DLNBAC) are at time 5 and at time 12. Those times are happen on DLNBAC too, and soon. From Table III and Fig. 2, we obtain that both return of Private National Banks (BSN) and Regional Government Bank (BPD) interest rates have top two highest volatilities (risky interest rates).

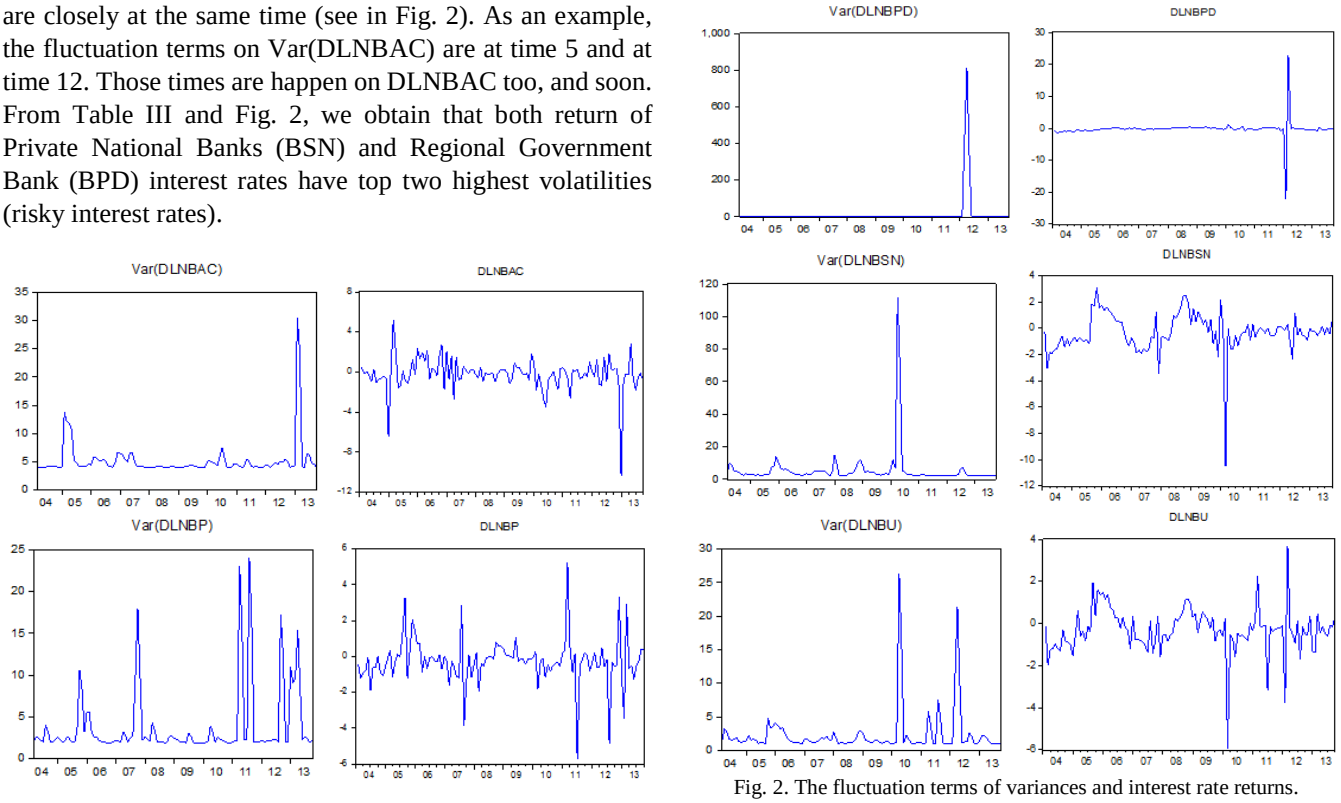

Fig. 2. The fluctuation terms of variances and interest rate returns.

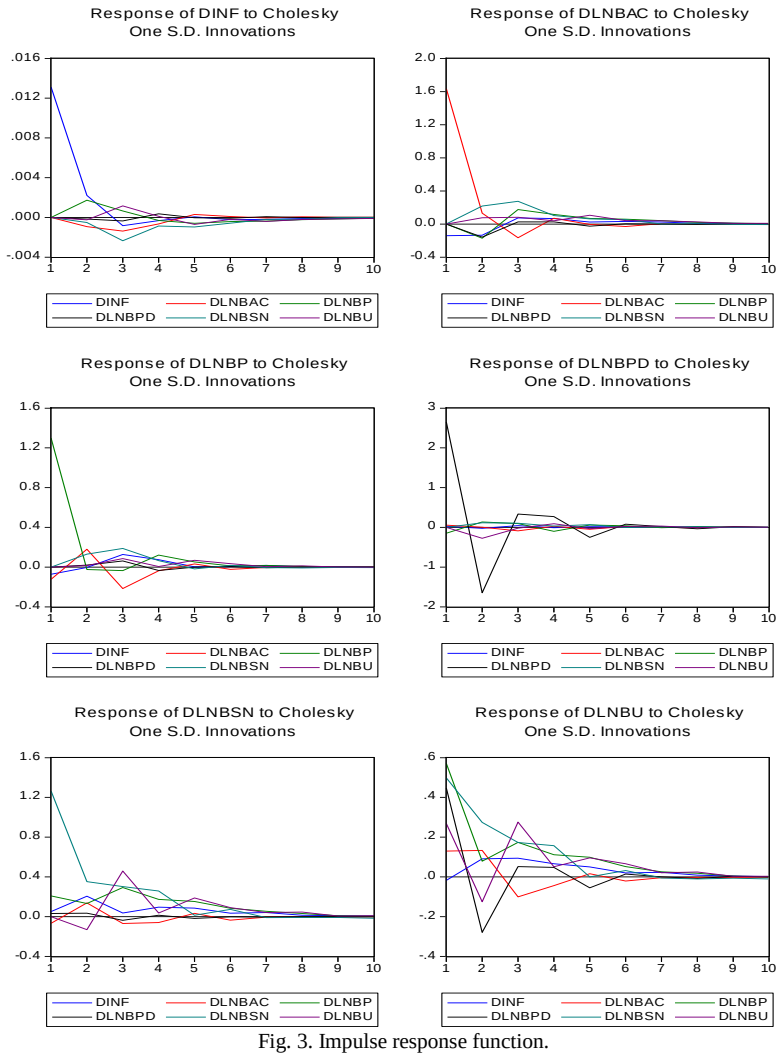

Fig. 3. Impulse response function.

Impulse response functions (IRF) trace the effects of a shock to one endogenous variable on to the other variables on the VAR. Impulse response function plots, as in Fig. 3 and variance decomposition plots, as in Fig. 4, give some

empirical evidence on the interdependences among interest rate return banks and inflation in the short-term and long-term [7], [13]. The main assumption of the IRF in the VAR model is that the structural shock is unanticipated [1]. Shock from inflation has impact on the interest rate return banks in the short-term (one year). Most studies only used the short-term length of interest rates to carry out the empirical results [13]. The inflation shocks could not be anticipated by the banks. After that, there is no impact, due to the all variables lead to decreasing and will be closed to zero. The largest shock is coming from Regional Government Bank (BPD) interest rate return that influence others.

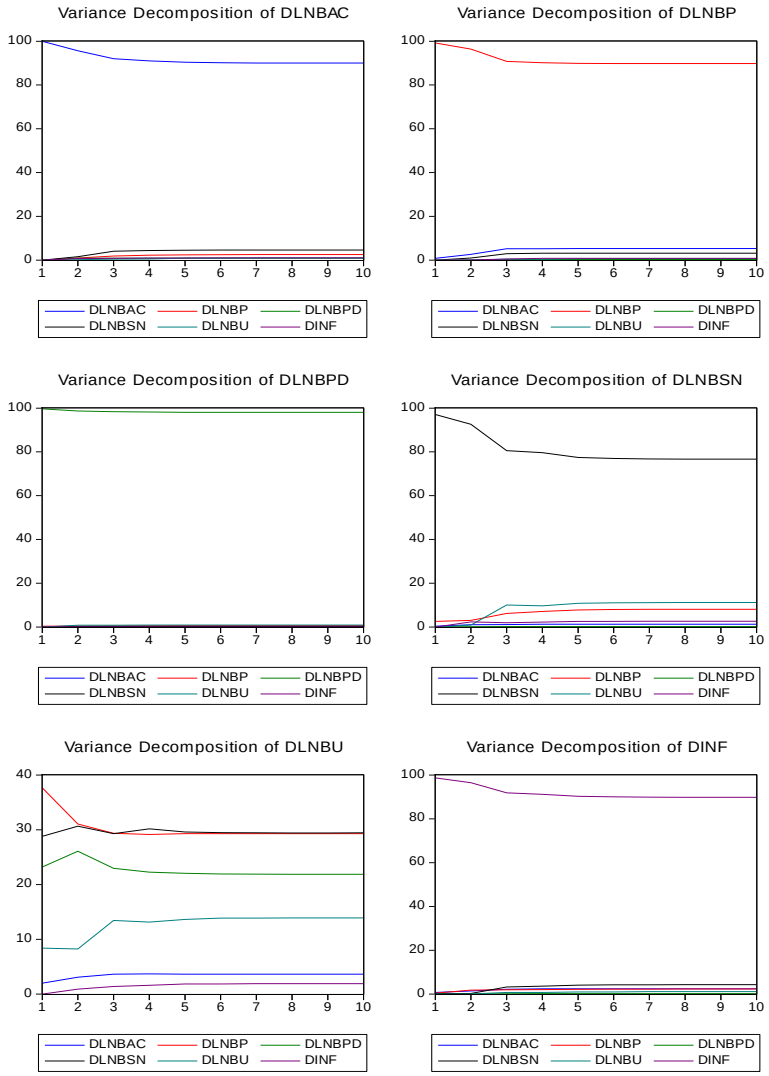

Fig. 4. Variance decomposition.

The variance decomposition (VDC) provides information about the relative importance of each random innovation in affecting the variables on the VAR. The variance decomposition plots describe that the return of Commercial Banks (BU) interest rate can create the largest turbulence to the other banks loan. It could be possible that Commercial Banks (BU) has banking activities mostly deals with on making business in consumer loans than other banks.

IV. Summary

The all of interest rate returns have kurtosis more than 6. That is means that the data tend to has heteroskedasticity. The highest kurtosis value tend to has the highest volatility. Consequently, we need to make modeling in volatilities so that the assuming of constant variance can be handled. The best model for volatilities is MGARCH-BEKK where the log likelihood estimation is multivariate student's t-distribution. Private National Banks (BSN) and Regional Government Bank (BPD) interest rate returns have top two highest volatilities (risky interest rates). There are exist the interdependences among interest rate return banks and inflation. Inflation has influence on banks loan in the short term (one year). The largest shock is coming from Regional Government Bank (BPD) interest rate return that influence others. The return of Commercial Banks (BU) interest rate can create the largest turbulence to the other banks loan.

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