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A Vector Autoregressive (VAR) Approach**

by

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The Effects of Monetary Policy Shocks to The Philippine Economy: A Vector Autoregressive (VAR) Approach¹

by

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ABSTRACT

This paper used Vector Autoregressive (VAR) model to estimate the impacts of a monetary policy shock through the reverse repurchase rates on M3, value of the manufacturing production and inflation rate

Results of the study showed that monetary shocks produced impulse responses that showed transitory cyclical fluctuations on macroeconomic variables that dissipated over time. Monetary shocks had the following properties: (1) they were associated with a fall in domestic liquidity or M3 stock; (2) they led to a transitory increase on the inflation rate or the price level as observed with the *price puzzles*; and, (3) they generated sharp but temporary decline on the output of the manufacturing sector. Variance decomposition results revealed that the reverse repurchase rate (RRP) is not a significant measure of monetary policy shocks due to its insignificant effect on M3, value of the manufacturing production and inflation rate

I. Introduction

Monetary policy refers to the action taken by the central banks and monetary authorities to regulate monetary aggregates such as money supply and interest rates in the economy (Tetangco, 2003). The conduct of monetary policy remains to be one of the central themes in applied macroeconomics and nearly all central banks and monetary authorities around the world have acknowledged the role of monetary policy as a key instrument in stabilization and growth in the economy (Tuaño-Amador, 2003).

In the Philippines, the *Bangko Sentral ng Pilipinas* (BSP), is the chief monetary authority that sets the wide-ranging policy directions related to the monetary policy. It is tasked to make policy decisions particularly on money, credit, and banking aimed at maintaining a stable price-level conducive for promoting sustained growth and economic development (BSP, 1999). During the last few decades, however, there has been a shift in the understanding of the role of monetary policy. A slightly higher inflation, on account of accommodating monetary policy, was permitted to facilitate faster economic growth. This old view of the role of monetary policy assumed the existence of a trade-off between inflation, on one hand, and employment and growth, on the other.

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Nonetheless, developments in the past twenty years have acknowledged a review of this paradigm. Accommodative or expansionary monetary policy has always been equated to higher inflation without necessarily contributing to growth in the economy since higher growth rate of the money supply has been also highly inflationary and that it does not really contribute to the increase in national output (BSP, 1999). The link between expansionary monetary policy hence, higher inflation and economic growth proved to be operative only in the short run. Thus, there has been a shift in the focus of monetary policy from promoting economic growth to maintaining price stability.

Given the conflicting nature on how monetary policy should be conducted, it would be interesting to examine the country's monetary policy stance in the light of examining the responses of some pivotal macroeconomic variables to policy actions conducted by the BSP for the past few years. Since there has been no empirical study conducted yet in the Philippines with regard to the effects of monetary shocks to the economy specifically on the value of manufacturing production, money supply and prices, investigating on the shocks to monetary policy basically reflects the need to understand the profound inter-relationships of macroeconomic factors and how they respond, following a disturbance in the conduct of monetary policy in the economy.

Monetary policy shocks and its implications to the economy have been widely recognized in several empirical literatures to date. In the past decades, there has been a resurgence of interest in developing quantitative models that estimate the relationship between the effects of monetary policy shocks and the economy (Christiano *et al.*, 1998). The desire to attain a more robust explanation of the effects of monetary policy shocks has motivated a large amount of recent works re-examining the statistical relationship between the conduct of monetary policy and the economy by using other frameworks aside from the conventional simultaneous equation models. Most of the studies have been completed following the vector autoregression models, which provided a new macroeconomic framework that held great promise (Stock and Watson, 2001; Romer, 2000; Christiano *et al.*, 1998). Vector autoregressive models have been used extensively in recent empirical studies, particularly in the context of macroeconomic analysis, from relatively *a theoretical* exercise to a more extensive modeling and forecasting purpose (Jacobson *et al.*, 1999). In its simplest form, a VAR is a system of equations where each variable in the system is regressed on a set of its own lagged values and lagged values of each of the other variables.

II. Objectives

- 1) To examine the trend of the important economic variables, and;
- 2) To estimate empirically the effects of monetary policy shocks on other macroeconomic aggregates using variance decomposition and impulse response functions.

III. Methodology

This study focused on the estimation of the effects of monetary shocks in the Philippine economy, more particularly the effects of reverse repurchase rate shocks on various economic aggregates, using the vector autoregressive (VAR) model. The VAR model comprised of output in terms of value of production index (VAPI), the log of money supply (M3), reverse repurchase rates (RRPs), and inflation rate. These variables were identified in the conceptual framework of the study. The RRP rate was considered as the policy variable of the Bangko Sentral ng Pilipinas, money stock (M3) as the monetary variable, VAPI represented manufacturing output variable, and the rate of inflation reflecting the changes in prices.

IV. The Model

Based on the earlier work of Christiano, et al. (1998), Berument (2001), a monetary shock is identified with the disturbance term in the regression equation of the form:

$$S_t = f(\Omega_t) + e_t$$

where S_t is the policy instrument used by central bank authorities, f is a linear function, O_t is the information set at time t and e_t is the monetary shock which is uncorrelated and orthogonal to each element of O_t . The residual, e_t , represents the unexplained movements in the variables, reflecting the influence of exogenous shocks (i.e. shocks that arise out of the assumed model). To justify the e_t as exogenous monetary policy shocks, equation (1) is interpreted as the reaction function of the Central Bank. The response of a variable to monetary shock was measured using the coefficients in the regression of the variable on current as well as the lagged value of the fitted residuals in Equation 1 (Berument, 2001).

V. Vector Autoregression and Identification

The trend of each macroeconomic variable was examined before VAR estimation procedures were done. Using a time series plot of each variable, the movement of a particular variable was described as it fluctuated significantly at various times.

A matrix notation of a multivariate VAR model is represented by:

$$\begin{pmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ y_{nt} \end{pmatrix} = \begin{pmatrix} ?_{1t} \\ ?_{2t} \\ \vdots \\ ?_{nt} \end{pmatrix} + \begin{pmatrix} ?^{(1)}_{11} & ?^{(1)}_{12} & \dots & ?^{(1)}_{1m} \\ ?^{(1)}_{21} & ?^{(1)}_{22} & \dots & ?^{(1)}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ ?^{(1)}_{n1} & ?^{(1)}_{n2} & \dots & ?^{(1)}_{nm} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \\ \vdots \\ y_{n,t-1} \end{pmatrix} + \dots + \begin{pmatrix} ?^{(p)}_{11} & ?^{(p)}_{12} & \dots & ?^{(p)}_{1m} \\ ?^{(p)}_{21} & ?^{(p)}_{22} & \dots & ?^{(p)}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ ?^{(p)}_{n1} & ?^{(p)}_{n2} & \dots & ?^{(p)}_{nm} \end{pmatrix} \begin{pmatrix} y_{1,t-p} \\ y_{2,t-p} \\ \vdots \\ y_{n,t-p} \end{pmatrix} + \begin{pmatrix} ?_{1t} \\ ?_{2t} \\ \vdots \\ ?_{nt} \end{pmatrix}$$

where p equals the number of lags included in the VAR model.

In its simplest form, a vector autoregression is an unrestricted reduced form model that expresses each variable as a linear function of a constant and the lags of that and each other variable in the system. According to Berument (2001), an asymptotically equivalent way of writing Eq. (1) is fitting a p th order vector autoregressive model generalization of a multivariate VAR model as:

$$x_t = A_0 + A_1 x_{t-1} + A_2 x_{t-2} + \dots + A_p x_{t-p} + e_t \quad (2)$$

where x_t is a $k \times 1$ vector containing each of the k variables included in the VAR, A_0 is a $k \times 1$ vector of intercept terms, A_i is an $k \times k$ matrices of estimated coefficients and e_t is an $k \times 1$ vector of residuals which is serially uncorrelated and has a variance-covariance matrix of Σ . Here it is assumed that e_t is related to underlying economic shocks η_t by

$$e_t = B \eta_t \quad (3)$$

where η_t is a $k \times 1$ vector that consists of the orthogonalized residuals for k variables including η_t and we assume B is a lower triangular matrix and the variance covariance matrix of η_t is diagonal.

The significant characteristics that the error term holds in a standard VAR model in equation (2) are:

- (i) $E(e_t) = 0$;
- (ii) $\text{var}(e_{it}) = \sigma_i^2$ is independent of time;

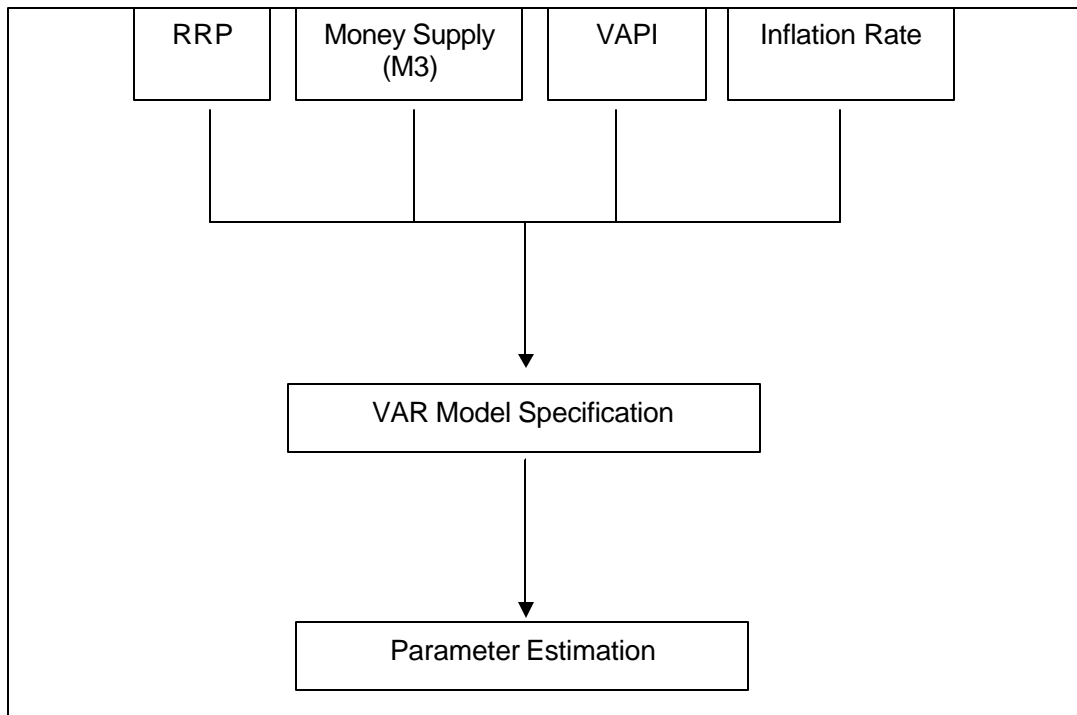
$$(iii) \quad E(e_{it}e_{it-k}) = 0 \text{ for all } k > 0, i = 1, 2, \dots, n;$$

$$(iv) \quad E(e_{1t}e_{2t}) = S_{ij} \neq 0, i \text{ and } j = 1, 2, \dots, n.$$

It is assumed that e_t is the residual term which has zero means, constant variances and is serially uncorrelated and has a variance-covariance matrix of S .

VI. Conceptual Framework

Figure 1. Conceptual Framework



VII. Test of Stationarity

A time-series is said to be stationary if its mean value and correlation function are constant over time, and the covariance between two time periods depends only on the lag between the two time periods. Any disturbance or exogenous shock introduced to the series will bring a temporary effect. Over time, the effects of the shocks will dissipate and the series will revert back to its long-run mean level (Enders, 1995).

The variables were tested for stationarity using the following procedures:

- I. Correlogram
- II. Augmented Dickey-Fuller test
- III. Phillips-Perron Test

A correlogram is a numerical and graphical form of the autocorrelation and partial autocorrelation function of the variable to determine graphically the nature and the behavior of the series. The Augmented Dickey-Fuller (ADF) and the Phillips-Perron test procedures were used to examine the presence of a unit root. The unit root test provides another basis for assessing whether a time series is nonstationary and integrated of a particular order. If the general null hypothesis $H_0 : \rho = 0$ is accepted, presence of the unit root is detected, thus, the series is nonstationary. But if it is rejected, there is no unit root, hence, the series is stationary and the alternative hypothesis, $H_0 : \rho < 0$ is accepted.

VIII. Lag Length Determination

In this study, the likelihood ratio test was used to aid in deciding for the fitting lag length of the VAR model. The following likelihood ratio statistic has the asymptotic χ^2 distribution with degrees of freedom equal to the number of restrictions in the system:

$$LR = (T - C)(\log|S_r| - \log|S_n|)$$

where:

T = number of usable observations

C = number of parameters estimated in each equation of the unrestricted system

S = variance-covariance matrix of $n \times n$ dimension

$\log|S_n|$ = is the natural logarithm of the determinant of S_n

Moreover, alternative test criteria were used to determine appropriate lag length specification and/or seasonality in the form of multivariate generalizations of the Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC). The AIC and SBC have the following equations:

$$AIC = T \log|S| + 2N$$

$$SBC = T \log|S| + N \log(T)$$

where:

$|S|$ = determinant of the variance/covariance matrix of the residuals

N = total number of parameters estimated in all equations

T = number of usable observations

Results of the VAR Analysis were summarized using:

- I. Impulse Response Function (IRF)
- II. Variance Decomposition

Since over parameterization is one major problem of VAR estimation that may contribute to unreliability of coefficient estimates, standard practice of quantifying the effect of such monetary shocks in VAR analysis is to report results from VAR summary statistics as impulse responses and variance decomposition. An IRF traces out the response of current and future values of each of the endogenous variables included to a one unit increase in the current value of one of the VAR errors (or the shock to the policy instrument variable), assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero (Watson, undated). The variance decomposition is the percentage of the variance of the error made in forecasting a variable due to a specific shock at a given horizon (Stock and Watson, 2001). Likewise, it provides the variance of the forecast errors in a specific variable to its own shocks and those of the other variables in the VAR model.

IX. Findings:

1. Results obtained from time series plots showed that Reverse Repurchase (RRP) rates followed relatively sharp fluctuations on its movement and did not follow a predictable trend. The value of production index (VaPI) for total manufacturing sector was observed to follow an upward trend but with cyclical upward-downward fluctuations. Domestic liquidity (M3) followed a modest and relatively smoother trend with respect to the other variables. The decline in inflation could be explained in a large part by the independence of the Bangko Sentral in monetary decision-making, and to structural changes that have contributed to greater economic efficiency (Tuano-Amador, 2003).
2. Correlogram results showed that, except for the RRP, the ACFs of the three other variables begin with a very high value and taper off very gradually while the sample PACF exhibited a significant spike - an indication that the time series is nonstationary. RRP at levels was stationary while inflation rate, M3 and value of production index were nonstationary.
3. The Augmented Dickey-Fuller test applied to RRP did not indicate the presence of a unit root process, so that the series is stationary at levels. This confirms initial findings on correlograms. Results further indicated that ADF test applied to inflation rate, value of output in the manufacturing sector and log of M3 failed to reject the null hypothesis of unit root, hence pointing out that the three series have unit root processes and are nonstationary. The same conclusions were arrived at using the Phillips-Perron test.

4. The VAR framework produced impulse responses and variance decomposition results that were consistent with widely accepted views on the qualitative impact of a monetary policy shock on various macroeconomic variables. Monetary tightening (measured by a positive shock on the RRP), decreased output in terms of value of manufacturing output, decreased monetary aggregate or M3, however it increased prices and inflation.
5. Positive innovations on reverse repurchase rates using a VAR system with an order of $(rrp_t, inf_t, logM3_t, vapi_t)$ resulted to an initial transitory increase in inflation for two months followed by cyclical fluctuations. The inflationary effect however dissipated over time, a clear indication of a *price puzzle* (prices responded positively to monetary tightening). After monetary tightening, money supply (M3) dropped temporarily but increased dramatically after a short period. Manufacturing output temporarily dropped but fluctuated cyclically over time. Using the alternative identifying assumptions (that monetary shocks do not have contemporaneous relationship with output and prices) produced the same results for both inflation and money supply, except for the value of manufacturing output that actually increased after the first month following a monetary shock. The effects of monetary shocks, however, were more pronounced in manufacturing output, although the effect is only marginal.
6. Variance decomposition results showed that monetary tightening due to a positive shock on the reverse repurchase rates is not the dominant factor that explained the variation in prices, value of manufacturing output and money supply. It only accounted for a minimal variation in manufacturing production, money supply (M3) and inflation. Monetary shocks, however, accounted for the largest variation in inflation when it is assumed that positive innovations in RRP contemporaneously affect both value of the manufacturing output, prices and M3 while monetary tightening accounted for the largest variation in M3 for the first four months when it is assumed that output and prices contemporaneously affected monetary shocks
7. The use of positive innovation to RRP as a measure of monetary policy shock did not capture the true measure of monetary shocks. Only a minimal percentage of the variation in various economic aggregates can be attributed to RRP shocks as an indicator of monetary tightening.
8. The economic variables used might not be the true aggregates that are directly affected following a monetary contraction@anticipated rise in the RRP rates. Hence, the measured effects of monetary tightening on inflation, value of manufacturing output and

M3 due to an increase in the RRP rates might prove to be empirically unimportant and inconsequential due to the *short-term* impacts of the RRP rates.

9. The shape or slope of the IS-LM curves might be another important interest to be considered in the context of Philippine monetary policy conduct. Prantilla (pers. com., 2006) suggested that the impulses generated from the responses of manufacturing output, M3 and inflation to contractionary monetary policy shock might provide an idea that output is not responsive to changes in the interest rates curves. Hence, an inelastic IS-LM model is obtained, disregarding the open-economy assumption that holds true for most economies during the recent past. This, however, needs to be investigated empirically.

X. Conclusions and Policy Implications

Two important conclusions have been reached for this study: Firstly, the use of positive innovation to RRP as a measure of monetary policy shock did not capture the true measure of monetary shocks. Only a minimal percentage of the variation in various economic aggregates can be attributed to RRP shocks as an indicator of monetary tightening. The economic variables used might not be the true aggregates that are directly affected following a monetary contraction—unanticipated rise in the RRP rates. Hence, the measured effects of monetary tightening on inflation, value of manufacturing output and M3 due to an increase in the RRP rates might prove to be empirically unimportant and inconsequential due to the *short-term* impacts of the RRP rates.

Secondly, the shape or slope of the IS-LM curves is another important interest to be considered in the context of Philippine monetary policy conduct. Prantilla (pers. com., 2006) suggested that the impulses generated from the responses of manufacturing output, M3 and inflation to contractionary monetary policy shock might provide an idea that output is not responsive to changes in the interest rates curves. Hence, an inelastic IS-LM model is obtained, disregarding the open-economy assumption that holds true for most economies during the recent past. This, however, needs to be investigated empirically.

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