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Reverse Repurchase Rate on Selected Monetary Policy Indicators: A Vector Autoregression

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Abstract

This study evaluated the effectiveness of the reverse repurchase (RRP) rate as the main monetary policy instrument of the Bangko Sentral ng Pilipinas in affecting selected monetary policy indicators, particularly output gap, inflation, and nominal exchange rate, through a modified New Keynesian monetary policy model using vector autoregression (VAR). The results showed that changes in the RRP rate affects output gap, inflation, and nominal exchange rate, albeit not statistically significant. In addition, the "price puzzle" was seen in the results. This pertains to an increase in inflation after monetary policy contraction which is in contrast with the standard monetary policy theory.

Keywords: *Interest rate, Inflation rate, Monetary Policy, Monetary Economics*

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1. Introduction

Milton Friedman stated that "*an economic system will work best when the average level of prices will behave in a known way in the future and preferably that it will be highly stable*" (Friedman, 1968). The tasks of monitoring and controlling the price level are usually delegated to central banks through its conduct of monetary policy. Central banks broadly have two (2) monetary policy instruments in order to regulate price level, namely: monetary aggregate targeting approach wherein a central bank controls the supply of money; and interest targeting approach wherein a central bank controls its policy interest rate. These approaches, with all other factors being equal, affects the price level in the economy.

In the Philippines, the Bangko Sentral ng Pilipinas (BSP) is mandated under Republic Act (RA) No. 7653, as amended by RA No. 11211, to maintain price stability conducive to a balanced and sustainable growth of the economy. The BSP is also tasked to promote and maintain monetary stability and the convertibility of the peso through an appropriate monetary policy. From 1980s to 2001, the BSP used a monetary aggregate targeting approach in controlling inflation. However, this approach was unable to stabilize price and exchange rate fluctuations, particularly during the Asian Financial Crisis in which the Philippines was hit hard (Gochoco-Bautista, 2001). Finally, in January 2002 the BSP formally adopted the inflation targeting framework to address the shortcomings of a monetary aggregate targeting approach. In this approach, the BSP announces an inflation target range for the year and strongly commits over a policy horizon using various monetary policy instruments to stabilize the economy through the monetary transmission mechanism. This is a process in which monetary policy tries to affect economic activity and inflation through various channels.

The BSP's main monetary policy instrument is the adjustment in the policy interest rate, also known as reverse repurchase (RRP) rate, for the overnight RRP facility. The RRP rate is the rate at which the BSP borrows money from commercial banks within the country. The BSP then adjusts its RRP rate depending on its assessment of the inflation and gross domestic product (GDP) growth targets. The process of monetary transmission mechanism will then take place wherein it is the process in which monetary policy influences the economic activity of a country (Bangko Sentral ng Pilipinas, 2018).

In 2018, the BSP aimed for the inflation target of 3±1 percent. However, the official statistical data for inflation from the Philippine Statistics Authority (PSA) indicate that said inflation target was not achieved. It must be noted that the four (4) percent mark was breached on March 2018, in which it reached 4.3 percent and peaked at 6.7 percent last September and October 2018. Given the following events, it is worthwhile to investigate the effects of the RRP rate as the main monetary policy instrument employed by the BSP. This study aims to do an analysis of the effects of the policy rate in affecting output gap and inflation using vector autoregression model.

2. Literature review

2.1. Evolution of Monetary Policy in the Philippines

Tan (1972) provided a historical discussion of the monetary policy of the BSP, which was formerly known as the Central Bank of the Philippines, from 1950 to 1971, divided into two (2) timeline periods: 1950–1960 and 1961–1971. During the first period, the main objective of the central bank was to maintain the pre-World War II fixed exchange rate of US$2/Php1 by maintaining a reasonable level of foreign reserves. Maintaining price stability was also important but only secondary. However, maintaining said exchange rate became unrealistic. That is why at the start of the 1961–1971, the central bank changed the main objective of monetary policy wherein the Bank was eventually mandated to maintain price stability but without announcing a target unlike the current setup. This was also the time where the central bank also employed the money supply targeting as its main policy instrument.

Moreover, the money supply targeting as an instrument was tested during the 1980s and 1990s due to various global economic climate, such as the adoption of floating exchange rate, an external financial crisis in 1983 caused by the difficulty of the country to pay its debt, and the Asian Financial Crisis of 1997, among others (Goldsbrough & Zaidi, 1989; Gochoco-Bautista, 2001). That is why the BSP announced that the central bank will shift to an inflation targeting regime at the start of 2002 (Angeles & Tan, 2007; Bangko Sentral ng Pilipinas, 2018). The central bank is now compelled to annouce a target inflation rate range on the succeeding year and will do its best not to exceed on the determined range. Failure to do so will make the BSP to write an open letter to the Office of the President and explain the reason behind not achieving the target.

2.2. Monetary Policy Rate and Output Gap Relationship

Rafiq and Mallick (2008) examined the effects of monetary policy shocks on output gap in the three largest euro area economies – Germany, France and Italy (EMU3) using VAR with sign restrictions. Their results showed that changes in monetary policy rates are at their most potent in Germany. Long–term output gap in Germany declined after a change in the policy rate but France and Italy exhibited the reverse. The authors pointed that results for the latter two (2) countries differ from Germany as they have different business cycles.

Akram and Eitrheim (2008) studied whether a central bank can promote financial stability by stabilizing inflation and output gap, and whether additional stabilization of asset prices and credit growth would enhance financial stability in particular. Using a vector error correction model (VECM) of the Norwegian economy, they evaluated the performance of simple interest rate rules vis-à-vis inflation and output. Their results showed that changes in monetary policy faces a tradeoff between inflation and output gap stability, wherein an increase in policy rate will decrease inflation but increases output gap.

Raghavan et al. (2011) analyzed the Malaysian monetary policy using a structural VAR model. They provided two (2) specifications in order to assess Malaysian monetary policy during the pre- and post-Asian financial crisis last 1997 and how it affected the Malaysian economy. The study assessed the effect of interest rate shock, which pertains to the tightening of monetary policy through an increase in the policy rate, and monetary shock, which pertains to monetary expansion through the increase of money supply. They noticed that there is a persistent negative response in output despite a monetary shock during the pre-crisis period. A possible explanation given by the authors is that it could be due to a rise in the real cost of borrowing, the appreciation of the Malaysian Ringgit, and a degree of price rigidity in the economy. The negative response from a sudden monetary shock was less persistent during the post-crisis period. In addition, the output after an interest rate shock decreased in the short to medium run and subsequently returned to the baseline in the long run.

Meanwhile, Şahin (2014) tested the effect of inlation targeting using the policy rate of the Turkish Republic Central Bank to output gap and public current expenditures. Using an ARIMA model, the author used quarterly data from 1998 to 2013 of Turkey. His study finds that a one (1) percentage point increase in the policy rate resulted into 1.97 percentage points increase in public current expenditures and 5.71 percentage points increase in output gap.

Kastrati et al. (2018) investigated the effect of excessive expanionary monetary policy, i.e. excessive lowering of interest rates, on output gap. Using a seemingly unrelated regression (SUR) model, the authors used the data from Czech Republic, Estonia, and Kosovo for the period of 2005 to 2013. The authors hypothesized that a sudden contraction of monetary policy will lead to a smaller (negtive) output gap. They conclude that their research could not establish this causal relationship since both variables are an outcome of the general state of the economic activity, i.e. both represent under-utilised resources in a depressed economy.

2.3. Monetary Policy Rate and Inflation Rate Relationship

Standard economic theory states that there is a direct relationship between nominal interest rate and inflation through the Fisher effect. The Fisher effect posits a positive effect of inflation on the nominal interest rate or, in neo-Fisherian view, a positive effect of the nominal interest rate on inflation (Williamson, 2018). Numerous studies have examined this relationship and some are presented in this section.

Akyurek et al. (2011) provided an insight on the effectivity of inflation targeting regime in Turkey using the policy rate to stabilize inflation. The authors used a five-variable Vector Auto Regression (VAR) to test the effect of the policy rate using data from 1989 to 2008. They concluded that since adopting the inflation targeting framework, a one (1) percent increase in the policy rate resulted, in average, to a two (2) percent decrease in subsequent inflation.

Another study from Turkey by Kosa et al. (2012) examined the relationship between nominal interest rates and the expected inflation rate for the Turkish economy between 2002 and 2009, a period when the inflation-targeting regime was implemented as monetary policy. They used a Vector Error Correction Model (VECM) to measure the relationship among nominal short-term and long-term interest rates, and expected inflation rates. The results showed that long-term co-integrating relationship exists between short-term interest rate and expected inflation rate. Moreover, they established that there is a causal relationship between the policy rate and inflation rate in Turkey. Their study showed that decreases in the policy rate rate will prompt both firms and individuals to alter their investments and spending decisionswhich leads to higher real output and ultimately increasing the inflation rate.

Meanwhile, Emerenini and Eke (2014) studied the impact of monetary policy rate on inflation in Nigeria. The authors used data monthly data from 2007 to 2015 and utilized ordinary least squares (OLS) to measure this relationship. The result showed that a one (1) percent increase in policy rate resulted to 0.054 percentage points decrease in inflation. They concluded that using the policy rate as the tool to control inflation is not significantly effective and suggested that the Central Bank of Nigeria use other available monetary policy tools on top of the policy rate.

In the Philippines, Medalla and Fermo (2013) examined the behavior of month-on-month (m-o-m) inflation and finds empirical evidence that the BSP's inflation targeting policy regime over the past 10 years using an autoregressive-moving average (ARMA) model. Based on their estimation results, in general, RRP rate is effective in controlling inflation. In addition, they determined that monetary policy should not respond to unanticipated supply-side shocks coming from global commodity prices which had moved the changes in m-o-m inflation permanently away from the long-term trend. It was, in fact, the higher increases in administered prices, particularly minimum wages, which were implemented in response to the higher commodity prices that appeared to consistently affect inflation expectations significantly, and hence should signal the need for future monetary policy action. They recommended that the BSP needs to discipline, to some extent, the wage-setters even when they do not coordinate their wage-setting, as higher wages will be met with a rise in the policy rate. However, they also noted that international comparisons show that countries with coordinated wage setting generally have lower unemployment than countries with less coordinated wage setting. Going forward, the authors recommended that closer coordination of the BSP with the wage board and the education of the labor unions could help anchor inflation expectations even more firmly with the BSP's long-run inflation target.

2.4. Monetary Policy Rate and Exchange Rate Relationship

Dornbusch (1976) first hypothesized the effect of monetary policy in influencing the movement of exchange rate. He theorized that an changes monetary policy will, in the short run, cause "overshooting" in exchange rate movement. Using a structural VAR model and and data from Australia, Canada, New Zealand, and Sweden, Bjørnland (2008; 2009) observed that there is a strong effect on the exchange rate whenever said countries conducted contractionary monetary policy, i.e. increase in policy rate. In addition, the studies revealed that there is an immediate increase in the exchange rate and said increase reached its maximum impact within one (1) to two (2) quarters.

Sek (2009) also investigated the interaction of monetary policy rate and exchange rate. The author employed structural VAR and general method of moments (GMM) regression to test this relationship from three (3) Asian countries, namely South Korea, the Philippines, and Thailand. Monthly data from 1990 to 2007 were used in his study. The results of the structural VAR and GMM regression were consistent in such that both models showed that an increase in monetary policy rate lead to an appreciation in exchange rate.

The study is related to various monetary policy literature wherein it aims to examine the effects of the policy rate (RRP rate) to various economic indicators. Most prominent in the existing literature is the relationship between the policy rate and inflation. Both foreign (Kosa et al., 2012; Akyurek et al., 2011; Emerenini & Eke, 2014) and local literature (Guinigundo, 2008; Medalla & Fermo, 2013) conclude that changes in the policy rate is effective in stabilizing inflation, albeit in varying degrees of success. It can be noted, however, that there are relatively few existing literature that measured the effects of changes in policy rate vis-à-vis output gap. The studies also provided mixed effects on how the change in policy rate affects the output gap. Most of the cited literature conform with the theory that expansionary monetary policy, i.e. increase in monetary policy rate, subsequently increased the output gap such as Akram and Eitrheim (2008) and Şahin (2014). However, some works such as Rafiq and Mallick (2008) that led to the opposite effect while Kastrati et al. (2018) could not establish a causal relationship. Unfortunately, no Philippine–specific literature could be found with regards to this relationship and this study hopes to contribute on this.

Meanwhile, the effects of changes in policy rate vis-à-vis exchange rate were examined in Bjørnland (2008; 2009). In both works, the author utilized a structural VAR model to analyze the existence of the “overshooting” dynamics proposed by Dornbusch (1976) in Australia, Canada, New Zealand, and Sweden. Meanwhile, Sek (2009) also studied the same effect for three (3) Asian countries, namely South Korea, the Philippines, and Thailand. The result from said studies lead to the conclusion that expansionary monetary policy lead to foreign exchange appreciation.

Overall, despite the numerous studies cited there is a dearth of literature that focused in measuring the multiple effects of the changes in RRP to various economic indicators. This study fills this gap in such a way that it aims to provide review of the conduct of monetary policy in the Philippines by analyzing the multiple effects to output gap, inflation rate, and nominal exchange rate by the change in the policy rate.

In relation to the goal of the BSP to maintain price stability and its employment of the RRP rate as its main policy instrument to stabilize inflation rate and its multiple effects to various economic variables, this study aimed to examine the response of output gap, inflation rate, and nominal exchange rate vis-à-vis the movement of the policy rate. Specifically, this study tried to answer the following questions:

1. Given the dynamics of the monetary transmission mechanism in the Philippines, how does the lagged values of RRP rate affect output gap, inflation rate, nominal exchange rate?
2. Do the lagged values of RRP significantly affect output gap, inflation rate and nominal exchange rate when taken individually and collectively?
3. Given the lagged effect of monetary policy adjustments, how long does the RRP rate have its full effect on output gap, inflation rate and nominal exchange rate?

Hypotheses

1. The lagged values RRP rate do not significantly affect output gap, inflation rate and nominal exchange rate.
2. The lagged values of output gap, inflation rate, RRP rate, and nominal exchange rate have no significant correlation with the current value of the RRP rate when treated as individually and collectively.
3. The lagged values of output gap, inflation rate, RRP rate, and nominal exchange rate do not significantly affect the current value of the RRP rate when treated as individually and collectively.

The study focuses on the effect of the BSP's RRP rate on selected monetary policy indicators. This study will follow in spirit the research of Angeles and Tan (2007) in using selected key variables anchored on as a parsimonious representation of the Philippine economy presented by Guinigundo (2008). Other possible macroeconomic indicators or variables, particularly the 91-day T-bill rate, were not used or given emphasis in this study. This is due to the uncertain nature of the data set, i.e., many data points are marked as no entry specifically on 2008 wherein there were only three (3) public offerings out of the possible 12. Moreover, the dynamics and nuances of the monetary transmission mechanism is not discussed in this study. The reader may consult Bernanke and Gertler (1995) and Taylor (1995) for a general discussion about the topic, and Mishra et al. (2012) in the context of low-income countries.

3. Research Framework

3.1. Theoretical Framework

Taylor Rule. The benchmark model for inflation targeting is the *Taylor rule* as proposed by Taylor (1993). Modeled using the behavior of the federal funds interest rate in the United States, he proposed a simple and straightforward monetary policy rule which revolves on the following variables: (i) the short-term interest rate; (ii) inflation rate from previous four quarters; (iii) the deviation of actual inflation relative to the target and (iv) the percent deviation of real GDP from the trend GDP. Modifying the notation of Taylor and Williams (2011), the core Taylor rule can be expressed as:

$$i_t = r^* + \pi_t + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t$$

where:

i_t = nominal interest rate;

r^* = real interest rate;

π_t = rate of inflation over the previous four quarters;

π^* = target inflation rate;

y_t = output gap;

ϕ_π = parameter assigned to inflation gap; and

ϕ_y = parameter assigned to output gap.

The rule explains that the nominal policy rate deviates from the level consistent with the economy's equilibrium real interest rate and the target inflation rate if the output gap is non-zero or if inflation deviates from target. A positive output gap leads to a rise in the nominal interest rate, as does a deviation of actual inflation above target (Walsh, 2017). Meanwhile, the Taylor rule can be specified in order to adopt certain economic dynamics such as incorporating government spending and exchange rate, among others (Agénor & Montiel, 2015).

Monetary Transmission Mechanism. The monetary transmission mechanism is the process through which monetary policy affects economic activity and inflation through various channels. A key concept in monetary transmission mechanism is the pass-through of policy rate, which is defined as the extent to which changes in short-term policy rates affect market interest rates. Adjustments in policy rates will trickle into investment spending, which then ultimately leads into output, inflation, and exchange rate.

In the Philippines, the monetary transmission mechanism and its dynamics were discussed by Guinigundo (2008). He outlined the distinct channels in which changes in the policy rate have to pass through to subsequently affect output, inflation, and exchange rate, namely the credit channel, expectations channel, and exchange rate channel, respectively.

First, he outlined the credit channel. He emphasized its importance since changes in the policy rate directly affects the bank lending rates. This interaction is significant because producers mainly rely on banks for their liquidity requirement and the amount in which the producers will borrow is highly affected by the bank lending rate, which in turn will affect their production or output.

Meanwhile, the expectations channel gauges the inflation expectations of the public due to the changes in the RRP rate, i.e. whether the public expects future inflation rate will ease or not if the BSP decides to adopt an expansionary or contractionary monetary policy. He highlighted the channel's importance since the effect of the RRP rate extends on the short–term interest rate, represented by the 91-day T-bill rate, to long–term interest rate, which is represented by the 182-day T-bill rate, both of which businesses and household decisions are made (Guinigundo, 2008).

Lastly, the exchange rate channel in the Philippines can be described as free-floating exchange rate with occasional but subtle interventions from the BSP. It is because the BSP is closely monitoring events in the foreign exchange market and, when needed, the central bank adjusts its policy instruments (e.g., policy interest rate) when there are extreme fluctuation in the Philippine Peso that could adversely affect the inflation target. This approach is consistent with its price stabilization mandate because volatility in the exchange rate tend to feed directly into domestic prices of imported goods and services, and indirectly through to the prices of goods and services that use imported inputs. The increase in prices of both the imported and import-intensive goods in turn feed into demand for adjustments in wages and transport fares. Through this channel, exchange rate movements affect both actual inflation and inflation expectations.

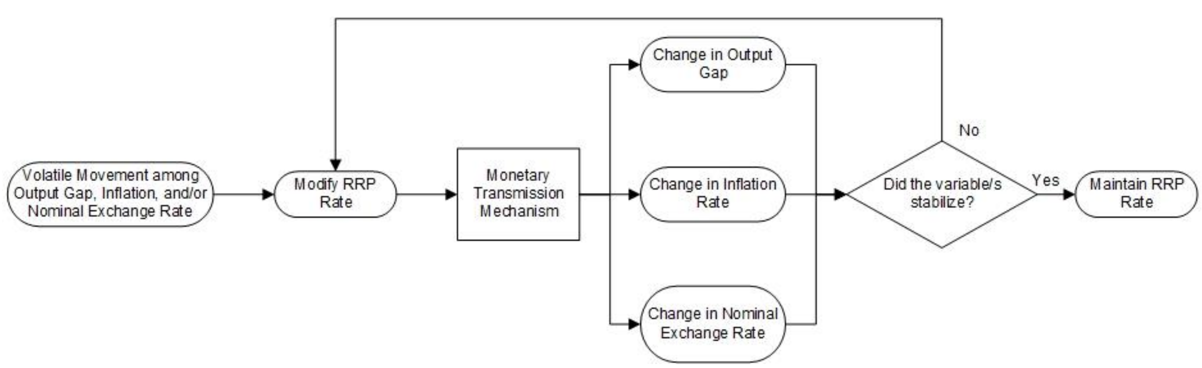
3.2 Conceptual Framework

The conceptual framework of the study resembles the decision-making dynamics of a central banker to stabilize certain indicator/s in the economy. As mentioned in the current charter of the BSP, the primary objective of the bank is to maintain price stability (i.e. stabilize inflation). The BSP then announces in advance its inflation target wherein the bank will do its best to achieve said goal by closely monitoring the stability of the financial system and employ monetary policy instruments as necessary.

The main monetary instrument being employed by the BSP to stabilize inflation is the reverse repurchase (RRP) rate wherein the Bank can raise or reduce to implement contractionary or expansionary monetary policy, respectively (Bangko Sentral ng Pilipinas, 2018). However due to the monetary transmission mechanism, the adjustments in the RRP rate also affect other variables such as output gap and foreign exchange and in effect can also be used to stabilize said variables. The BSP will then assess if the movement of its target variable has subsequently stabilized. If not, the RRP can be modified again to achieve the desired result or maintain the policy rate if the variable is stabilized. Figure 1 shows the mechanics of said process.

Figure 1

Conceptual Framework



In selecting the variables, the study adapted the paper of Angeles and Tan (2007) that used a VAR model composed of the following variables: (i) output gap; (ii) inflation rate; (iii) RRP rate; and (iv) nominal exchange rate. The study remarked that these variables represented the Philippine economy due to the absence of a full-blown macroeconomic model.

4. Methodology

4.1. Research Design

This study used quantitative type of research design using descriptive and empirical analysis to observe the effect of the change in RRP to certain monetary policy indicators, particularly on output gap, inflation, and exchange rate. In addition, this research also used inferential statistics to establish relationships among the RRP rate, output gap, inflation rate, and exchange rate to make valuable predictions, including hypothesis testing.

4.2. Sources of Data

The timeline of the quarterly data used in this study is from 2002 to 2018. The data for GDP, unemployment, and inflation rates were gathered from the Philippine Statistics Authority (PSA). The output gap was extracted from the GDP data using HP filter, as recommended by Angeles and Tan (2007). Moreover, in accordance with the BSP, the data used for 2002-2004, 2005-2006, 2007-2017, and 2018 inflation rates were the 1994-, 2000-, 2006-, and 2012-based CPI series, respectively. Lastly, the data for RRP rate were gathered from the BSP website and the nominal exchange rate from the International Monetary Fund Website.

4.3. Statistical Treatment of Data

The study used a reduced form VAR model to examine the effect of changes in the RRP rate to other relevant monetary policy indcators, particularly the output gap, inflation, and exchange rate. The choice of VAR as the main model was motivated by Sims (1980, 1986), Stock and Watson (2001), and Kilian and Lütkepohl (2017) who mentioned that since VAR models in general provides reliable results that can aid policy makers without being too much restricted by theory unlike by using structural equation models. Moreover, the dynamic and simultaneous nature of the model is well-suited to policy analysis, and in this case monetary policy analysis, since it captures the multiple effects of the change in the policy variable of choice to other variables.

Other tests were performed on the data such as measurement of correlation to determine meaningful relationships among the selected variables, goodness of fit test to determine if the variations of the dependent variable can be explained by the explanatory variables, number of lags test using Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC) to determine the optimal number of lags in the equation, and HP filter in order to extract the output gap from the GDP data.

Measure of Correlation. To measure the correlation among variables, the Pearson correlation coefficient (R) is used. Given random variables X and Y, R is expressed as:

$$R = \frac{cov\ (X, Y)}{\sqrt{var(X)\ var(Y)}}$$

where $cov\ (X, Y)$ is the covariance of X and Y, $\sqrt{var(X)\ var(Y)}$ denotes the product of the standard deviations of X and Y, respectively, and the value of R ranges from -1 to 1.

Measure of Regression. The overall model is regressed using a reduced form vector autoregression (VAR) model. A reduced form expresses each variable as a linear function of its past values or lags (Stock & Watson, 2001). For this study, the reduced form VAR model has the form:

$$YGAP_t = \alpha_{11}YGAP_{t-1} + \cdots + \alpha_{1p}YGAP_{t-p} + \beta_{11}INF_{t-1} + \cdots + \beta_{1p}INF_{t-p} + \gamma_{11}RRP_{t-1} + \cdots + \gamma_{1p}RRP_{t-p} + \delta_{11}EXRATE_{t-1} + \cdots + \delta_{1p}EXRATE_{t-p} + \varepsilon_{YGAP,t}$$

$$INF_t = \alpha_{21}YGAP_{t-1} + \cdots + \alpha_{2p}YGAP_{t-p} + \beta_{21}INF_{t-1} + \cdots + \beta_{2p}INF_{t-p} + \gamma_{21}RRP_{t-1} + \cdots + \gamma_{2p}RRP_{t-p} + \delta_{21}EXRATE_{t-1} + \cdots + \delta_{2p}EXRATE_{t-p} + \varepsilon_{INF,t}$$

$$RRP_t = \alpha_{31}YGAP_{t-1} + \cdots + \alpha_{3p}YGAP_{t-p} + \beta_{31}INF_{t-1} + \cdots + \beta_{3p}INF_{t-p} + \gamma_{31}RRP_{t-1} + \cdots + \gamma_{3p}RRP_{t-p} + \delta_{31}EXRATE_{t-1} + \cdots + \delta_{3p}EXRATE_{t-p} + \varepsilon_{RRP,t}$$

$$EXRATE_t = \alpha_{41}YGAP_{t-1} + \cdots + \alpha_{4p}YGAP_{t-p} + \beta_{41}INF_{t-1} + \cdots + \beta_{4p}INF_{t-p} + \gamma_{41}RRP_{t-1} + \cdots + \gamma_{4p}RRP_{t-p} + \delta_{41}EXRATE_{t-1} + \cdots + \delta_{4p}EXRATE_{t-p} + \varepsilon_{EXRATE,t}$$

where:

$YGAP$ = output gap;

INF = inflation rate;

RRP = reverse repurchase rate;

$EXRATE$ = nominal exchange rate in logs;

$\alpha, \beta, \gamma, \delta$ = coefficients;

t = time; and

p = number of lags.

For compactness of notation, a VAR model is expressed in matrix form as:

$$\mathbf{Y_t} = \mathbf{B_1}\mathbf{Y_{t-1}} + \cdots + \mathbf{B_p}\mathbf{Y_{t-p}} + \mathbf{e_t}$$

or equivalently, borrowing the notation of Angeles & Tan (2007) the above system of equations can be expressed as:

$$\underbrace{\begin{bmatrix} YGAP_t \\ INF_t \\ RRP_t \\ EXRATE_t \end{bmatrix}}_{\mathbf{Y_t}} = \mathbf{B_1} \underbrace{\begin{bmatrix} YGAP_{t-1} \\ INF_{t-1} \\ RRP_{t-1} \\ EXRATE_{t-1} \end{bmatrix}}_{\mathbf{Y_{t-1}}} + \cdots + \mathbf{B_p} \underbrace{\begin{bmatrix} YGAP_{t-p} \\ INF_{t-p} \\ RRP_{t-p} \\ EXRATE_{t-p} \end{bmatrix}}_{\mathbf{Y_{t-p}}} + \underbrace{\begin{bmatrix} \varepsilon_{YGAP,t} \\ \varepsilon_{INF,t} \\ \varepsilon_{RRP,t} \\ \varepsilon_{EXRATE,t} \end{bmatrix}}_{\mathbf{e_t}}$$

where:

Y = vectors containing the variables $YGAP$, INF, RRP, and $EXRATE$;

B = square matrices of coefficients; and

$\mathbf{e_t}$ = is a vector of error terms.

Generally, the total number of equations will depend on the number of variables and the parameters will depend on the number of lags as determined by the Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC).

Goodness-of-fit Test. R-squared of the regression, sometimes called the coefficient of determination, is used to determine how well the regression line fits the data.

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(e_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

where R^2 is the coefficient of determination; e is the error term; y is a random sample; and $\bar{y}$ is the sample average (Wooldridge, 2016).

Number of Lags Test. Simplicity or parsimony of the model may be referred as the trade-off between goodness-of-fIt and the number of regressors employed in the model, as measured by the number of parameters k. The determination of lags of a VAR model may be tested by comparing lowest value between the Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC). The AIC and BIC are computed as follows:

$$AIC = \ln \frac{1}{n} \sum_{i=1}^{n} e_i^2 + \frac{2k}{n}$$

$$BIC = \ln \frac{1}{n} \sum_{i=1}^{n} e^2 + \frac{k}{n} \ln n$$

where e is the error term, k is the number of parameters, and n is the number of observations.

Filtering Method for Output Gap. Output gap is measured as the percentage deviation of actual output against potential output. However, unlike actual output, potential output cannot be observed and measured directly. Hence, potential output and output gap can only be estimated. Numerous estimation methods or filters can be employed to decompose trend and cyclical components to extract the output gap such as Hodrick–Prescott (HP) filter, band-pass filter, and structural time series techniques. Contemporary literature commonly use HP filter as the preferred method in extracting output gap from actual output. Hodrick and Prescott (1997) presented their conceptual framework wherein they deconstructed a time series variable into its growth and cyclical components. Formally, it is expressed as:

$$y_t = g_t + c_t$$

where:

y_t = time series variable;

g_t = growth component;

c_t = cyclical component; and

$t = 1, \ldots, T$.

The determination and smoothing of the growth component leads to the dynamic programming problem in the form of:

$$\min_{\{g\}_{t=-1}^{T}} \left\{ \sum_{t=1}^{T} c^2 + \lambda \sum_{t=1}^{T} [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\}$$

The parameter λ is a positive number which penalizes variability in the growth component series. The larger the value of λ, the smoother is the solution series. For quarterly time series data, the recommended value of λ is 1,600.

Software. The study used Stata 13 and gretl in developing necessary figures and and analyzing statistical data. However, the tabulation was utilized from Microsoft Excel and served as an aid in the said software.

5. Findings and Discussion

5.1. Correlation Test

The results from Pearson correlation test showed that the variables INF and RRP, and RRP and $EXRATE$ are positively correlated and statistically significant at least at one (1) percent level. Meanwhile, the variables INF and $EXRATE$ are positively correlated and statistically significant at five (5) percent level.

5.2. Number of Lags Test

Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used to test the total number of lags for the overall VAR model. As recommended by Stock and Watson (2015), VAR models with quarterly data are tested using four (4) to eight (8) lags. Using eight (8) lags as the maximum lag order, the test determined that the appropriate number of lags of the model are five (5) in reference with the result under BIC. The test result is shown in Table 1.

Table 1

Number of Lags Test for the Model

No. of Lags	Akaike Information Criterion	Bayesian Information Criterion
1	3.8192	4.3777
2	3.2102	4.3272
3	2.6596	4.3351
4	1.3517	3.5857
5	0.7179	3.5104*
6	0.4015	3.7525
7	0.2438	4.1533
8	–0.18779*	4.2802

Note: * refers to the lowest value of the computed AIC and BIC, respectively

5.3. Regression Results

The model was regressed using vector autoregression model. Given that the interest of this study is to see the effect of RRP vis-à-vis the other variables, the tables below presented the regression result of the relationship among the lagged values of RRP to the present values of $YGAP$, INF, and $EXRATE$, respectively. The number of equations and parameters are affected by the number of variables in the model. In this study, the total number of equations is four (4) with 20 parameters per equation.

For the $YGAP$ equation, the estimated equation is as follows:

$$\begin{aligned} YGAP_t = {} & 0.458YGAP_{t-1} - 0.165YGAP_{t-2} - 0.24YGAP_{t-3} + 0.781YGAP_{t-4} - 0.612YGAP_{t-5} \\ & + 0.416INF_{t-1} - 0.783INF_{t-2} + 0.226INF_{t-3} + 0.199INF_{t-4} - 0.76INF_{t-5} \\ & - 6.413EXRATE_{t-1} + 1.084EXRATE_{t-2} + 2.086EXRATE_{t-3} \\ & + 1.319EXRATE_{t-4} + 1.795EXRATE_{t-5} - 0.340RRP_{t-1} + 1.141RRP_{t-2} \\ & - 0.882RRP_{t-3} - 0.931RRP_{t-4} + 1.088RRP_{t-5} \end{aligned}$$

As shown in the estimated $YGAP$ equation, a one (1) percentage change in RRP will cummulatively change $YGAP$ by 0.076 percent after five (5) quarters. However, this cummulative change is not statistically significant since the F-statistic for the lagged values RRP when it is restricted to zero is 1.680. Hence, since it is less than the F-critical value for F(5,43) at 0.05 probability level of 2.432 the null hypothesis that the lagged values of RRP do not significantly affect $YGAP$ is not rejected. The R^2 for this equation amounted to 0.980 which means that the 98 percent of variations in $YGAP_t$ can be by the regressors.

In addition if the lagged values of RRP are taken individually, only the variable RRP_{t-5} is statistically significant at five (5) percent level. This can be interpreted that a one (1) percent change in RRP will change the $YGAP$ by 1.088 percent with the probability of 95 percent. Table 2 summarizes the relevant variables and statistical tests of the regression.

Table 2

Summary Result of the Relationship Among the Lagged Values of RRP to YGAP

Dependent Variable	**Regressor**	**β**	**t**	**F**	**R^2**	**p**
$YGAP_t$						
	RRP_{t-1}	-0.340	-0.70			0.489
	RRP_{t-2}	1.141	1.43			0.159
	RRP_{t-3}	-0.882	-1.06			0.295
	RRP_{t-4}	-0.931	-1.16			0.254
	RRP_{t-5}	1.088	2.11			0.041
F-test of zero restriction for variable *RRP F(5,43)*				1.680	0.980	0.160

For the INF equation, the estimated equation is as follows:

$$\begin{aligned} INF_t = {} & 0.076YGAP_{t-1} + 0.091YGAP_{t-2} + 0.068YGAP_{t-3} + 0.051YGAP_{t-4} + 0.019YGAP_{t-5} \\ & + 1.357INF_{t-1} - 0.649INF_{t-2} + 0.240INF_{t-3} - 0.365INF_{t-4} + 0.207INF_{t-5} \\ & + 1.009EXRATE_{t-1} - 2.100EXRATE_{t-2} - 0.401EXRATE_{t-3} \\ & + 11.376EXRATE_{t-4} - 9.798EXRATE_{t-5} - 0.056RRP_{t-1} + 0.095RRP_{t-2} \\ & - 1.059RRP_{t-3} + 1.553RRP_{t-4} - 0.413RRP_{t-5} \end{aligned}$$

Meanwhile, the estimated INF equation shows that one (1) percent change in RRP will cummulatively change INF by 0.121 percent after five (5) quarters. However, this cummulative change is not statistically significant since the F-statistic of the RRP lags when restricted to zero 1.874. This is less than the F-critical value for F(5,43) at 0.05 probability level which is 2.432. This leads to not rejecting the null hypothesis that the lagged values of RRP do not have significant effect to $YGAP$ when taken collectively. Lastly, the R^2 for this equation amounted to 0.983 which means that the 98.3 percent of variations in INF_t can be by the regressors in the estimated equation.

In addition, when the lagged values of RRP are taken individually, only RRP_{t-4} is statistically significant at five (5) percent level. It can be interpreted that one (1) percent change in RRP will increase INF by 1.553 percent after four (4) quarters. Table 3 summarizes the relevant variables and statistical tests of the regression.

Table 3

Summary Result of the Relationship Among the Lagged Values of RRP to INF

Dependent Variable	**Regressor**	**β**	**t**	**F**	**R²**	**p**
INF_t						
	RRP_{t-1}	-0.056	-0.12			0.902
	RRP_{t-2}	0.095	0.13			0.897
	RRP_{t-3}	-1.059	-1.38			0.174
	RRP_{t-4}	1.553	2.09			0.043
	RRP_{t-5}	-0.412	-0.87			0.391
F-test of zero restriction for variable *RRP F(5,43)*				1.874	0.983	0.119

For the $EXRATE$ equation, the estimated equation is as follows:

$$EXRATE_t = -0.004YGAP_{t-1} - 0.001YGAP_{t-2} + 0.001YGAP_{t-3} - 0.0004YGAP_{t-4} + 0.002YGAP_{t-5} + 0.001INF_{t-1} + 0.0009INF_{t-2} - 0.0007INF_{t-3} + 0.0007INF_{t-4} - 0.006INF_{t-5} + 1.078EXRATE_{t-1} - 0.101EXRATE_{t-2} + 0.070EXRATE_{t-3} - 0.145EXRATE_{t-4} + 0.104EXRATE_{t-5} + 0.007RRP_{t-1} - 0.010RRP_{t-2} - 0.026RRP_{t-3} + 0.035RRP_{t-4} - 0.007RRP_{t-5}$$

The estimated $EXRATE$ equation shows that one (1) percent change in RRP will cummulatively change $EXRATE$ by -0.001 percentage points after five (5) quarters. The cummulative change is not statistically significant since the F-statistic of the RRP lags when restricted to zero 1.310 which is less than the F-critical value for F(5,43) at 0.05 probability level of 2.432. This leads to not rejecting the null hypothesis that the lagged values of RRP do not have significant effect to $EXRATE$ when taken collectively. Moreover, when the lagged values of RRP are taken individually, none of the lags is statistically significant. Lastly, the R^2 for this equation amounted to 0.999 which means that the 99.9 percent of variations in $EXRATE_t$ can be by the regressors in the estimated equation.Table 4 summarizes the relevant variables and statistical tests of the regression.

Table 4

Regression Result of Relationship Between the Lagged Values of RRP to EXRATE

Dependent Variable	Regressor	*β*	*t*	*F*	R^2	*p*
$EXRATE_t$						
	RRP_{t-1}	0.007	0.50			0.619
	RRP_{t-2}	-0.010	-0.46			0.646
	RRP_{t-3}	-0.026	-1.14			0.263
	RRP_{t-4}	0.035	1.57			0.124
	RRP_{t-5}	-0.007	-0.52			0.606
F-test of zero restriction for variable *RRP F(5,43)*				1.310	0.999	0.278

6. Conclusion

This study showed the effect of the RRP rate to selected monetary policy indicators, particularly on output gap, inflation, and nominal exchange rate using a VAR model. The results show that as the primary monetary instrument of the BSP, the RRP rate can reduce the overall output of the economy albeit not significantly. In addition, contrary to standard monetary policy theory, the result of this study show that monetary policy tightening or increasing the policy rate increases inflation instead of reducing it. Sims (1986) called this phenomenon as “price puzzle”. It is in contrast with the economic intuition that monetary policy tightening results to a decrease in inflation. This can be problematic to the BSP since the RRP rate is the main monetary policy tool to manage inflation. This study also showed that in contrast to the standard New Keynesian monetary policy, the RRP rate cannot be used as a tool to significantly tweak the nominal exchange rate.

Given the results of this study, the BSP must evaluate the appropriate channels where the interest effect passes through. A possible avenue for BSP’s evaluation is the informal lenders in the country. As a developing country, the Philippine economy is prone in having informal credit channels such as credit associations/corporations and loansharks wherein the BSP has little to no control at all. The said informal credit channels are patronized by micro, small, and medium enterprises for additional capital. The central bank can exercise its regulatory function by formulating a comprehensive regulation framework to such credit channels in order to have a steady grip in controlling inflation.

The BSP could also also link with price monitoring and competition regulation agencies such as the Department of Agriculture, Department of Trade and Industry, and Philippine Competition Commission, among others, and see how can the central bank help the aforementioned agencies in performing their price regulation duties and curb existing noncompetitive industry practices. It is logical to think that if said agencies perform their functions well then inflation may be stabilized, all other things being equal. This, in turn, may also positively affect the credibility of the central bank in managing inflation.

In addition, the BSP may also seek an alternative monetary policy rule in order to highlight its another mandate which is to promote a balanced and sustainable growth of the economy and employment. A possible candidate for this is nominal GDP targeting which sets interest rates in response to deviations of nominal GDP growth from a target path (McCallum & Nelson, 1999). A handful of economists advocated this approach such as Hall and Mankiw (1994), McCallum and Nelson (1999), Sumner (2012), and Sheedy (2014), among others. One notable argument in adopting this rule is that a stable path of nominal GDP growth would tend to stabilize employment more effectively than an inflation target, because employers' ability to meet their wage bills depends more on nominal GDP growth than on the rate of inflation (Sumner, 2012). Given that the Philippines is targeting both high employment and economic growth aside from price stability, this approach can be a worthwhile endeavor for the BSP to consider.

Lastly, extending the presented model by including additional foreign and domestic variables may be beneficial. Methods such as structural VAR, Vector Error Correction Model or other more sophisticated time series models may be adapted in such investigation. These ideas would constitute new topics for the future research.

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