The Nexus Between Monetary Policy and Economic Growth: Evidence from Vietnam

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Abstract

The study estimates the Structured VAR and the Dynamic Stochastic General Equilibrium Model for the Vietnamese economy based on the new Keynesian model for small and open economies, with the output gap, inflation, policy interest rate, the Vietnamese exchange rate, and the inflation and interest rate in the United States. The paper aims to clarify the impulse response of the macro variables through their shocks. It offers to model the SVAR and DSGE processes, as well as describe why and how interest rate policy is important in the impulse response of macro variables like the output gap and inflation process. The study supports the central role of monetary policy by giving empirical evidence for the new Keynesian theory, according to which an interest rate shock causes the output gap to widen and inflation to decrease. Finally, the application of the DSGE model is becoming more and more popular in the State Bank of Viet Nam to improve its policy planning, analyzing, and forecasting policy towards sustainable and stable growth.

Keywords: Monetary Policy, The New Keynesian Theory, Structural VAR, DSGE, Rational Expectations

JEL Classification Code: E12, E37, E52

1. Introduction

The study builds a New Keynesian small open economy model (Leu, 2011). This model is a combination of structured shocks and rational expectations of agents in the economy to evaluate how macro variables such as output gap, inflation, exchange rates, and policy interest rates respond to impacts from their own shocks and forecast the change of macro variables in the future. The study also reinforces the State Bank of Viet Nam's (SBV) policies as well as the empirical evidence of previous studies on monetary policy. Especially, this study underlines the crucial role of policy rate and exchange rate manipulation which are important conditions for Vietnam's broader integration into the global economy with stable inflation towards macroeconomic stability.

2. Literature Review

2.1. Background Theories

2.1.1. The New Keynesian Theory

The research is based on the dynamic stochastic general equilibrium theory, which explains the relationship between supply and demand and the economy's price level using subjects interacting with one another to maintain a general equilibrium state in an economy under perfect and imperfect market conditions. Macroeconomic instability leads to the development of a macroeconomic policy system with policy guidelines to maintain financial stability by controlling indicators such as economic growth, inflation, interest rates, and currency rates. Monetary policy is one of the policies that can help achieve this goal (MP). The SBV employs monetary policy to alter the money supply or the policy interest rate to achieve inflation, economic growth, and exchange rate stability. When policy response mechanisms cannot be explained in terms of independent variables

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(Mishkin, 2012), rational expectations (Leu, 2011; Sbordone et al., 2010), as well as macroeconomic fluctuations resulting from supply-side shocks, are based on the assumption that flexible price and salary cause macroeconomic fluctuations according to the real business cycle theory (Kydland et al., 1982; Tran & Nguyen, 2020; Riyanto, Erlando, Haryanto, 2021) or micro-based New Keynesian theory (Rotemberg & Woodford, 1997; Woodford, 2003; Galí, 2008) under imperfect market conditions and constraints on rigid price and salary (Romer, 2000) to assess the impact of monetary policy (Clarida et al., 1999).

2.1.2. The New Keynesian SVAR

Leu (2011) introduced the new Keynesian model that is consistent with the underlying behavior of intertemporally optimizing economic agents. The relationships that formed the contemporaneous part of the SVAR model are derived from dynamic general equilibrium setting, in which agents are assumed to be rational and forward-looking through the New Keynesian SVAR model of the Australian economy as an open and small economy to determine the interaction between exogenous structural shocks and behavior toward the future of the economic proxy of Leu (2011) and the proxies assume reasonable and rational expectations with 4 equations: IS equation, AS equation, Uncovered interest parity (UIP) and A forward-looking monetary policy rule. This study also uses Keating's (1990) rational expectations scheme and evaluates the strength of the interest rate channel for the new Keynesian open economy such as Viet Nam (Sethi et al., 2019).

2.1.3. The New Keynesian DSGE Model

The DSGE model is a part of the general equilibrium theory application. This property of the model is reflected in the relationship of three blocks: aggregate supply, aggregate demand, monetary policy equation and expectations of the economic agents include households, enterprises, financial intermediaries, and government. Each of these agents interacts with each other and leads to the general equilibrium of the model. On the other hand, the micro-based DSGE model with financial intermediaries is the main cause of MP shocks (Sbordone et al., 2010) or stochastic shocks provided that economic behavior is constrained to maximize benefits and rational expectations. Accordingly, the study reaffirms that DSGE is an important model of central banks in the world in policy analysis and macro forecast (Smets & Wouters, 2007). Extensions of this model include the inclusion of rigid salary and market friction (Smets & Wouters, 2007) or the study of MP transmission mechanism. Finally, the DSGE model is divided into (i) model for medium and large economies

(Smets & Wouters, 2007); and (ii) DSGE model structure for small and open economies.

The DSGE model begins by describing the fields of the economy to be modeled. The research model is related to models developed by Clarida et al. (1999) and Woodford (2003). The DSGE model according to Sbordone et al. (2010) has three areas: (i) households are represented through an equation showing the relationship between output, expected output, and the policy interest rate; (ii) enterprises (including financial intermediaries) are represented through equation showing the relationship between current and future inflation; (iii) the State bank establishes the nominal interest rate equation to control inflation. The DSGE model can be written in nonlinear form and linear form. In any analysis of simultaneous equations, solving a model means to express the equations with the model's endogenous variables as a function of its exogenous variables. The built model includes an equation relating control variables to state variables and represents the state variables in time series. Therefore, the DSGE model can provide estimating equations and post-estimating policy analysis for several important macro variables through impulse response and forecast functions. This study applies the linear DSGE model. The study estimates the parameters of this model, thereby generating shocks of increase in interest rates or tight monetary policy, and plots the response of the model variables to the shocks and forecasts interest rates and inflation variables. However, this model also shows some limitations but the discrepancies of the DSGE model are not a major problem (Smets & Wouters, 2007). Even the DSGE model is considered to be more predictive than the Fed's Greenbook model.

2.2. Empirical Studies Related to the New Keynesian SVAR Model

Raghavan and Silvapulle (2008) investigated the transmission mechanism of monetary policy in the post-crisis period in Malaysia, a small, open economy, by looking at the reaction of macro variables to various shocks. The findings suggest that domestic monetary policy is vulnerable to commodity price and output shocks in the post-crisis period.

Leu (2011) examines the impact of monetary policy on macroeconomic variables in Australia (1984–2009) using the New Keynesian SVAR model. The outcome reflects the effects of four shocks on the Australian economy: aggregate demand, aggregate supply, monetary policy shock (via interest rates), and exchange rate shock. Positive monetary policy, in particular, narrows output and inflation, whereas high-interest rates add to the exchange rate. Large exchange rate swings, which may have a detrimental impact on real output, have confirmed a positive shock to the local currency

(currency appreciation) or a decline in exchange rates. The shock of aggregate demand, which caused inflation to rise in tandem with output growth, led the central bank to tighten control. When the economy experiences a supply shock, central banks lag behind the policy response, boosting nominal interest rates to combat inflation but negative real interest rates to close the production gap.

Kilinc and Tunc (2014) investigated the effects of shocks on monetary policy in Turkey, a small and open economy. The research examines the effects of four shocks: two endogenous shocks, namely interest rate and risk premium, and exogenous shocks, namely import prices and world production. The risk premium leads the exchange rate to rise (negative value of the local currency) and has a negative influence on inflation, whereas a positive interest rate shock causes the exchange rate to fall (the value of the currency increases) and reduces inflation. The shock of global output, particularly in the open economy, has had an impact on Turkey's inflation.

2.3. Empirical Studies Related to the New Keynesian DSGE Model

Smets and Wouters (2002) investigated the large-scale DSGE model in the EU, which was based on the New Keynesian scholastic philosophy and included inflexible pricing and salary components. The model takes into account real rigidity in purchasing habits and behavioral characteristics, as well as adjusted capital accumulation costs and several optimal options. The DSGE model estimates better than traditional vector regressional approaches in terms of empirical results.

The policy analysis utilizing the DSGE model was first introduced by Sbordone et al. (2010). The authors empha-sized the significance of the DSGE model in the creation and study of the central bank's MP once more. Households, corporations producing final commodities, intermediate companies, and monetary policy are the four active actors in the economy. Although it is a small-scale and simple model, it meets the assumption of explaining macro variables such as US production, inflation, and nominal interest rates between 1984 and 2006. The study demonstrated the importance of the expectation component in shock transmission and policy responses, establishing the groundwork for the DSGE.

With empirical evidence from China, Zheng and Guo (2013) estimated the DSGE model of the open economy. The paper examined whether monetary policy instabilities are to be blamed for the macroeconomic imbalances that occurred between 1992 and 2011. The empirical result revealed that changes in the production gap, inflation, and the nominal exchange rate affect the nominal interest rate. Furthermore, the author discovered that monetary policy shocks had a large short-term influence on macroeconomics and a

long-term impact on nominal variables (inflation and exchange rate), but no impact on real output.

Dizioli and Schmittmann (2015) studied the new Keynesian DSGE model for Vietnam. This model is referred to as the Forecasting and Policy Analysis System (FPAS) but expands a few elements to better suit the characteristics of Vietnam's economy. The FPAS model has become popular for monetary policy analysis due to its simplicity and covers important economic aspects for monetary policy analysis. Endogenous and exogenous shocks (Fed's interest rates) are used to examine the volatility of crucial macro variables (output, inflation, and exchange rate). The model combines future expectations, such as (1) aggregate demand curves depicting expected and past real output, real interest rates, and real exchange rates; (2) two Phillips curves related to the composition of past and expected inflation and exchange rate; (3) the uncovered interest rate parity equation without exchange rate hedging (UIP); and (4) the normal interest rate equation as a function of output deviation, change in the exchange rate, and deviation of the normal interest rate. The findings revealed that the State Bank's policy function has kept the exchange rate relatively steady for a long period when the economy is subjected to endogenous and external shocks, implying that the implementation of the shock absorption function has numerous constraints. The findings supported the interest rate transmission mechanism, which showed that an increase in interest rates causes a fall in output after four quarters and a decrease in the consumer price index after eight quarters. This is analogous to the monetary policy transmission process in developing and emerging countries when the SBV raises interest rates in response to rising inflation. Furthermore, because the demand shock reduces output and lowers inflation, the SBV has adjusted by lowering interest rates to re-stimulate output growth.

3. Research Methods

3.1. Overview of the Research Method

The study presented in the form of SVAR models with variable order based on Leu's (2011) which used estimation method is the full–information maximum–likelihood (FIML). This is also the New Keynesian model for open economies, with low income based on empirical studies for African countries such as Uganda, Kenya, and Tanzania and summarized in the study on the monetary transmission mechanism of low-income countries (Mishra et al., 2012). Finally, the study applies the DSGE model to forecast changes in macro variables.

3.2. Data

Data for variables collected quarterly from 2000 to 2020, with I Policy interest rate (r vn), which was the treasury

bill rate before 2010, according to IMF-IFS data; Since 2010, this data has been standardized by the IMF - IFS as policy rate - interest rates in the money market are classified into two groups: those affected by the supply-demand relationship and those announced by the Central Bank to run monetary policy; (ii) Output gap (ygap_vn) which is calculated as the difference between the logarithm of the actual output and the potential output, with data from IMF – IFS (HP filter); (iii) (iv) Domestic inflation (inf_vn), which is represented by the domestic consumer price index quarterly (IMF – IFS) and is derived from the USD/VND exchange rate (IMF – IFS) using logarithm nepe (lne) to compute the data. The adjusted price index for time t is CPIt, while the adjusted price index for period t–1 is CPI_{t-1}. The adjusted price index is a base-year normalized price index (in 1994 and 2010) (**) making up observations from a data series representing inflation, % inflation = $[(CPI_t - CPI_{t-1})/CPI_{t-1}]*100\%$; (v) The inflation and the US Federal Funds rate (cpi_us, int_us) which gets data from the IMF – IFS and the Board of Governors of the Federal Reserve (FED). The experimental result shows that the use of US economic variables significantly improves the accuracy of the estimated parameters and the domestic economic forecasting ability.

3.3. SVAR Identification Incorporating Rational Expectations

A Closed Economy New Keynesian Model

The study demonstrates the SVAR model under the rational expectations (Keating, 1990) with a closed economy version of the new Keynesian model (1) (Clarida et al., 1999; Leu, 2011). The aggregation relationships that formed the contemporaneous part of the SVAR model are derived from dynamic general equilibrium setting, in which agents are assumed to be rational and forward-looking expectations expressed by equations (3) suggests nonlinear restrictions across the coefficients of each contemporaneous structural equation. Economic agents such as consumers, firms, and the SBV are assumed to combine all relevant innovations in forecasting the future value of endogenous variables including (i) IS equation, (ii) Aggregate Supply equation, (iii) A forward-looking monetary policy rule, respectively:

$$\begin{aligned} \text{ygap\_vn}_t &= \alpha_0 + E_t \text{ygap\_vn}_{t+1} - \alpha_1(i_t - E_t \inf\_\text{vn}_{t+1}) \\ &+ \varepsilon_t^{\text{ygap\_vn}} \\ \inf\_\text{vn}_t &= \beta_0 + \beta_1 E_t \inf\_\text{vn}_{t+1} + \beta_2 \text{ygap\_vn}_t + \varepsilon_t^{\inf\_\text{vn}} \quad (1) \\ \text{r\_vn}_t &= \gamma_0 + \inf\_\text{vn}_t + \gamma_1(E_t \inf\_\text{vn}_{t+1} - \inf\_\text{vn}^T) \\ &+ \gamma_2 \text{ygap\_vn}_t + \varepsilon_t^{\text{r\_vn}} \end{aligned}$$

An Open Economy New Keynesian model

With (1), this study adds the uncovered interest rate parity (UIP) - A standard feature in most small open economic models to describe the nominal exchange rate:

$$\begin{aligned} \text{ygap\_vn}_t &= \alpha_0 + E_t \text{ygap\_vn}_{t+1} - \alpha_1(i_t - E_t \inf\_\text{vn}_{t+1}) + \varepsilon_t^{\text{ygap\_vn}} \\ \inf\_\text{vn}_t &= \beta_0 + \beta_1 E_t \inf\_\text{vn}_{t+1} + \beta_2 \text{ygap\_vn}_t + \varepsilon_t^{\inf\_\text{vn}} \\ \text{r\_vn}_t &= \gamma_0 + \inf\_\text{vn}_t + \gamma_1(E_t \inf\_\text{vn}_{t+1} - \inf\_\text{vn}^T) \quad (2) \\ &+ \gamma_2 \text{ygap\_vn}_t + \varepsilon_t^{\text{r\_vn}} \\ \ln e\_\text{vn}_t &= E_t \ln e\_\text{vn}_{t+1} - (\text{r\_vn}_t - \text{r\_us}_t) + \varepsilon_t^{\ln e\_\text{vn}} \end{aligned}$$

The study also examines uses a system of conditional equations (2) in terms of structural disturbances and VAR innovations with the theory of rational expectations (1990). In the process of conversion, the excess of exogenous variables (i.e., the US inflation and the Fed fund rate) becomes endogenous factors within the system of VAR innovations to four endogenous variables. Therefore, the residues now include only endogenous variable innovations:

Following that, the identification system procedure is centered on transforming the current structure system into an equations representation system that includes structural disturbance and VAR innovations (Leu, 2011). In the process of conversion, the excess of exogenous variables becomes endogenous factors within the system of VAR innovations to four endogenous variables. Therefore, the residues now include only endogenous variable innovations:

$$\begin{aligned} \varepsilon_t^{\text{ygap\_vn}} &= e_t^{\text{ygap\_vn}} - (E_t \text{ygap\_vn}_{t+1} - E_{t-1} \text{ygap\_vn}_{t+1}) + \alpha_1 e_t^{\text{r\_vn}} \\ &\quad - \alpha_1(E_t \inf\_\text{vn}_{t+1} - E_{t-1}\inf\_\text{vn}_{t+1}) - \alpha_2\left(e_t^{\ln e\_\text{vn}} - \frac{e_t^{\inf\_\text{vn}}}{400}\right) \\ \varepsilon_t^{\inf\_\text{vn}} &= e_t^{\inf\_\text{vn}} - \beta_1(E_t\inf\_\text{vn}_{t+1} - E_{t-1}\inf\_\text{vn}_{t+1}) - \beta_2 e_t^{\text{ygap\_vn}} \quad (3) \\ \varepsilon_t^{\ln e\_\text{vn}} &= e_t^{\ln e\_\text{vn}} - (E_t \ln e\_\text{vn}_{t+1} - E_{t-1} \ln e\_\text{vn}_{t+1}) + e_t^{\text{r\_vn}} \\ \varepsilon_t^{\text{r\_vn}} &= e_t^{\text{r\_vn}} - e_t^{\inf\_\text{vn}} - \gamma_1(E_t\inf\_\text{vn}_{t+1} - E_{t-1}\inf\_\text{vn}_{t+1}) - \gamma_2 e_t^{\text{ygap\_vn}} \end{aligned}$$

where the domestic price innovation is equal to domestic inflation innovation over 400 (Leu, 2011). Economic agents are required to update their expectations on the output gap, inflation, and exchange rates, i.e. $\sum_{a=\text{ygap\_vn}}^{\text{ygap\_vn,inf\_vn,ln e\_vn}} (E_t a_{t+1} - E_{t-1} a_{t+1})$. The article computes the expected revision processes through the equation:

$$\begin{aligned} E_t \text{ygap\_vn}_{t+1} - E_{t-1}\text{ygap\_vn}_{t+1} &= r'_{\text{ygap\_vn}} \text{AQe}_t; \\ E_t \inf\_\text{vn}_{t+1} - E_{t-1}\inf\_\text{vn}_{t+1} &= r'_{\inf\_\text{vn}} \text{AQe}_t; \quad (4) \\ E_t \ln e\_\text{vn}_{t+1} - E_{t-1}\ln e\_\text{vn}_{t+1} &= r'_{\ln e\_\text{vn}} \text{AQe}_t \end{aligned}$$

Then, the system of equations (5) is the constraint used in the model estimation to calculate the value of the deep structural parameters for policy shock analysis and variance decomposition:

$$\varepsilon_t^{\text{ygap\_vn}} = e_t^{\text{ygap\_vn}} - r_{\text{ygap\_vn}}' \text{AQe}_t + \alpha_1(e_t^{\text{r\_vn}} - r_{\text{inf\_vn}}' \text{AQe}_t)$$
$$- \alpha_2 \left(e_t^{\text{ln e\_vn}} - \frac{e_t^{\text{inf\_vn}}}{400} \right)$$
$$\varepsilon_t^{\text{inf\_vn}} = e_t^{\text{inf\_vn}} - \beta_1 r_{\text{inf\_vn}}' \text{AQe}_t - \beta_2 e_t^{\text{ygap\_vn}} \qquad (5)$$
$$\varepsilon_t^{\text{ln e\_vn}} = e_t^{\text{ln e\_vn}} - r_{\text{ln e\_vn}}' \text{AQe}_t + e_t^{\text{r\_vn}}$$
$$\varepsilon_t^{\text{r\_vn}} = e_t^{\text{r\_vn}} - e_t^{\text{inf\_vn}} - \gamma_1 r_{\text{inf\_vn}}' \text{AQe}_t - \gamma_2 e_t^{\text{ygap\_vn}}$$

3.4. New Keynesian DSGE model

A nonlinear DSGE model can be represented as follows: $E_t \{f(x_{t+1}; y_{t+1}; x_t; y_t; \theta)\} = 0$; where f is the vector of equations, x_t is the vector of state variables, y_t is the vector of control variables, and θ represents the vector of structural parameters. Solving a DSGE model means writing it in the form of state space.

A linear DSGE model can be represented as follows:

$$A_0 y_t = A_1 E_t (y_{t+1}) + A_2 y_t + A_3 x_t$$
$$B_0 x_{t+1} = B_1 E_t (y_{t+1}) + B_2 y_t + B_3 x_t + C \varepsilon_{t+1}$$

where y_t is the vector of control variables, x_t is the vector of state variables, and ε_t is the vector of shocks. A_0 to A_3 and B_0 to B_3 are the matrices of the parameters. A_0 and B_0 are diagonal matrices. The sections in all these matrices are functions of the structural parameters denoted by e vector θ. The economic theory places constraints in the matrix. C is a choice matrix that determines which state variables are affected by the shocks. The reduced form of the DSGE model represents the control variables as functions of the state variables alone and specifies how the state variables over time. The state-space form of the model is given by:

$$y_t = G x_t$$
$$x_{t+1} = H x_t + M \varepsilon_{t+1}$$

Accordingly, y_t is the vector of the control variable, x_{t+1} is the vector of the state variable, and ε_{t+1} is the vector of shocks. G is the policy matrix, and H is the transition matrix. M is diagonal and contains the standard deviation of the shocks. y_t is divided into observed and unobserved control variable, $y_t = (y_{1,t}, y_{2,t})$. The observed control variables are related to the control variables through the equation: $y_{1,t} = D_y$.

Where D is the choice matrix. Only the observed variables play the role of regression estimate in the model. The number of observed control variables in the model can be the same as the number of state equations and include shocks to the system of equations:

$$\text{inf\_vn}_t = \beta * E_t (\text{inf\_vn}_{t+1}) + \kappa * \text{ygap\_vn}_t$$
$$\text{ygap\_vn}_t = E_t * (\text{ygap\_vn}_{t+1})$$
$$- \{r\_vn_t - E_t * (\text{inf\_vn}_{t+1}) - g_t\}$$
$$r\_vn_t = \psi * \text{inf\_vn}_t + u_t$$
$$u_{t+1} = \rho_u u_t + \varepsilon_{t+1}$$
$$g_{t+1} = \rho_g g_t + \xi_{t+1}$$

These equations include state variables, control variables, and expectations of future values of control variables and shocks. The endogenous variables are called control variables, and exogenous variables are called state variables. Variable ygap_vn_t represents the output deviation. Output deviation measures the difference between actual output and potential output calculated through the HP filter. The notation $E_t (x_{t+1})$ defines the future and conditional expectations based on available information at time t, of the output deviation in a period of time $t + 1$. The nominal interest rate is r_vn_t, and the inflation rate is inf_vn_t.

The equation (inf_vn) is called the Phillips curve or the price equation that determines inflation as a combination of expected inflation and output deviation. The parameter κ is called the slope of the Phillips curve that determines the inflation level depending on the output deviation and κ is a measure of that dependence.

The equation (ygap_vn) is called the Euler equation that determines the output deviation as a combination of expected output deviation, real interest rate, and state variable g_t. At the same time, the equation shows that there is a covariant relationship with expected output deviation $\{E_t (x_{t+1})\}$ and state variable g_t, contravariant with real interest rate $\{r_t - E_t(\pi_{t+1}) - z_t\}$.

Finally, equation (r_vn) defines the interest rate as a linear combination of inflation and state variable u_t, representing the behavior of the central bank. This is also known as Taylor's (1993) rule which defines the interest rate as a linear combination of inflation and state variable u_t. State variables are modeled as first-order autoregression processes. State variable u_t is the deviation of r_vn_t from the equilibrium value of ψp_t. State variable g_t is also the deviation of ygap_vn_t from its equilibrium value. Discount coefficient β (beta) has two roles in the above model. It represents the relationship between the current inflation deviation and the expected inflation deviation and between the interest rate deviation and the inflation deviation. Parameter κ (kappa)

is called the slope coefficient of the Phillips curve and is predicted to be a covariate. Parameter β is the discount factor that represents the change level in the expected value from the present value. The parameter ψ (psi) measures the degree to which interest rates respond to movements of inflation.

Endogenous variables $ygap\_vn_t$, inf_vn_t & r_vn_t are affected by two exogenous variables u_t & g_t. Theoretically, g_t is the natural interest rate (Orphanides & Williams, 2003). The exogenous variable u_t records all movements in interest rates arising from factors other than the movements of inflation, which is referred to as a monetary policy shock. Two exogenous variables are modeled:

$$u_{t+1} = \rho_u u_t + \varepsilon_{t+1}$$
$$g_{t+1} = \rho_g g_t + \xi_{t+1}$$

Before carrying out policy analysis, the study assigns values to the model's parameters. The study will estimate the parameters of the above model using Vietnam's data on inflation and interest rates with dsge in Stata 15. Shocks ε_t and ξ_t participate in the system of equations through the equations of state of respective variables. By default, the shock is related to each state equation. The number of shocks must be equivalent to the number of observed control variables in the model.

Then, declaration of DSGE into dsge. Then, the study sets up a model using data on Vietnam's output deviation, interest rate, and inflation rate. In the DSGE model, there are two observed control variables, namely inflation and policy interest rates, accordingly, the model has two shocks. Variables have been adjusted and tested for stationarity.

4. Empirical Results

4.1. The New Keynesian SVAR Results

4.1.1. Stationary Test (Unit Root Test) For Data Series

This study uses unit root tests for a series of data: output gap (ygap_vn), domestic inflation (inf_vn), natural logarithm of the nominal exchange rate (lne_vn) and the policy rate (r_vn), the United States (US) inflation (inf_us) and the US Federal Interest rate (int_us). This test assumes H_0: The data series has a unit root (i.e., unstationary). The null hypothesis (H_0) is accepted or rejected based on the *P*-value of the test. For data series lne_vn with a 10% significance level, the hypothesis H_0 is accepted. Or the data series lne_vn is unstationary. Therefore, the study performs a first-order difference for the lne_vn string and continues to check whether the string has stationary. The results in Table 1 show that for *P*-value = 0.0000 < 0.01, it can be concluded that lne_vn was stopped when taking the first-order difference (dlne_vn).

4.1.2. Selection of Optimal Lag and Stability of the Model

According to the LR, FPE, AIC standards, a four-lag for endogenous variables should be selected (Leu, 2011). The study selects a lag of 4 to estimate the parameters in the model. From the statistical lag of the above standards, it can be seen that 4 is the most appropriate lag for exogenous variables which the residuals of these equations are not autocorrelation (LM Test).

Table 1: The Var Lag Order Selection Criterion for Endogenous Variables

Endogenous Variables: YGAP_VN D1INF_VN D1LNE_VN R_VN						
Exogenous Variables: C INF_US(–1) INT_US(–1) INF_US(–2) INT_US(–2) INF_US(–3) INT_US(–3) INF_US(–4) INT_US(–4) Q1 Q2 Q3						
Sample: 2000Q1 2020Q4 - Included observations: 79						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	–365.6952	NA	0.419482	10.47330	11.91296	11.05007
1	–287.6137	124.5350	0.088286	8.901614	10.82117*	9.670645*
2	–271.6698	23.81493	0.090405	8.903034	11.30247	9.864323
3	–246.8389	34.57466	0.074807	8.679467	11.55880	9.833014
4	–225.5904	27.43484*	0.068814*	8.546592*	11.90581	9.892397

Note: *p* < 0.1; **p* < 0.05; ***p* < 0.01. Significant at the 0.05 level.

4.1.3. Diagnostics of the Reduced-Form VAR

The study determines the lag order of endogenous and exogenous variables, using three seasonal dummies in each endogenous variable equation to eliminate seasonal factors affecting the data series ($q_1 = 1$ if q_1, $q_1 = 0$ if it is another quarter, similar to q_2, q_3 & q_4). After the regression of quadratic equations and obtaining the reduced-form VAR, the study will perform the tests (Spanos, 1990; Leu, 2011).

4.1.4. Test of Residuals of Equations in the VAR Model

4.1.4.1. Autocorrelation Test

The study uses the LM test, with hypothesis H_0: There is no autocorrelation. Considering the residuals of the system of equations, as Table 2 may accept hypothesis H_0, or no autocorrelation exists.

4.1.4.2. Normal Distribution Test

The results of Skewness & Kurtosis for residuals of equations in the VAR model, with hypothesis H_0: There is a standard distribution Pro. = 0.118 > 0.1. Therefore, with the significance level of 10%, it is possible to accept hypothesis H_0, or the standard excess, satisfying the necessary conditions to estimate VAR quantitatively.

4.1.4.3. ARCH Effect Test

The research uses the Heteroskedasticity Test, with hypothesis H_0: No effect on ARCH.

Consider the residual of the VAR model, Prob = 0.3130 > 0.1; It is, therefore, possible to accept hypothesis H_0 or to conclude that no effect of ARCH exists.

Table 2: Results of LM Test for Residuals of Equations in the VAR Model

VAR Residual Serial Correlation LM Tests						
Sample: 2000Q1 2020Q4						
Included observations: 79						
Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao *F*-stat	df	Prob.
1	42.34876	16	0.0003	2.931671	(16, 135.1)	0.0004
2	26.01988	16	0.0537	1.696759	(16, 135.1)	0.0542
3	15.49731	16	0.4886	0.972961	(16, 135.1)	0.4896
4	12.86441	16	0.6826	0.800087	(16, 135.1)	0.6835

4.1.4.4. VAR Model Stability Test

The results of the Inverse Roots of AR Characteristic Polynomial show that the values are in the range [–1, 1] or all the values in the circle, so the VAR model is stable.

4.1.4.5. Determination of Restraint Conditions in SVAR Estimation

Based on matrix A obtained from the estimation parameters for reduction from VAR, the article identifies the following limitation conditions:

$$u_1 = e_1 - (0.2269 * e_1 - 0.71066 * e_2 + 4.47037 * e_3 + 0.64166 * e_4)$$
$$+ \alpha_1 * (e_4 - (-0.00207 * e_1 - 0.1553 * e_2 + 21.5585 * e_3$$
$$+ 0.12089 * e_4)) - \alpha_2 * (e_3 - 0.0025 * e_2)$$
$$u_2 = e_2 - \beta_1 * (-0.00207 * e_1 - 0.1553 * e_2 + 21.5585 * e_3$$
$$+ 0.12089 * e_4) - \beta_2 * e_1$$
$$u_3 = e_3 - (-5.49017270421E - 05 * e_1 + 0.000707 * e_2$$
$$+ 0.315768 * e_3 + 0.00374 * e_4) + e_4$$
$$u_4 = e_4 - e_2 - \gamma_1 * (-0.00207 * e_1 - 0.1553 * e_2 + 21.5585 * e_3$$
$$+ 0.12089 * e_4) - \gamma_2 * e_1$$

With e_1, e_2, e_3, e_4 as residuals of the equations ygap_vn, inf_vn, dlne_vn, r_vn, respectively in VAR and; u_1, u_2, u_3, u_4 as structural innovations of the equations ygap_vn, inf_vn, dlne_vn, r_vn, respectively in the SVAR model.

4.1.4.6. Impulse Response Function (IRF)

The IRF has a 95% confidence interval for four structural shocks: monetary policy shock, exchange rate shock, aggregate supply shock, and aggregate shocks. All reactions show mean - reversion which reflects the stationary properties of the structural model (Figure 1).

Before the monetary policy shock, the increase in interest rates had an impact on the output gap, which had also expanded proportionally in the fifth period. Thus, in Vietnam, the phenomenon of output puzzle (increase in output when tightening monetary policy) exists. However, from the sixth period onwards, the output gap decreased when the tightening of the monetary policy started to take effect despite the lag.

Secondly, an increased interest rate has the effect of lowering inflation. This is in line with the current policy of the central bank when an interest rate is a tool implemented to curb inflation.

The exchange rate movements follow the theory: the increase in interest rate shock makes the price of domestic currency increase or the exchange rate decrease. Thus, Vietnam does not have the phenomenon of exchange rate puzzle in the long term period (Leu, 2011). In conclusion, the impossible trinity theory (Mundell - Flemming model)
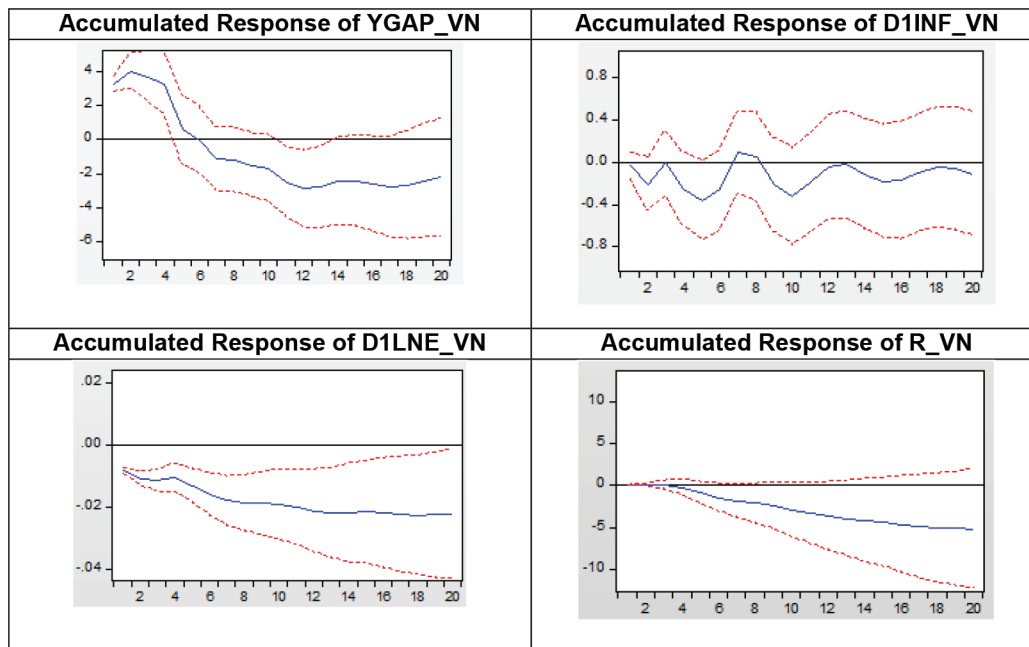
Figure 1: Response of Macroeconomic Variables to the Monetary Policy Shock
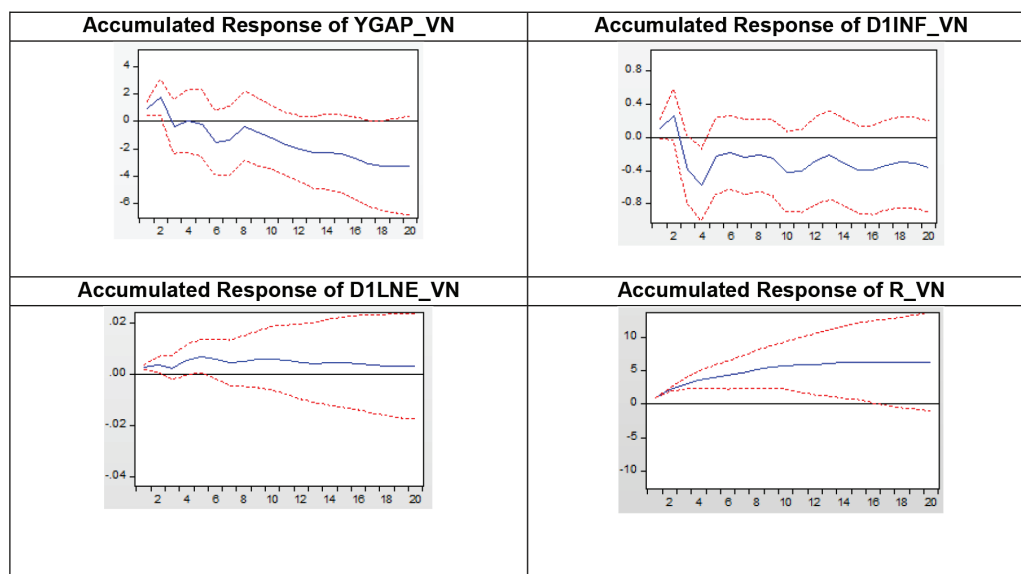

Figure 2: Response of Macroeconomic Variables to Exchange Rate Shock

implies that the effectiveness of the monetary policy depends on the exchange rate regime and the level of capital flow control in each country, particularly in the fixed exchange rate regime and the open capital flows, the monetary policy is independent and less important in the economy. However, the empirical results (see Figure 2) show that the monetary policy shock has an impact on the output gap, inflation, and

exchange rate or the crucial - positive role of the SBV in macro-management to guide the market to maintain stability through the announcement of the central exchange rate, and the exchange rate of VND versus other foreign currencies.

The exchange rate shock reduces the output gap and inflation but increases the interest rate. In addition, foreign exchange reserves increase sharply to strengthen the SBV's

commitment to stabilize the exchange rate through the ability to intervene to stabilize the forex market. So, the central bank focuses on attracting the amount of VND in curbing inflation, in which credit tightening policy has led to shrinking domestic capital inflows that reduce the output in the economy. However, the supply of foreign currencies can lead to a decrease in national foreign exchange reserves and slow down the exchange rate at the same time, the interest rate tool is used to adjust the increase to recover the value of the domestic currency simultaneously and to curb inflation (Figure 2).

The aggregate supply shock or inflation shock increases the output gap and the exchange rate is consistent with the Uncovered Interest rate Parity (Figure 3). Besides, the inflation increases, the SBV raises interest rates to curb inflation. Finally, the study shows that the impact of the output gap shock has no significant impact on the fluctuation of macro variables such as inflation, exchange rate, and interest rate.

4.1.4.7. Variance Decomposition

An assessment of the relative importance of four structural shocks at different limits can be achieved by examining the forecast error rate calculated by each shock and is reported in Table 3.

First, the VD of r_vn shows the forecast error rate corresponding to each shock with the threshold of 20. According to the research result, the exchange rate shock contributes primarily to explaining the changes in interest rates. Next is inflation and all shocks are to have a diminishing effect in the long term.

Second, the VD of d1lne_vn shows the contribution of shocks in explaining the volatility of the exchange rate. The biggest impact factor is the interest rate shock. In addition, the role of the inflation factor also contributes to the explanation of exchange rate changes.

Thirdly, the VD of d1inf_vn shows the impact of shocks on inflation volatility. The exchange rate contributes primarily to the change in inflation, suggesting a clear role for the central bank in stabilizing inflation, contributing to fiscal stability. In addition, the impact of inflation explains itself in addition to the effects of exchange rate shock and the output gap.

Finally, the VD of ygap_vn shows the importance of each shock to variation in the output gap. In particular, the shock of interest rate mainly explains in the short term with more than 70%. Next, the exchange rate shock and inflation shock have contributed to the change in output or economic growth, respectively.

4.2. The Impulse Response Analysis of the New Keynesian DSGE Model

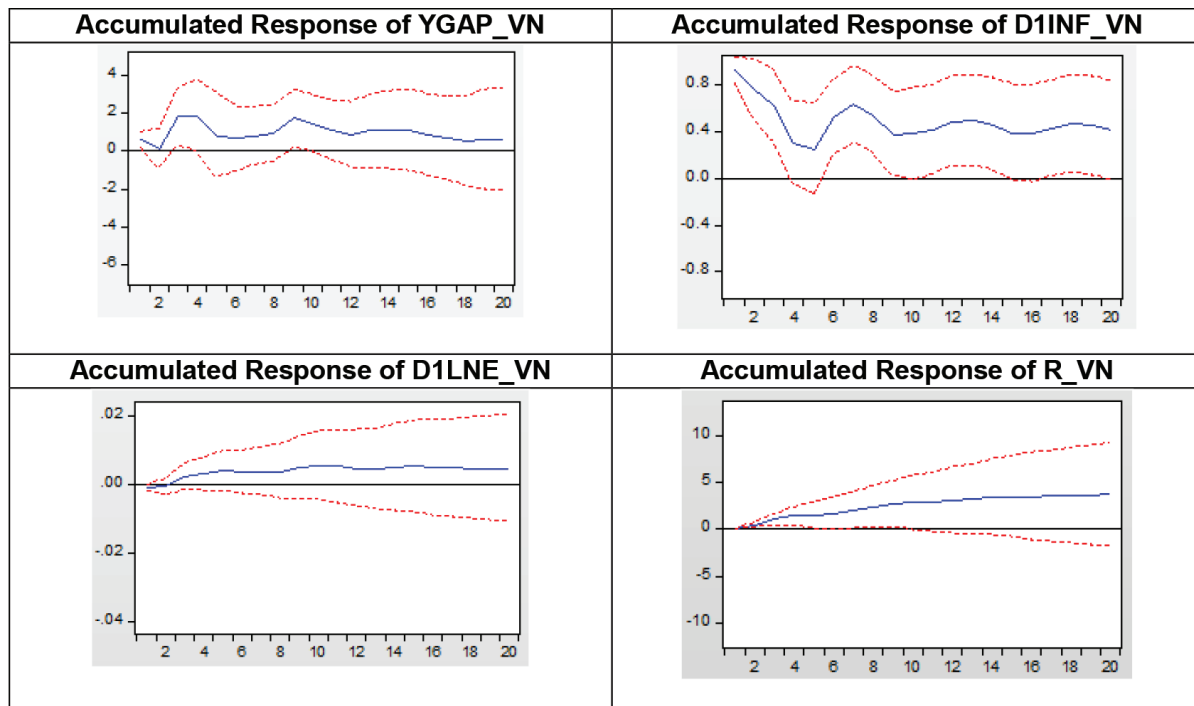The slope coefficient of Phillips curve - parameter {kappa} is estimated to be positive. The coefficient of

Figure 3: Response of Macroeconomic Variables to AS Shock

Table 3: Variance Decomposition (VD) of Endogenous Variables

	VD of r_vn					VD of d1inf_vn			
Period	S.E.	Shock1	Shock2	Shock3	Shock4	S.E.	Shock1	Shock2	Shock3	Shock4
1	0.9944	9.07E–1	0.0001	99.996	0.0028	0.9306	0.0509	98.651	1.1797	0.1179
4	2.049461	0.0017	16.5693	80.6393	2.7896	1.2790	0.0336	61.0761	30.5299	8.3603
8	2.4772	0.0053	16.0847	66.1981	17.7116	1.4237	0.04	54.6295	31.0543	14.2760
12	2.6691	0.0050	15.603	59.5681	4.8229	1.4921	0.0373	51.2777	30.3131	18.3717
20	2.7541	0.0063	15.6333	6.6335	27.7267	1.51265	0.03651	50.4172	30.6363	18.9098
	VD of d1lne_vn					VD of ygap_vn			
1	0.0085	0.0045	1.4261	9.7550	88.8143	3.68804	12.0191	2.9599	6.4760	78.5448
4	0.0101	0.0054	10.6794	17.6651	71.65	4.7847	7.8761	15.7321	26.2073	50.1843
8	0.0114	0.0075	9.3049	18.9127	71.7747	5.9969	5.0338	13.3110	25.0186	56.6364
12	0.0116	0.0094	10.2551	19.2316	70.5037	6.2044	4.7034	14.6726	25.2166	55.4073
20	0.0117	0.01	10.3327	19.4304	70.2268	6.2723	4.6036	14.7474	25.6417	55.0071

inflation in the interest rate equation has an estimated value of 2.65, which means that the state bank is expected to raise interest rates by about 2.65 times for each incremental change in inflation. Both state variables u_t and g_t are estimated to be stable, with regression estimate coefficients of 0.47 & 0.88 respectively (Table 4).

4.2.1. Testing the Stability of the Model

4.2.1.1. Policy Matrix and Transformation Matrix

The factors of the policy matrix show the response of the control variables to a 1-unit increase in the state variable (Table 5).

Policy Matrix

When u_t increases, inflation falls below its equilibrium value in the short term. This change reduces the output gap and interest rates. An increase in g_t raises inflation above its equilibrium value in the short term. This change also increases the output gap and interest rate. Because the state variables are not correlated with each other, the factors of the transformation matrix are fixed parameters in the model.

Transform matrix of state variables

State variables are interdependent when state variables depend on control variables, state vectors. Accordingly, dsge represents the first value used in immediate solutions, it shows warnings indicating that the model cannot resolve values by implying that the model is not stable.

4.2.1.2. Model's Stability Results

According to the description features with 3 specific value stable (0.4733, 0.8812, 0.639) and the remaining unstable (1.369, 1.369). So, the model is stable when the

Table 4: DSGE Model Estimation Research Result

Sample: 2000q1–2020q4		Observational number = 84	
[/structural]beta = 0.96		Log likelihood = –282,15166	
Structural Parameters	Regression Coefficient	Standard Deviation	P > |z|
beta	0.96	(constrained)	0.110
kappa	0.6685	0.4179	0.004
psi	2.6588	0.9238	0.000
rhou	0.4733	0.0949	0.000
rhog	0.8811	0.0492	
sd(e.u)	3.7165	1.3437	
sd(e.g)	0.8092	0.1447	

number of stable specific values is balanced with the number of state variables. Thus, the estimation result is suitable for impulse response analysis and policy forecasting.

4.2.2. Forecast One Step in Advance

As shown in Figure 4, the study makes one-step forecasts for inflation and interest rates, and the forecast data tends to match the actual data.
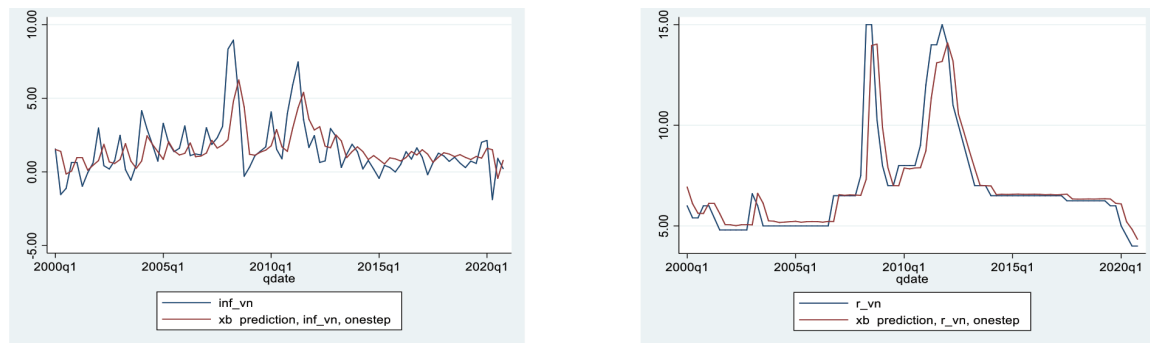
4.2.3. Impulse Response

The study uses the model to evaluate the effect of unexpected changes in interest rates for inflation and output deviation. Accordingly, an unexpected change in interest

Table 5: Policy Matrix and Transformation Matrix

	Regression Coefficient	Standard Deviation	*P > |z|*		Regression Coefficient	Standard Deviation	*P > |z|*
inf_vn				F.u			
u	−0.3823	0.1245	0.002	u	0.4733	0.0949	0.000
g	0.5540	0.2829	0.050	g	0.0949	1.21e–11	1.000
ygap_vn				F.g			
u	−0.3120	0.2064	0.131	u	0		
g	0.1276	0.1205	0.290	g	0.8811	0.0492	0.000
r_vn							
u	−0.0166	0.0396	0.675				
g	1.4730	0.2450	0.000				

Note: The standard error of the report of constraint values of the transformation matrix is missing.

Figure 4: Forecast for Inflation and Interest Rates

rates is described as a shock to equation u_t. In the language of the model, this shock represents a tight monetary policy. The impulse response is a series of values of shocks in Figure 5. Then, the shock transmits into the state variables of the model, leading to an increase in u_t. Thereby, an increase in u_t leads to a change in all control variables of the model. The impulse response function shows the effect of a shock on the model variables, taking into account all inter-relationships among the variables included in the model. The study builds and plots the impulse response where the irf set containing the IRF file will store the impulse responses.

The impulse response graph shows the response of the model variables to a standard deviation shock. Each table is the response of a variable to the shock. Figure 5 shows the response of the monetary state variable or rising interest rate shock, u_t. The remaining three tables show the response of inflation, interest rates, and output deviation. Inflation in Figure 5 shows a decrease in inflation due to the impact of the shock. The interest rate impulse response in Figure 5 is the weighted sum of the impulse response of inflation

and policy interest rate. Interest rates rise by about half of a percentage point and output deviation decreases. Therefore, the model predicts that after monetary tightening, inflation and output deviation tend to decrease. Over time, the effects of the shock will return to equilibrium. Besides, the study uses the irf function to evaluate the impact of the shock itself and the control variable of the model.

All variables of the model respond positively to the shock of g (interest rate). Most variables increase in the short term and then return to equilibrium in the long term (about 12 periods) (Figure 6).

4.2.4. Policy Forecasting

Forecast for the following 3 years or 12 quarters. To set the forecasting, the study sets up a forecast model, then estimates dsge to a forecast model (dsge_est), and finally generates a dynamic forecast starting from the first quarter (2018q1) according to the selection (forecast solve).

The model (Figure 7) predicts that inflation has the equilibrium value in the long run, besides the study can
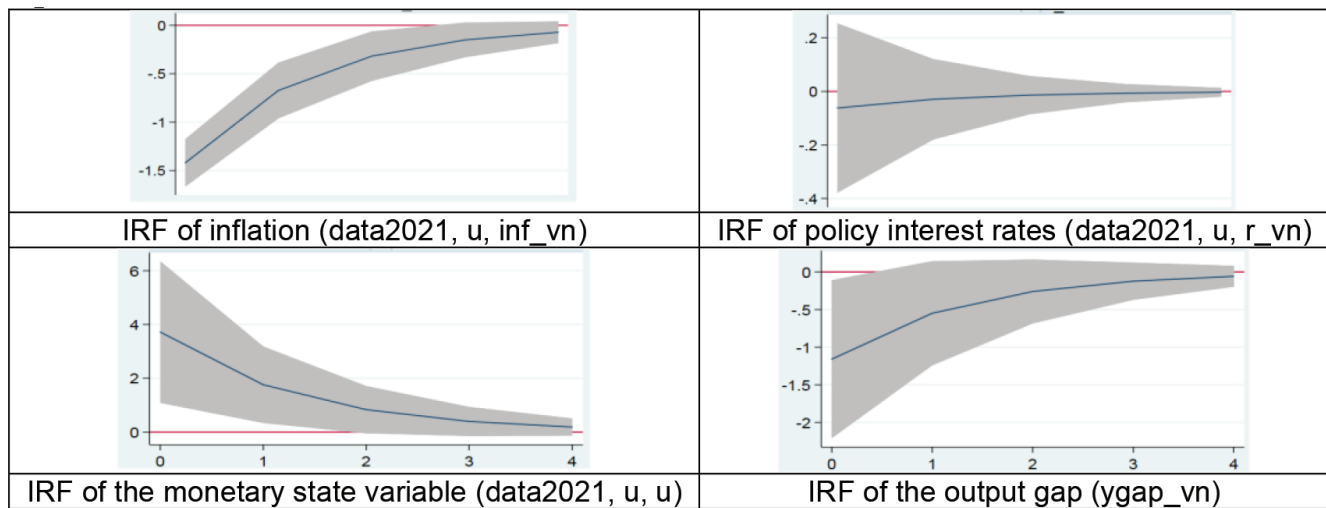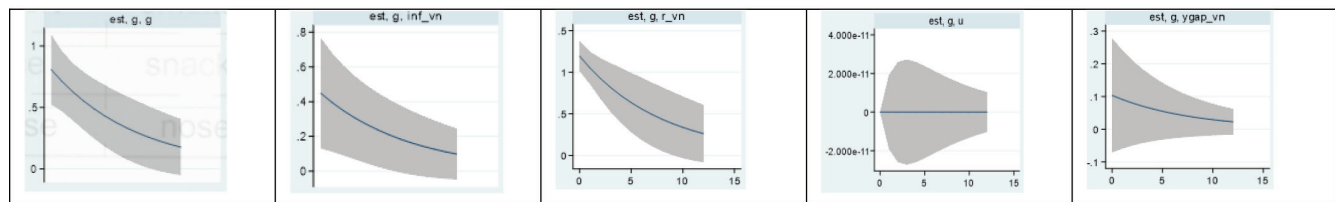
Figure 5: Impulse Response of Macro Variables

Figure 6: Description of Shocks of Macro Variables
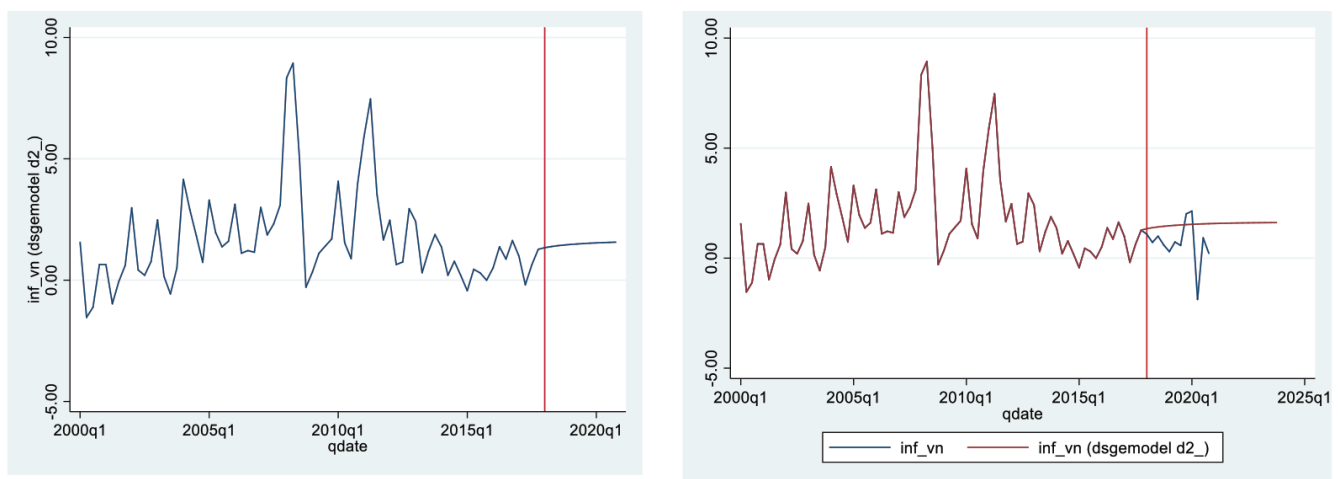

Figure 7: Forecasting Process for the Following 3 Years or 12 Quarters

forecast during the course when observations are available. Assuming to start with (2018q1), the study starts with a dynamic forecast by comparing inflation in the 2018–2020 period with real observations in that period. Figure 7 also shows observed and forecasted inflation. The forecast result shows a neutral level of inflation in the following years, but it does not predict the different values around this stable trend.

5. Conclusion

In the new Keynesian theory, through the rational expectations in the SVAR model, the study assesses the impact of macroeconomic variables in Vietnam. The results show that the interest rate shock increases output deviation and reduces inflation. Relatively higher local currency interest rates lower the exchange rate without any sign of an exchange rate puzzle in Vietnam. Next, exchange rate shocks and inflation also provide empirical evidence that affects macro variables. In a small, open economy with relatively tight capital flow control like Vietnam, through the influence of monetary policy on the exchange rate, it can be referred that the Government's message is towards more flexible exchange rate management. Moreover, the DSGE model is built on two basic principles in modern macroeconomics that model the behavior of economic subjects, including the rational expectation and maximizing benefits, so the model has a foundation. An important feature of the DSGE model is the reflection of proxies' expectations and therefore, the use of the DSGE model for analysis and forecasting positively supports the theory of monetary policy. One of the main applications of the DSGE model is forecasting, namely forecasting shocks or forecasting remaining variables based on hypothetical shocks or conducting scenario analysis with risk assessments. The advantage of using the DSGE model in forecasting is that it can explain the forecasting results based on equations of shocks and economic theory in the model. For these reasons, the application of the DSGE model is becoming more popular in central banks, gradually supplementing and replacing the classical econometric models, especially in central banks that pursue the inflationary monetary policy.

References

Clarida, R., Galí, J., & Gertler, M. (1999). The science of monetary policy: A Keynes mới perspective. *Journal of Economic Literature*, *37*(4), 1661–1707. https://doi.org/10.1257/jel.37.4.1661

Dizioli, A., & Schmittmann, J. M. (2015). *A macro–model approach to monetary policy analysis and forecasting for Viet Nam* (IMF Working Paper No. WP/15/273). Washington DC: International Monetary Fund (IMF). https://www.imf.org/en/Publications/WP/Issues/2016/12/31/A-Macro-Model-Approach-to-Monetary-Policy-Analysis-and-Forecasting-for-Vietnam-43491

Galí, J. (2008). *Monetary policy, inflation, and the business cycle: An introduction to the new Keynesian framework.* Princeton: Princeton University Press.

Keating, J. W. (1990). Identifying VAR models under rational expectations. *Journal of Monetary Economics*, *25*(3), 453–476. https://doi.org/10.1016/0304-3932(90)90063-A

Kilinc, M., & Tunc, C. (2014). *Identification Turkey: A structural VAR approach* (Working Paper No. 1423). Ankara, Turkey: Research and Monetary Policy Department, Central Bank of the Republic of Turkey. https://www.tcmb.gov.tr/wps/wcm/connect/cd0c8e6a-7c70-4439-a746-68fee16a00a4/WP1423.pdf?

Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. *Econometrica*, *50*(6), 1345–1370. https://www.jstor.org/stable/1913386

Leu, S. C. Y. (2011). A new Keynes SVAR model of the Australian economy. *Economic Modelling*, *28*(1), 157–168. https://doi.org/10.1016/j.econmod.2010.09.015

Mishkin, F. S. (2012). *The economics of money, banking, and financial markets.* UK: Pearson Education.

Mishra, P., Montiel, P. J., & Spilimbergo, A. (2012). Monetary transmission in low-income countries: effectiveness and policy implications. *IMF Economic Review*, *60*(2), 270–302. https://doi.org/10.1057%2Fimfer.2012.7

Nguyen, V. T. H., Hoang, T. T. T., & Nguyen, S. M. (2020). The Effect of Trade Integration on Business Cycle Synchronization in East Asia. *Journal of Asian Finance, Economics and Business*, *7*(8), 225–231. https://doi.org/10.13106/jafeb.2020.vol7.no8.225

Raghavan, M., & Silvapulle, P., (2008). *Structural VAR approach to Malaysian monetary policy framework: Evidence from the pre-and post-Asian crisis periods.* https://www.nzae.org.nz/wp-content/uploads/2011/08/nr1215397050.pdf

Riyanto, F. D., Erlando, A., & Haryanto, T. (2021). The Synchronization of ASEAN +3 Business Cycles: Prerequisites for Common Currency Union. *The Journal of Asian Finance, Economics and Business*, *8*(3), 781–791. https://doi.org/10.13106/jafeb.2021.vol8.no3.0781

Romer, D. (2000). Keynes macroeconomics without the LM curve. *Journal of Economic Perspectives*, *14*(2), 149–169. https://doi.org/10.1257/jep.14.2.149

Rotemberg, J. J., & Woodford, M. (1997). An optimization-based econometric framework for the evaluation of monetary policy. *NBER Macroeconomics Annual*, *12*, 297–346. https://www.nber.org/system/files/chapters/c11041/c11041.pdf

Sbordone, A. M., Tambalotti, A., Roa, K., & Walsh, K. (2010). Policy analyses using DGSE models: An introduction. *SSRN Journal*, *11*, 169. https://doi.org/10.2139/ssrn.1692896

Sethi, M., Baby, S., & Dar, V. (2019). Monetary policy transmission during multiple indicator regime: A case of India. *The Journal of Asian Finance, Economics and Business*, *6*(3), 103–113. https://doi.org/10.13106/jafeb.2019.vol6.no3.103

Smets, F., & Wouters, R. (2002). *An estimated dynamic stochastic general equilibrium model of the Euro area* (Working Paper Series 171) Frankfurt, Germany: European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp171.pdf

Smets, F., & Wouters, R. (2007). *Shocks and frictions in US business cycles: A Bayesian DSGE approach* (Working Paper Series 722). Frankfurt, Germany: European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp722.pdf

Spanos, A. (1990). The simultaneous equations model revisited: statistical adequacy and identification. *Journal of Econometrics*, *44*, 87–105. https://doi.org/10.1016/0304-4076(90)90074-4

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, *39*, 195–214. https://doi.org/10.1016/0167-2231(93)90009-L

Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy*. Princeton, NJ: Princeton University Press.

Zheng, T., & Guo, H. (2013). Estimating a small open economy DSGE model with indeterminacy: Evidence from China. *Economic Modelling*, *31*, 642–652. https://doi.org/10.1016/j.econmod.2013.01.002