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THE SHOCK REACTION IN A SMALL OPEN ECONOMY WITH PRICE FRICTION

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ABSTRACT
This work presents the analysis of a small open economy DSGE model with price friction to investigate the effect of various shocks on the economy. The model is estimated by the Bayesian technique with the quarterly de trended data of Thailand, 2001: Q1-2019: Q2. By separating the analysis into two cases, the results showed that the flexible price model is more sensitive to the shocks and able to adjust to equilibrium faster than the price friction model. Therefore this work suggests that to formulate the model to capture the dynamic within an economy one need to recognize the nature of the economy under analysis and correctly formulate the model that reflects the level of price friction.

INTRODUCTION

Dynamic stochastic general equilibrium (DSGE) model is a useful tool for economists to learn the business cycles, to carry out hypothetical policy experiments, to forecast [1], to identify sources of fluctuations, and to answer the questions of structural changes. Especially, they allow establishing a link between structural features of the economy and reduced-form parameters that were not always possible with large-scale macroeconomic models [2].

Even though the DSGE model is data specific [3] and requires a sufficient skill to work with it, it facilitates analysts who want to explore the interaction between variables of interest. Not only the interaction between variables can be learned, DSGE model also allowed analysts to augment uncertainty which implies changes and various assumptions to the model to capture the anomaly phenomena in the economy, e.g., change of preference, technology, and risk. However, the basic application of this model is to analyze the effect of monetary and fiscal policy changes on the economy.

To analyze the hypothesis economy, the small open economy (SOE) model has been widely used as it supports the exploration of the external effects that transmits into a particular small scale economy, e.g., the change of oil-price [4], the choice of investment [5], the change of the exchange rate [6], the crisis of credit [7], the occurrence of financial frictions [8], the volatility of asset market [9], and the change in one country on another country [10].

In the case of monetary policy analysis within the SOE model, there are many works conducted to investigate the effect of policy change on the major macroeconomic variables. Some of them showed the negative reaction of macroeconomics variables to a positive monetary policy shock, e.g., price, working hour, and output [11], investment [12,13], consumption [14-16]. For fiscal policy analysis, the evidence from the previous work shows that positive shock on government spending will induce the level of private consumption [17,18] but put down the interest rate and crowded out private investment [19,20]. In some case, however, government spending can cause a reduction in both household consumption and investment[21-24].

Other shocks that are prevalently analyzed in the SOE model include consumption preference, technology, exchange rate, foreign price, and foreign income. The effects of these shocks on the domestic economy are as follow. For the consumption preference shock, when this shock occurs, it will push up the household consumption but make a drop in the investment. However the reaction to this shock is very sensitive to the elasticity of substitution between domestic and foreign goods and, especially, when there is no price and wage stickiness, this shock has a large effect on the inflation [25,26]. The shock of technology can raise the level of employment [24] and output [25] but reduce the level of the price [29,30] and interest rate [28]. In the case of exchange rate shock, it can make a decrease in price [29], output, and interest rate [30][31]. For a world prices shock, it primarily causes an increase in household consumption. While the shock of world income leads to the growth of foreign demand for domestic goods and the investment demand for goods to increase the country’s exports [32]. The other works that try to analyze the impact of various changes in SOE model can found in, e.g., [36- 41].

In the analysis, the following two well-know frameworks are employed. Initiated by the New Classical framework which assumes no friction in the economy, the concept of long-run neutrality of money is proposed. In this framework, it hypothesizes that all prices are set by market clearing condition, i.e., all agents behave optimally based on their objectives and expectations [35]. In contrast, the New-Keynesian framework highlights the role of frictions that cause the markets deviate from the clearing condition. In particular, the price frictions are such a cause and become a core feature of the New-Keynesian framework and hence the money non-neutrality, at least in a short-run, is assumed in this framework [36].

Regarding the cause of frictions, they are aroused by, e.g., the production input acquiring cost, the inability of absorbing or processing information, and other related factors that give firms the inabilities of changing prices. The price frictions are the sources of inflation inertia since the non-optimizing firms stick their prices to the past period inflation. According to Calvo[37], the sticky-price firms can set their profit-maximizing price with probability $(1-\omega)$, while the rest with probability ω cannot. As a result, the inflation in the sticky price model reacts with delay and gradually to, e.g., monetary, technology, and government expenditure shocks [38]. In the case of monetary policy shock, it was revealed that price friction can affect the pass-through of the short-term money market rate [39]. Because the combination of the different components of prices with different speed of change in the price friction model, the inflation persistence can occur. In this model, some firms react to a shock immediately and the price is set based on the current state of the economy, whereas others take time to respond and change price less often so they drive the persistence of aggregate inflation. Thus when there incur the monetary shock, it was likely that inflation is more persistent in the sticky-price sector than in the flexible-price sector since the sticky-price firms are slower to respond to that shock [40].

Because the price frictions prevent firms from continuously adjusting their prices to reflex economic conditions and cause the delay response of inflation to a monetary shock, firms thus react to interest rate changes by reducing their capital expenditures, job demands, capital utilization rate, and investment, all of which lead to a drop in GDP but in the smooth manner [41]. Also, the previous works showed that the shock on monetary policy can make, e.g., the real output, nominal wage inflation, and inflation rate in the price friction framework gradually decline [39], the inflation in fixed price sector fall by roughly half as much on impact as inflation in the flexible-price sector, and the inflation in the fixed price sector persist for longer than the flexible-price sector [40].

Motivated by the effect of monetary, fiscal policy, and the price frictions on major macroeconomic variables discussed above, this work is hence designed to show the result of these policies and price friction on the economy by utilizing the SOE DSGE model and the Bayesian estimation. Also, the usual shocks of the consumption preference, technology, foreign inflation, and foreign income will be included in this analysis. The remaining of this work is organized as follow. In the next section, a model that is subsequently estimated will be discussed. Section 3 will describe the data used for model estimation. In section 4, the model will be estimated. Finally, the result of the analysis will be discussed in Section 5.

THE MODEL

The following model is assumed to represent a small open economy that is a part of the world economy but produce nothing potentially affect the rest of the world. Let begin our model formulation by discussing the term of the trade

(TOT) which express a relationship between the price of import goods and domestic good [49,50] as follow

$$S_t = \frac{E_t P^*_{M.t}}{P_{H,t}} \quad , \qquad (1)$$

here E_t denote the exchange rate which expresses in domestic currency. $P^*_{M,t}$ and $P_{H,t}$ represent the price of import good and domestic good, respectively. As a small open economy, we simply assume that the import price is determined by the foreign economy. Therefore we set import price equal to aggregate foreign price, $P^*_{M.t} = P^*_t$ [44]. In the log-linear form, TOT can be written as

$$\tilde{S}_t = \tilde{E}_t + \tilde{P}^*_{M,t} - \tilde{P}_{H,t} \,. \qquad (2)$$

Because households consume goods produced from both domestic and foreign economy, we can write the consumption bundle C_t as follow

$$C_t = \left(\left(1-\delta\right)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \delta^{\frac{1}{\eta}} C_{M,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} ,(3)$$

where C_{Ht} and C_{Mt} represent the consumption of domestic goods and imported goods, respectively. δ is the share of imports in consumption, and η is the elasticity of substitution between domestic and foreign goods. The solutions to the household problem are given by

$$C_{H,t} = \left(1-\delta\right)\left(\frac{P_t}{P_{H,t}} \right)^{\eta} C_t \,, \qquad (4)$$

$$C_{M,t} = \delta \left(\frac{P_t}{P_{M,t}} \right)^{\eta} C_t \,. \qquad (5)$$

and

$$P_t = \left(\left(1-\delta\right) P_{H,t}^{\;1-\eta} + \delta P_{M,t}^{\;1-\eta} \right)^{\frac{1}{1-\eta}} . \quad (6)$$

Similarly, we have

$$I_{H,t} = (1-\delta)\left(\frac{P_t}{P_{H,t}}\right)^{\eta} I_t , \qquad (7)$$

$$G_{H,t} = (1-\delta)\left(\frac{P_t}{P_{H,t}}\right)^{\eta} G_t , \qquad (8)$$

In the log-linear form, (3) can be written as

$$\tilde{C}_t = (1-\delta)\tilde{C}_{H,t} + \delta\tilde{C}_{M,t} . \qquad (9)$$

Incorporating with (2), we can derive the log-linear form of (4) and (5) as follow

)

$$\tilde{C}_{H,t} = \eta\delta\tilde{S}_t + \tilde{C}_t , \qquad (10)$$

and

$$\tilde{C}_{M,t} = \tilde{C}_t - \eta(1-\delta)\tilde{S}_t . \qquad (11$$

Again by using (2), the log linear form of (6) become

$$\tilde{P}_t = \tilde{P}_{H,t} + \delta\tilde{S}_t , \qquad (12)$$

which imply

$$\tilde{\pi}_t = \tilde{\pi}_{H,t} + \delta\Delta\tilde{S}_t , \qquad (13)$$

where $\tilde{\pi}_t = \tilde{P}_t - \tilde{P}_{t-1}$ and $\tilde{\pi}_{H,t} = \tilde{P}_{H,t} - \tilde{P}_{H,t-1}$.

Let define the foreign demand for domestic good [45] by the following equation

$$C_{X,t} = \delta^* \left(\frac{P_{X,t}}{P_{H,t}}\right)^{\eta^*} Y_t^* , \qquad (14)$$

where $P_{X,t} = E_t P_t^*$. Its log linear form is thus given by

$$\tilde{C}_{X,t} = \eta^*\tilde{S}_t + \tilde{Y}_t^* . \qquad (15)$$

For simplicity, we assume $\eta^* = \eta$.

Recognizing that in the steady-state we have import equal to export so the net export in the log-linear form can be written by

$$N\tilde{X}_t = \delta\left(\tilde{C}_{X,t} - \tilde{C}_{M,t}\right) , \tag{16}$$

Next, let define the real exchange rate [46] by

$$Q_t = \frac{E_t P_t^*}{P_t} , \tag{17}$$

which can be turned into the log-linear form as follow

$$\tilde{Q}_t = \tilde{E}_t + P_t^* - P_t . \tag{18}$$

By some manipulating, we have

$$\tilde{Q}_t = (1-\delta)\tilde{S}_t . \tag{19}$$

In the following sections, we will derive the optimal condition from each agent within this hypothesized economy.

Households

The representative household in our hypothesized economy seeks to maximize its lifetime utility which is increased by the consumption and decreased by the working hour. This utility [54-56] thus can be described by the following function

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\xi_t \frac{\left(C_t - \gamma C_{t-1}\right)^{1-\theta}}{1-\theta} - \frac{N_t^{1+\varphi}}{1+\varphi} \right] , \tag{20}$$

where N_t is household working hour. β, θ, φ , and γ denote the intertemporal discount factor, the inverse of the intertemporal elasticity of consumption, the inverse elasticity of labour supply, and the persistence of consumption habits, respectively. ξ_t is stationary preference shocks that account for anomaly changes in consumption [45]. This shock follows a first-order autoregressive process expressed by

$$\ln\left(\xi_t\right)=\left(1-\rho_\xi\right)\ln\left(\xi_{ss}\right)+\rho_\xi\ln\left(\xi_{t-1}\right)+\varepsilon_{\xi,t}\ , \qquad \left|\rho_\xi\right|<1, \varepsilon_{\xi,t}\sim N\left(0,Q_\xi\right). \tag{21}$$

In each period, the household derives income from working, renting out capital to the domestic firm, retaining the profit from investment in the domestic firm, and holding bonds denominated in domestic currency. Therefore, the budget constraint of the household can be represented by

$$\begin{aligned} & W_t N_t + R_{K,t} K_{t-1} + \frac{R_{t-1}}{\pi_t} B_{t-1} + \prod\nolimits_t + E_t \frac{R^*_{t-1}}{\pi_t} Z_{t-1} B^*_{t-1} \\ & + Tn_t = C_t + I_t + B_t + E_t B^*_t + T_t \end{aligned} , \tag{22}$$

where K_t, B_t, $\prod_t, B^*_t$, Tn_t, I_t, and T_t are capital, domestic bond, profit, foreign bond, government transfer, investment, and lump-sum tax, respectively. $Z_t = e^{-\psi \frac{B^*_t}{Y_t}}$ is the risk premium. ψ is the risk sensitivity parameter. W_t, $R_{K,t}$, and E_t denote, respectively, the wage, capital rental rate, and exchange rate which in domestic currency. $R_t = 1+i_t$ and $R^*_t = 1+i^*_t$ are the gross rate of domestic return and foreign return.

The usual law of motion of capital with adjustment costs on investment is defined by

$$K_t = \left(1-\zeta\right)K_{t-1} + I_t\left[1-\frac{\chi}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2\right], \tag{23}$$

where ζ is the capital depreciation rate and χ is the sensitivity parameter for the investment adjustment cost. The log-linear form of the law of motion of capital is given by

$$\tilde{K}_t = \left(1-\zeta\right)\tilde{K}_{t-1} + \zeta\tilde{I}_t. \tag{24}$$

For the foreign asset evolution, we define it in the following form [49,50]

$$E_t\left(B^*_t - \left(\frac{R^*_{t-1}}{\pi_t} Z_{t-1}\right)B^*_{t-1}\right) = NX_{t-1}. \tag{25}$$

The log-linear form of (16) is given by

$$B^*_t + \psi\left(B^*_{t-1} - Y_{t-1}\right) + \pi_t = B^*_{t-1} + i^*_{t-1}. \tag{26}$$

The first-order condition of the household's problem provides us with the labour supply, Tobin's Q, investment demand, and Euler equation respectively.

$$W_t\left(C_t-\gamma C_{t-1}\right)^{-\theta}\xi_t=N_t^{\varphi} \quad , \qquad (27)$$

$$Q_t=\beta Q_{t+1}\left(1-\zeta\right)+\xi_{t+1}\beta\left(C_{t+1}-\gamma C_t\right)^{-\theta}R_{Kt} \quad , \; (28)$$

$$\begin{aligned}&\left(C_t-\gamma C_{t-1}\right)^{-\theta}\xi_t\\&=Q_t\left(\frac{\chi}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2+\chi\frac{I_t}{I_{t-1}}\left(\frac{I_t}{I_{t-1}}-1\right)-1\right)\end{aligned} \quad , \; (29)$$

$$\left(C_t-\gamma C_{t-1}\right)^{-\theta}=\frac{\xi_{t+1}}{\xi_t}\frac{R_t}{\pi_{t+1}}\beta\left(C_{t+1}-\gamma C_t\right)^{-\theta} \quad , \; (30)$$

$$\left(C_t-\gamma C_{t-1}\right)^{-\theta}=\frac{\xi_{t+1}}{\xi_t}\frac{E_{t+1}}{E_t}\frac{R_t^*}{\pi_{t+1}}\beta\left(C_{t+1}-\gamma C_t\right)^{-\theta}Z_t \,. \qquad (31)$$

The log-linear form of (27)-(30) are as follow

$$\tilde{W}_t+\xi_t=\varphi\tilde{N}_t+\frac{\theta}{\left(1-\gamma\right)}\left(\tilde{C}_t-\gamma\tilde{C}_{t-1}\right) , \qquad (32)$$

$$\begin{aligned}\tilde{Q}_t&=\beta\left(1-\zeta\right)\tilde{Q}_{t+1}\\&+\left(1-(1-\zeta)\beta\right)\left(\tilde{\xi}_{t1}-\frac{\theta}{\left(1-\gamma\right)}\left(\tilde{C}_{t+1}-\gamma\tilde{C}_t\right)+\tilde{R}_{K,t+1}\right)\end{aligned} , \qquad (33)$$

$$\tilde{Q}_t=\chi\tilde{I}_t-\chi\tilde{I}_{t-1}-\frac{\gamma\theta}{1-\gamma}\tilde{C}_{t-1}+\frac{\theta}{1-\gamma}C_t-\xi_t \quad , \qquad (34)$$

$$\begin{aligned}&\left(\tilde{C}_{t+1}-\gamma\tilde{C}_t\right)=\\&\left(\tilde{C}_t+\gamma\tilde{C}_{t-1}\right)-\frac{\left(1-\gamma\right)}{\theta}\left(\tilde{\xi}_{t+1}+\tilde{i}_t-\tilde{\xi}_t-\tilde{\pi}_{t+1}\right)\end{aligned} , \quad (35)$$

From (30) and (31), we can express the uncovered interest parity (UIP) condition by

$$R_t=\frac{E_{t+1}}{E_t}Z_tR_t^* , \qquad (36)$$

By using the definition of TOT, we have

$$\tilde{i}_t = \tilde{i}_t^* - \psi\left(\tilde{B}_t^* - \tilde{Y}_t\right) + \Delta\tilde{S}_{t+1} - \pi_{t+1}^* + \tilde{\pi}_{H,t+1} , \quad (37)$$

Domestic firms

The domestic final good Y_t is produced by a competitive wholesale firm that aggregates differentiated domestic goods produced by a continuum of intermediate goods producers which are indexed by $j \in [0,1]$. The wholesale firm uses the following CES technology:

$$Y_t = \left(\int_0^1 Y_{jt}^{\frac{\psi_Y - 1}{\psi_Y}} \, \mathrm{d}j \right)^{\frac{\psi_Y}{\psi_Y - 1}} , \qquad (38)$$

where Y_{jt} is the demand for intermediate good j and $\psi_Y > 1$ is the elasticity of substitution between the differentiated domestic goods. The maximization problem of the wholesaler is given by:

$$\max_{Y_{jt}} \; P_{H,t} Y_t - \int_0^1 P_{H,j,t} Y_{jt} \, \mathrm{d}j \quad , \qquad (39)$$

subject to (38). The solutions to this problem provide a demand function $Y_{j,t}$ and a corresponding price $P_{H,t}$ of the differentiated good

$$Y_{j,t} = Y_t \left(\frac{P_{H,t}}{P_{H,j,t}} \right)^{\psi_Y} , \qquad (40)$$

and

$$P_{H,t} = \left(\int_0^1 P_{H,j,t}^{\;1-\psi_Y} \mathrm{d}j \right)^{\frac{1}{1-\psi_Y}} . \qquad (41)$$

The intermediate good firm j uses capital and labour to produces output $Y_{j,t}$. The production function is formed by the following Cobb-Douglas technology:

$$Y_{j,t} = A_t K_{j,t}^{\alpha} N_{j,t}^{1-\alpha} , \qquad (42)$$

where α is shares of capital in the production and A_t is a technology shock which evolves exogenously according to:

$$\ln(A_t) = (1-\rho_A)\ln(A_{ss}) + \rho_A \ln(A_{t-1}) + \varepsilon_{A,t} , \qquad |\rho_A| < 1, \varepsilon_{A,t} \sim N(0, Q_A) .$$
(43)

The solution of the minimization problem provides the following capital and labour demand

$$N_{j,t} = (1-\alpha) MC_{j,t} \frac{Y_{j,t}}{W_t}, \qquad (44)$$

$$K_{j,t} = \alpha MC_{j,t} \frac{Y_{j,t}}{R_t}. \qquad (45)$$

The log-linear form of (44) and (45) are given by

$$\tilde{N}_{j,t} = \tilde{Y}_{j,t} - \tilde{W}_t + \tilde{MC}_{j,t} \quad , \qquad (46)$$

and

$$\tilde{K}_{j,t} = \tilde{Y}_{j,t} - \tilde{R}_{K,t} + \tilde{MC}_{j,t} \ . \qquad (47)$$

Let define the total cost by the following equation

$$TC_{j,t} = W_t N_{j,t} + R_{K,t} K_{j,t} \ . \qquad (48)$$

Using (44), (45), and (50), we obtain

$$MC_{j,t} = \frac{1}{A_t} \left(\frac{W_t}{(1-\alpha)} \right)^{1-\alpha} \left(\frac{R_{K,t}}{\alpha} \right)^{\alpha}, \qquad (49)$$

which have the log-linear form as follow

$$\tilde{MC}_{j,t} = (1-\alpha)\tilde{W}_t + \alpha \tilde{R}_{K,t} - \tilde{A}_t \ . \qquad (50)$$

Based on the Calvo rule, it assumes that the firm has a ω probability of keeping the price of its good fixed in the next period and a $(1-\omega)$ probability of optimally defining its price $AP_{j,t}$. The problem of the firms that are capable of readjusting their price is

$$MAX_{AP_{j,t}} \ E_t \sum_{i=0}^{\infty} (\beta\omega)^i \left(AP_{j,t} Y_{j,t+i} - TC_{j,t+i} \right), \qquad (51)$$

where $TC_{j,t+i} = Y_{j,t+i} MC_{j,t+i}$.

The FOC provides

$$AP_{j,t} = \frac{\psi_Y}{(\psi_Y - 1)} E_t \sum_{i=0}^{\infty} (\beta\omega)^i MC_{j,t+i}, \qquad (52)$$

which can be written in the log-linear form as

$$\tilde{A}P_{j,t} = (1-\beta\omega)E_t\sum_{i=0}^{\infty}(\beta\omega)^i\,\tilde{M}C_{j,t-i}. \quad (53)$$

Combining (41) with (52), we obtain the following domestic price index

$$P_{H,t} = \left(\omega P_{H,t-1}{}^{1-\psi_Y} + (1-\omega)\,AP_t^{1-\psi_Y}\right)^{\frac{1}{(1-\psi_Y)}}, \quad (54)$$

which can be written in the log-linear form as follow

$$\tilde{P}_{H,t} = \omega\tilde{P}_{H,t-1} + (1-\omega)\,\tilde{A}P_t \quad , \quad (55)$$

Now using (53) and (55) to get the following New Keynesian Philips curve

$$\tilde{\pi}_{H,t} = \beta\tilde{\pi}_{H,t+1} + \frac{(1-\omega)(1-\beta\omega)}{\omega}\left(\tilde{M}C_t + \delta\tilde{S}_t\right), \quad (56)$$

where $\tilde{\pi}_{H,t} = \tilde{P}_{H,t} - \tilde{P}_{H,t-1}$.

Monetary authority

The fiscal authority makes the spending decision by taking into account the previous level of national income [51,52] and inflation. Therefore the spending rule can be written in the following form

$$\frac{G_t}{G_{ss}} = \left(\frac{G_{t-1}}{G_{ss}}\right)^{\varphi_G}\left(\frac{Y_{ss}}{Y_{t-1}}\frac{\pi_{ss}}{\pi_{t-1}}\right)^{(1-\varphi_G)\kappa_G} A_{G,t}, \quad (57)$$

For monetary authority, it was assumed to sets a short-term nominal interest rate, i_t according to a simple Taylor type rule [53,54] as follows

$$\frac{i_t}{i_{ss}} = \left(\frac{i_{t-1}}{i_{ss}}\right)^{\varphi_M}\left(\left(\frac{Y_t}{Y_{ss}}\right)^{\kappa_Y}\left(\frac{\pi_t}{\pi_{ss}}\right)^{\kappa_\pi}\right)^{(1-\varphi_M)} A_{M,t}, \quad (58)$$

where $A_{G,t}$ and $A_{M,t}$ are government spending and monetary policy evolution which follow a first-order autoregressive process.
The log-linear form of (54) and (55) are as follow

$$\tilde{G}_t = \varphi_G\tilde{G}_{t-1} - (1-\varphi_G)\kappa_G\left(\tilde{\pi}_{t-1} + \tilde{Y}_{t-1}\right) + \tilde{A}_{G,t}, \quad (59)$$

$$\tilde{i}_t = \varphi_M\tilde{i}_{t-1} + (1-\varphi_M)\left(\kappa_\pi\tilde{\pi}_t + \kappa_Y\tilde{Y}_t\right) + \tilde{A}_{M,t}. \quad (60)$$

Foreign economy

we model the external forces according to the following processes[55]

$$\frac{i_t^*}{i_{ss}^*} = \left(\frac{i_{t-1}^*}{i_{ss}^*}\right)^{\varphi_M^*} \left(\left(\frac{Y_t^*}{Y_{ss}^*}\right)^{\kappa_{Y^*}} \left(\frac{\pi_t^*}{\pi_{ss}^*}\right)^{\kappa_{\pi^*}}\right)^{\left(1-\varphi_M^*\right)}, \quad (61)$$

$$\ln\left(F_t\right) = \left(1-\rho_F\right)\ln\left(F_{ss}\right) + \rho_F \ln\left(F_{t-1}\right) + \varepsilon_{F,t}, \quad \left|\rho_F\right| < 1, \varepsilon_{F,t} \sim N\left(0, Q_F\right), \quad (62)$$

where $F = \left\{\pi_t^*, Y_t^*\right\}$.

Equilibrium Condition

After the domestic good is produced, it is sold to both domestic and foreign consumer. Within the country, the domestic produced good is consumed by household and government. For the rest, it is exported to foreign consumers. Therefore, we can write the domestic produced good market-clearing condition[56] as follow

$$Y_t = C_{H,t} + I_{H,t} + G_{Ht} + C_{X,t}. \quad (63)$$

Using (4), (7), (8), (14), and as well as the steady-state conditionthat $P = EP^* = P_H$ and $Y_{ss} = C_{ss} + I_{ss} + G_{ss} = Y_{ss}^*$ we obtain the log-linear form as follow

$$\begin{aligned} Y_t &= \left(1-\delta\right)\left(C_{ss}\, C_t + I_{ss}\, I_t + G_{ss}\, G_t\right) \\ &+ \eta\delta\left(2-\delta\right)S_t + \delta Y_t^* \end{aligned}. \quad (64)$$

DATA

The model is estimated by using the quarterly data of Thailand which obtain from the World Bank database. The four series of the de trended data [57], shown in Figure 1, which cover the period of 2001:Q1-2019: Q2 and include GDP, policy rate, employment, and export.

BAYESIAN ESTIMATES

To estimate DSGE models, scholars often employ Bayesian techniques, especially, in the complexed models to incorporate more realistic features found in the data. Bayesian techniques provide a formal way to estimate the parameters by combining prior information with the data. Also, it provides a framework for designing policies that are robust to the estimated uncertainty surrounding the parameters and constitute a potentially more accurate way to derive reasonable parameter values. When Bayesian techniques are used, if one has confidence in one’s priors, there is no need to be concerned about whether the posterior estimates are. However, some of the parameter estimates were highly sensitive to the choice of priors so they make difficulty for economic inference [3].

In this work, the prior distribution and mean, show in Table 2, are selected from the related literature. However, some parameters, shown in Table 1, will be calibrated according to the values that are used in the relevant literature.

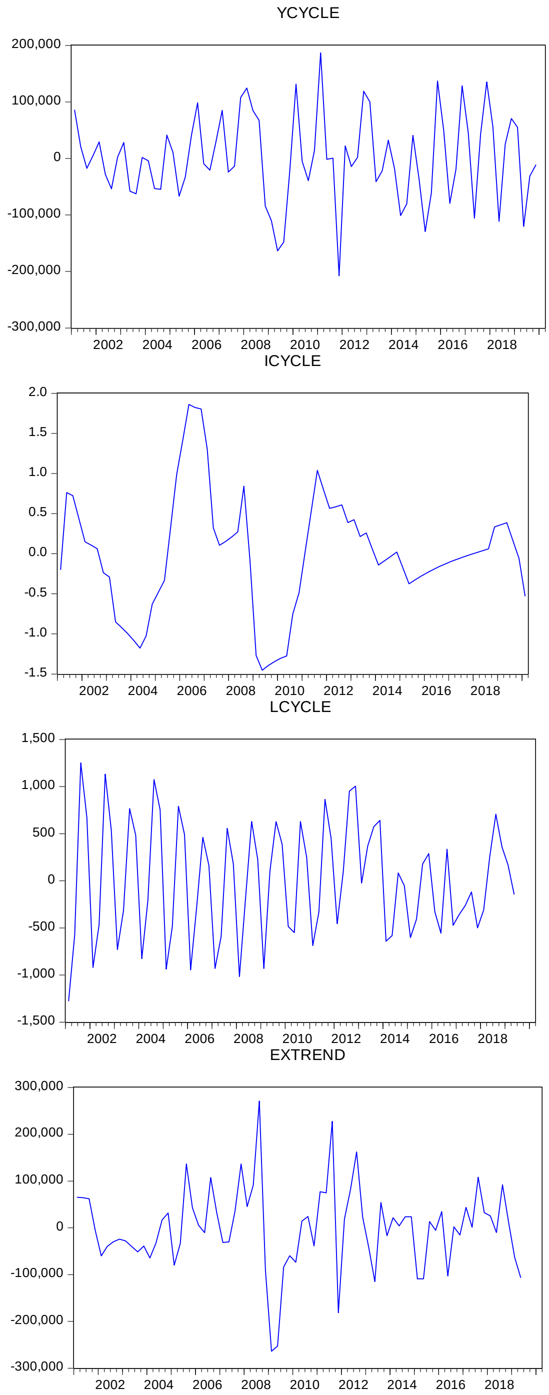

Figure1: The quarterly detrended data series of GDP, policy rate, employment, and export of Thailand.

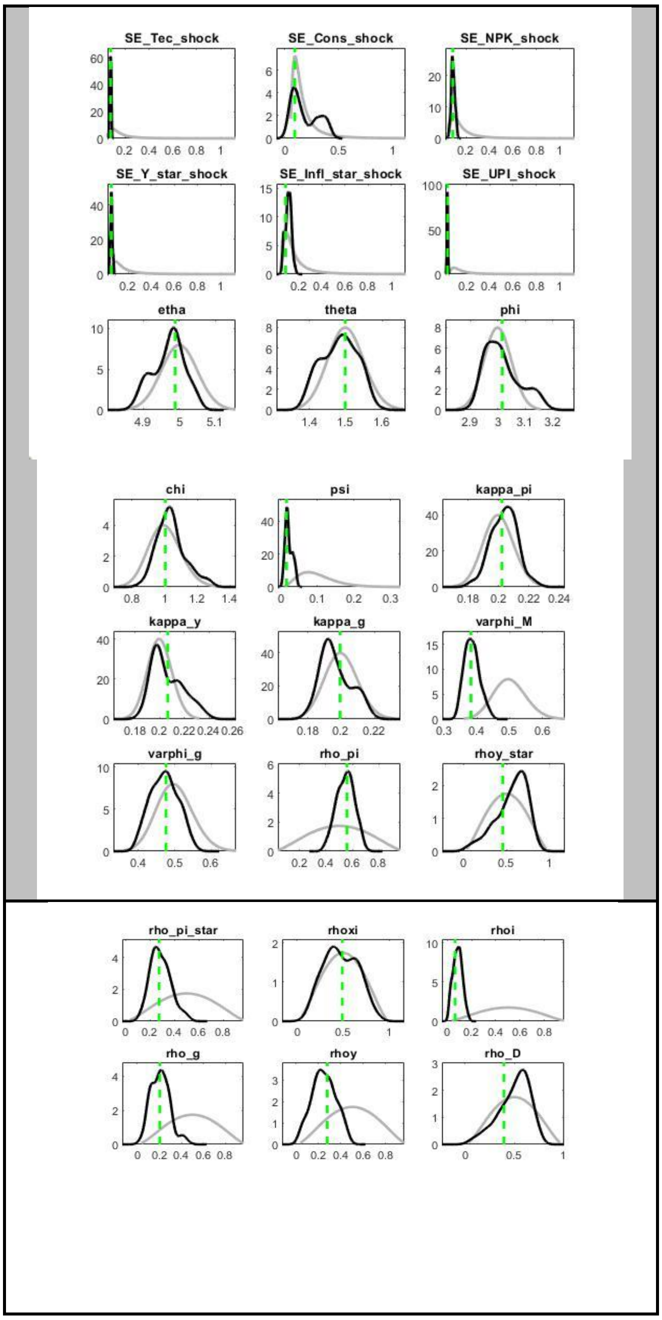

Figure 2: Priors and posteriors

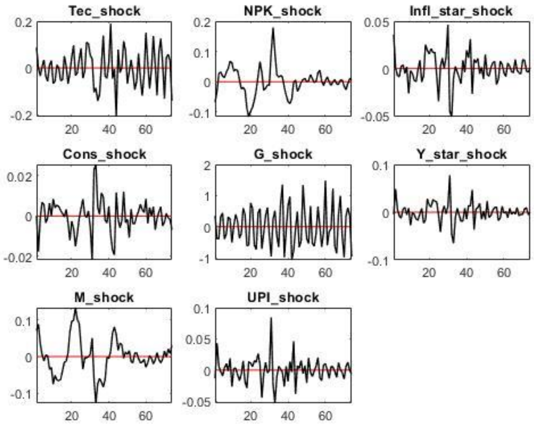

Figure 3: Smoothed shock.

Table 1: Calibrated parameters

Parameters	Value	Source
β	0.99	Tanboon (2008) [58]
γ	0.85	
ζ	0.011	
α	0.3	
ω	0.75	Alba et al. (2011) [59]
δ	0.4	Pakdeesana (2015) [60]

The results from the estimation are presented in Table 2, Figure 2, and Figure 3.

Table 2: Priors and posteriors of model parameters

Parameter	Prior		Posterior		
	Distr.	Mean	Mean	HPD inf	HPD sup
η	gamma	5.000	4.9944	4.9305	5.0598
θ	gamma	1.500	1.4977	1.4316	1.5641
φ	gamma	3.000	3.0339	2.9743	3.0890
χ	gamma	1.000	1.1069	0.9632	1.2329
ψ	gamma	0.100	0.0229	0.0087	0.0378
κ_π , κ_{π^*}	gamma	0.200	0.2065	0.1937	0.2211
κ_Y , κ_{Y^*}	gamma	0.200	0.2075	0.1932	0.2213
κ_G	gamma	0.200	0.1951	0.1863	0.2052
φ_M , φ_M^*	gamma	0.500	0.3689	0.3365	0.4065
φ_G	gamma	0.500	0.4606	0.4128	0.5168
ρ_π	beta	0.500	0.4663	0.3375	0.5925
ρ_{Y^*}	beta	0.500	0.5003	0.2716	0.7678
ρ_{π^*}	beta	0.500	0.3395	0.0786	0.5768

ρ_ξ	beta	0.500	0.4508	0.1321	0.7955
ρ_M	beta	0.500	0.1172	0.0315	0.2033
ρ_G	beta	0.500	0.2638	0.0701	0.4822
ρ_A	beta	0.500	0.2029	0.0860	0.3276

RESULTS

In this section, the results of the analysis will be briefly discussed. For the convenient of discussion, we separately graph the shock reaction by using the two values of ω, i.e., $\omega = 0$ and $\omega = 1$. For $\omega = 0$, it represents the price flexibility hypothesis which means that all firms in the economy can adjust their price. While $\omega = 1$represents the price friction hypothesis such that all firms index their price to the last period price level.

Expressed by Figure 4 (a), there increase in the labour work as a result of consumption preference shock. The increase of the consumption may be supported by the income acquired from increasing of work hour. The rising of the work hour can, in turn, improve the marginal product of capital and thus encourage capital demand and investment. The improvement of the marginal product can lead to the reduction of marginal cost and hence drive down inflation. The fall of inflation then benefit the term of trade and rise the real interest rate can thus make the real exchange rate appreciate. This currency appreciation can be a source of export and net export reduction. As the positive effects of consumption preference shock override the negative effects the output is grown. However, it successively declined after the central bank and government react to the inflation and output growth by increasing the interest rate and reducing the expenditure. In Figure 4 (b) which show the results generated form the price friction case, it appears that some variables are slowly responded and less sensitive to the shock of consumption. This finding is partially supported by the results in [61].

Figure 5 (a) shows the effect of positive technology shock which makes production more efficient and thus support the increase of output and the decrease of investment and prices. The expansion of output and employment thus makes the inflation increase. Since the rise of this inflation deteriorates the term of trade and real interest rate, the domestic currency becomes depreciate and hence increase the export and the net exports. As central bank and government respond to inflation and output growth by increasing the policy rate and reducing expenditure, inflation and output are brought back to their equilibrium. Figure 5 (b) shows nearly the same movement of each variable in responding to the technology shock but with the time delay in adjustment to their equilibrium. It could be of benefit to note that the effect of technology shock on the economy are inconsistence. According to [61], the impact of productivity shocks on consumption and the real exchange rate varies, i.e., in some countries when they encounter with the technology shock, they experience the fall of inflation and the rise of consumption, while others face with the consumption fall. For the real exchange rate, it becomes to depreciate in some countries but appreciate in the others. However in the price friction model, it likely that the economy cannot grab the benefit of technology shock since firms cannot adjust their price and increase their production much enough to hire more worker. Therefore in the full price friction economy, the output only slightly increases with inflation and employment decrease. The results generated in this price friction model partially come along with the results in [62-67].

Figure 6 (a) shows that the shock in government spending initially raises employment, output, and inflation. Although an increase in government spending can reduce inflation through the marginal cost channel, this effect is suppressed by the output growth. The reaction to inflation and output growth by central bank make inflation decline and hence rises TOT and real interest rate which in turn make domestic currency appreciate. The movement of variables in Figure 6 (a) is nearly resembled by Figure 6 (b) except that of inflation and output since the inflation is initially decreased before jumped up above its equilibrium. Also, the benefit of government expenditure on output intends to vanish right before that of price flexibility model. The results obtained from the price friction model are partly supported by the results of the work in [68-72].

Figure 7 (a) shows the effect of monetary shock that make inflation, real exchange rate, net export, output, and employment decrease. However, the force of the inflation that jump above its equilibrium generate a significant effect to make the real exchange rate depreciate. Therefore the net export firstly decreases and then increase above and move back to its equilibrium. The results shown in Figure 7 (b) are nearly similar to that of [63,64][73-75]. For the interpretation of Figure 8 (b) can be found in [76] and the interpretation of Figure 9 (b) can be found in [62][77].

CONCLUSIONS

In this work, we formulate the small open economy DSGE with price friction to investigate the effect of shock in the consumption preference, technology, fiscal policy, monetary policy, foreign inflation, and foreign income. The model is estimated by the Bayesian technique using quarterly detrended data of Thailand, 2001:Q1-2019: Q2 obtained from World bank databased. In the analysis, we separate the model into two cases based on the value of the probability of setting the price. the results, which most of them are support by previous works, showed that the flexible price model is more sensitive to the shocks and able to adjust to equilibrium faster than the price friction model. Therefore this work reveals that the level of price friction can potentially affect the capability of the model to capture the dynamic of an economy.

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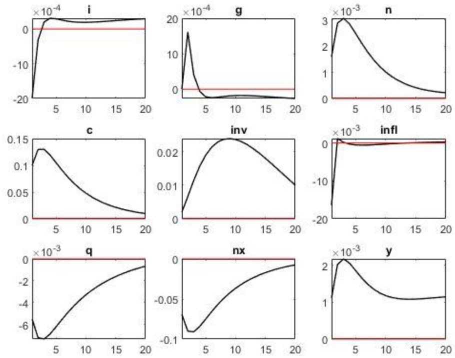

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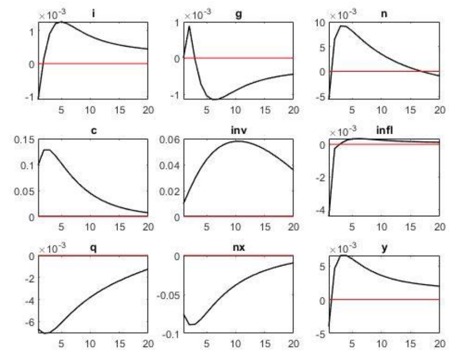
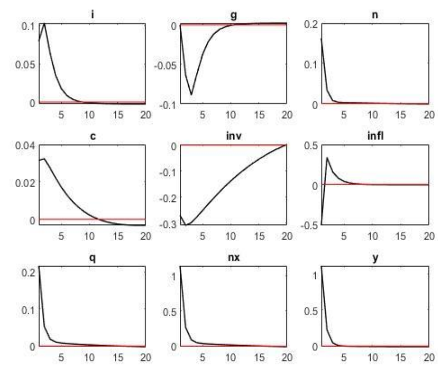


(b)

Figure 4: Consumption preference shock (a) $\omega = 0$ price flexibility and (b) $\omega = 1$ price



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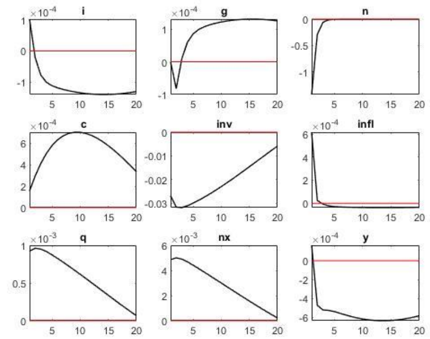
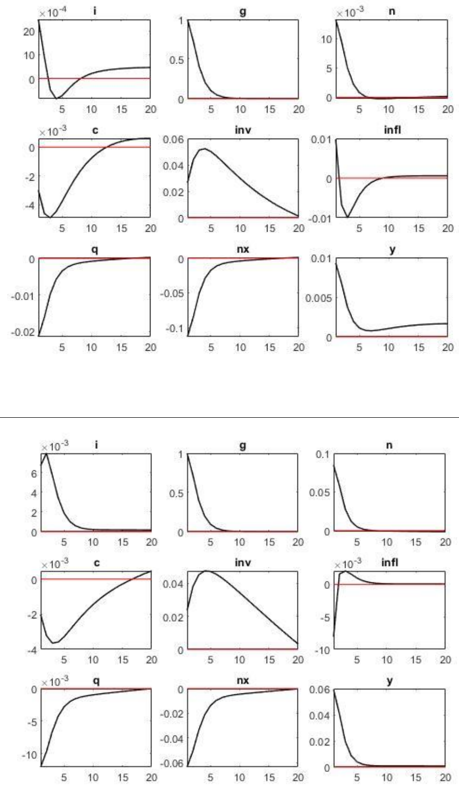


(b)

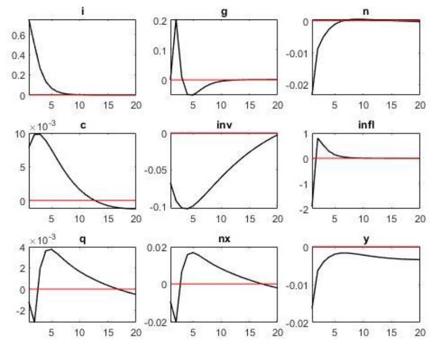
Figure 5: Technology shock (a) $\omega = 0$ price flexibility and (b) $\omega = 1$ price friction



(a)

(b)

Figure 6: Fiscal policy shock (a) $\omega = 0$ price flexibility and (b) $\omega = 1$ price friction



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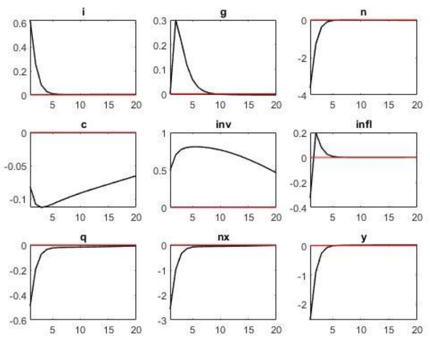
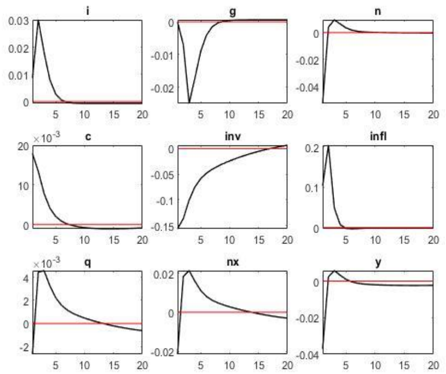
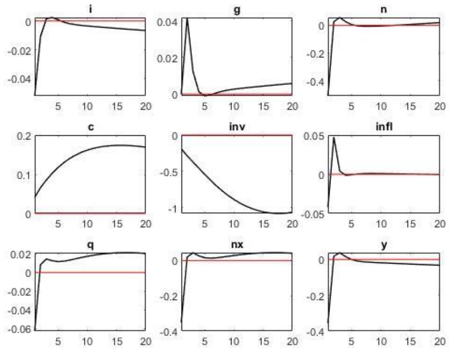


(b)

Figure 7: Monetary policy shock (a) $\omega = 0$ price flexibility and (b) $\omega = 1$ price friction

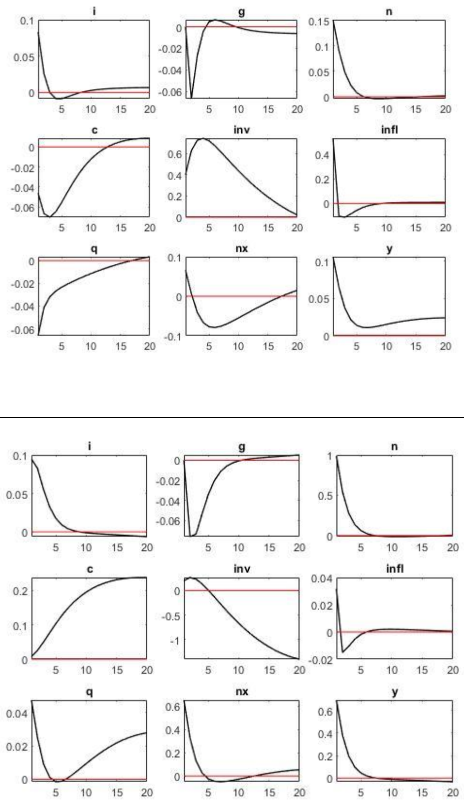


(a)



(b)

Figure 8: Foreign inflation shock(a) $\omega = 0$ price flexibility and (b) $\omega = 1$ price friction



(a)

(b)

Figure 9: Foreign income shock (a) $\omega = 0$ price flexibility and (b) $\omega = 1$ price friction

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