The Shock Reactions in the Closed Digital Economy

ADIREK VAJRAPATKUL, ATHAKRIT THEPMONGKOL
School of Development Economics
National Institute of Development Administration
148 Serithai Road, Klong-Chan, Bangkapi, Bangkok 10240
THAILAND

Abstract: - Economic variability can affect economic agents' risk perception and behavior, which in turn affects negatively economic activities and prosperity. The government, therefore, tries to raise their confidence by designing proper policies to stabilize the economy. To learn the effects of the policies, several models are utilized, and the Dynamic Stochastic General Equilibrium (DSGE) model is recognized as a potential choice for discovering such effects. Also, this work applies the DSGE model to extend its application and contributes to this research area in terms of model construction technique by learning the policy effects in the Thai context through the closed economy models. In this study, Thailand's quarterly detrended data from 2001:Q1 to 2019:Q2 and the Bayesian estimation method were used. The results showed that the positive effect of technological evolution on economic growth occurred in both economies, but the effect in the two-sector economy was less than what occurred in the one-sector economy. Additionally, it was demonstrated that monetary policy was more effective than fiscal policy. Hence, the recommendations were that policy designers had to design policies to improve technology in all sectors simultaneously, and the fiscal authority had to recognize the effect of the number of related agents on the effectiveness of its policies. Also, the monetary authority had to design a boundary for interest rate volatility to stabilize the economy.

Key-Words: - Business cycle, DSGE, Bayesian estimation, Digital economy, Technology shock, Thailand

Received: July 25, 2021. Revised: February 27, 2022. Accepted: March 13, 2022. Published: March 24, 2022.

1 Introduction

The risks emerging from an unpredictable economic situation can affect the decisions of related agents within the economy. When those agents, such as consumers, producers, and investors, are unsure about the future, they often delay or change their actions, which can have a negative impact on economic activities and transactions as well as economic growth. To instill confidence in these agents, the government attempts to establish policies that promote economic unpredictability within an acceptable range. For these purposes, the effects of two major types of policies, namely fiscal and monetary policy, on the economy are thoroughly investigated. To understand the potential effects of those policies, economists have utilized several econometric methods and models to investigate the reactions of the target macroeconomic variables to such policies. Dynamic Stochastic General Equilibrium (DSGE) is a candidate that is often used to meet that objective. This model has been recognized as a useful tool because it enables analysts to work with various assumptions in the analysis. Although this model is primarily used to analyze the economic consequences of monetary policy, fiscal policy, and technological advancement, it has been extended to examine the economic implications of numerous anomalous phenomena, such as preferences and risks [1, 2].

Concerning monetary policy's effects on the economy, earlier research established that certain macroeconomic indicators, e.g., the marginal cost [3], work hours, investment [4, 5], consumption, inflation, and output [6 - 8], reacted unfavorably to a positive monetary policy shock. However, it has been recognized that there are many factors that can influence the pattern of reactions [9]. Also, when the analysts change their model assumptions, some variables may react in the reversed direction. Fiscal policy is likewise inconclusive in terms of the implications of a government expenditure shock on the economy [10], i.e., it may produce crowding-in, crowding-out, or a neutral outcome, which depends on how the government finances its spending [11]. For technological evolution, it is a critical variable in explaining economic growth because it has the potential to affect productivity improvement. In recent years, it has been asserted that technological evolution is responsible for changes in production and consumption patterns [12]. It is referred to as "disruptive technology" in the so-called "digital economy" [13]. The importance of technology and the digital economy in economic growth and volatility is discussed in detail in the works of, for example, [14–18]. In terms of technological evolution's effects, it has been discovered that advancement can enhance employment and output while simultaneously lowering prices and interest rates [19]. What is learned from the preceding discussion is valuable, particularly for government officials, as they can utilize it to make policy decisions that will help stabilize the economy. As stated previously, the pattern of reaction might change depending on the model specification, assumptions, and context of analysis; hence, model modification and assumptions that are appropriate for a particular context, i.e., time and location, become critical.

The importance of economic stability and the volatility caused by numerous shocks motivate this effort. This study use a dynamic stochastic general equilibrium model and Bayesian estimate techniques to examine the impact of shocks on the Thai economy in a closed economy context in order to identify appropriate policies to promote stability and growth. In the process of investigating the results, two models are constructed, i.e., a one-sector model and a two-sector model, which separate the digital sector from the non-digital ones, and then the results are compared to highlight the dynamic properties of the economy when it is integrated by digital production activity. This effort is organized in the following manner. The following section will describe how the models are constructed. Section 3 will summarize the findings and make policy recommendations.

2 Problem Formulation

2.1 Model Construction

In the following, how the models are constructed will be explained, and the details are as follows.

Let's begin with a one-sector model that acts as the baseline model for comparison. In this model, the representative household is supposed to maximize its lifetime utility by consuming at the optimal amount and working the optimal number of hours. Their utility [20] is represented by the following function:

$$E_t \sum_{t=0}^{\infty} \beta^t \left(A_{C,t} \frac{(C_t)^{1-\theta}}{1-\theta} - \frac{N_t^{1+\varphi}}{1+\varphi} \right), \tag{1}$$

where the constant β, θ, and φ, respectively, represent the intertemporal discount factor, the inverse elasticity of consumption, and the inverse elasticity of labor supply. C_t and N_t stand for consumption and working hours. A_{Ct} denotes consumption evolution that takes into account anomaly changes in consumption [21] which is evolved according to a first-order autoregressive process. The constraint of household's budget is represented by:

$$\begin{aligned}&(1-\tau_N)W_t N_t + (1-\tau_K) R_{K,t} K_{t-1} + R_{t-1} B_{t-1} \\ &= (1+\tau_C) P_t (C_t + I_t) + B_t\end{aligned}, \tag{2}$$

where the constant τ_N, τ_K, and τ_C are , respectively, labor tax, capital tax, and consumption tax. The variables K_t, B_t, and I_t are capital, riskless one-period bonds, and investment, respectively. W_t, $R_{K,t}$, R_t, and P_t stand for, respectively, wage, capital rental rate, policy rate, and general price index. The capital is assumed to be evolved according to the following law:

$$K_t = (1-\zeta) K_{t-1} + I_t \ , \tag{3}$$

where ζ is capital depreciation rate.

For the representative firm, it is assumed to process its final output by using Cobb-Douglas technology which represented by:

$$Y_t = A_{T,t} K_{t-1}^{\alpha} N_t^{1-\alpha}, \tag{4}$$

where α is the share of capital in the production and $A_{T,t}$ is a technology evolution which is also assumed to followed a first-order autoregressive process.

The rules that government authority impose in the economy include fiscal and monetary rules [22 - 23]are represented respectively as follows.

$$\frac{R_t}{R_{SS}} = \left(\frac{R_{t-1}}{R_{SS}}\right)^{\zeta_R} \left(\frac{Y_{t-1}}{Y_{SS}} \frac{P_{t-1}}{P_{SS}}\right)^{(1-\zeta_R)\kappa_R} A_{M,t} \ , \tag{5}$$

$$\frac{G_t}{G_{SS}} = \left(\frac{G_{t-1}}{G_{SS}}\right)^{\zeta_G} \left(\frac{Y_{SS}}{Y_{t-1}} \frac{B_{t-1}}{B_{SS}}\right)^{(1-\zeta_G)\kappa_G} A_{G,t} \,. \tag{6}$$

where $A_{G,t}$ and $A_{M,t}$ denote fiscal and monetary policy evolutions which also follows the first-order autoregressive process. The government budget constraint is defined by:

$$\tau_C P_t(C_t+I_t)+\tau_K R_{K,t}K_t+\tau_N W_t N_t+B_t=P_t G_t+R_{t-1}B_{t-1}, \quad (7)$$

Finally, the market clearing condition can be expressed by $Y_t=C_t+G_t+I_t$.

By following the regular process, we get the following key log-linear equations.

$$\tilde{W}_t=\theta\tilde{C}_t+\varphi\tilde{N}_t-\tilde{A}_{C,t}+\tilde{P}_t, \quad (8)$$

$$1+\beta(\zeta-1)\tilde{R}_{K,t+1}=(\zeta-1)\beta P_{t+1}+\tilde{P}_{t+1} +\theta(\tilde{C}_{t+1}-\tilde{C}_t)+\tilde{A}_{C,t}-\tilde{A}_{C,t+1}, \quad (9)$$

$$\theta(\tilde{C}_{t+1}-\tilde{C}_t)=\tilde{A}_{C,t+1}-\tilde{A}_{C,t}+\tilde{P}_t-\tilde{P}_{t+1}+\tilde{R}_t, \quad (10)$$

$$\tilde{W}_t+\tilde{N}_t=\tilde{P}_t+\tilde{Y}_t, \quad (11)$$

$$\tilde{R}_{K,t}+\tilde{K}_{t-1}=\tilde{P}_t+\tilde{Y}_t, \quad (12)$$

$$\tilde{P}_t=(1-\alpha)\tilde{W}_t-\alpha\tilde{A}_{T,t}+\alpha\tilde{R}_{K,t}, \quad (13)$$

$$\tilde{G}_t=\zeta_G\tilde{G}_{t-1}-\kappa_G(1-\zeta_G)(\tilde{Y}_{t-1}+B_{t-1})+\tilde{A}_{G,t}, \quad (14)$$

$$\tilde{R}_t=\zeta_R\tilde{R}_{t-1}+\kappa_R(1-\zeta_R)(\tilde{P}_{t-1}+\tilde{Y}_{t-1})+\tilde{A}_{R,t}. \quad (15)$$

In a two-sector model, the representative household's utility function is identical to that in a one-sector economy. However let define:

$$N_t=\left(\left(N_{N,t}\right)^{1+\vartheta}+\left(N_{D,t}\right)^{1+\vartheta}\right)^{\frac{1}{1+\vartheta}}, \quad (16)$$

where $\vartheta>0$ controls the willingness of households to substitute labour between sectors. $N_{N,t}$ and $N_{D,t}$ are the working hours in non-digital and digital sector, respectively. The household's budget constraint as follow:

$$(1-\tau_N)\sum_{i=N,D}W_{i,t}N_{i,t}+(1-\tau_K)\sum_{i=N,D}R_{Ki,t}K_{i,t-1} +R_{t-1}B_{t-1}=(1+\tau_C)P_t\left(C_t+\sum_{i=N,D}I_{i,t}\right)+B_t, \quad (17)$$

As N denoted the non-digital sector and D is for the digital sector, the further variables augmented by these letters will be assigned to such sectors accordingly, e.g., P is the aggregated price, P_N is the non-digital product's price, and P_D is the digital product's price.

In this model firm is separated into two groups, i.e., non-digital and digital firms, with the following explanations.

The representative non-digital firm uses the Cobb-Douglas technology of the form:

$$Y_{N,t}=A_{TN,t}K_{N,t-1}^{\alpha_N}N_{N,t}^{1-\alpha_N}, \quad (18)$$

where $A_{TN,t}$ is a technological evolution in non-digital sector which usually assumed to follow a first-order autoregressive process.

Also the representative digital firm uses the same technology and hence its production function is expressed by:

$$Y_{D,t}=A_{TD,t}K_{D,t-1}^{\alpha_D}N_{D,t}^{1-\alpha_D}, \quad (19)$$

For the final good firm, it assembles the outputs by using the following production function:

$$Y_t=\left(\varpi^{\frac{1}{\eta}}Y_{N,t}^{\frac{\eta-1}{\eta}}+(1-\varpi)^{\frac{1}{\eta}}Y_{D,t}^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}}, \quad (20)$$

where ϖ is the share of non-digital input in the production of the final good and η is the intratemporal elasticity of substitution between the non-digital and digital good.

Similarly, this model assumes the role of fiscal and monetary authority as the same in the one-sector model. However the market clearing condition is defined by $Y_t=C_t+I_{N,t}+I_{D,t}+G_t$.

The key log-linear form of the two-sector model can be written as follows.

$$\tilde{W}_{N,t}+\vartheta\tilde{N}_t+\tilde{A}_{C,t}=\theta\tilde{C}_t+\vartheta\tilde{N}_{N,t}+\varphi\tilde{N}_t+\tilde{P}_t, \quad (21)$$

$$\tilde{W}_{D,t}+\vartheta\tilde{N}_t+\tilde{A}_{C,t}=\theta\tilde{C}_t+\vartheta\tilde{N}_{D,t}+\varphi\tilde{N}_t+\tilde{P}_t, \quad (22)$$

$$(1+\beta(\zeta-1))\tilde{R}_{KN,t+1}=(\zeta-1)\beta\tilde{P}_{t+1}+\tilde{P}_{t+1} +\theta(\tilde{C}_{t+1}-\tilde{C}_t)+\tilde{A}_{C,t}-\tilde{A}_{C,t+1}, \quad (23)$$

$$(1+\beta(\zeta-1))\tilde{R}_{KD,t+1}=(\zeta-1)\beta\tilde{P}_{t+1}+\tilde{P}_{t+1} +\theta(\tilde{C}_{t+1}-\tilde{C}_t)+\tilde{A}_{C,t}-\tilde{A}_{C,t+1}, \quad (24)$$

$$\tilde{W}_{N,t}+\tilde{N}_{N,t}=\tilde{P}_{N,t}+\tilde{Y}_{N,t}, \quad (25)$$

$$\tilde{W}_{D,t}+\tilde{N}_{D,t}=\tilde{P}_{D,t}+\tilde{Y}_{D,t}, \quad (26)$$

$$\tilde{R}_{KN,t}+\tilde{K}_{N,t-1}=\tilde{P}_{N,t}+\tilde{Y}_{N,t}, \quad (27)$$

$$\tilde{R}_{KD,t}+\tilde{K}_{D,t-1}=\tilde{P}_{D,t}+\tilde{Y}_{D,t}, \quad (28)$$

$$\tilde{P}_{N,t}=(1-\alpha_N)\tilde{W}_{N,t}-\alpha_N\tilde{A}_{TN,t}+\alpha_N\tilde{R}_{KN,t}, \quad (29)$$

$$\tilde{P}_{D,t}=(1-\alpha_D)\tilde{W}_{D,t}-\alpha_D\tilde{A}_{TD,t}+\alpha_D\tilde{R}_{KD,t}, \quad (30)$$

$$\tilde{Y}_{N,t}=\eta\tilde{P}_t-\eta\tilde{P}_{N,t}+\tilde{Y}_t, \quad (31)$$

$$\tilde{Y}_{D,t}=\eta\tilde{P}_t-\eta\tilde{P}_{D,t}+\tilde{Y}_t, \quad (32)$$

$$\tilde{P}_t=\frac{\varpi\tilde{P}_{N,t}P_{Nss}^{1-\eta}-\tilde{P}_{D,t}P_{Dss}^{1-\eta}\varpi+\tilde{P}_{D,t}P_{Dss}^{1-\eta}}{\varpi P_{Nss}^{1-\eta}-\varpi P_{Dss}^{1-\eta}+P_{Dss}^{1-\eta}}, \quad (33)$$

The Bayesian estimation technique is then used to estimate the models using Thailand's quarterly data acquired from the World Bank database. These data included three detrended series [24]: GDP, policy rate, and employment, which covered the period 2001:Q1 to 2019:Q2.

2.2 Estimation Technique

This section will highlight the methods used for determining parameters and the basic idea behind Bayesian estimation. For the method of determining the parameters, it could be separated into two main groups of approaches [25]. In the first approach, a DSGE model duplicates the world in a certain set of dimensions using a calibration procedure that assigns values to parameters based on data from past research and scholarly knowledge. Another technique in this approach is the Generalised Method of Moments (GMM), which involves the selection of parameters for a specific equilibrium. In contrast, the second approach attempts to obtain an estimation that provides a full characteristic of the observed data. This category includes two methods: classical and Bayesian maximum likelihood estimation (MLE). These techniques are based on the likelihood function, which represents the chance of observing a particular dataset as a function of the model's parameters. This likelihood can be computed for various parameter combinations in order to make the data set "more likely". Parameter estimations are obtained directly from this method in classical MLE. However, in Bayesian MLE, an additional function, namely the prior function, is considered before observing the data. The prior is then mixed with the likelihood, and the resulting function can be maximized in terms of the parameters until the objective function is maximized. With the whole information provided by the Bayesian MLE technique, it is possible to characterize the data production process more consistently. Another significant advantage of Bayesian approaches is that they generate probability distributions for model parameters, IRFs, and forecasts, etc., and so explicitly quantify the uncertainty associated with model-based analysis and forecasting. Basically, Bayesian estimation is a technique that combines calibration with maximum likelihood estimation. The model is calibrated by specifying priors, whereas the maximum likelihood is derived from the data. These priors and the likelihood function are linked according to the Bayes rule. The first step in applying Bayesian MLE is to determine the likelihood function that corresponds to the joint density of all variables in the data sample, depending on the model's structure and parameters. The following step is to specify the prior distributions. Each prior is a probability density function for a parameter, providing a formal manner of expressing the probabilities associated with the values that parameters can adopt based on previous research. It is a representation of belief within the model's context, set independently of the data and serving as an additional source of information. After deriving the likelihood and specifying the priors, the posterior distribution is computed, which indicates the probability given to various parameter values after observing the data. It is essentially an update of the prior probability based on the additional information provided by the sample variables. Consider this concept further by applying the Bayes theorem to the following two random events [26, 27].

Let $P(\theta)$ is the probability of θ, $P(\theta/Y)$ is the conditional probability, and $P(Y)$ is the marginal probability. Also, define the joint probability of obtaining such θ on data Y by $P(\theta \cap Y) = P(\theta/Y)P(Y)$ and vice versa. Hence we have:

$$P(\theta/Y) = \frac{P(Y/\theta)P(\theta)}{P(Y)}, \qquad (34)$$

where $P(\theta)$ and $P(\theta/Y)$ are, respectively, the prior and the posterior distribution of θ, given the observed data Y. $P(Y/\theta)$ is the density of the data that is conditional on the parameters (the likelihood). Note that $P(Y)$ does not depend on θ and therefore can be treated as a constant for the estimation, producing:

$$P(\theta/Y) \propto P(Y/\theta)P(\theta) \equiv \mathrm{K}(\theta/Y), \qquad (35)$$

where $\propto$ denotes proportional to. $\mathrm{K}(\theta/Y)$ is the posterior kernel. Using this fundamental equation, it is possible to acquire all the posteriors of interest. In order to obtain the likelihood, one must use the Kalman Filter and then simulate the posterior kernel by a Monte Carlo method with the help of Matlab and a toolbox called Dynare.

3 Problem Solution

To perform the estimation by using the Bayesian estimation technique, the first step is to set particular values of parameters [28, 29] as shown in Table 1.

Table 1. Predefined parameters

Parameters	Value
α	0.300
θ	3.200
φ	2.000
β	0.997
ζ_G	0.950
κ_G	0.100
γ	0.900

Then the rest of the parameters will be estimated based on the available information of priors obtained from previous studies and the results from the one-sector economy are shown in Table 2

Table 2. One-sector estimated parameters.

Par.	Prior		Posterior		
	Distr.	Mean	Mean	HPD inf	HPD sup
ζ	gamma	0.050	0.057	0.039	0.069
ζ_M	gamma	0.510	0.789	0.718	0.862
κ_R	gamma	0.280	0.274	0.184	0.367
ρAT	beta	0.500	0.335	0.212	0.485
ρAC	beta	0.500	0.487	0.190	0.822
ρAG	beta	0.500	0.953	0.919	0.987
ρAM	beta	0.500	0.632	0.522	0.749

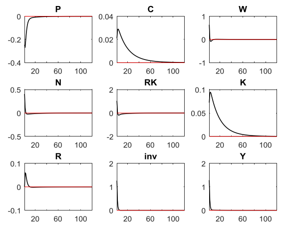
Source: Authors' calculation

For the reactions of economic variables to shocks in the one-sector economy, they are presented in Fig. 1. In the case of the two-sector economy, the results are presented in Table 3 and Fig. 2 to Fig. 5.

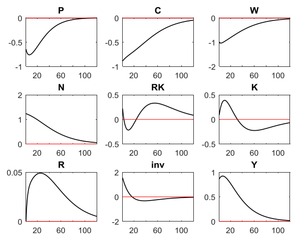
Table 3. Two-sector estimated parameters.

Par.	Prior		Posterior		
	Distr.	Mean	Mean	HPD inf	HPD sup
ϑ	gamma	1.000	1.007	0.935	1.115
ζ	gamma	0.050	0.060	0.049	0.071
η	gamma	2.000	2.160	1.972	2.353
ϖ	gamma	0.500	0.569	0.453	0.700
ζ_G	gamma	0.510	0.763	0.675	0.845
κ_R	gamma	0.280	0.208	0.156	0.262
ρATN	beta	0.500	0.288	0.117	0.417
ρATD	beta	0.500	0.519	0.170	0.849
ρAC	beta	0.500	0.493	0.192	0.817
ρAG	beta	0.500	0.974	0.966	0.982
ρAM	beta	0.500	0.704	0.577	0.825

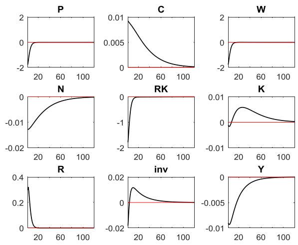
Source: Authors' calculation



(a)



(b)



(c)

Fig. 1: Reactions in the one-sector economy: (a) Tech. shock, (b) Gov. shock, (c) Mon. shock
Source: Authors' presentation

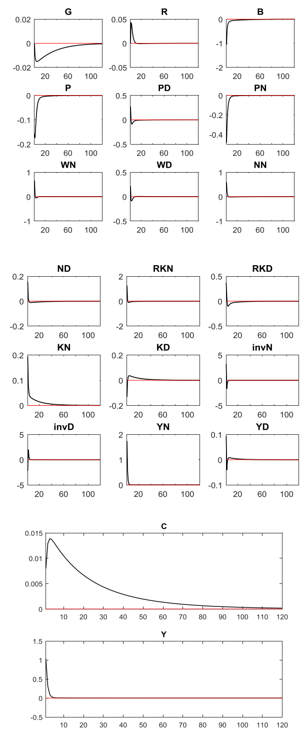


Fig. 2: Reactions to Tech. shock in non-digital sector
Source: Authors' presentation

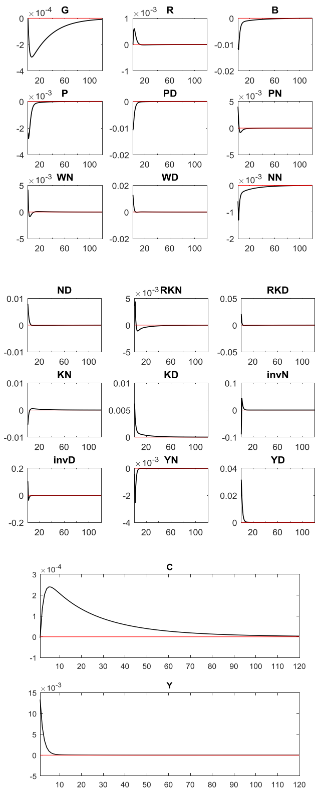


Fig. 3: Reactions to Tech. shock in digital sector.
Source: Authors' presentation

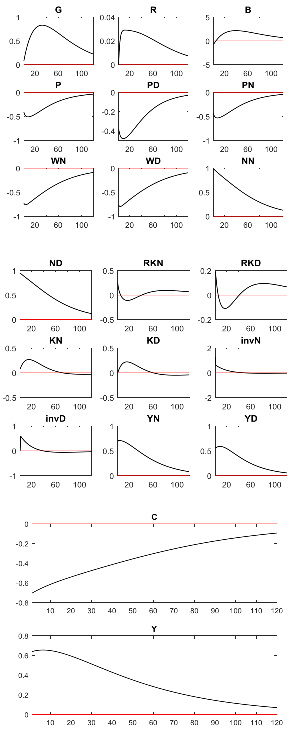


Fig. 4: Reactions to Gov. shock in two sector economy.
Source: Authors' presentation

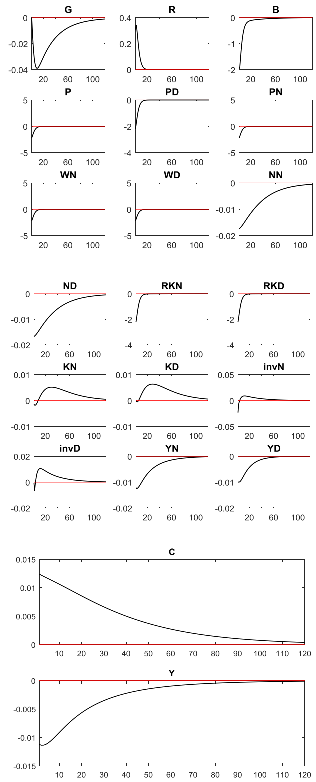


Fig. 5: Reactions to Mon. shock in two sector economy.
Source: Authors' presentation

Three shocks that are frequently mentioned in DSGE analysis will be explored in the following, namely the technology shock, the government spending shock, and the monetary policy shock.

Let's begin with the results obtained from a one-sector economy. According to Fig. 1(a), which represents the reactions to the technology shock, it is discovered that when there is an improvement in technology, there is an increase in demand for inputs of production, i.e., demand for labor and capital, and investment. The price of these inputs, i.e., wages and capital rental rates, has also increased. However, the fall in the cost of production caused by technological progress supports the reduction of the aggregated price. The increase in demand for labor and capital, as well as wage and capital rental rates, supports the rise in output, income, and consumption, which in turn encourages national income. To stabilize the economy, the central bank raised the interest rate. Fig. 1(b), which presents the reactions to a government spending shock, shows that when the government increases its spending, it incurs an increase in demand for labor and capital as well as investment. Although wages are decreased, the capital rental rate is increased. An increase in this spending suppresses the aggregated price. Although there is an increase in demand for labor, demand for capital, and capital rental rates, consumption has decreased. It is possible that the increase in government spending and investment will overcome the decrease in consumption, thereby increasing national income. This situation may be interpreted as a crowding-out effect, as the increase in government spending causes a reduction in private consumption and investment thereafter. Regarding Fig. 1(c), which presents the reactions to a monetary policy shock, it shows that when the central bank raises the interest rate, there is a decrease in demand for labor and capital as well as investment. Also, wages and capital rental rates have decreased. An increase in interest rates suppresses the aggregated price, which in turn encourages consumption. As labor and capital demands, capital rental rates, and wages are decreased, national income is also decreased.

The results obtained from the two-sector economy will now be discussed. According to Fig. 2, which represents the effects of a technology shock in the non-digital sector, it is discovered that when there is an improvement in technology in this sector, there is an increase in demand for non-digital and digital labor, non-digital capital, as well as non-digital investment. Also, non-digital and digital wages, as well as non-digital and digital capital rental rates, are increased. However, the fall in the cost of production in the non-digital sector caused by technological progress supports the reduction of the non-digital price and the aggregated price. The increase in demand for labor and capital, along with wage and capital rental rates, supports the rise in output, income, and consumption, and hence national income. To stabilize the economy, the central bank raised the interest rate. In Fig. 3, which represents the effects of a technology shock on the digital sector, it is discovered that when there is an improvement in technology in this sector, there is an increase in demand only for digital labor and digital capital. But both non-digital and digital investments have increased. Also, non-digital and digital wages, as well as non-digital and digital capital rental rates, are increased. However, the fall in the cost of production in the digital sector caused by technological progress supports the reduction of the digital price and the aggregated price. The increase in demand for labor and capital, as well as wage and capital rental rates, supports the rise in output, income, and consumption, and hence national income. To stabilize the economy, the central bank raised the interest rate. Figure 4, which depicts the reactions to a government spending shock, shows that when the government increases its spending, demand for both non-digital and digital labor rises, as does demand for capital and investment. Here, the wage is decreased but the capital rental rate is increased. An increase in this spending makes the aggregated price decline. Although there is an increase in demand for labor and the capital rental rate, consumption has decreased. It is possible that the effect of an increase in government spending and investment will overcome the decrease in consumption, thereby increasing national income. To stabilize the economy, the central bank raised the interest rate. Referring to Fig. 6, which represents the reactions to a monetary policy shock, it shows that when the central bank increases the interest rate, there is a decrease in demand for both non-digital and digital labor, investment in both non-digital and digital sectors, and a slight decrease in capital in both non-digital and digital sectors. In this case, both the wage rate and the capital rental rate are decreased. An increase in interest rates makes the aggregate price decline, which in turn encourages domestic consumption. However, it is possible that the increase in aggregated consumption is overcome by the decline in returns from inputs, investment, and government spending, and hence national income is decreased.

The implications of these findings are as follows. In the case of the technology shock, when comparing the results obtained from a one-sector economy and a two-sector economy, it is found that although the reaction of each variable is in the same direction, some variables, i.e., aggregate price, aggregate consumption, and national income, are less sensitive to partial shocks from each sector, i.e., in a two-sector economy, aggregate price decreases more and aggregate consumption, as well as national income, increase less than in a one-sector economy. When comparing between non-digital and digital sectors, it is found that the effect of a technology shock in the non-digital sector on national income is larger. This is because the proportion of non-digital output in the final goods is larger than the digital ones. Hence, it reflects that the effect of digital goods on economic growth depends on how much it is integrated into the final goods. In the case of the government spending shock, when comparing results obtained from a one-sector economy and a two-sector economy, it is found that some variables react in the same direction, but all of them in the two-sector economy are less volatile to this shock, i.e., the aggregated price and aggregated consumption are less decreased, while national income is more increased than what happens in the one-sector economy. Therefore, it can be concluded that the positive effect of government spending on economic growth is smaller in the two-sector economy, i.e., this policy is less effective when the number of sectors is increased in the economy. For monetary policy shock, when comparing results obtained from a one-sector economy and a two-sector economy, it is discovered that some variables react in the same direction but become more volatile, i.e., the aggregated price and national income decrease more, while aggregated consumption increases more than what happens in the one-sector economy. Therefore, it can be concluded that the negative effect of monetary policy contraction on economic growth is larger in a two-sector economy, i.e., this policy is more effective when the number of sectors is increased in an economy.

Therefore, the interpretation of these discoveries is that in the two-sector economy, technology development in a particular sector can produce a partially positive effect on economic growth. This effect is, however, less than what happens when the overall technology in one sector is improved. Thus, a valuable strategy is to encourage technology development in all sectors, instead of focusing on a particular sector. In the case of policies for stabilizing the economy, monetary policy is perceived as an effective tool for governments.

The recommendations based on the results of the analysis include: 1) the policy designers should take into consideration the importance and benefits of technology development in all sectors for economic growth, i.e., only paying attention to technology development in a particular sector will produce less benefit than supporting all technology development in all sectors; 2) the fiscal authority should be aware of how to allocate its budget as when there is an increase in the number of economic agents, the effectiveness of this policy declines; and 3) the monetary authority should define an appropriate boundary of interest rate volatility as it can effectively impact on economic growth and hence stability.

4 Conclusion

Unpredictable economic situations can create risk and affect the decisions of economic agents within the economy. They intend to delay or change their actions when they feel less confident in the economy. This situation can have a potentially negative effect on economic activity and prosperity. Hence, to raise their confidence, the government tries to design policies to stabilize the economy. Here, two major types of policy, i.e., fiscal policy and monetary policy, with the application of some economic models, are utilized to meet that objective. To learn the effects of these policies on the variability of the economy, the DSGE model is often employed for this purpose. Also, this work tries to apply this model to understand such a situation by using two models of the closed economy, i.e., one-sector and two-sector models, and comparing their results. The analysis is conducted by using the quarterly detrended data of Thailand, 2001:Q1 to 2019:Q2, and the Bayesian estimation technique. The results show that although the positive effect of technology evolution on economic growth occurs in both economies, the effect in a two-sector economy is less than what occurred in a one-sector economy. In the case of policies for stabilizing the economy, monetary policy is perceived as an effective tool for governments. Hence, this work recommends that policy designers should place an importance on improving technology in all sectors. While fiscal authority should allocate its budget by considering the number of related agents within the economy. Also, the monetary authority should define an appropriate boundary for interest rate volatility to stabilize the economy.

Acknowledgement:
This research is supported by the School of Development Economics, National Institute of Development Administration, Thailand.

References:

[1] M. Adolfson, S. Laséen, J. Lindé, and M. Villani, Bayesian Estimation of An Open Economy DSGE Model with Incomplete Pass-Through, *J. Int. Econ*., Vol. 72, No. 2, 2007, pp. 481–511.

[2] F. Breuss and K. Rabitsch, An Estimated Two-Country DSGE Model of Austria And The Euro Area, *Empirica*, Vol. 36, No. 1, 2009, pp. 123–158.

[3] M. Rubio and S. Schuh, Monetary Policy And The Role of Inventory Investment, *Appl. Econ. Lett.*, Vol. 24, No. 21, 2017, pp. 1605–1612.

[4] S. Mouabbi and J. Sahuc, Evaluating The Macroeconomic Effects of The ECB's Unconventional Monetary Policies, *J. Money Credit Bank.*, Vol. 51, No. 4, 2019, pp. 831–858.

[5] R. Wang, Unconventional Monetary Policy in Japan: Empirical Evidence from Estimated

Shadow Rate DSGE Model, *J. Int. Commer. Econ. Policy*, Vol. 10, No. 02, 2019, pp. 1-29.

[6] G.-A. Ionita, Monetary Policy in A DSGE New Keyesian Model–Case Study for Romania, *Acta Univ. Danub. Econ.*, Vol. 13, No. 1, 2017, pp. 5–16.

[7] W. E. Melesse, Business Cycles in Ethiopia Under Alternative Monetary Policy Rules, *Afr. J. Econ. Manag. Stud*., Vol. 10, No. 3, 2019, pp. 299-313.

[8] A. Goyal and A. Kumar, A DSGE Model-Based Analysis of The Indian Slowdown, *J. Int. Commer. Econ. Policy*, Vol. 11, No. 01, 2020, pp. 1-57.

[9] B. Perry, K. Phillips, and D. E. Spencer, Real Wages and Monetary Policy: A DSGE Approach, *Journal of Economic Studies*, Vol. 42, No 5, 2015, pp. 734-752.

[10] A. Nandi, Indian Fiscal Policy: A DSGE Primer, *J. Dev. Areas*, Vol. 54, No. 2, pp. 179-200, 2020.

[11] C. Jooste and R. Naraidoo, The Macroeconomics Effects of Government Spending Under Fiscal Foresight, *South Afr. J. Econ*., Vol. 85, No. 1, 2017, pp. 68–85.

[12] N. Ahmad and J. Ribarsky, Towards A Framework for Measuring The Digital Economy, *presented at the 16th Conference of the International Association of Official Statisticians*, 2018, pp. 1-33.

[13] P. Schreyer and I. Mexico, Measuring GDP in a Digitalised Economy, *Paris*, *OECD Conference Centre*, 2016, pp. 1-24.

[14] M. Afonasova, E. Panfilova, and M. Galichkina, Social and economic background of digital economy: conditions for transition, *European Research Studies Journal*, Vol. XXI, Special Issue 3, 2018, pp. 292-302.

[15] K. B. Murthy, A. Kalsie, and R. Shankar, Digital Economy In A Global Perspective: Is There A Digital Divide?, *Transnatl. Corp. Rev.*, Vol. 13, No. 1, 2021, pp. 1–15.

[16] S. Abendin and P. Duan, International Trade and Economic Growth in Africa: The Role of The Digital Economy, *Cogent Econ. Finance*, Vol. 9, No. 1, 2021, pp. 1-25.

[17] I. Irtyshcheva et al., The Effect Of Digital Technology Development on Economic Growth, *Int. J. Data Netw. Sci.* , 2021, Vol. 5, No. 1, pp. 25–36.

[18] X. Jiang, X. Wang, J. Ren, and Z. Xie, The Nexus Between Digital Finance and Economic Development: Evidence from China, *Sustainability*, 2021, Vol. 13, No. 13, pp. 2-17.

[19] I. W. Bache, L. Brubakk, and J. Maith, Simple Rules Versus Optimal Policy: What Fits?, *fra Norges Bank Working papers* , 2010, pp. 1-34.

[20] J. Jääskelä and R. McKibbin, Learning in An Estimated Small Open Economy Model. *Economic Group, Reserve Bank of Australia*, 2009, pp. 1-46.

[21] M. H. Alp and S. Elekdag, Shock Therapy! What Role for Thai Monetary Policy?, *IMF Working Paper*, 2012, pp.1-48.

[22] Y. Iwata, Fiscal Policy in an Estimated DSGE Model of the Japanese Economy: Do Non-Ricardian Households Explain All?, *Economic and Social Research Institute, Cabinet Office* , 2009, pp. 1-64.

[23] K. Bhattarai and D. Trzeciakiewicz, Macroeconomic Impacts of Fiscal Policy Shocks in The UK: A DSGE Analysis, *Econ. Model*., 2017, Vol. 61, pp. 321–338.

[24] S. Xiaojin and T. K. Ping, What Cycles? Data Detrending in DSGE Models, *Studies in Nonlinear Dynamics & Econometrics*, 2019, Vol. 23, No. 3, pp. 1-23.

[25] V. Almeida, Bayesian Estimation of A DSGE Model for The Portuguese Economy, *Estud. E Doc. Trab. Work. Pap*., 2009, pp. 1–65.

[26] A. Carriero, T. E. Clark, and M. Marcellino, Bayesian VAR: Specification Choices And Forecast Accuracy, *J. Appl. Econom*., 2015, Vol. 30, No. 1, pp. 46–73.

[27] C. Lidiema, A. G. Waititu, and A. Ngunyi, Forecasting Household Credit in Kenya Using Bayesian Vector Autoregressive (BVAR) Model, *Am. J. Appl. Math. Stat*., Vol. 6, No. 1, 2018, pp. 17–24.

[28] S. Tanboon, The Bank of Thailand Structural Model for Policy Analysis, *Bank of Thailand. Work. Paper*, 2008, pp. 1–41.

[29] K. Phrommin, Monetary Policy Analysis Under Headline and Core Inflation Targeting In Thailand, *Thailand and The World Economy*, 2018, Vol. 36, No. 2, pp. 1–31.

Author Contributions:
Adirek Vajrapatkul carried out the simulation and discussion on the result.
Athakrit Thepmongkol organized and executed the literature review and experiments.

Sources of funding:
School of Development Economics, National Institute of Development Administration, Thailand.