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PANDEMIC SHOCKS AND MACRO-FINANCIAL POLICY RESPONSES: AN ESTIMATED DSGE-VAR MODEL FOR INDONESIA

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ABSTRACT

This paper attempts to investigate the impact of policy mix in dealing with the COVID-19 pandemic. We employ the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) framework and the Del Negro *et al.* (2007) approach to estimate the model. We investigate the effectiveness of policy mix in Indonesia by taking into account real and financial linkages, as well as other market imperfections. We intend to analyze and evaluate the adequacy of monetary, fiscal, and macroprudential policy by simulating each policy option using Indonesian-specific factors and comparing them. Our findings show that policy mix has a greater impact on accelerating economic recovery but does not necessarily lead to anchor inflation.

Keywords: Financial frictions; Policy mix; General equilibrium.
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I. INTRODUCTION

This paper attempts to investigate the impact of policy mix in dealing with the COVID-19 pandemic. This has become necessary given that the COVID-19 pandemic has generated unprecedented shocks not only on the demand but also on the supply side (Cantu *et al.*, 2021) that could potentially change our understanding regarding policy responses forever. Throughout the world, the governments have taken steps to alleviate the impact of the crisis on non-financial firms and households, including increased healthcare spending and subsidies, as well as funds raised through the issuance of government securities. The relationship between sovereigns and banks has grown stronger as banks' exposure to domestic government securities reached all-time highs during the pandemic (see Figure 1). With significant public debt, a negative shock to the sovereign balance sheet promotes an adverse feedback loop between sovereigns and banks, endangering macro-financial stability. A feedback loop from macro to financial could develop via a number of channels, including defaulted loans, which impair the bank's balance sheet condition. Emerging markets are especially vulnerable to the macro-financial stability risks associated with a strong sovereign-bank nexus in the face of an adverse shock (IMF, 2022). Given the severity and complexity of sovereign-bank interactions, policymakers should be more cautious about combining policies. However, it is believed that using monetary and fiscal policy together, also known as a policy mix, will have a greater impact than otherwise separately (Bartsch *et al.*, 2020). Therefore, we should take the existence of macro-financial linkages into account when deciding what policies are required to intensify the economic recovery from the COVID-19 pandemic (Narayan, 2021).

Figure 1.
Banking Sector Portfolio

These figures provide detail data description bank portfolio and their contribution to fiscal financing (Source: Bank Indonesia, March 2021).

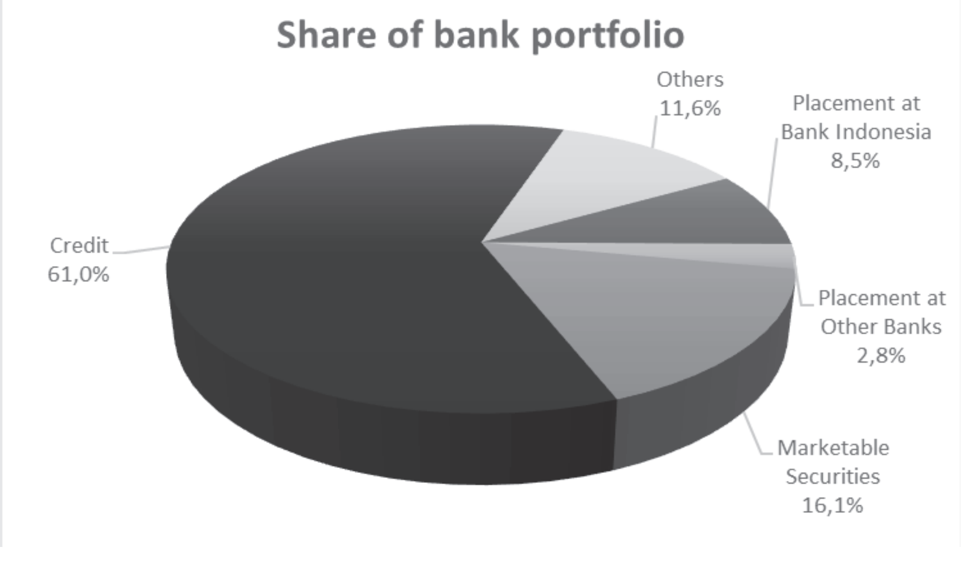
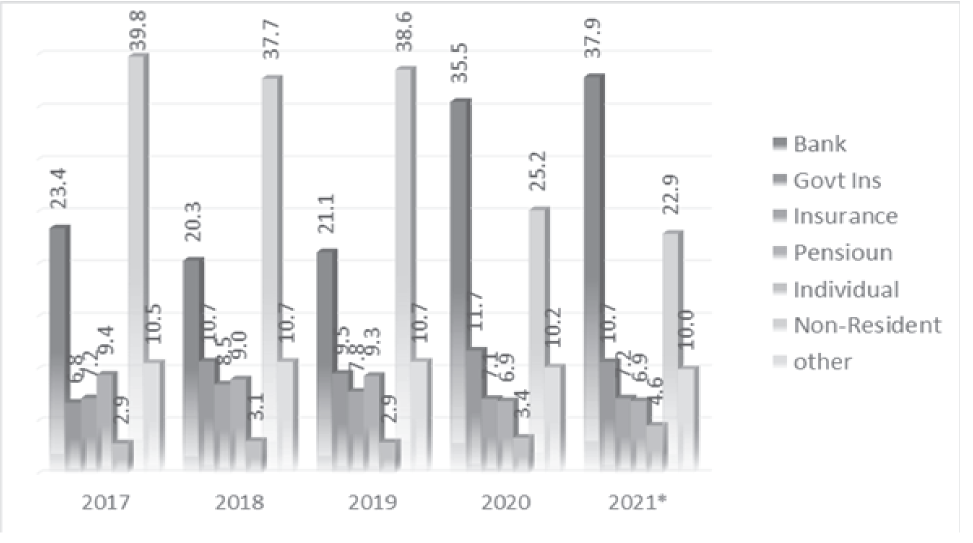


Figure 1.
Banking Sector Portfolio (Continued)



Banking sectors that own considerable quantities of government securities have the potential to rapidly spread sovereign crises to the banking sector. During the pandemic, central bank used extraordinary policies to boost economic recovery, including implementing a low-interest-rate policy, expanding the maximum duration for repo transactions, and reducing the macroprudential intermediation ratio. In order to improve bank financial condition, the financial services authority has also loosened prudential regulation, but the banking industry is also still hesitant to lend to the private sector. The government was then pursuing unconventional policy in order to assist vulnerable households as well as firms' liquidity and solvability. To mitigate the impact of the pandemic, the government must support hard-hit industries such as tourism and other labor-intensive industries, and also the healthcare system, through providing capital injections and loans to state-owned enterprises and credit guarantees on labor-intensive working capital loans, resulting in an increase in government deficit (IMF,2021). Since global investor appetite for government securities has decreased, domestic banks have become the dominant investor in government securities, amplifying the relationship between sovereigns and banks.

The sovereign and banking sectors are linked by banks' direct exposure to sovereign risk as a result of their holdings of government securities, as well as banks' exposure to borrower default risk (IMF, 2022). These channels interact with and magnify vulnerabilities in each sector, transmitting and amplifying shocks from one to the other, and creating self-reinforcing cycles. Negative shocks resulting from large quantities of government securities are particularly prone to macro-financial stability risks, which can be amplified by a strong sovereign-bank nexus. We considered it was important to investigate two-way linkages between sovereign, banking, and borrower default risks especially in Indonesia in order to estimate macro-financial risk linked to the overall strength of the nexus while accounting for other factors. We propose a dynamic general equilibrium framework to investigate all interacting channels in order to investigate the nexus.

Previous research (Bhatarai and Trazeciakiewicz, 2017; Bianchi *et al.*, 2021; and Das, 2021) has examined the interaction of monetary and fiscal policy by if the financial sector operates in a frictionless market. However, it provides limited attention to the numerous types of financial frictions in the banking sector. We will discuss a number of financial regulations, such as minimum capital requirements, risk weighted assets, loan loss provisions, and loan to value regulations, in order to fill in the gap. In addition, we are also incorporating a wide range of credit market imperfections into framework to be able to explain macroeconomic fluctuations (Bernanke *et al*., 1999). We also included the non-performing loan dynamic as a link between the macroeconomic and financial sectors, which has the potential to transmit and amplify macroeconomic fluctuations.

This study proposes a general equilibrium framework for a closed economy with three key representative agents: banks, household savers, and household borrowers. We introduce the banking sector to explain the role of financial intermediary in monetary policy transmission. We introduce government intervention in our framework through regulation on credit market either through debtor balance sheet (Bernanke and Gertler, 1989; Carlstrom and Fuerst, 1997; Kiyotaki and Moore, 1997; Iacoviello, 2005) and through bank balance sheet by using capital regulation (Holmstrom and Tirole, 1997; Meh and Moran, 2010; Arango and Valencia, 2015; Rubio and Carrasco-Gallego, 2016; Angeloni and Faia, 2013). We analyze asymmetric information through lenders' perceptions of on borrowers, using the approach of Alpanda *et al.* (2018) to capture monitoring costs that limit asymmetric information. We investigate how management risk perception, also known as risk taking behavior, has a significant impact on policy transmission while exacerbating procyclicality with in financial system (Satria and Juhro, 2011). We also capture two forms of macro-financial linkages that explain real-financial linkages through banking sector ownership of government securities and risky portfolios (Liu and Molise, 2020). Both linkages are explicitly modeled to capture procyclical behavior in the financial sector and how it will affect the dynamics of the aggregate demand.

We emphasize capital regulation in our approach to demonstrate how banking regulation influences the credit market. It is crucial to include since changes in financial regulation and monetary policy have an impact on the effectiveness of policy transmission. Although capital regulation aims to promote financial stability by increasing risk absorption capacity, it also creates friction and magnifies procyclicality (Meh and Moran, 2010; Angeloni and Faia, 2013; Rubio and Carrasco-Gallego, 2016; Liu and Molise, 2020). Naiborhu (2020) empirically shows that higher capital buffers moderate the impact of monetary policy on credit growth. As a consequence, we evaluate how banking regulations impact intermediary process. We further incorporate other frictions, such as risk weighted assets, loan loss provisions, and Loan-to-Value Regulations, in addition to capital regulation. We explicitly model the impact of risk weighted asset regulation as a source of financial frictions by following the approach used by Falagiarda and Saia (2017). These capital characteristics are modeled to find out the influence of the balance sheet of the financial intermediary on the transmission mechanism of monetary policy.

Bhatarai and Trazeciakiewicz (2017), Bianchi *et al.* (2021), and Das (2021) done studies on policy interaction, however they did not include the banking sector in their framework. Our finding contributes to current knowledge by including the banking sector and incorporating prudential regulation in our framework. We also include financial imperfections, such as the dynamic preference for riskier investments, in order to capture the relationship between management perceptions on lending behavior and overall aggregate demand. This paper also contributes to recent literature on Indonesia's policy mix of monetary and macroprudential policies, such as Chawwa (2021) and Setiastuti *et al.* (2021). They also studied financial frictions in the banking sector, but did not include asymmetric information between lenders and borrowers as a friction. We incorporate the non-performing loan dynamic as a link between the macroeconomic and financial sectors, as well as the monitoring cost toward borrowers, to ensure investment returns that describe financial intermediaries' risk perception toward borrowers (Carlstrom and Fuerst, 1997; Bernanke *et al.*, 1999). To minimize the risk caused by asymmetric information, we describe monitoring activities in our framework as fixed auditing costs (Townsend, 1979). Our study differs from Zams (2021) in at least two ways: first, we include the banking sector in this study, and second, we use Bayesian DSGE-VAR to estimate the parameters and ensure that the estimated parameters are robust. In addition, while this is a DSGE model that may be applied to other emerging economies, the estimated parameters can be employed in future DSGE models for policy analysis. This study concluded that a policy mix is the most effective way to boost economic recovery and improve our understanding of the most effective policy mix under difficult conditions, allowing us to better respond to future unprecedented events.

This work will be divided into five main sections in order to address the research questions. The introduction is the first section, and the overview of the modeling framework is the second section. The data used, parameter calibration, and estimation results are all explained in Section III. The analysis of the impulse response function is explained in Section IV for each shock. Then, section V discusses the policy implications.

II. MODEL

In using the new Keynesian framework, we follow Iacoviello (2005) and Rubio and Carrasco-Gallego (2016) model. Our economy is represented by Household, Final and Intermediate goods Firms, and the government sector consisting of monetary and fiscal authorities. We divide households into two groups, each of which can smooth its consumption over time by accessing financial intermediaries. Firms represent the producers of consumer goods for households consisting of final good producers, and intermediate goods producers. The intermediate goods work in a monopolistic market and are able to adjust their prices using a Calvo-style approach (1983).

A. Household Savers

The household maximizes the following utility functions:

$$\sum_{t=0}^{\infty} \beta_s^t \left[(1-\eta_s)log\left(C_{s,t}-\eta_s C_{s,t-1}\right) + jjA_{j,t}loglog\, H_{s,t} - \xi_{s,t}log\left(1-N_{s,t}\right)\right] \quad (1)$$

where β_s represents the discount factor for Household savers, $C_{s,t}$ describes the level of consumption at the time t, $H_{s,t}$ describes the Housing stock of the Household saver, and $N_{s,t}$ describes the labor services for household saver to the intermediate goods firms and earn income from wages of $w_{s,t}N_{s,t}$. $A_{j,t}$ captures housing price shock and *jj* is the amount of weight given to the housing stock. Each period the household accumulates a housing stock of $H_{s,t}$ and saving deposit D_t. Household savers are also subject to a tax of τ^c on consumption goods and pay a tax of τ^N for any wages received. Household savers also receive a lump sum profit from a retail company of $F_{s,t}$ and get a transfer from the government of Tr_t^s. The household's problem is to maximize utility where the household is faced with the following budget constraint:

$$(1-\tau^c)C_{s,t} + D_t + q_t\left(H_{s,t} - H_{s,t-1}\right) = \frac{R_{d,t-1}D_{t-1}}{\pi_t} + (1-\tau^N)w_{s,t}N_{s,t} + F_{s,t} + Tr_t^S \quad (2)$$

where $q_t \equiv \frac{Q_t}{P_t}$ is the real house price and Q_t is the nominal value of the house price, $\pi_t = \frac{P_t}{P_{t-1}}$ is the inflation rate, $\frac{R_{d,t-1}}{\pi_t}$ is the real gross return for one period of the deposit placed in a financial intermediary, $R_{d,t-1}$ is the nominal deposit rate, $F_{s,t} = \frac{X_t - 1}{X_t}Y_t$ is the lump sum profit of the company, X_t is a markup on the price of goods from Intermediate good firms, and Y_t is the output produced by the firms.

B. Household Borrower

Household borrowers maximize the expected discounted lifetime utility as follows:

$$E_0 \sum_{t=0}^{\infty} \beta_b^t \left[(1-\eta_b)log\left(C_{b,t}-\eta_b C_{b,t-1}\right) + jjA_{j,t}loglog\, H_{b,t} - \xi_{b,t}log\left(1-N_{b,t}\right)\right] \quad (3)$$

where β_b is the discount factor of the household borrower, $C_{b,t}$ is the level of consumption, $H_{b,t}$ is housing stock, $N_{b,t}$ is the supply of labor from household borrowers. Subject to the following Budget constraint:

$$(1-\tau^c)C_{b,t} + \frac{R_{b,t-1}(1-\zeta_{L,t})L_{b,t-1}}{\pi_t} + q_t\left(H_{b,t} - H_{b,t-1}\right) = L_{b,t} + (1-\tau^N)w_{b,t}N_{b,t} + Tr_b \quad (4)$$

$$L_{b,t} \le m_b E_t\left(\frac{q_{t+1}}{R_{b,t+1}} H_{b,t}\pi_{t+1}\right)\gamma_{b,t} \quad (5)$$

where $L_{b,t}$ is loan to household borrowers with an interest rate for each period of $\frac{R_{b,t-1}}{\pi_t}$, $w_{b,t}$ is the real wage of the household borrower, m_b is the maximum amount of credit that the household borrower can obtain based on the amount of collateral they own, $\gamma_{b,t}$ is the exogenous shock to the borrowing capacity, $\zeta_{L,t}$ is the fraction of non-performing loans from that evolves as follows:

$$\zeta_{L,t} = \zeta\left(\zeta_{L,t-1}\right)^{\rho\zeta}\left(\frac{Y_t}{Y_{t-1}}\right)^{-\chi\zeta} e^{\xi\zeta} \tag{6}$$

where ζ is the steady state value of the NPL, χ_ζ describes the Marginal effect of output to NPL, ρ_ζ describes the coefficient of persistence of the existing NPL level in the economy, ξ_ζ stands for the shock to the normally distributed NPL.

C. Financial Intermediary

Financial intermediary role is to mediate funds from households(savers), supply the funds to the household (borrower), and finance the government deficit through marketable securities. the financial intermediary chooses dividends ($C_{f,t}$) to maximize expected discounted lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta_f^t\left[\left(1-\eta_f\right) log\left(C_{f,t}-\eta_f C_{f,t-1}\right)\right] \tag{7}$$

where β_f is the discount factor from the banking sector. Bankers solve the utility function subject to the following budget constraint:

$$(1-\tau^c)C_{f,t} + \frac{R_{d,t}D_{t-1}}{\pi_t} + (1+\Psi_t)L_{b,t} + B_t = \left(1-\tau^d\right)D_t + \frac{R_{b,t-1}\left(1-\zeta_{L,t}\right)L_{b,t-1}}{\pi_t} + \frac{R_{t-1}B_{t-1}}{\pi_t} \tag{8}$$

$$\frac{L_{b,t}+B_t-D_t-E_t\zeta_{L,t+1}}{\omega_B B_t+\omega_L\left(L_{b,t}-E_t\zeta_{L,t+1}\right)} > \text{car} \tag{9}$$

D_t explain the level of real savings owned by household savers, $L_{b,t}$ is a loan given by the bank to the borrower's house, Ψ_t describe monitoring costs by banks, and $\zeta_{L,t}$ is the amount of Non-Performing Loan (NPL). Despite of a percentage level of capital(car) to be maintained, banks are also required to s*et al*lowance for expected loan loss ($E_t\ \zeta_{L,t+1}$). Indonesia Financial Service Authority (Indonesia FSA) regulations required banks to retain a minimum capital of 8 to 14 percent depending on their risk profile. In addition, Indonesia FSA set difference risk weighted asset for government bond (ω_B) and for loan (ω_L) where $\omega_B<\omega_L$. However, banks still have to pay monitoring cost to ensure their investment based on household leverage position:

$$(1+\Psi_t) = \gamma_1\left(\frac{(1-m_b)q_t H_{b,t}}{n_{b,t}}\right)^{\gamma_2} e^{\varepsilon\Psi} \tag{10}$$

$$n_{b,t} = q_t H_{b,t} - L_{b,t} \tag{11}$$

where γ_1 is a parameter that affects the monitoring cost, γ_2 is the elasticity of the monitoring cost of the household borrower's financial condition, and ε_Ψ is a shock to monitoring costs.

D. Retailers

There is a continuum of monopolistically competitive retailers purchases for undifferentiated intermediate goods, $Y_t(Z)$, from entrepreneurs at the price $P_T(Z)$. The final good, Y_t, is a composite of the continuum of differentiated goods with Constant Elasticity of Substitution (CES):

$$Y_t = \left[\int_0^1 Y_t(z)^{\left(\frac{\epsilon-1}{\epsilon}\right)} dz\right]^{\frac{\epsilon}{\epsilon-1}} \tag{12}$$

where ϵ is the elasticity of substitution across intermediate goods. The optimal choice of intermediate good $Y_t(z)$ yields to demand for good z as:

$$Y_t(Z) = \left(\frac{P_T}{P_T(Z)}\right)^{\varepsilon} Y_T \tag{13}$$

With the aggregate price level is given b $P_T = \left[\int_0^1 P_T(Z)^{1-E} dz\right]^{\frac{1}{1-E}}$ (14)

To introduce the price rigidity, the retailers operate in a monopolistically competitive market (Calvo, 1983). Intermediate good producer sell goods for P_t with an opportunity to adjust prices with a probability of . Then, the optimal price is set by solving the following equation:

$$\sum_{k=0}^{\infty} (\theta\beta_s)^k E_t \left\{\Lambda_{t,k}\left[\frac{P_t^*(z)}{P_{t+k}} - \frac{\frac{\varepsilon}{\varepsilon-1}}{X_{t+k}} Y_{t+k}^*(z)\right]\right\} = 0 \tag{15}$$

Where aggregate price is given by:

$$P_t = \left[\theta P_{t-1}^{1-\varepsilon} + (1-\theta) P_t^{*\,1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{16}$$

By using equation (15) and equation (16) it can be determined the optimal value of all prices in the economy. The log-linearization of the two equations will give the basic equation of the New Keynesian Phillips Curve (NKPC) $\pi_t=\beta_s E_t\{\pi_{t+1}\}+\Psi\hat{x}_t$. Where future inflation has positive relationship with markup $\psi = \frac{(1-\theta)(1-\theta\beta_s)}{\theta}$.

E. Monetary and Fiscal Policy

The central bank's policy focuses on stabilizing prices following the Taylor rule as described in the following equation:

$$R_t = R\left(\frac{R_{t-1}}{R}\right)^{\rho}\left(\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi^R}\left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_y^R}\right)^{1-\rho} e^{\varepsilon_{Rt}} \tag{17}$$

ρ is a parameter that describes the magnitude of the persistence of the interest rate policy, ϕ_{π}^{R} and ϕ_{y}^{R} are parameters, each of which explaining how much policy rate responds to inflation and economic growth, and ε_{Rt} is a shock to the interest rate policy carried out by the central bank.

The fiscal authority is in charge of collecting taxes (Tax_t), spending (g_t), transfer (Tr_t), and issuing one period bonds (B_t), the government budget constraint is given by:

$$g_t + Tr_t^s + Tr_t^b + \frac{B_{t-1}}{R_{B,t}} = Tax_t + B_t \quad (18)$$

The government collects taxes from households through every good and service consumed, from household income, and financial intermediaries as follows:

$$Tax_t = \tau^c C_t + \tau^N W_t + \tau^d d_t \quad (19)$$

Government has an active fiscal policy through transfer in response to output gap and government financing as in the following equation:

$$Tr_t^i = \left(Tr_{t-1}^i\right)^{\rho_{Tr}^i} \left(\frac{y_t}{y}\right)^{-\rho_{Tr,y}^i} \left(\frac{B_t}{B}\right)^{-\rho_{Tr,B}^i} e^{\varepsilon_{trs}^t}, \forall\, i = s, b \quad (20)$$

where ρ_{Tr}^i , $\forall\, i = s, b$ is a parameter that describes the persistence of transfer to households, $\rho_{Tr,y}^i$ is the output response to transfer, and $\rho_{Tr,B}^i$ is the debt response to transfer.

F. Market Clearing Condition and Equilibrium

In this economy, the total of housing is fixed and normalized so that the resource of housing stock is constrained. The Market Clearing Conditions are as follows and could be described in the equation as follows.

$$H_{s,t} + H_{b,t} = 1 \quad (21)$$

$$C_t = C_{s,t} + C_{b,t} + C_{f,t} \quad (22)$$

Finally, the aggregate resource constraint in this economy can be described in $Y_t = C_t + g_t$.

III. DATA, PARAMETER CALIBERATION, AND ESTIMATION RESULTS

To increase models' ability to represent the data, we examine the parameters obtained from Bayesian estimation. All parameters must be calibrated before they can be used for estimation. The goal of calibration is to obtain a steady-state value for each variable in the model. Using earlier research on the Indonesian economy, all parameters are set to characterize the Indonesian economy. We used parameters from Chawwa (2021), Setiastuti *et al*. (2021), and Zams (2021) to calibrate our model to obtain the steady state value and use it as the initial value in estimating using Bayesian. Such parameters are used as prior information, which then matched with observational data from the Indonesian economy. To explain this procedure, we provide observation data, the calibrated parameter, prior and posterior distribution for each parameter used.

A.I. Data

We follow Smets and Wouters (2003), who used Bayesian techniques to calculate DSGE models for the Eurozone utilizing seven main macroeconomic variables. We just selected six important macroeconomic indicators that represent the aggregate macroeconomics and banking sector since we are constructing a small scale closed economy for Indonesia. We utilized outstanding government securities owned by banks to represent the government-bank nexus and non-performing loan ratios to reflect the link between the bank and the real economy when evaluating the interaction between the sovereign, banks, and the real economy. We collect observable variables from 2009Q4 through 2021Q1, such as the output, annualized net inflation, outstanding credit, outstanding government bonds owned by banks, loan interest rates, and the NPL ratio. Our samples are in line with the inflation-targeting framework and states that interest rates should be set based on inflation expectations. All data used in this study was taken from Indonesian Economic and Financial Statistics from the Bank Indonesia website.

Figure 2.
Observed Variables

These figures provide detail data description of all variables considered in this study.

Output

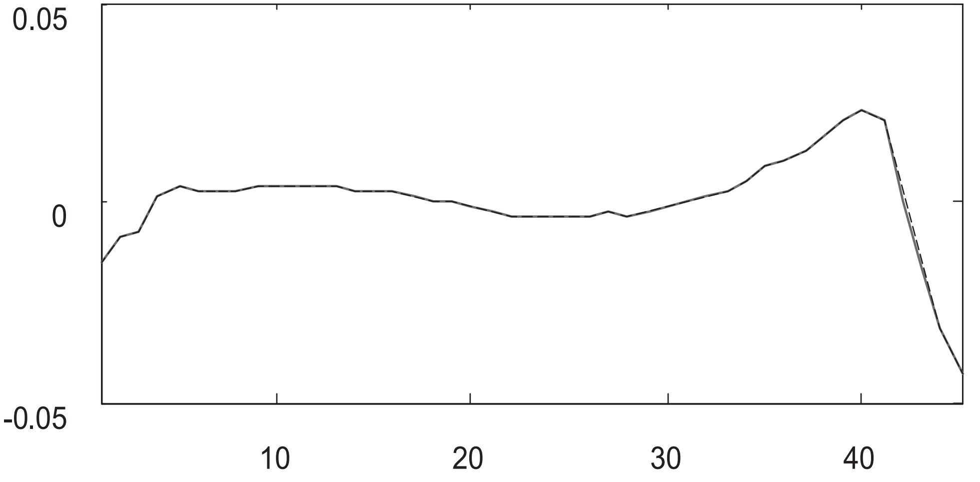
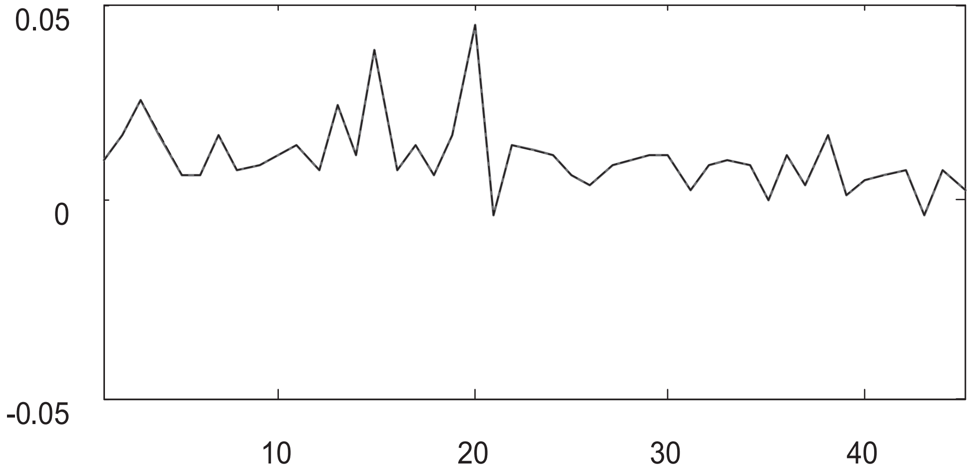


Figure 2.
Observed Variables (Continued)

Inflation



Loan

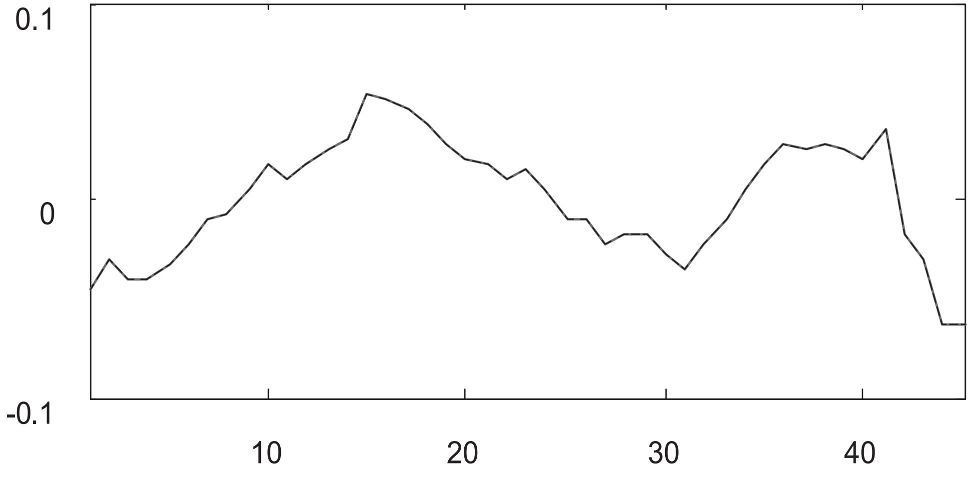


Figure 2.
Observed Variables (Continued)

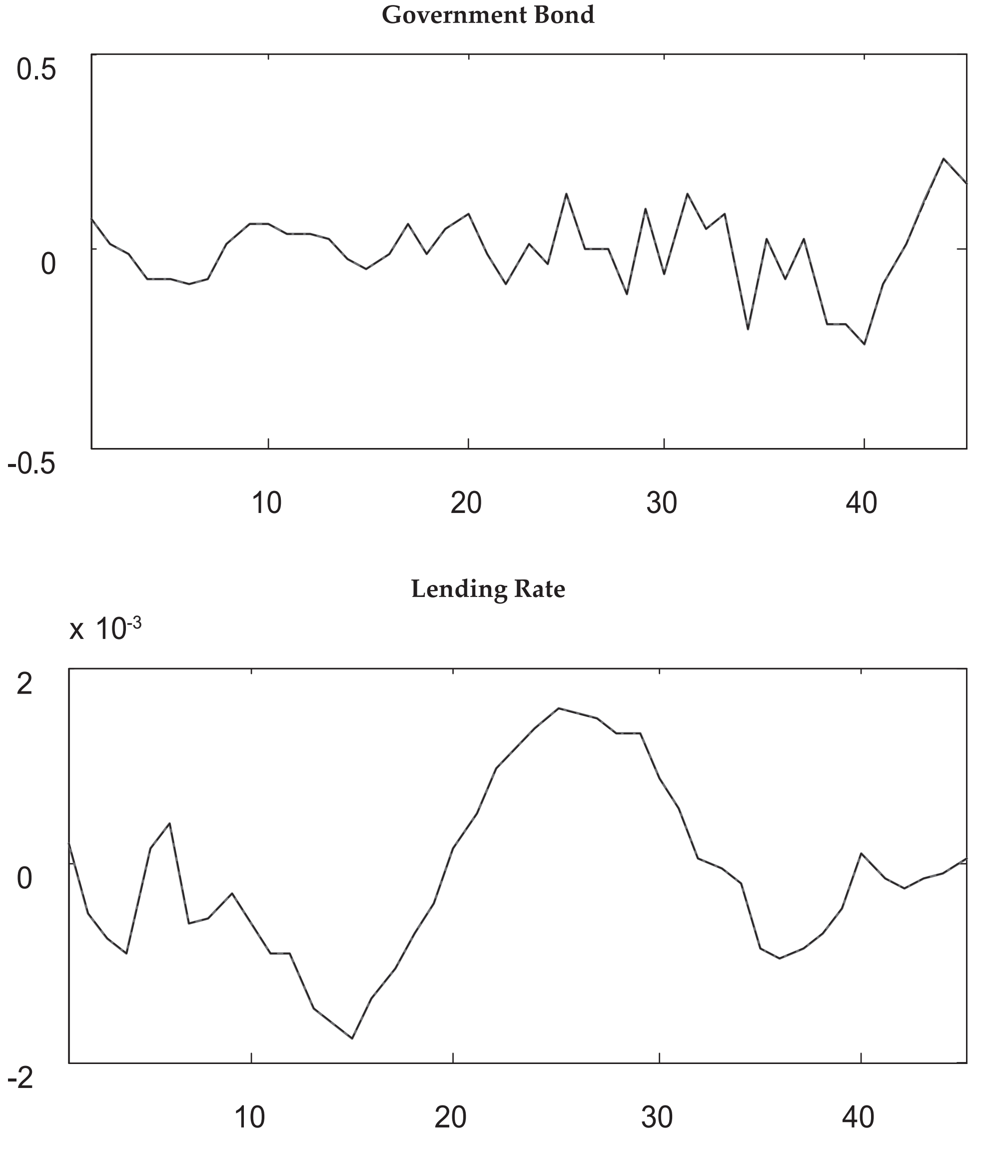


Figure 2.
Observed Variables (Continued)

Non-performing Loan

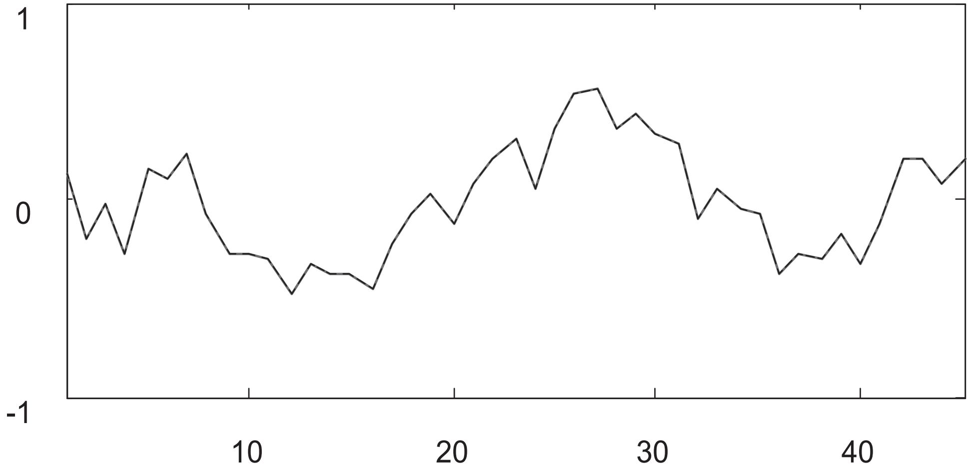


Table 1.
Observed Variables

This table list detail data description of all variables considered in this study.

No	Variables		Seasonally adjusted	Detrended	
1	Output	Nominal, constant price	Yes	yes	
2	Inflation	Consumer price index	No	no	%
3	loan	Nominal	Yes	yes	
4	Government bonds	Nominal	Yes	yes	
5	Lending rate	percentage	No	no	%
6	Non-performing loan	percentage	No	no	%

Figure 2 illustrates the observation data used in the estimation. For the estimation purpose, we consider used variables in real terms. The output gap, outstanding loan, and outstanding government bonds owned by banks are logarithmic converted, The Hodrick–Prescott method used to remove seasonality and time trend from the transformed data. Therefore, the ratio of two times' consumer price index data used to calculate inflation data on a gross basis. By eliminating the temporal trend of inflation, loan interest rate, and non-performing loan percentage, we apply Hodrick–Prescott to make data stationary.

A.II. Parameter Calibration

Rather than using generic values that could apply to a variety of countries, we used values from Indonesia, which shares many of the same characteristics as emerging countries. The parameter values were taken from papers such as Chawwa

(2021) and Setiastuti *et al.* (2021), which calibrated DSGE model parameters for Indonesia. Because the most of studies on micro-founded DSGE models have been constructed for developed countries, the parameters used in previous studies may be unsuitable for the case of Indonesia. To the best of our knowledge, these three papers are recent publications on Indonesian economy that employ DSGE frameworks, and they are relevant to our study.

Table 2.
Calibrated Parameters

This table list the calibrated parameters used in the model based on DSGE literature in Indonesia.

No.	Parameters	Symbol	Value
1.	discount factor for HH savers	β_s	0.97
2.	Smoothing parameter on HH saver consumption	η_s	0.36
3	discount factor for HH borrowers	β_b	0.96
4	Smoothing parameter on HH borrower consumption	η_b	0.51
5	discount factor for bankers	β_f	0.94
6	Smoothing parameter on financial intermediaries' consumption	η_f	0.69
7	weight of housing in utility function	jj	0.1
8	persistence coefficient on non-performing loan	ρ_ζ	0.75
9	RWA on govt bond	ω_b	0.05
10	RWA on Commercial loan	ω_L	0.7
11	Loan to Value requirement	m_b	0.75
12	capital requirement	car	0.14
13	Coefficient on monitoring cost	γ_1	0.25
14	elasticity on monitoring cost	γ_2	0.24
15	share of firms optimize price	θ	0.68
16	Monetary Policy: interest rate persistence	ρ	0.75
17	Monetary Policy: inflation response	ϕ_π^R	0.25
18	Monetary Policy: output response	ϕ_y^R	0.75
19	Share between factor productivity	α	0.72
20	Marginal effect of output to NPL	ξ_ζ	0.74
21	Coefficient borrowing capacity shock	ρ_γ	0.35
22	coefficient govt shock	ρ_g	0.73
23	coefficient housing demand shock	ρ_a	0.94
24	technological shock	ρ_z	0.31
25	coefficient transfer on HH saver	ρ_{trs}	0.12
26	coefficient transfer on HH borrower	ρ_{trb}	0.36
27	coefficient transfer on consumption tax	ρ_{taxC}	0.35
28	coefficient transfer on Deposit tax	ρ_{taxD}	0.26
29	HH saver labor supply shock	ρ_{wcs}	0.14
30	HH borrower labor supply shock	ρ_{wcb}	0.36
31	HH borrower labor supply shock	ρ_{wcb}	0.36

The discount factor for patient households is β_s=0.97, as impatient household being β_b=0.96. Meanwhile, β_f=0.94 is the discount factor for financial intermediaries.

These parameters are calibrated with the criteria that $\beta_f<\beta_b$. The LTV regulation is another parameter used in the simulation that was taken from previous research. According to Setiastuti *et al*. (2021), the LTV ratio used is 0.75 and the persistency of policy rate parameters is ρ=0.75. Another parameter that describes the behavior of the central bank is the parameters used in the Taylor rule. The weight on the inflation response in the Taylor rule is ϕ_π^R=0.25, and the weight on output gap is ϕ_y^R=2. As a requirement for entering Bayesian estimation, these calibrated parameters must meet the Blanchard condition. Furthermore, we calibrated the fiscal response, which is influenced by the bonds issued and the output gap, through spending and transfers, using parameters from other countries.

A.III. Estimated Parameters

In Tables 3 and 4, we present the prior mean derived from the Bayesian parameter estimate findings. We use Metropolis Hasting algorithm and use harmonic mean estimator to calculate the likelihood of the model. We use the random walk metropolis hasting algorithm with 100.000 draws to perform the posterior simulation as presented in the following tables:

Table 3.
Estimated Structural Parameters

This table provides Posterior modes, medians, 90% posterior credible sets, and prior moments for the structural parameters. The letters in the column with the heading "Prior Type" indicate the prior density function.

	Prior Mean	Post. Mean	5% Interval	95% Interval	Density	Posterior Deviation
β_s	0.97	0.7355	0.7145	0.7566	Beta	0.02
η_s	0.345	0.3708	0.3379	0.4036	Beta	0.02
β_b	0.96	0.9719	0.9521	0.9938	Beta	0.023
η_b	0.75	0.5567	0.5135	0.6004	Beta	0.05
ρ_ζ	0.75	0.7721	0.6919	0.8473	Beta	0.05
β_f	0.94	0.9249	0.8801	0.9711	Beta	0.023
η_f	0.75	0.5878	0.4888	0.6897	Beta	0.05
γ_2	0.25	0.2414	0.225	0.2574	Normal	0.01
χ_ζ	0.75	0.7511	0.6693	0.8346	Beta	0.05
θ	0.65	0.6801	0.6534	0.7061	Normal	0.02
ρ	0.75	0.7242	0.6533	0.7928	Beta	0.06
ϕ_π^R	0.25	0.2711	0.1731	0.3739	Gamma	0.06
ϕ_y^R	2	2.0103	1.9163	2.1119	Normal	0.06
α	0.5	0.5457	0.4983	0.5914	Beta	0.05
ρ_g	0.76	0.8377	0.7933	0.881	Beta	0.05
ρ_{trs}	0.123	0.0818	0.0266	0.1366	Beta	0.05
ρ_{trb}	0.355	0.3682	0.2895	0.4512	Beta	0.05
ρ_{taxC}	0.356	0.3579	0.2727	0.4403	Beta	0.05
ρ_{taxD}	0.252	0.2546	0.1705	0.3342	Beta	0.05
ρ_{wcs}	0.135	0.241	0.1324	0.342	Beta	0.05
γ_1	0.25	0.25	0.2336	0.2657	Gamma	0.01
$\rho^s_{Tr,B}$	0.2	0.1941	0.1125	0.2715	Beta	0.05

Table 3.
Estimated Structural Parameters

This table provides Posterior modes, medians, 90% posterior credible sets, and prior moments for the structural parameters. The letters in the column with the heading "Prior Type" indicate the prior density function.

	Prior Mean	Post. Mean	5% Interval	95% Interval	Density	Posterior Deviation
$\rho^{s}_{Tr,y}$	0.5	0.5031	0.4176	0.5814	Beta	0.05
$\rho^{b}_{Tr,B}$	0.2	0.2043	0.1186	0.2852	Beta	0.05
$\rho^{b}_{Tr,y}$	0.5	0.4992	0.4184	0.5845	Beta	0.05
$\lambda_{DSGE\text{-}VAR}$	0.7	1.2701	1.134	1.4	Uniform	0.4041

Table 4.
Estimated Shock Parameters

This table provides Posterior modes, medians, 90% posterior credible sets, and prior moments for the structural parameters. The letters in the column with the heading "Prior.

	Prior Mean	Post. Mean	5% Interval	95% Interval	Density	Posterior Deviation
ε_{wcs}	0.234	0.142	0.1127	0.1707	Inv. Gamma	0.06
ε_{ζ}	0.48	0.333	0.2854	0.3772	Inv. Gamma	0.06
ε_{trs}	0.234	1.1808	0.872	1.4741	Inv. Gamma	0.06
ε_{trb}	0.234	0.6296	0.4175	0.8276	Inv. Gamma	0.06
ε_{Rt}	0.234	0.1081	0.0897	0.1261	Inv. Gamma	0.06
ε_{g}	0.234	0.0996	0.0823	0.1125	Inv. Gamma	0.06

Table 3 indicates the posterior information of each parameter with confidence ranges of 5% and 95%. Our findings differ slightly from those of earlier studies as previously shown by Chawwa (2021) and Setiastuti *et al.* (2021). The differences that may develop in our studies may arise since all parameters come from Bayesian estimation and not from calibrated. We also evaluate the impulse response function created from the predicted parameters to ensure the accuracy of our estimation. Our calibrated parameters are defined as $\beta_f < \beta_b$. Such a condition ensures that the bank will discount the future of household borrowers less than the banking sector. The Bayesian estimation results, on the other hand, show that the banking sector discounts futures less than the household borrower ($\beta_f > \beta_b$). Higher discounted factors in the financial industry show that the financial intermediary values future utility more than current utility. In other words, financial intermediaries are more concerned with future consumption than the household sector.

IV. RESULTS AND ANALYSIS

In this section, we will examine how pandemic shocks affect the economy and how policy mix shocks affect aggregate demand in order to mitigate risk of both real and financial shocks. We examine separate monetary and fiscal policy shocks and compare their responses using the impulse-response function. Then, we combine these two policy shocks and investigate how they affect the economy when implemented simultaneously.

A. Response of Variables to Pandemic Shocks

We analyze five-impulse response function scenarios based on the estimation results and clarify the fundamental distinctions in the propagation processes present in diverse situations. In figure 3, the first scenario (black line) explains the social distancing measure to prevent the spread of COVID-19, causing a negative shock to supply of labor to production factors. We analyze the interest rate cut by the central bank after the pandemic shock in the second scenario (blue line) and combine with a pandemic shock. We analyze positive fiscal policy shock and combine with pandemic shock in the third scenario (red line). We simulate shocks through household transfers and government spending. The fourth scenario (blue dashed line) involves a combination of monetary and fiscal policy responses in response to pandemic shocks. Finally, to assess the impact of easing LTV regulation, we add a scenario of easing macroprudential regulation to monetary and fiscal shocks scenario (black dash line).

Figure 3.
Impulse Response Function to Pandemic Shock

These figures provide impulse response function from 5 scenario; (1) Black-line- (labor supply, NPL); (2) Blue - line- (labor supply, NPL, monetary policy); (3) Red - line - (labor supply, NPL, fiscal policy); (4) Blue - dash line - (labor supply, NPL, monetary policy, fiscal policy); and (5) Blue - dash line - (labor supply, NPL, monetary policy, fiscal policy).

y: Output gap	Trs: Transfer to HH saver	Trb: Transfer to HH borrower	B: Govt Bond	Zeta: NPL
C: Consumption	Cs: HH Saver Consumption	Cb: HH borrower Consumption	Psi: Monitoring Cost	nw: HH net worth
g: Govt Expenditure	D: Deposit on bank	L: Loan to HH Borrower	Rb: Loan rate	q: House price
Pi: CPI (%)	Ws: HH Saver's Wage	Wb: HH borrower's Wage	Rd: Deposit rate	tax: tax

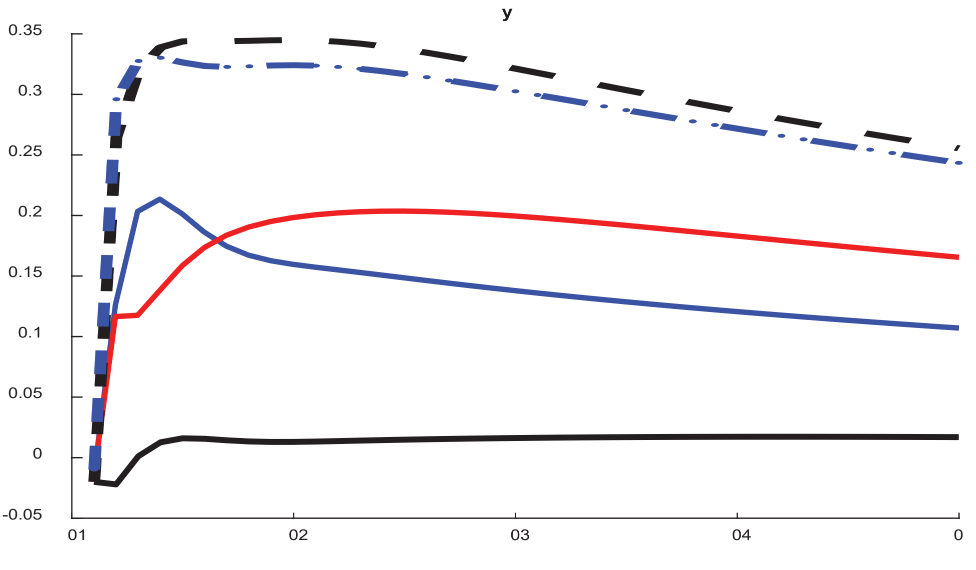


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

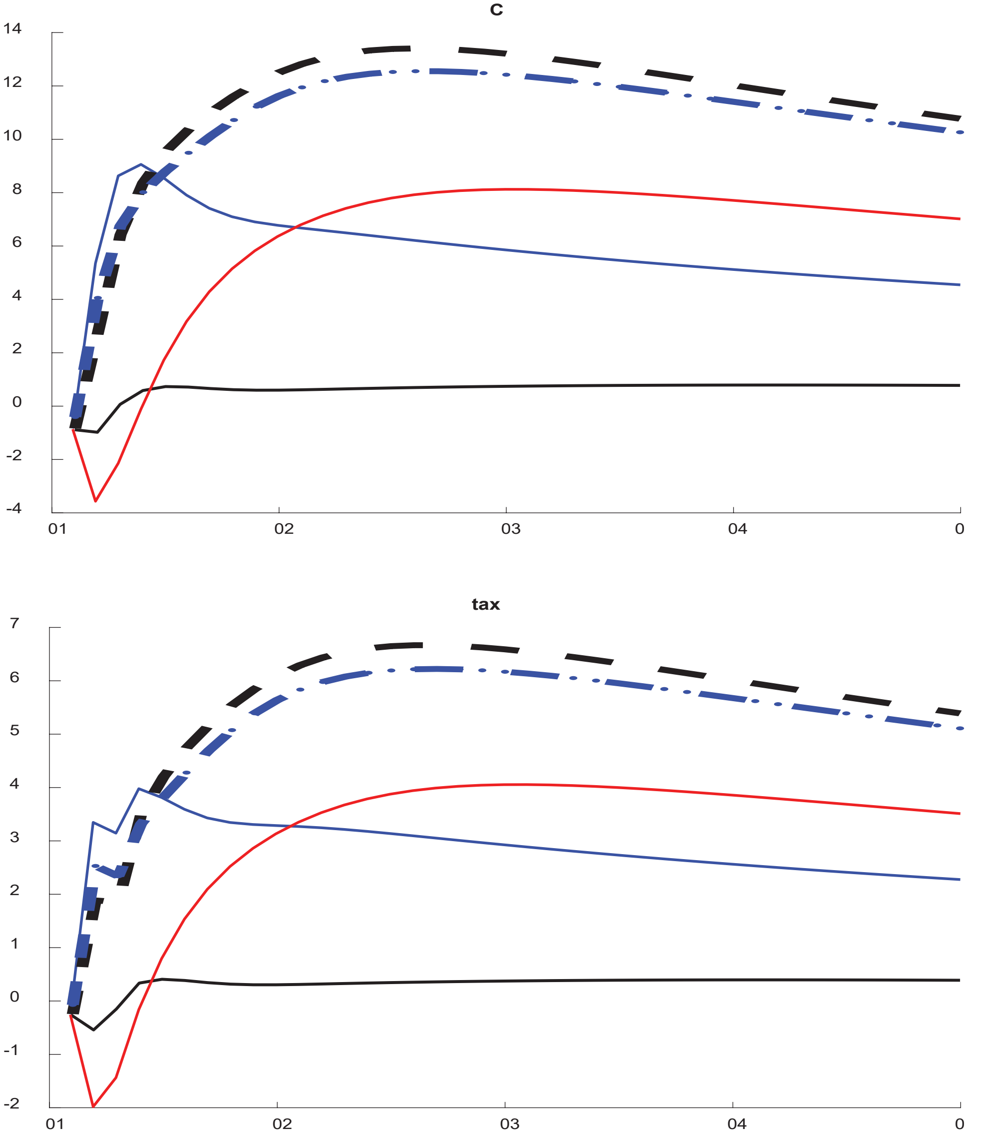


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

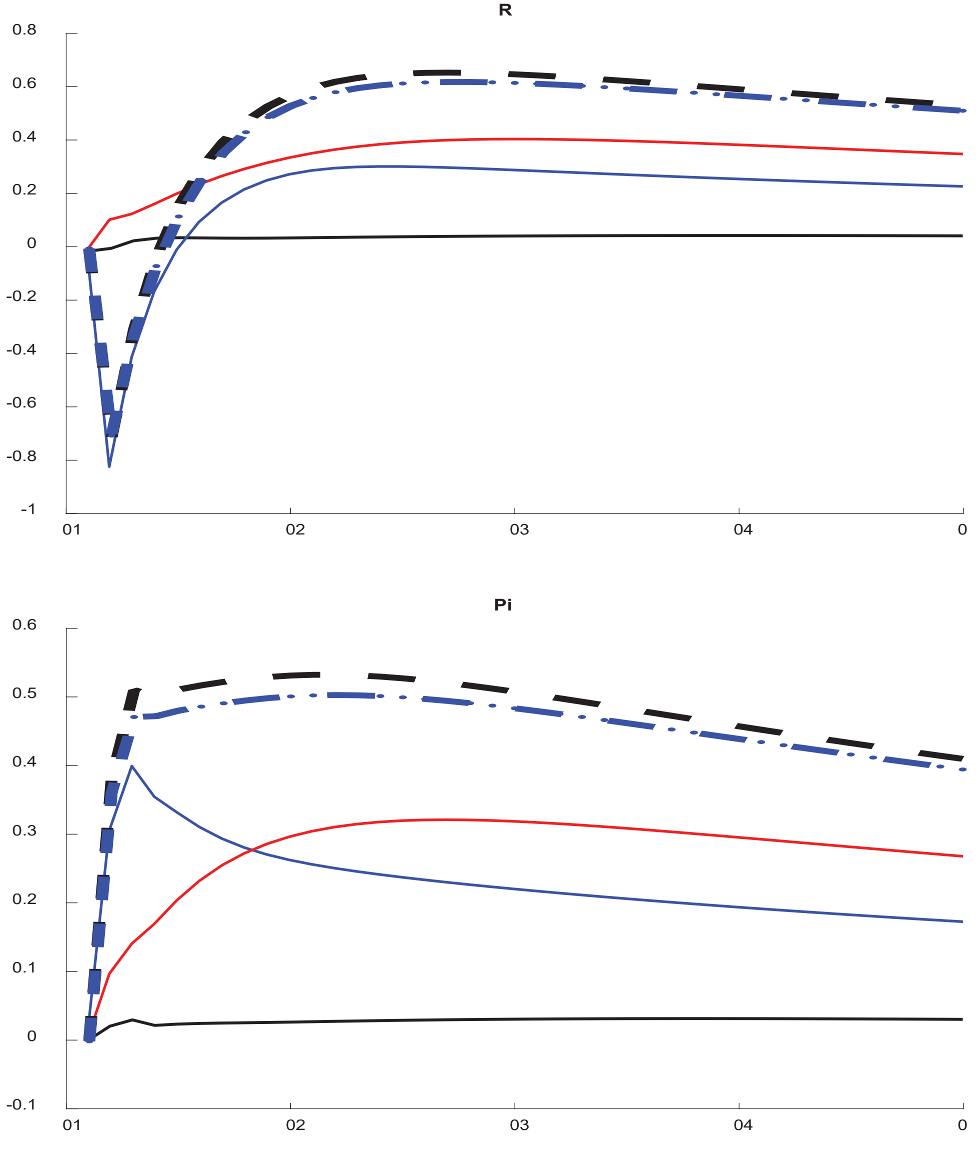


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

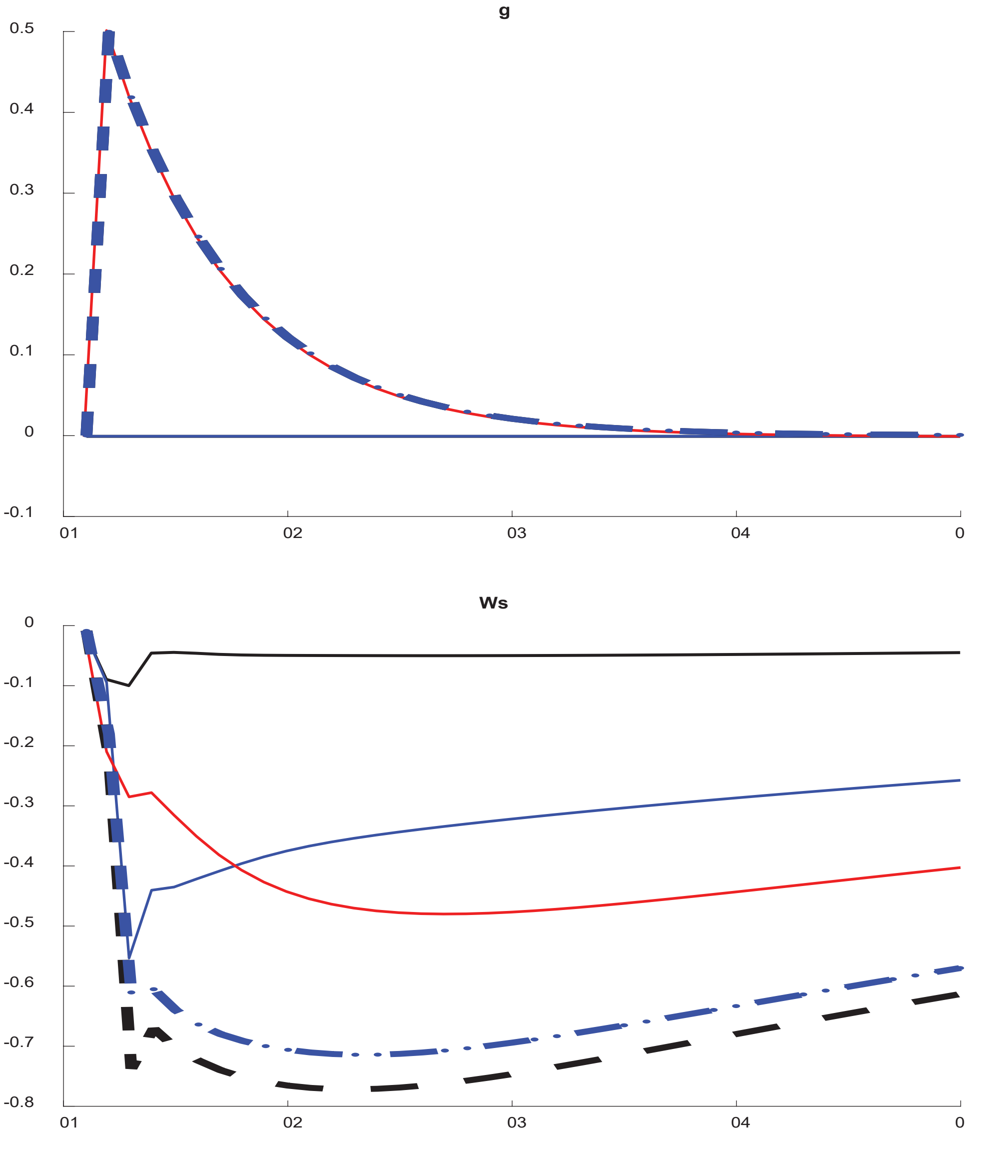


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

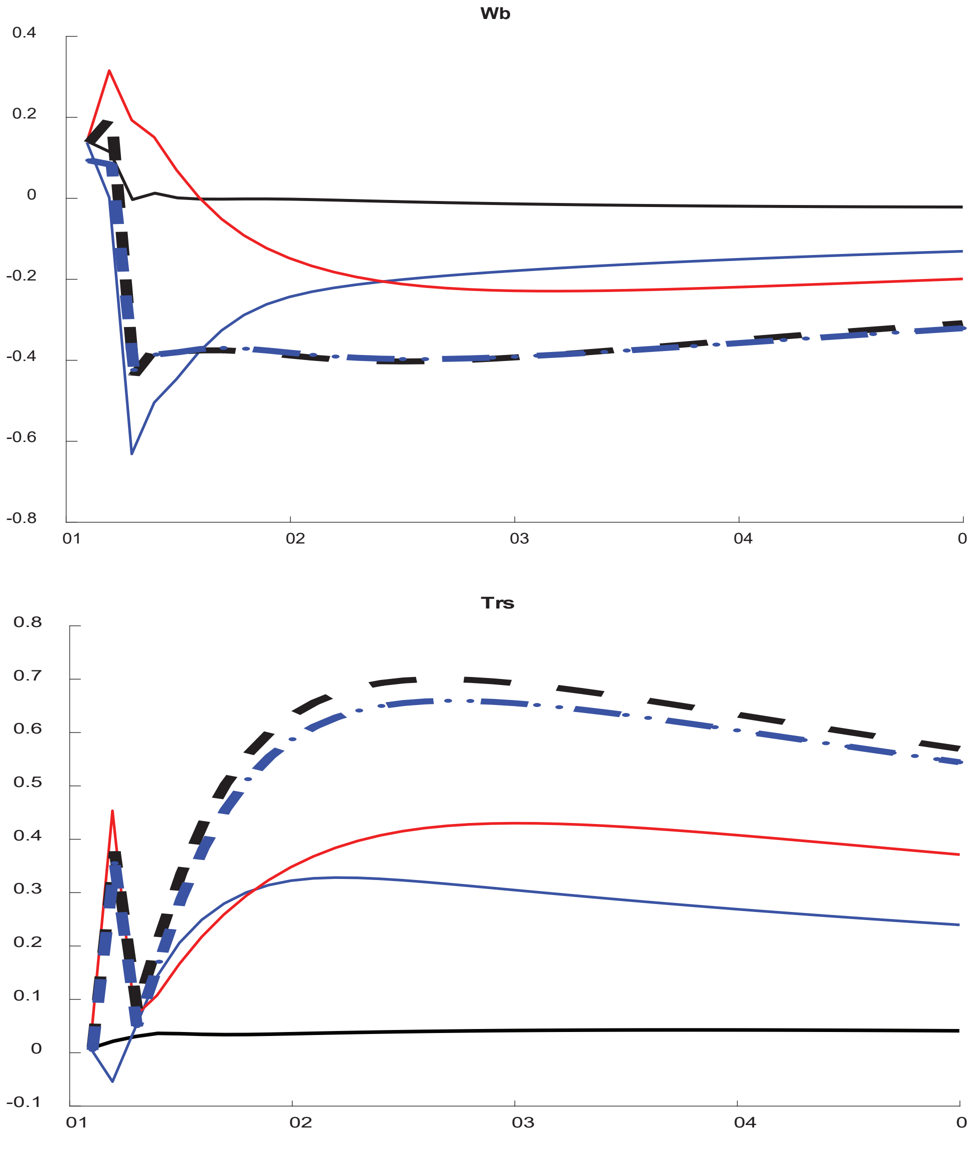


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

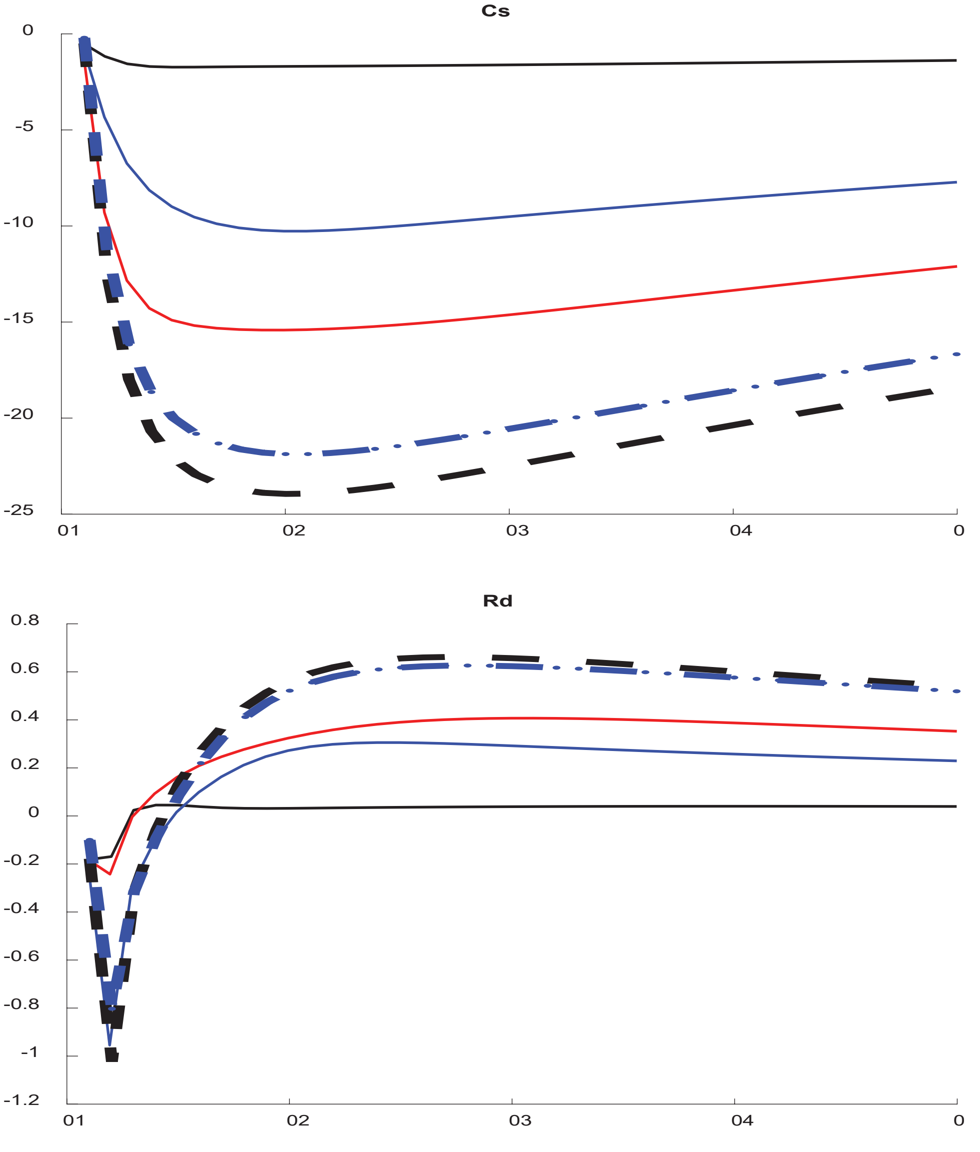
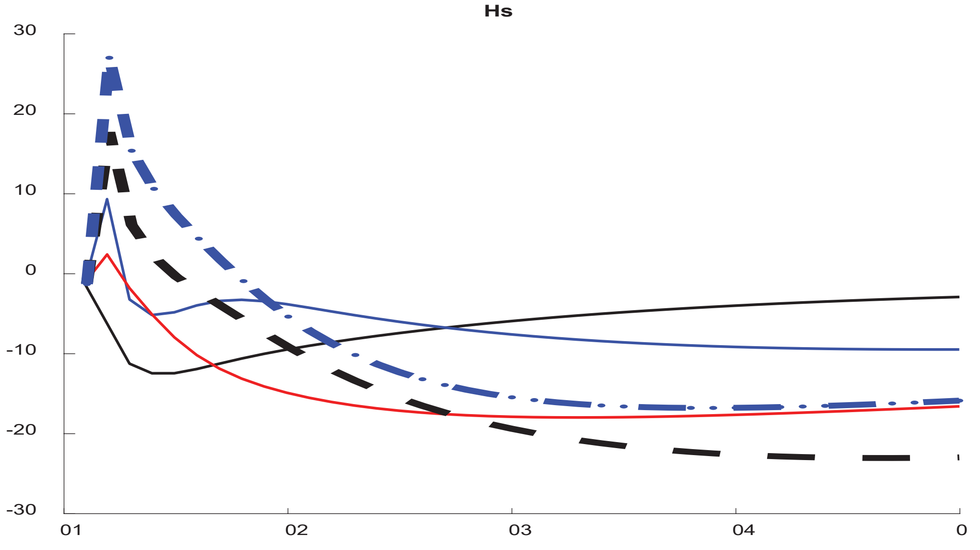


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)



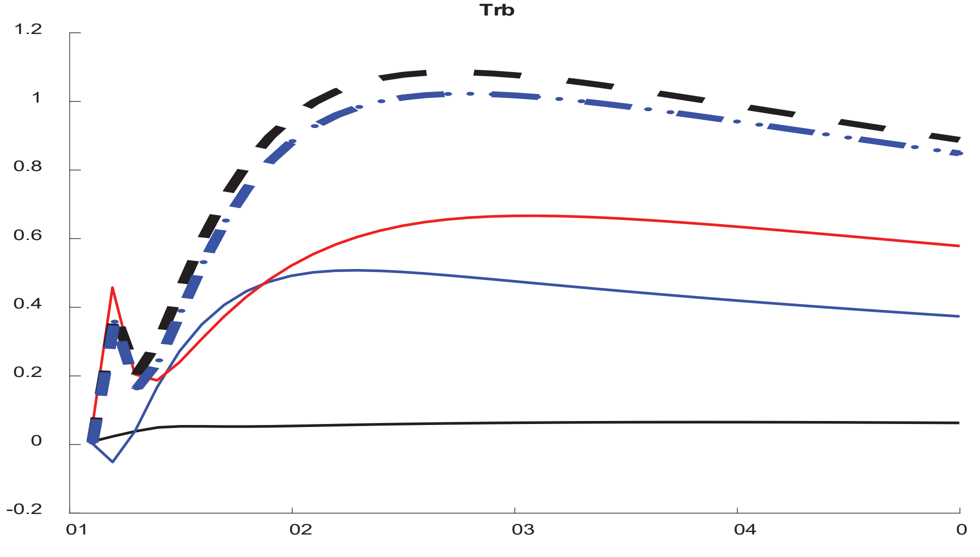
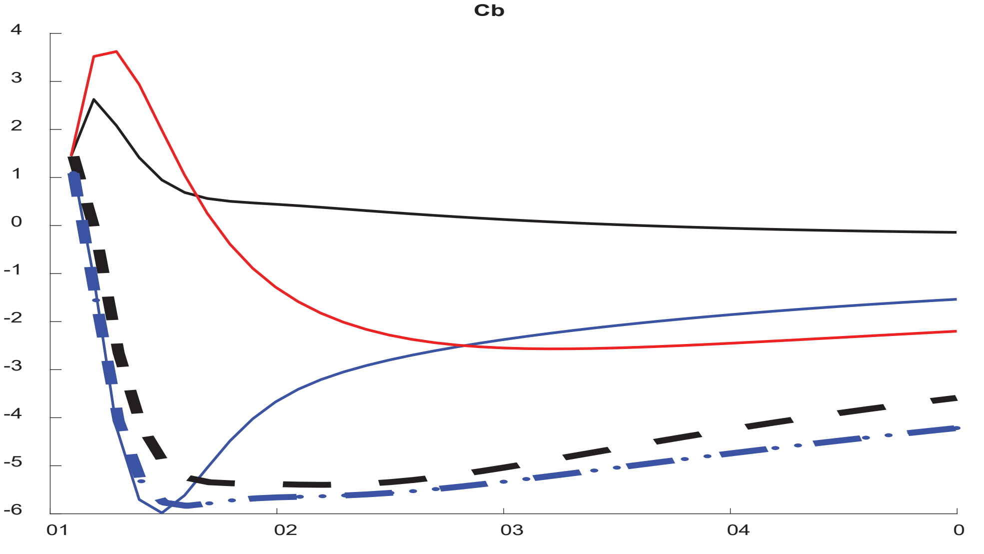


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)



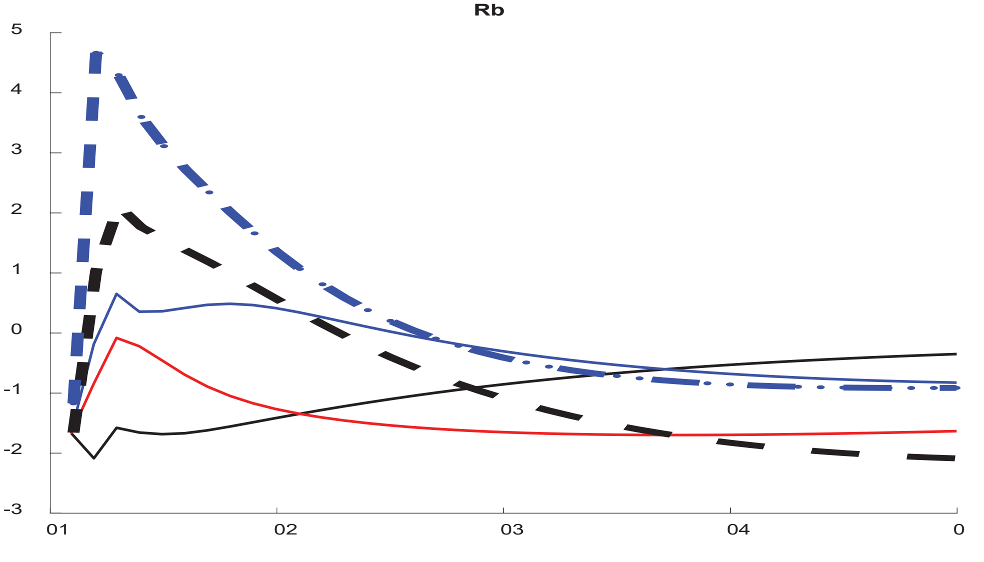


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

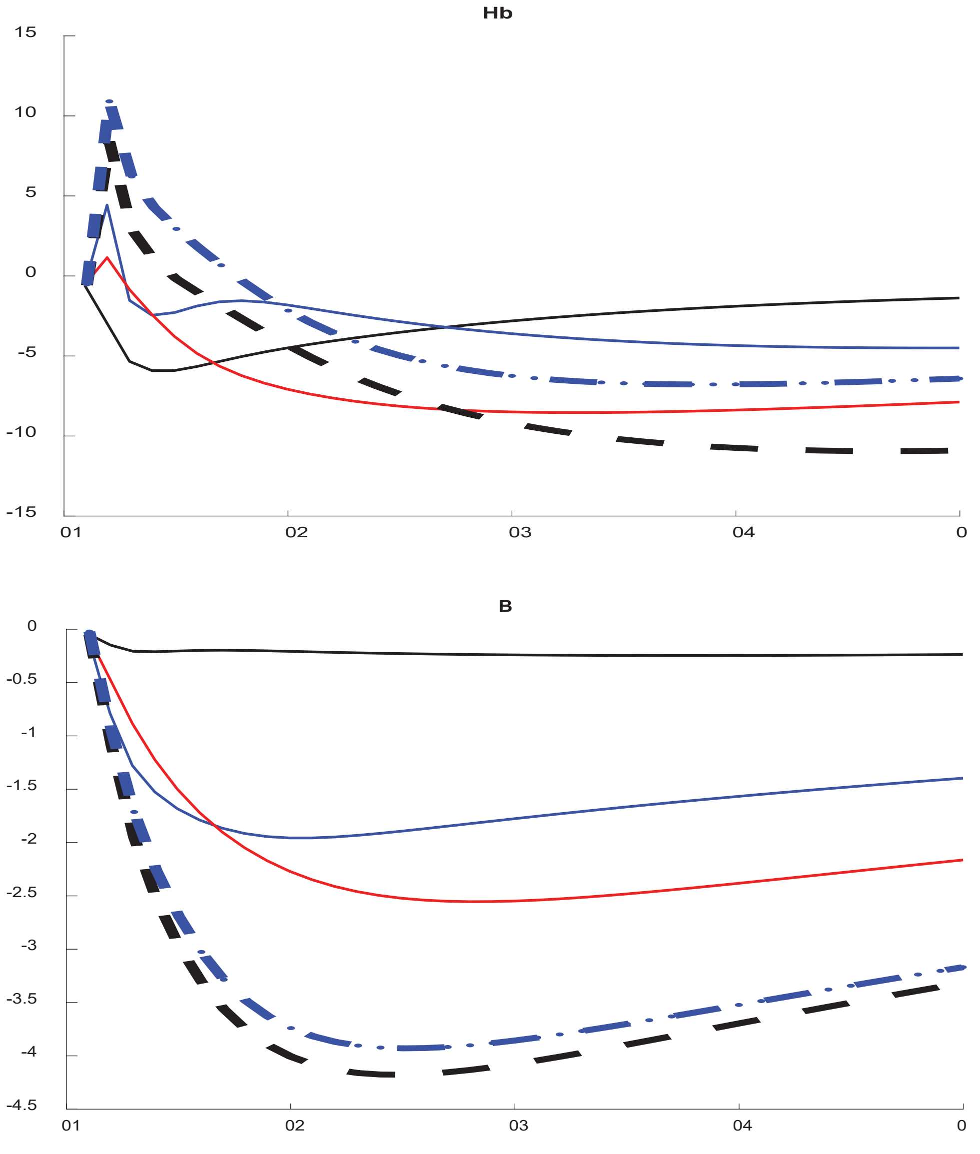
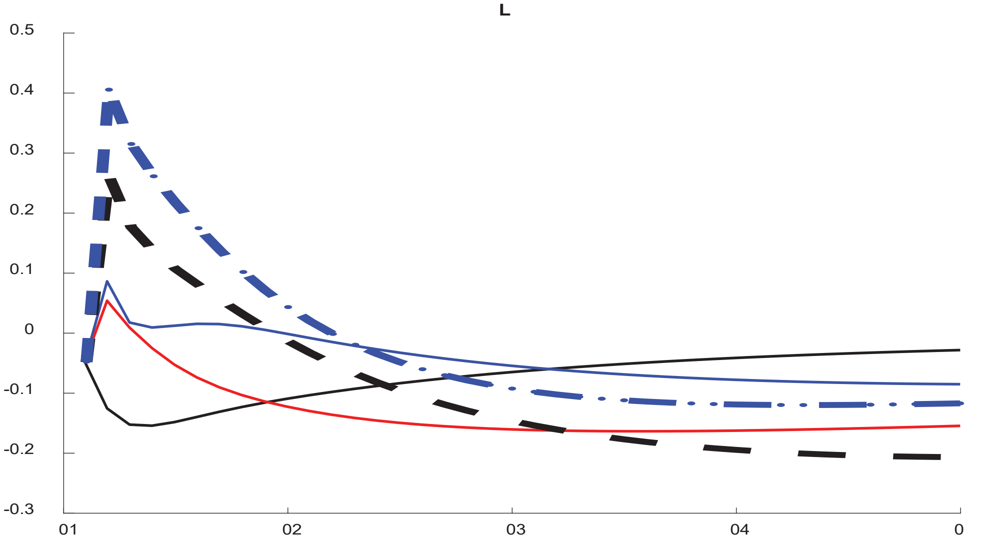


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)



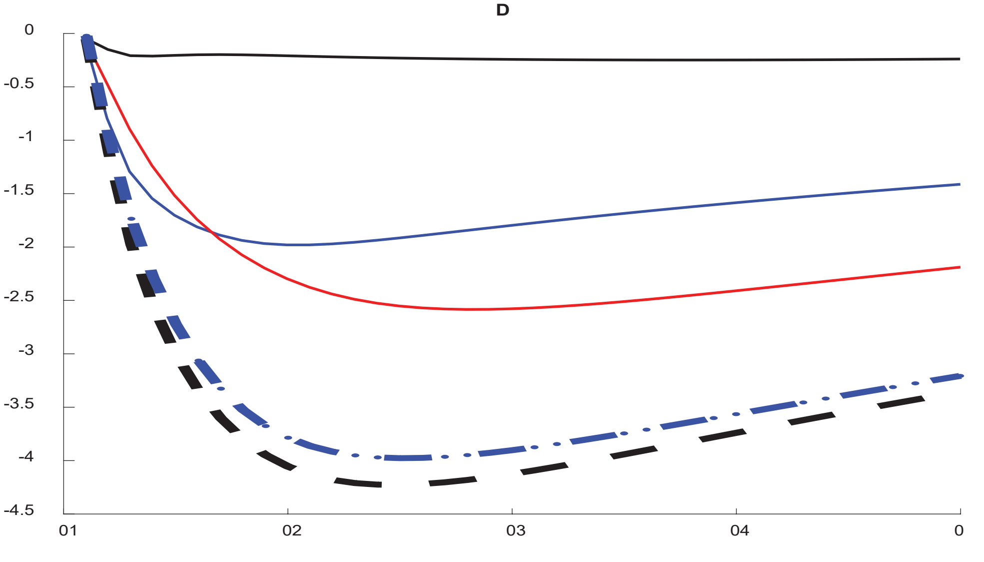
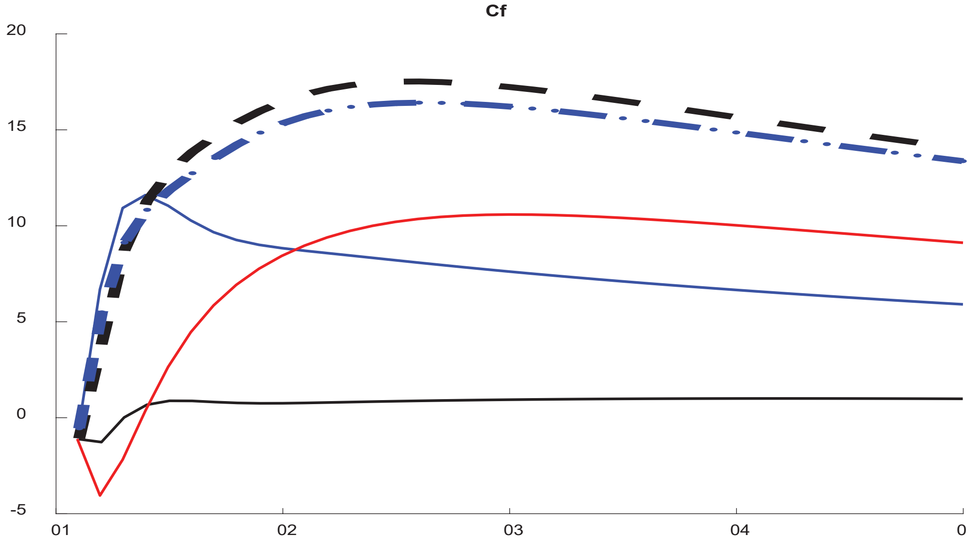


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)



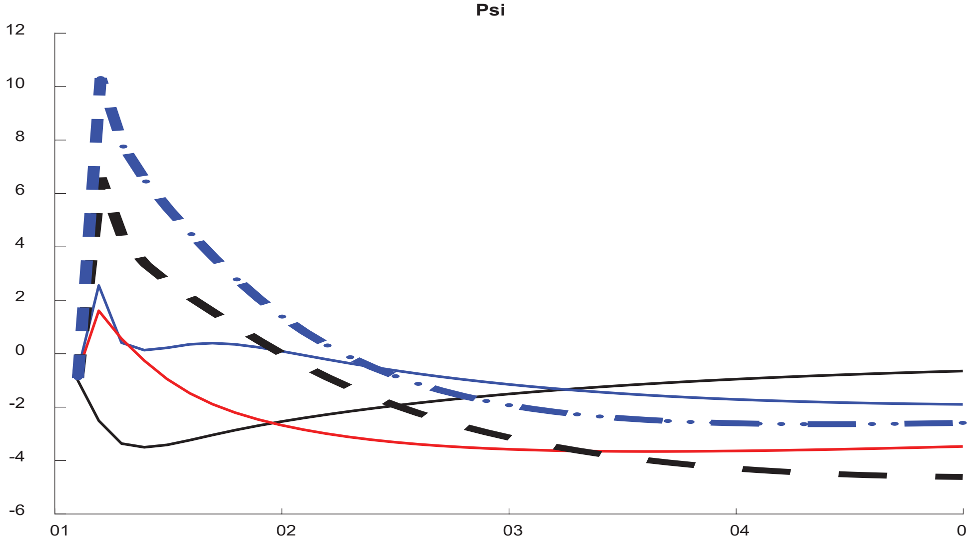


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)

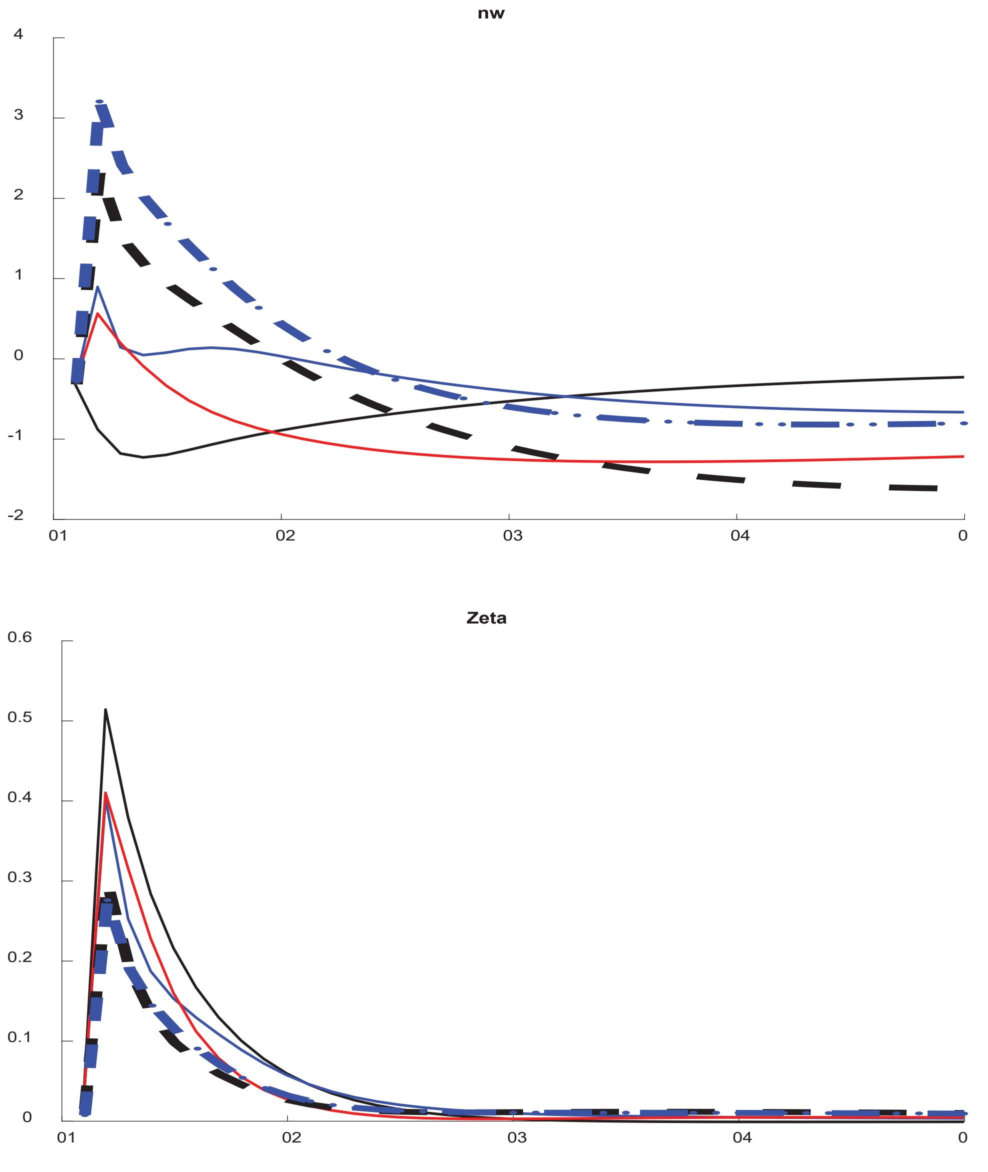
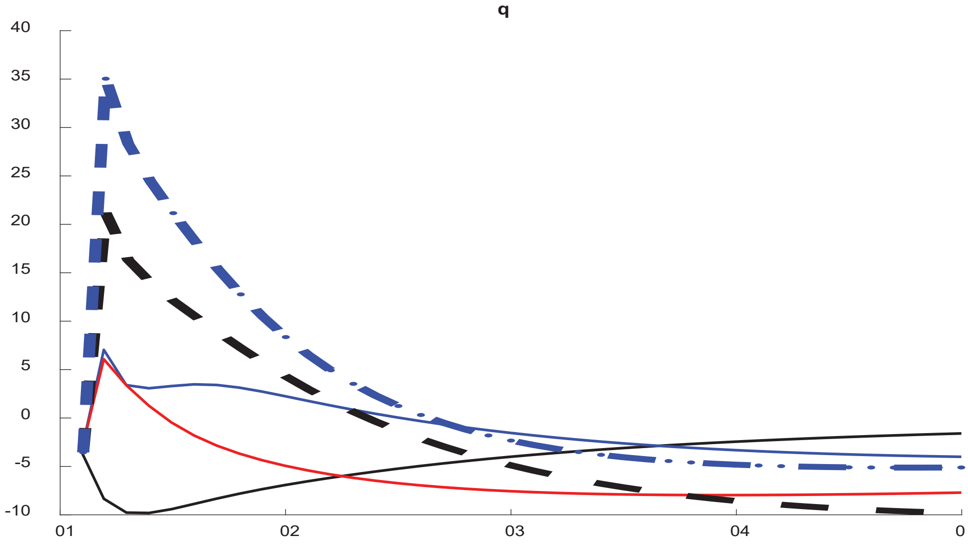


Figure 3.
Impulse Response Function to Pandemic Shock (Continued)



As shown by the impulse response, the negative labor supply shock has a contractionary effect on public consumption. Pandemic shocks cause fluctuations in household wages on the demand side. Because of lower wages, household saver income falls, reducing household saver spending. Household borrowers, on the other hand, can still increase their spending because they could smooth out their consumption by accessing bank loans. Due to the lack of a housing producer in our model, housing prices are solely determined by demand similar to that used by Iacoviello (2005), Rubio and Carrasco-Gallego (2016), and Liu and Molise (2019). Because of the labor supply shock, household income will fall, reducing household purchasing power and lowering demand for housing stock. As a result, it will reduce the equilibrium level of credit. Our finding is similar to those of Rubio and Carrasco-Gallego (2016) and Liu and Molise (2019). Moreover, IRF analysis shows there has been a positive response to inflation. This means that the labor shortage will lead to a drop in production and reduce the availability of consumer goods, which will lead to an increase in overall prices. In so doing, the banking sector is equally affected by the pandemic, as the pandemic shock declining the equilibrium household deposit and reducing banking liquidity. On the other hand, decreasing household financial conditions increased the risk of defaulting on loan contracts. Consequently, banks' overall performance suffers, as does their ability to channel credit.

B. Response of Variables to Policy Shocks

Policy rate cuts during the pandemic aims to support overall liquidity in the system and prevent the pandemic from spreading further into the financial sector. From the IRF analysis, reducing policy rate encourages aggregate consumption levels and boosts economic growth. Policy rate cuts, on the other hand, are likely to boost household demand for housing and increase the demand for credit from the banking sector. Furthermore, policy rate cuts increase interest rate margins from loan and deposit rates, increase financial condition of the banks and stimulate a larger consumption. As a result, policy rate cuts may be able to assist financial intermediaries in keeping their performance. In contrast, an impulse reaction shows that lowering policy rates will raise inflation faster than a pandemic shock with no policy response.

The fiscal policy shock in coping with the pandemic aimed at preserving household purchasing power. In the short run, the IRF shows that fiscal policy has a lower ability to push aggregate demand than monetary policy. Fiscal policy, on the other hand, has the potential to boost aggregate demand larger than monetary policy in the long run. The obvious distinction compared to monetary policy is that fiscal policy does not cause a greater inflation shock. Furthermore, fiscal policy has the potential to increase household demand for housing stock and credit while having a limited influence on inflation.

Hereafter, we examine the impact of the monetary and fiscal policy mix in dealing with pandemics. According to IRF analysis, such a policy mix could accelerate economic recovery. A decrease in household consumption is more severe than in the prior scenario. However, the drop in household spending was countered by a rise in housing stock demand. As the stock of housing rises, the household has a better financial condition since the amount of collateral available to households increases, resulting in an increase in creditworthiness. Subsequently, households will demand more external financing from the banking sector, resulting in an increase in the equilibrium level of credit. This result shows that policy mix is able to accelerate the economic recovery process larger compared to if the policies were implemented separately.

Finally, we simulate macroprudential policy through an easing LTV regulation. According to the IRF analysis, easing LTV regulation allows households to access more credit. This will improve financial conditions and accelerate credit recovery. Furthermore, easing LTV regulation could help the housing stock return to equilibrium faster. These findings suggest that the policy mix has the potential to speed up the economic recovery process, but it also has the potential to increase inflation more than each policy implemented separately.

C. Robustness Checks

The most serious problem with the DSGE model is misspecification generated by overly strict constraints. We utilized the Del Negro *et al.* (2007) approach to check that our model did not have a misspecification problem. We construct a mapping from the DSGE model to the VAR parameters using the VAR as an approximation model for the DSGE model. This technique relaxes the restrictions of the DSGE model and gives a VAR representation of DSGE models. by fitting the VAR to observed data as closely as possible to the DSGE restrictions. To assess deviations from the DSGE model constraints, we define the cross-coefficient constraints(λ).

Suppose that $\mathrm{y_t} = \left[\widehat{y_t}, \widehat{\pi_t}, \widehat{L_t}, \widehat{B}_t, R_{b,t}, \eta_t\right]$ then consider the VAR specification for y_t is written in the form

$$\triangle y_t = \Phi_0 + \Phi_\beta(\beta' y_{t-1}) + \Phi_1 \triangle y_{t-1} + \cdots + \Phi_p \triangle y_{t-p} + u_t \tag{23}$$

where innovation is normally distributed on past information $u_t \sim N(0, \Sigma_u)$. To obtain a structural var we express the forecast error of u_t as a function of the shocks ϵ_t that appear in the DSGE model.

$$u_t = \Sigma_{tr} \Omega \epsilon_t \tag{24}$$

Where Σ_{tr} is the cholesky decomposition of Σ_u and Ω is an orthonormal matrix. Starting from prior distribution of the parameter θ from DSGE models, obtain the mapping coefficient to parameter Φ and Σ_u of the VAR parameters. We use VAR as the approximation DSGE models to relax DSGE model restrictions. The hyperparameter lambda(λ) generates a continuum of models, which we call DSGE–VAR(λ), that essentially has an unrestricted VAR at one extreme (λ is near 0) and the VAR approximation of the DSGE model at the other extreme ($\lambda=\infty$). Construct the joint prior distribution for VAR and DSGE model parameters using the following structure

$$p(\theta, \Phi, \Sigma_u, \Omega | \lambda) = p(\theta) p(\Phi, \Sigma_u, \Omega | \theta, \lambda) \tag{25}$$

Del Negro *et al.* (2007) examines the marginal likelihood function of the hyperparameter λ to fit the DSGE model as

$$p(Y | \lambda) = \int p(Y | \theta, \Sigma, \Phi) p(\theta, \Sigma, \Phi | \lambda) \, d(\theta, \Sigma, \Phi) \tag{26}$$

Then use the modified harmonic mean estimator to obtain the numerical approximation of the marginal likelihood function based on the output of the MCMC computations. Finally, we can estimate hyper parameter taken form the posterior information of λ by taking

$$\hat{\lambda} = \arg \max_{\lambda \in \Lambda} p(Y | \lambda) \tag{27}$$

Figure 4.
Effects of the Monetary Policy Shock in the DSGE-VAR and DSGE Model

These figures provide impulse response function analysis from Bayesian DSGE and Bayesian DSGE-VAR; Black line is mean of DSGE IRF; Blue line is mean DSGE-VAR($\hat{\lambda}$). The dashed line represents the 90% Highest Probability Density Interval (HPDI) for corresponding IRF.

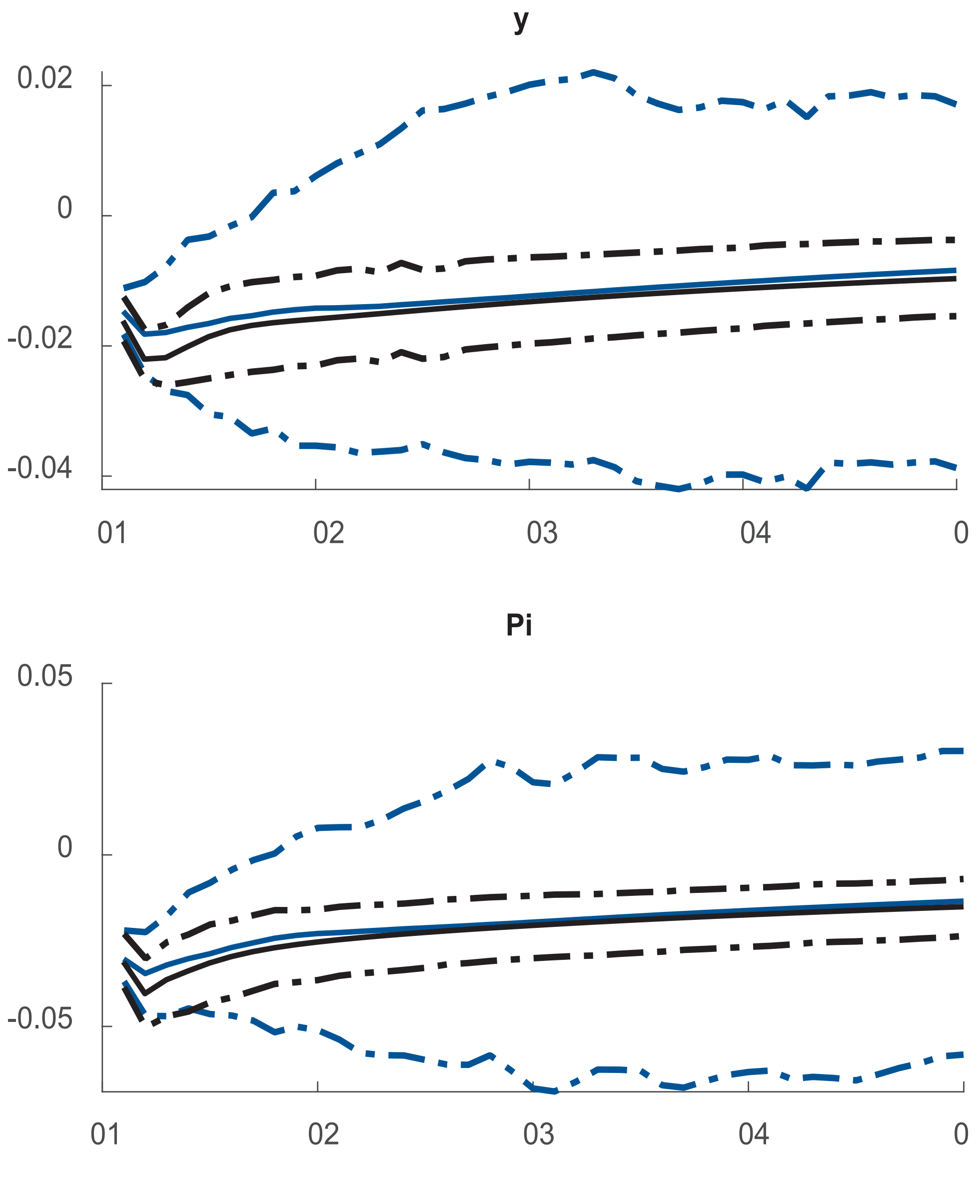


Figure 4.
Effects of the Monetary Policy Shock in the DSGE-VAR and DSGE Model
(Continued)

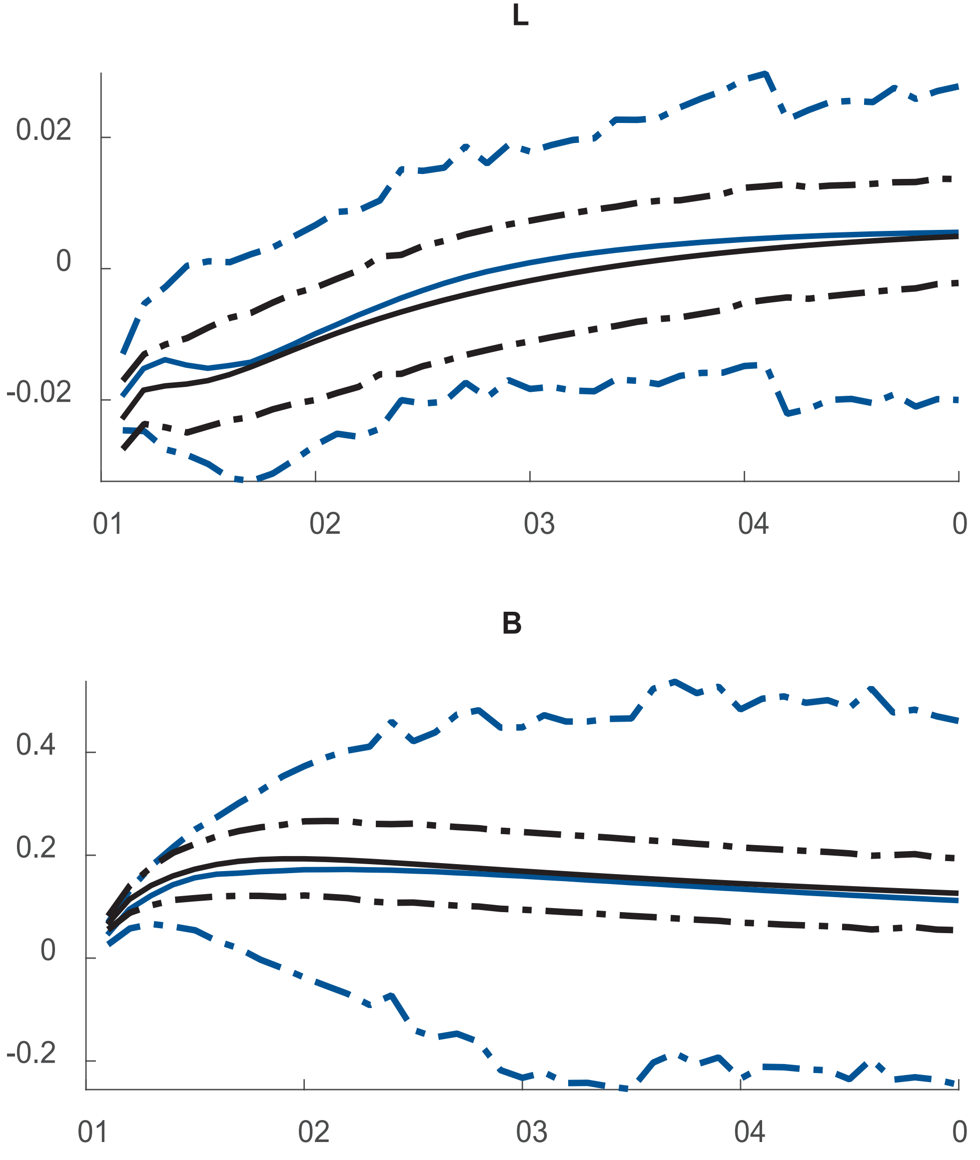


Figure 4.
Effects of the Monetary Policy Shock in the DSGE-VAR and DSGE Model (Continued)

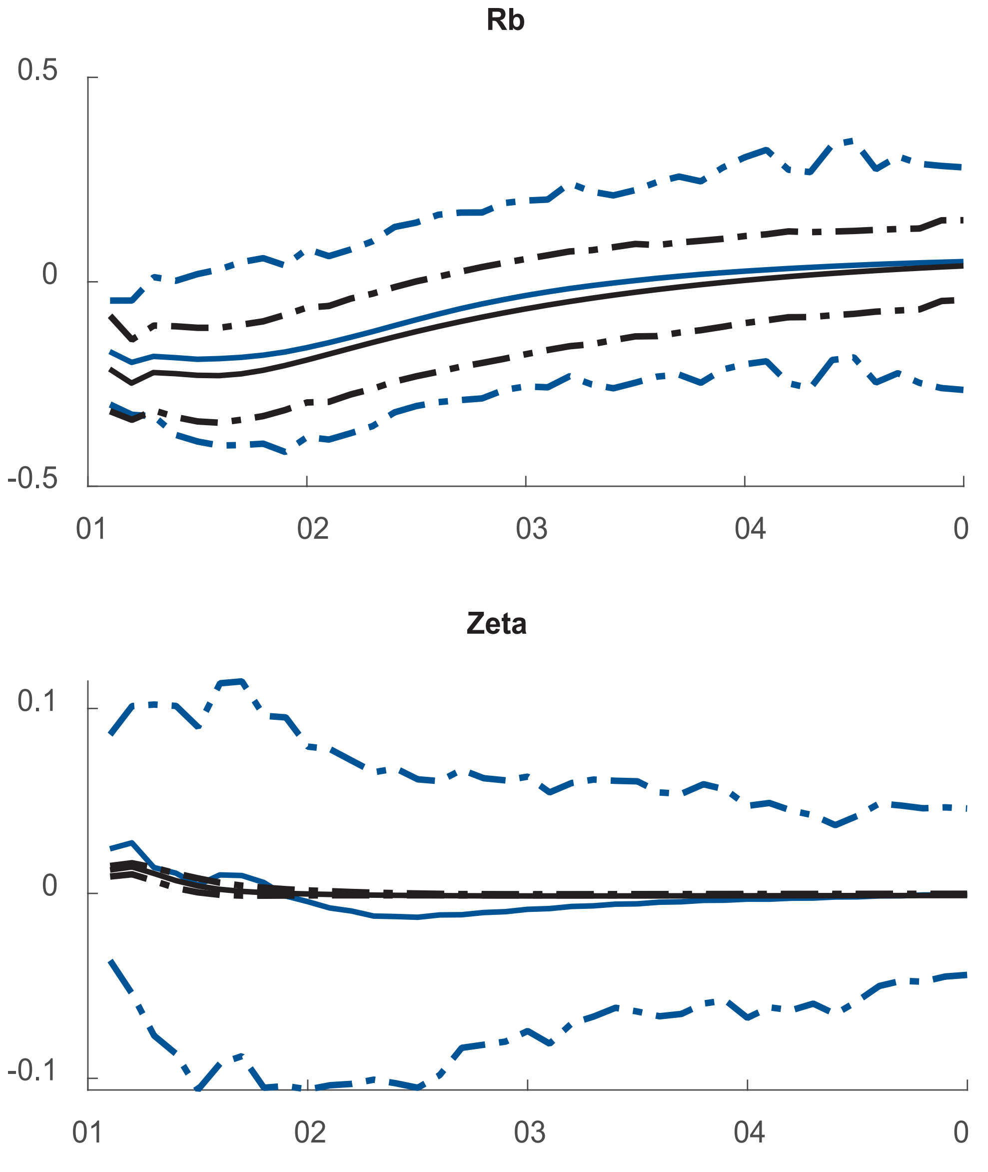


Figure 5.
Effects of the Government Expenditure Shock in the DSGE-VAR and DSGE Model

These figures provide impulse response function analysis from Bayesian DSGE and Bayesian DSGE-VAR; Black line is mean of DSGE IRF; Blue line is mean DSGE-VAR($\hat{\lambda}$). The dashed line represents the 90% Highest Probability Density Interval (HPDI) for corresponding IRF.

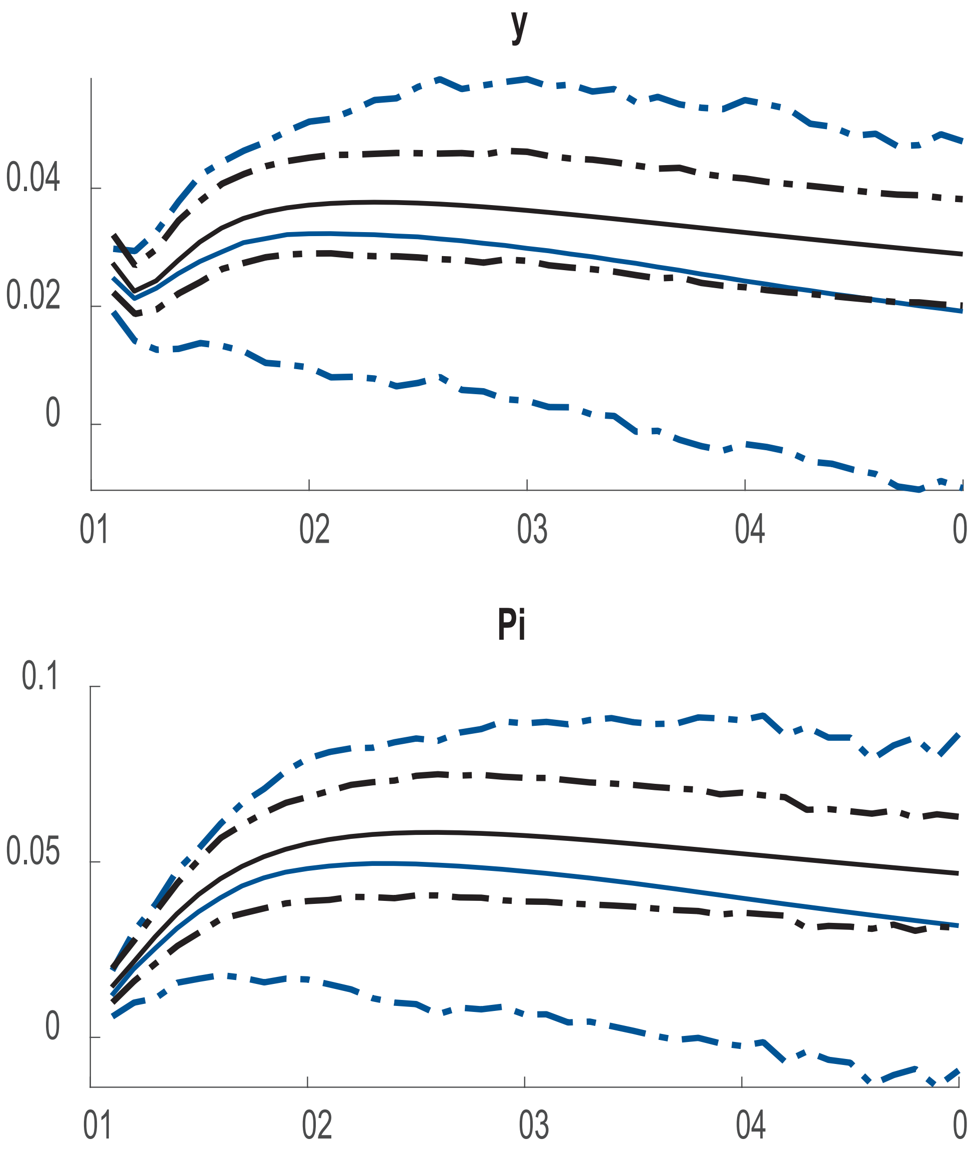


Figure 5.
Effects of the Government Expenditure Shock in the DSGE-VAR and DSGE Model (Continued)

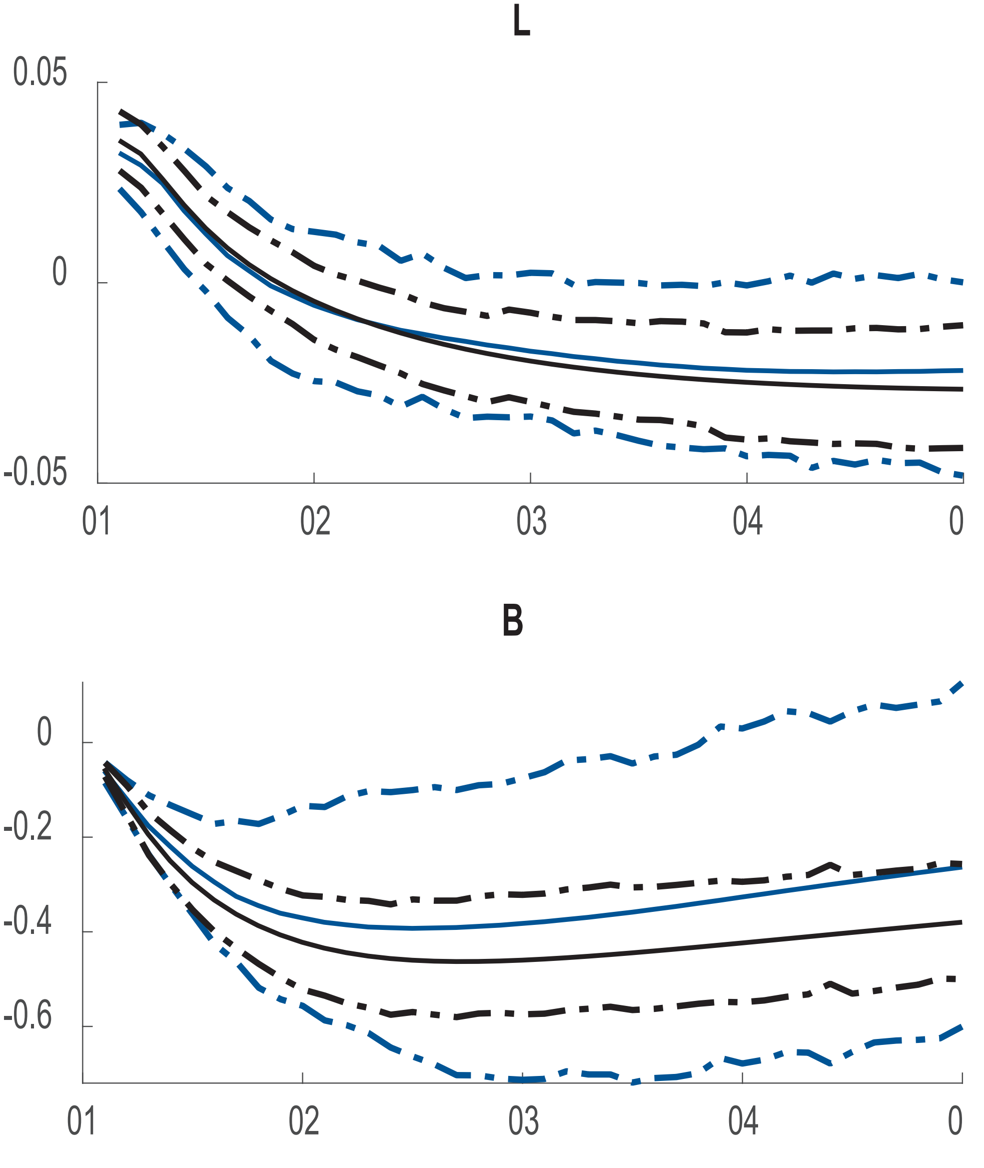
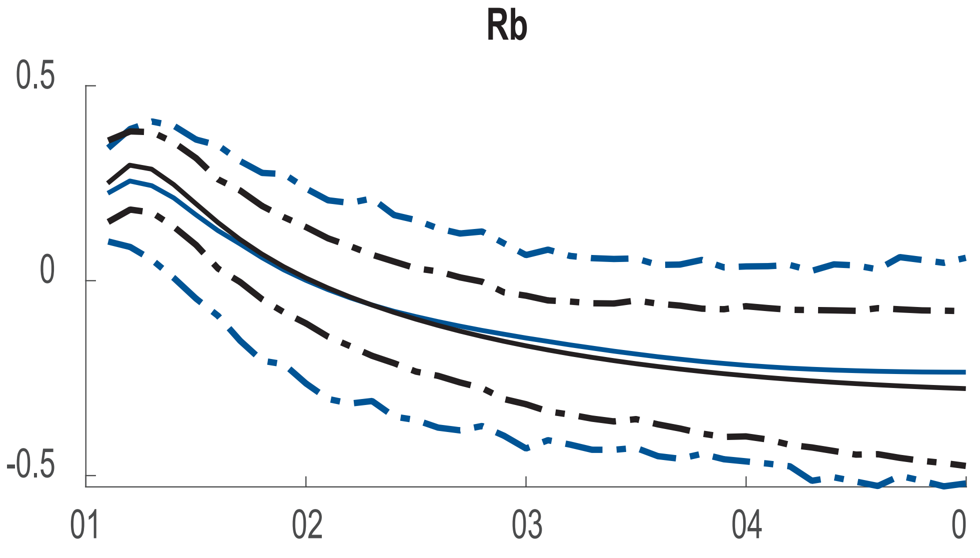
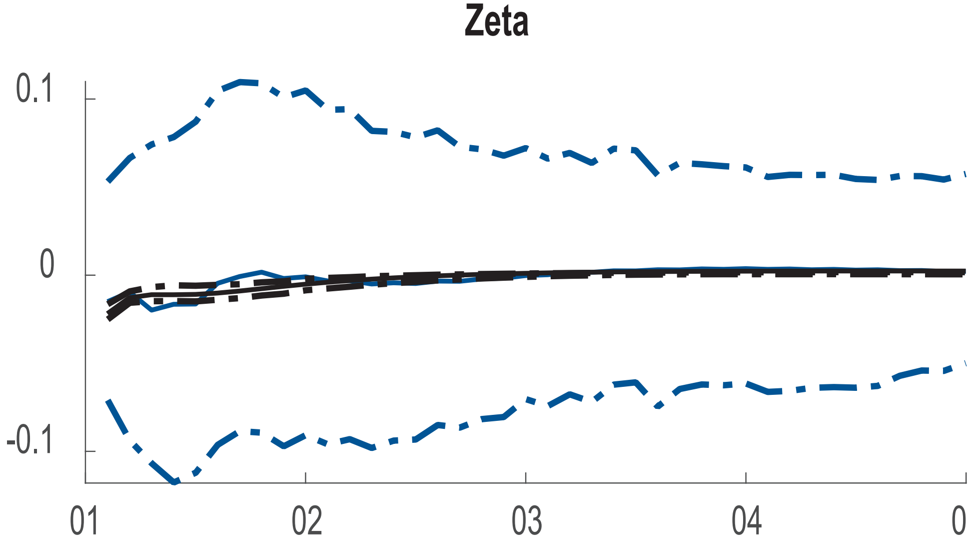


Figure 5.
Effects of the Government Expenditure Shock in the DSGE-VAR and DSGE Model (Continued)





We must investigate the model's robustness using DSGE-VAR Del Negro *et al.* (2007) to improve its performance. One advantage of adopting DSGE-VAR over reduced form statistical models is that we learn about the economy's structure. By studying the impulse response function, we want to assess the degree of DSGE model misspecification and learn how to improve DSGE model specification. Figure 4 and 5 show the impulse response functions from lambda estimated using data up to 2021Q1. The graphs show the DSGE impulse responses (black lines) and DSGE-VAR impulse responses (blue lines), as well as the corresponding 95% confidence intervals. Our findings indicate that the size and sign of the DSGE and DSGE-VAR impulse responses are relatively similar. We hypothesize that in the absence of DSGE model misspecification and VAR approximation error, the DSGE model and DSGE–VAR impulse responses to policy shocks would coincide. As shown in the figures, our DSGE is quite robust in terms of keeping the model's constraints as close to the original specification as possible. As a result, we proposed that our model, with better time series fit, could be used for macroeconomic forecasting and quantitative policy analysis.

V. CONCLUSIONS AND POLICY IMPLICATIONS

In this study, we develop a DSGE model for Indonesia in order to measure the effectiveness of policy mix in mitigating pandemic shocks. Our findings, based on the New Keynesian framework, show that the policy mix is the best way to accelerate the economic recovery process. Despite the existence of macroeconomic and financial linkages, this conclusion remains consistent with Bartsch *et al*. (2020): that the policy mix is the preferred choice for dealing with tail risk, resulting in a positive demand shock and recovery. However, we should be more concerned about the possibility that the policy mix would generate macroeconomic fluctuations. According to IRF analysis, the policy combination delivers the largest inflation reaction when compared to other scenarios.

Our findings show that the combination of fiscal and monetary policy has a higher multiplier effect on aggregate demand. Our findings are consistent with Gali (2020), who argues that increased government spending combined with central bank policies aimed at price stability will provide a larger multiplier for growth. However, strong coordination between fiscal and monetary authorities is required to reduce the impact of inflation risk, with the objective of accelerating economic recovery while maintaining macroeconomic stability. Following that, our findings are consistent with those of Liu *et al.* (2021), who argue that China's fiscal dominance may not result in a well-anchored inflation expectation, leading to higher and more volatile inflation. In our framework, we highlight the financial accelerator channel and how it influences mix policies throughout the housing sector. Our findings indicate a stronger credit equilibrium since fiscal policy through government transfers may support household purchasing power, leading in increased demand for housing stock from household borrowers. The increase in housing stock improves the household's financial situation (net worth) and increases creditworthiness. It will generate credit demand from the household sector, resulting in a faster return to equilibrium for bank credit. As a result, fiscal policy plays a significant role in the policy mix by accelerating the recovery of the pandemic-affected economy. However, we believe that cooperation across authorities is required in order to successfully employ its tools to achieve its policy objectives.

Finally, as we have seen, the credit market imperfection has a substantial impact on macroeconomic fluctuations. However, there are a number of other financial frictions that we do not consider in our analysis that can be included.

We propose that future studies include more frictions in order to have a better explanation of macroeconomic fluctuations.

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