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RESEARCH ARTICLE

The Role of Public Investment in Pandemic Recovery

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The goal of this study is to review the risk associated with increases in sovereign deficits and the role of public investment in pandemic recovery. The estimates of DSGE models show that fiscal authority provides more emphasis on debt to GDP than output and deficits. In addition, the stochastic simulation shows that increases in public investment do not limit the increases in private investment. And both public and private investment exhibit procyclical behaviors in the presence of government spending shock. Lastly, the output is more persistent during episodes of technology shocks than during an increase in government spending. The paper also shows that output, private investment, and government capital and deficit responded more to the fiscal rules that embed government capital than without.

Keywords: Deficit, Government Capital, Fiscal Rules, Public Investment

JEL Classification: E52, E61, E65, E22, E32

The current pandemic brought several uncertainties to the prospect of many economies, and the government responded to the health crisis by providing appropriate social safety nets for the marginalized segments of the population and restricting people's mobility to contain the pandemic. The direct result of the imposed restrictions is a much lower economic activity and tax revenue. With rising public expenditure and a much lower income stream, it is inevitable for the government to increase the public deficit. Together with limited resources and the inability to raise new taxes, the government enlarged the size of public debt to finance the deficit. The debt-funded deficit is invested in various infrastructure projects intended to speed the recovery. The associated risk of fiscal imbalance and the unsustainability of the rising debt-driven fiscal deficit led to public discussion and a continuous call for fiscal discipline. However, caution is needed in heeding the call for fiscal discipline. Lacking from the public discussion are tools that account for the macroeconomic effects of sovereign deficits in output and inflation.

The amount of associated output loss during lockdown requires the recalibration of the existing strategy in resolving the pandemic. Still, many questions need to be answered. Does policy to reduce interaction among the people result in an economic recession? Or does the pandemic only induce a temporary shock on employment, consumption, and investment? These are important questions that have

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been extensively studied in recent literature after the pandemic emerges (Costa Junior et al., 2021; Eichenbaum et al., 2020; Faria-e-Castro, 2021; Glover et al., 2020). For example, Eichenbaum et al. (2020) incorporated canonical epidemiology into a standard neoclassical model to study the economic outcomes of the pandemic. In their study, the decision to impose a lockdown reduce the severity of the pandemic at the expense of economic recession. Their general equilibrium model became the basis for the subsequent literature that incorporates pandemic features in the standard macro model.

This paper is different from the preceding literature as it does not endogenize the effects of the pandemic and its effects on the decision of household and firms, and how macroeconomic variable behaves under negative shocks from the pandemic. Rather, the paper aims to provide a counterfactual experiment on the government's response to the shock on demand and supply after the pandemic hit. The paper investigates an active fiscal authority, aiming to increase deficits in funding various investments in infrastructure projects. The objective of this public investment in infrastructure is to restore the economy from the effects of the lockdown. Economic theory suggests that increasing government capital induces increases in productivity and a lowering of price levels. However, the benefits of expanding the deficits and its efficacy as a countercyclical instrument require careful analysis and consideration.

This paper aims to provide credible tools for developing insight into an appropriate instrument needed for recovery from the pandemic. Also, the results are an important backdrop for the public debates on the role of the public deficit in pandemic recovery. In this study, I introduce a small-scale DSGE model as a tool for measuring the effects of public investment on output, inflation, and other economic variables. In a neoclassical model, the only driver of productivity is a positive shock on technology. This makes public investment irrelevant as a countercyclical tool. Multiple research aims to evaluate the effects of certain policies on the economy and assumes that government capital has a passive role in the firm's production function (Cantore et al., 2014; Fernández-Villaverde, 2010; Leith et al., 2015). In retrospect, modeling the channel in which fiscal policy affects the economy usually focuses on the government budget constraints, and the relevance of government capital in smoothing the business cycle is usually implied implicitly. I deviate from those studies by introducing stylized features that capture the productivity shock on firms' capital, induced by increases in government capital. In my model, activist fiscal authority stabilizes the economy by increasing government spending on public investment in infrastructure as a policy instrument. I modeled the shift of government policy toward increasing public investment in infrastructure by introducing productive government capital in the firm's production function, which is similar to Baxter and King (1993). This allows for government spending on the public capital outlay to play a crucial role in generating expansionary effects on output.

This paper contributes to the literature by investigating the role of relative shares of government capital in the firm's production function, and the response of different economic variables in the model. I also embed fiscal rules that capture the desire of the government to smooth the business cycles under the prudence of fiscal discipline. In this paper, the government follows the Taylor rule type, in which fiscal spending is conditional on output, debt, and deficit. I believe this modeling feature is important to incorporate into the model to match the observed economic realities in the Philippines. This paper wishes to answer two main questions. First, does an increase in the share of government capital on a firm's production function could lead to better economic outcomes? Second, using embedded fiscal rules does the government following debt and deficit targeting improve the dynamics in the business cycles?

Review of Literature

There is a different strand of study on how to model the effects of public spending as a policy instrument on the economy using the dynamic stochastic general equilibrium (DSGE) model. For example, Ramey (2020) highlighted the potential increase in long-run output using infrastructure as a policy tool. She attributed this result to the effects of the increased government investment in infrastructure on the stock of public capital. Also, she showed that the long-run benefits of infrastructure outweigh the short-run benefits. Aschauer (1989a) suggested that the flow of capital stock of public infrastructure is a major determinant of US productivity. This result is similar to Aschauer (1989b) and Zeyneloglu (2018). They showed that public investment spending on infrastructure produces a sizable increase in output. Dadgostar and Mirabelli (1998) reported that public investment positively affected private investment. Other studies, like Lim (2017), showed that government spending on infrastructure helps the economy recover after a natural disaster. In Lim's simulation, natural disasters, such as frequent storms in the Philippines, destroy different infrastructures. Thus, a foreign aid-funded program is a tool for fiscal policy to recover from a natural disaster. Leeper et al. (2010) and Dacuycuy and Sauler (2019) showed that implementation delays diminish the immediate effects of public infrastructure investment. Legal setbacks and other forms of delays impact the timing of infrastructure benefits.

On the other hand, studies are conducted to measure the effects of public investment on output in the Philippines context. Teruel and Kuroda (2004) observed that public infrastructure significantly contributed to the increase in productivity in the late 1970s in the Philippines. Using the SVAR model of the Philippines, Manasan (2011) found that government spending stabilized the decline in export and private investment during the Global Financial Crisis. Also, in his paper, he showed that a major part of the increase in GDP during that period was driven by government consumption and public infrastructure. Ducanes et al.(2006), using structural econometric models studied the effects of government expenditure composition among emerging Asian economies, including the Philippines. They showed that targeted spending on public investment produces a higher fiscal multiplier compared with spending focused on government consumption. Corong et al. (2013) studied the distributive impact of public investment. In their paper, they showed that government investment in infrastructure not only brings a positive spillover on GDP but also reduces poverty and inequality. Weak investment and low public infrastructure levels in the Philippines are being studied by Dohner and Intal (1989), Rodlauer et al. (2000), and Magnoli (2008).

Despite extensive use of fiscal DSGE models in the literature. The paper seeks to address the gap in the literature on Philippine macroeconomic analysis by introducing productive government capital in a general equilibrium model as a tool to understand the effects of increasing public investment on output and other macroeconomic variables.

Model

The model in this study is similar to Leeper et al. (2010). Households buy the products from the goods market and provide labor and capital to the inputs market. Also, the government raises taxes on households to finance its spending and sells government bonds to finance its deficit.

Household

A continuum of households that derive utility by consumption C_t lives the model, relative to the stock of habits h and disutility in providing labor hours L_t. The household stock of habit is given by the fraction of the household's previous consumption in the form, of hC_{t-1} where $h \in [0,1]$ is the habit parameter. The habit parameter measures the relative desires of households to smoothen consumption in the presence of shock. Also, the persistence of habits explains the nominal rigidities in consumption. Furthermore, the household utility maximization problem can be written as

$$E_t \sum_{s=0}^{\infty} \beta^{t+s} \chi_{t+s}^{u} \left[\frac{1}{1-\gamma} (C_{t+s} - hC_{t+s-1})^{1-\gamma} - \chi_{t+s}^{l} \frac{L_{t+s}^{1+\kappa}}{1+\kappa} \right] \tag{1}$$

where $\gamma, \kappa \in (0,1)$ are parameters that represent the inverse relative risk aversion of households and the inverse of the Frisch substitution elasticity of labor consecutively; $\beta \in (0,1)$ is the household discount factor. And χ_t^u and χ_t^l are shocks on preference and labor. The household budget constraint can be written as:

$$(1+\varphi_t^c)P_t C_t + I_t + B_t = (1-\varphi_t^l)W_t L_t + (1+\varphi_t^k)R_t^k K_t^p + R_t^b B_{t-1} + \phi_t \tag{2}$$

private capital follows a simple law of motion

$$K_t^P = (1-\delta)K_{t-1}^p + I_t^P \tag{3}$$

where $\delta \in (0,1)$ is the private capital depreciation rate. The representative agent purchases consumption C_t, private investment, I_t^p, and lend to the government by purchasing one-period government bonds B_t. Household wealth is derived from labor income $W_t L_t$, dividends from renting private capital to the firm, $R_t^k K_t^p$ and returns from holding government bonds $R_t^b B_{t-1}$. Where $W_t, L_t, R_t^k, K_t^p, R_t^b$ and $B_{t=1}$ are wage, labor, rent on capital, private capital, rate of return of one-period government bond, and household bond holding from the previous period consecutively. Lastly, the household received a transfer from the government ϕ_t. Dividing the household budget constraint by the price level P_t makes the variables in the model on a per capita basis which is denoted by lowercase letters. The φ_t^c, φ_t^l parameter and φ_t^k are the rate the government levied on household consumption, labor, and capital earnings, respectively.

I can write the real rates of the government bond as $r_t^b \equiv R_t^b - \pi_t$ and $\pi_t \equiv P_t/P_{t+1}$ as the gross inflation. Lastly, I assume that the household is subject to borrowing constraints that prevent them from engaging in Ponzi schemes.

Household chooses the sequences of consumption, labor, capital, and debt consecutively $\{c_t, l_t, k_t, b_t\}$ .Solving the household first-order condition yields the following:

$$(1+\varphi^c)\lambda_t = (c_t - hc_{t-1})^{-\gamma} - h\,\beta \mathrm{E}_t(c_{t+1} \tag{4}$$

$$\lambda_t = \frac{\chi^l l_t^\kappa}{(1+\varphi^l)w_t} \tag{5}$$

$$\frac{1}{(1+R_t^B)} = \beta^t \frac{\lambda_{t+1}}{\lambda_t} \tag{6}$$

$$\frac{1}{(1+R_t^B)} = \beta^t \frac{\lambda_{t+1}}{\lambda_t} \tag{7}$$

where λ_t is the langrage multiplier associated with the household optimization problem. Equation (4) defines the household marginal rate of substitution. Equation (5) is the household labor hour allocation, and Equation (6) is the portfolio of a government bond. Lastly, Equation (7) describes the household Euler equation. Collectively, Equations (4) to (7) describe the decision rules of the household's optimal resource allocation.

Firms

I divided the firm sector between perfectly competitive final goods firms and monopolistic competitive intermediate goods firms. There is a continuum of intermediate goods index by j which is distributed over an interval of that is being sold by the monopolistic competitive firm to the final goods firm.

The final good firms used Dixit-and-Stiglitz (1977) technology in aggregating intermediates goods.

$$Y_t = \left[\int_0^1 (y_{j,t})^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{8}$$

where $y_{j,t}$ is the quantity of intermediate goods j used at time t and ε is the elasticity of substitution between different goods. In every period the final good firms maximize their profit by

$$\max\left[P_t Y_t - \int_0^1 p_{j,t} y_{j,t}\, dj\right] \tag{9}$$

Solving Equation (9) given Equation (8) yields the demand for intermediate goods and the price index:

$$y_{j,t} = \left(\frac{p_{j,t}}{P_t}\right)^{-\varepsilon} Y_t\,; \tag{10}$$

$$P_t = \left[\int_0^1 (p_{j,t})^{1-\varepsilon}\, dj\right]^{\frac{1}{1-\varepsilon}} \tag{11}$$

The intermediate goods firm purchases labor and capital from the household sector and also uses government capital k_t^G to produce intermediate goods using Cobb-Douglas production technology.

$$y_{j,t} = A_t\left(k_{jt}^P\right)^\alpha l_{jt}^{1-\alpha}\,(k_{t-1}^G)^{\alpha_G} \tag{12}$$

where α is the parameter that shows the share of the private capital production process, and $A_t = \rho_A + (1-\rho_A)A_{t-1} + \varepsilon_{At}$ are the firm's technical productivity available to all intermediate firms that follow AR(1) process and ε_{At} is a stochastic shock on productivity that has zero mean and constant variance. Based on Leeper et al. (2010), α_G is defined as the efficiency parameter of government spending Lim (2017), have different interpretations of this which this paper follows. In his study, he defined this as the measure of the influence of government capital on intermediate goods production or simply, the share of government capital in the intermediate goods production function. Dacuycuy and Sauler (2019), in their paper on the Disbursement Acceleration Program (DAP), allowed the accumulation of government capital to have effects on the firm's production. Pfeiffer et al.(2021), on the impact of the European Economic Recovery Plan (ERP), showed the effectiveness of government investment in pandemic recovery. The interaction of public capital with private capital on the firm's production function allows the study to capture the macroeconomic effects of government investment on infrastructure.

I follow Fernandez-Villaverde (2009) on the exposition of firms' cost minimization problems.

$$\min_{k^P_{jt-1}, l_{jt}} r_t^P k_{j,t}^P + w_t l_{j,t} \tag{13}$$

Solving (12) given (13) yields the intermediate firms' demand for labor and capital.

$$r_t^P = \frac{\alpha w_t}{(1-\alpha)} \frac{l_{j,t}}{k_{j,t}^P} \tag{14}$$

Rewriting Equation (14) as $r_t^P k_{j,t}^P = \frac{\alpha l_{j,t} w_t}{(1-\alpha)}$ and substituting it with Equation (13) yields the real cost of the intermediate firms.

$$w_t l_{j,t} + \frac{\alpha w_t l_{j,t}}{(1-\alpha)} = \frac{w_t l_{j,t}}{(1-\alpha)} \tag{15}$$

Substituting Equation (14) to Equation (15) and letting it equal to 1, exploiting the fact that each intermediate firm uses constant return to scale (CRS) technology, similar to Fernandez-Villaverde (2009), yields

$$l_{j,t} = \frac{\left[\frac{\alpha w_t}{(1-\alpha) r_t^P}\right]^{-\alpha} (k_t^G)^{-\alpha_G}}{A_t} \tag{16}$$

Again, substituting Equation (16) into Equation (15) gives the intermediate firm's marginal cost.

$$l_{j,t} = \frac{\left[\frac{\alpha w_t}{(1-\alpha) r_t^P}\right]^{-\alpha} (k_t^G)^{-\alpha_G}}{A_t} \tag{17}$$

Based on the above exposition, the level of government capital affects the firm's marginal cost, which affects the firm's pricing decisions. This argument is similar to Dacuycuy and Sauler (2019) and Fernandez-Villaverde (2009) in their model on productive government capital. The second stage of the intermediate firm's problem is maximizing the discounted present value of its profit. Using Calvo pricing, $(1-\theta)$ a fraction of the firms will optimize their price, and the rest of the firms will index their price from past inflation. The indexation parameter $\chi \in [0,1]$ governs the relative desire of a non-optimizing firm to index its price. Given the optimal demand for intermediate goods,

$$y_{jt+\omega} = \left(\prod_{s=1}^{\omega} \pi_{t+s-1}^{\chi} \frac{P_{jt}}{P_{t+\omega}}\right)^{-\varepsilon} y_{t+\omega} \tag{18}$$

The firm's problem is to maximize Equation (19) subject to Equation (18),

$$\max_{P_{jt}} E_t \sum_{\omega=0}^{\infty} (\beta\theta)^{\omega} \frac{\lambda_{t+\omega}}{\lambda_t} \left(\prod_{s=1}^{\omega} \pi_{t+s-1}^{\chi} \frac{p_{jt}}{p_{t+\omega}} - mc_{t+\omega}\right) y_{jt+\omega} \tag{19}$$

where $\frac{\lambda_{t+\omega}}{\lambda_t}$ is the firm's discount factor for valuing its future profits. Taking the first-order condition of the firm's problem leads to

$$E_t \sum_{\omega=0}^{\infty} (\beta\theta)' \lambda_{t+\omega} \left\{ (-\varepsilon) \left(\prod_{s=1}^{\omega} \frac{\pi_{t+s-1}^{\chi}}{\pi_{t+s}} \frac{P_t^*}{p_t}\right)^{1-\varepsilon} \frac{p_t^*}{p_t} + \varepsilon \left(\prod_{s=1}^{\omega} \frac{\pi_{t+s-1}^{\chi}}{\pi_{t+s}}\right)^{-\varepsilon} mc_{jt+\omega} \right\} y_{jt+\omega} = 0 \tag{20}$$

Considering the result of the firm's pricing decision, the price index evolves according to the following rule:

$$p_t^{1-\xi} = \theta\left(\pi_{t-1}^{\chi}\right)^{1-\xi} p_{t-1}^{1-\xi} + (1-\theta) p_t^{*(1-\xi)} \tag{21}$$

Rearranging Equation (21) implies that

$$1 = \theta \left[\frac{\pi_t^{\chi}}{\pi_{t+1}}\right]^{-\varepsilon} + (1-\theta)\pi_t^{*(1-\varepsilon)} \tag{22}$$

Fiscal Authority

The government budget constraint can be represented by Equation (23)

$$\frac{B_{t+1}}{P_{t+1}} = G_t^C + G_t^I + \frac{R_t^b}{\pi_t}\frac{B_t}{P_t} + \phi_t - \left(\varphi_t^c P_t C_t + \varphi_t^k R_t^P K_t^P + \varphi_t^l W_t L_t\right) \quad (23)$$

where G_t^C and G_t^I represents the government purchase of consumption and investment consecutively, R_t^b is the nominal return on a one-period government bond, B_t , ϕ_t, is the government transfers, and the last term of government budget constraint represents the income from taxes on consumption, capital, and labor consecutively.

The government capital, K_t^g, follows the law of motion as represented by Equation (24). Where δ_G is the government capital depreciation rate.

$$K_t^g = (1-\delta_G)K_{t-1}^g + G_t^I \quad (24)$$

We can rearrange Equation (23) and define the government budget constraints as

$$\frac{B_{t+1}}{P_{t+1}} = \tau_t + \frac{R_t^b}{\pi_t}\frac{B_t}{P_t} + \phi_t \quad (25)$$

where τ_t is the fiscal authority's primary deficit, which is tax revenue deducting expenditure less interest payment on a government bond.

I allow government expenditure to contemporaneously respond to output and debt level by following the rules below, the same as Leeper et al. (2010). In this study, the fiscal agents target a certain level of debt to GDP and primary deficit as a fiscal stabilizer. Also, consumption, labor earnings, and capital earnings respond exogenously to government spending shocks.

$$G_{1,t} = \gamma_{1,y}(y_t) + \gamma_{1,\tau}\left(\frac{\tau_t}{y_t}\right) + \gamma_{1,b}\left(\frac{b_{t-1}}{y_t}\right) + \psi_{1,t}^G \quad (26)$$

$$G_{2,t} = \gamma_{2,y}(y_t) + \gamma_{2,\tau}\left(\frac{\tau_t}{y_t}\right) + \gamma_{3,b}\left(\frac{b_{t-1}}{y_t}\right) + \gamma_{2,K^G}(K_t^G) + \psi_{2,t}^G \quad (27)$$

The paper proposes two rules. The first rule, Equation (26), says that the fiscal instrument of the government responds conditionally to output y_t, deficit-to-output τ_t/y_t, debt-to-GDP b_{t-1}/y_t, and the shocks on government spending ψ. The second rule, Equation (27) is like Equation (26) except that now the fiscal instruments include government capital K_t^G. Lastly, γ is the coefficient for each variable in the fiscal rule.

Monetary Authority

There is a central bank that conducts monetary policy. The monetary authority sets the interest rate as a policy instrument. I assume that the central bank uses a simple Taylor Rule in the below form

$$i_t = \phi_i i_{t-1} + \phi_y(\bar{y} - y_t) + \phi_\pi(\bar{\pi} - \pi_t) + \psi_t^i \quad (28)$$

The monetary authority reaction function of Equation (28) conditionally responds to current inflation π_t and output y_t from its target level; and past policy rate i_{t-1}. In the context of the current monetary policy framework, the BSP responds to the deviation of current output from $\bar{y}$, which is the natural level of output without distortion and the deviations of current inflation from $\bar{\pi}$, the target inflation set by the Development Budget Coordinating Committee (DBCC). The parameter - ϕ_i, ϕ_y, and ϕ_π are the-coefficient on policy rates, output, and inflation.

Estimation Procedure

I used the Bayesian method in estimating the parameters in this DSGE model. There are several formal estimations and econometric procedures in the literature that evaluate the empirical fit of DSGE models. Christiano and Eichenbaum (1992) used generalized methods of moments to estimate the equilibrium relationship in the model exploited the difference between the impulse response function between DSGE and VAR classical estimation procedures such as maximum likelihood and general methods of moments, have an inherent limitation in solving complex DSGE models such as the curse of dimensionality.

Following the usual Bayesian estimation procedure in the literature (An & Schorfheide, 2007), I constructed two blocks of Markov Chain Monte Carlo (MCMC) simulation with 500,000 draws. The algorithm draws samples from a probability distribution and each draw sample is dependent on the previous sample. In other words, each draw hidden states creates a chain of states dependent on each draw. This characteristic allows

MCMC to fit in estimating high dimensional probability distribution such as common in DSGE models.

Data

I source the data for consumption, investment, and inflation from World Bank, and output and government debt are from the Federal Reserve of St. Louis. The data is composed of annual time series from 1976 to 2019. The estimation is done by linking endogenous variables to the model log linearized equation and to the four observable time series of investment, output, inflation, and government debt. This can be accomplished by constructing four measurement equations as below,

$$\begin{bmatrix} dlINV_t \\ dlGDP_t \\ dlP_t \\ dlDebt_t \end{bmatrix} = \begin{bmatrix} \bar{y}_i \\ \bar{y}_{GDP} \\ \bar{y}_p \\ \bar{y}_d \end{bmatrix} + \begin{bmatrix} \hat{\imath}_t - \hat{\imath}_{t-1} \\ \hat{y}_t - \hat{y}_{t-1} \\ \hat{p}_t - \hat{p}_{t-1} \\ \hat{d}_t - \hat{d}_{t-1} \end{bmatrix} \quad (29)$$

where $\bar{y}_i$,$\bar{y}_{GDP}$, $\bar{y}_p$ and $\bar{y}_d$ are the trend growth rate of investment, output, inflation, and government debt respectively. I get the first difference of the natural logarithm of those observable time series used in the estimation and scale it by 100, then it is deflated by a GDP deflator. All time series are converted into quarterly data.

Results and Discussion

In this section, I used the estimation results to study the macroeconomic effects of government spending on public investment using a DSGE model of the Philippine economy.

Analysis of the Estimation Results

As shown in Table 1, the estimates of the coefficient of fiscal rules suggest that the national government is more sensitive to Debt to GDP than Output and Deficits to GDP. This estimate is consistent with the different institutional arrangements and legislated rules to stabilize debt growth in the Philippines. As for rules, the general appropriation act apportions and prioritizes debt servicing. In addition, the institutional arrangement between fiscal and monetary authorities is crucial in Philippine debt management. There is coordination between the national government and BSP on matters of foreign borrowing. This arrangement may contribute to the significant sensitivity of the fiscal rules to the level of debt to GDP.

The changes in BSP monetary framework from targeting monetary aggregate to inflation targeting are evident in the estimation result shown in Table 2. In the presence of exogenous shock on output and inflation, BSP responds almost twice as aggressively to inflation compared to persistence on policy rate and output. This may characterize the BSP policy as leaning against the wind during the recent decades of inflation targeting. Also, the inertial behavior of BSP as shown by the interest smoothing parameter is relatively high compared to the coefficient of the output gap.

Macroeconomic Analysis of the Philippine Economy

Given the fiscal experience of the Philippines, the paper wants to understand the mechanism of the macroeconomic effect of government spending on public infrastructure. The study shows two counterfactual experiments. First, I simulated the model on different exogenous shocks. Second, I assessed the response of alternative fiscal rules to

Table 1. *Estimated Coefficient of Fiscal Rule*

		prior mean	posterior mean	90% HPD	Interval	Prior	Posterior Deviation
Notation	Parameter						
γ_Y	Output	0.5	0.5501	0.0334	0.323	beta	0.2
γ_τ	Deficit to GDP	0.5	0.1825	0.0264	0.2438	beta	0.2
γ_b	Debt to GDP	0.5	0.8801	0.859	0.988	beta	0.2

Table 2. *Estimated Coefficient of Taylor Rule*

		prior mean	posterior mean	90% HPD	Interval	Prior	Posterior Deviation
Notation	Parameter						
ϕ_π	Inflation	2	2.5297	1.8859	2.5562	norm	0.25
ϕ_i	Interest smoothing	0.75	0.6821	0.5251	0.8147	beta	0.10
ϕ_y	Output gap	0.125	0.1456	0.031	0.1445	norm	0.05

Table 3. *Estimated Parameters*

Parameter	Definition	Value
ρ_A	Persistence of technology	0.7343
ρ_G	Persistence of govt. Spending	0.0851
ρ_{MS}	Persistence of markup shock	0.1150
α_G	Share of govt. capital	0.1500
φ_C	Consumption tax	0.1200
γ_Y	Fiscal rule output	0.5501
γ_τ	Fiscal rule deficit	0.8801
γ_B	Fiscal rule Debt to GDP	0.9197
ϕ_i	Interest Smoothing	0.6821
ϕ_Y	Taylor rule output	0.1456
ϕ_π	Taylor rule inflation	2.5297
h	Habit persistence	0.9955
a	Private capital share	0.5711
χ	Degree of Indexation	0.2177
β	Discount Factor	0.9900
δ	Capital depreciation rate	0.0250
γ	Inverse elasticity of substitution	3.5207
θ	Calvo parameter	0.8397

government spending shock. Table 3 shows the estimated parameters used for this study

Effects of Technology Shocks on Macroeconomic Variables

As shown in Figure 1, a positive shock on technology results in an expansion of output and private investment. Output expansion peaks in the 5th quarter and then decreases up to the 10th quarter before it goes to its steady-state level. Private investment continues to increase up to the 5th quarter then decreases up to the 10th quarter before it goes back to its steady state. However, it appears that consumption and hours exhibit countercyclical behavior in the presence of technology shocks. BSP reacts by reducing interest rates which results in the reduction of inflation. Government capital decreases as private investments are more employed in the economy. Similar to private investment, deficits show cyclical behavior in the presence of technology shock. As the output expanded, government borrowing initially decreased, then increased up to the 10th quarter, then decreased up to its steady state.

Effects of Government Spending Shocks on Macroeconomic Variables

Increases in government spending have positive effects on output, consumption, private investment, and public investment. As shown in Figure 2, output expanded for the 2nd quarter and sharply declined to its steady state. This shows that output is more persistent during episodes of technology shocks than during an increase in government spending. Similarly, consumption and hours decrease and then rise after the 2nd quarter. Both private and public investment increases as the government increase its expenditure. This result replicates the prediction of the literature. Public investment does not crowd out private investment during positive shocks on government spending. BSP responded by reducing the interest rate and inflation. The increase in the deficit is much more muted during the shock on government spending than on technology shock. Government borrowing decreases then continues to increase until the 10th quarter then eventually dies down.

Effects of Mark-Up Shocks on Macroeconomic Variables

As shown in Figure 3, a shock on price markup reduces output, consumption, and hours from impact until the 10th quarter. Also, it increases both private and public investment for almost all 6th quarters. Inflation increased and BSP responded by raising interest rates. Government debt increases then decrease until the 5th quarter then move to its steady state.

Effects of Monetary Policy Shocks on Macroeconomic Variables

An increase in the BSP policy rate, depicted in Figure 4, reduces output, consumption, labor hours, and inflation. It appears to reduce both private and public investment for a short period and subsequently reach

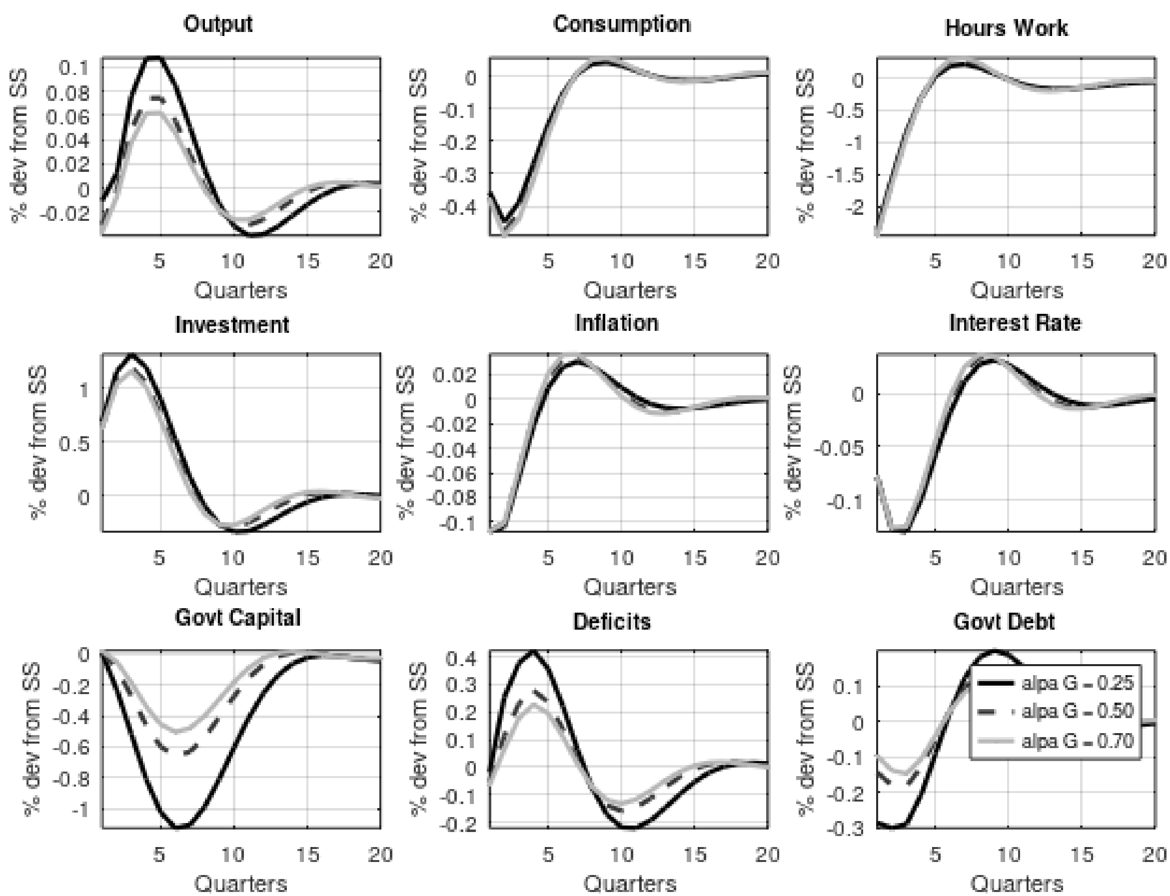

Figure 1. The Effects of Technology Shock

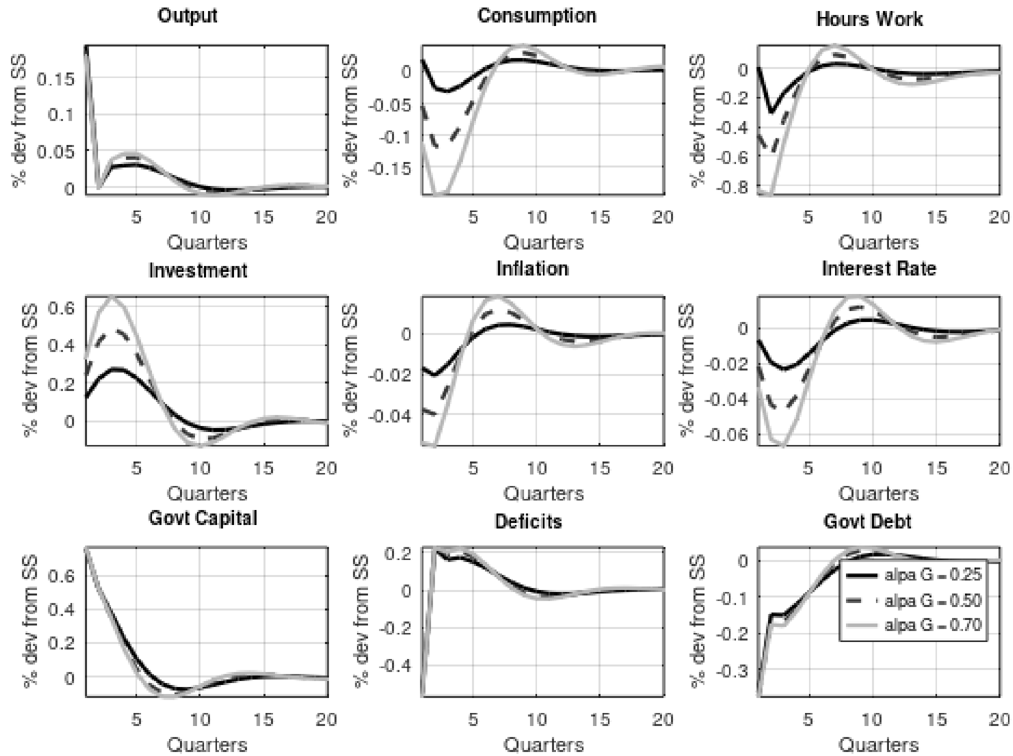

Figure 2. The Effects of Government Spending Shock

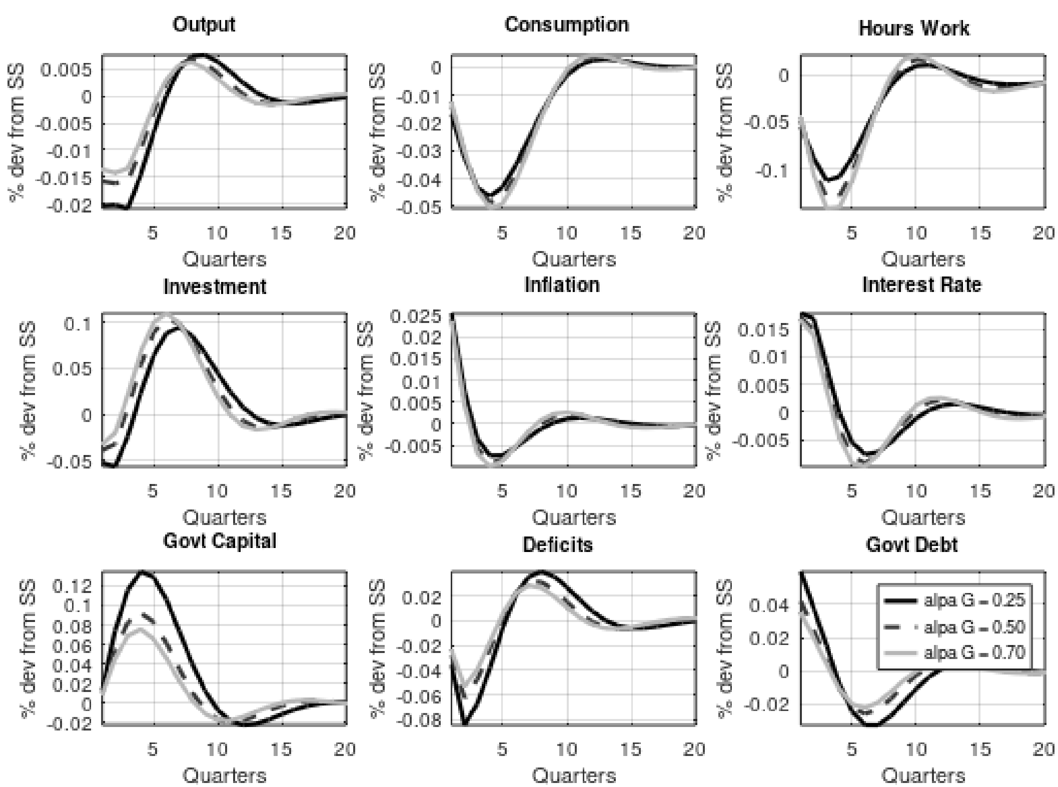

Figure 3. The Effects of Price Markup Shock

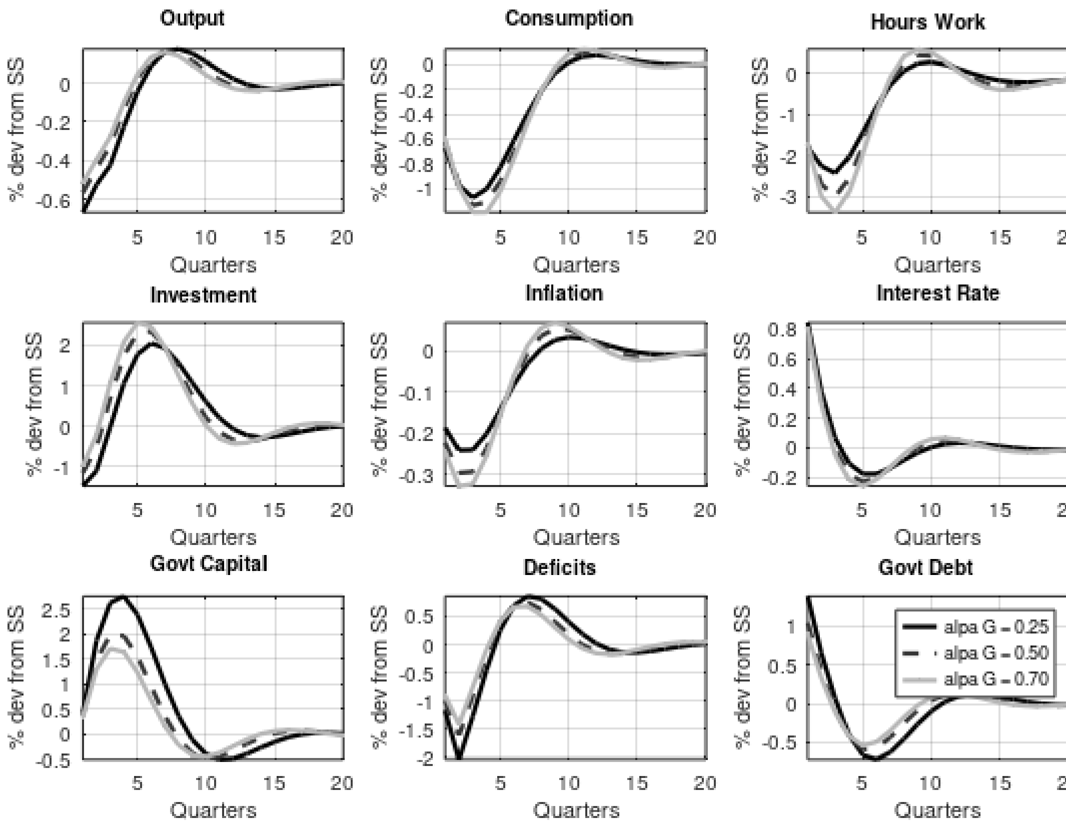

Figure 4. Monetary Policy Shock

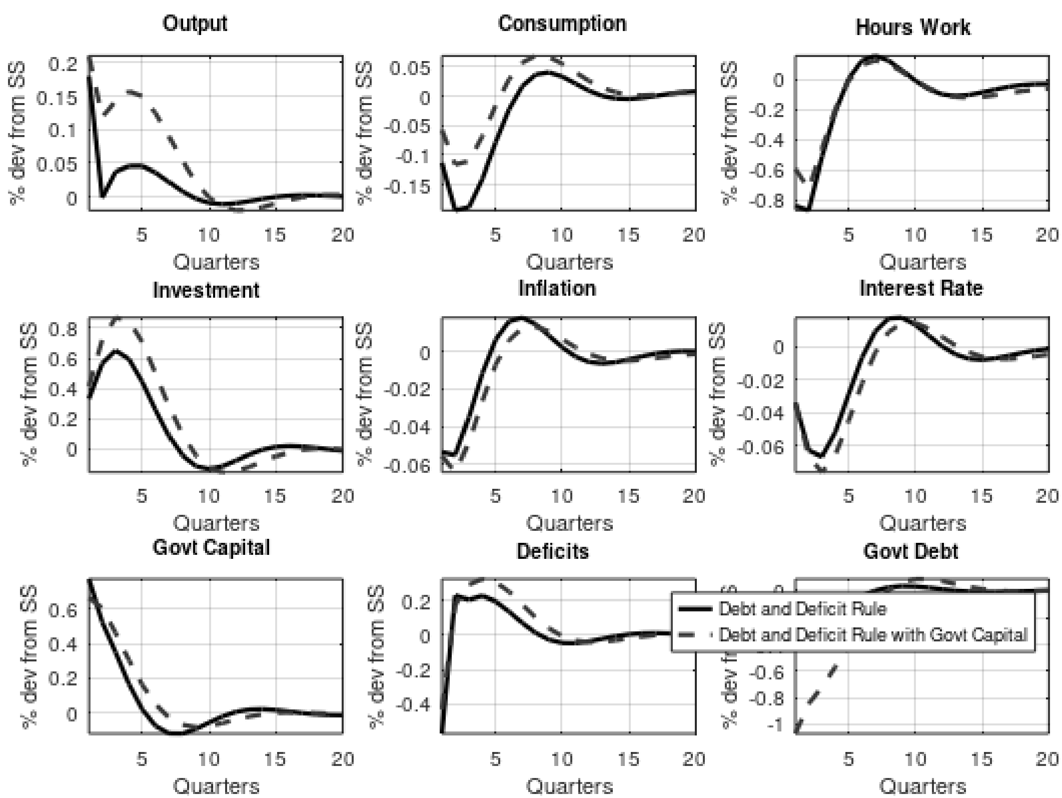

Figure 5. Alternative Fiscal Rules under Government Spending Shock

a peak of up to the 5th quarter. In similar ways, there is a reduction of deficits for a short period as a response to the increase of the BSP policy rate, which rises until around the 6th quarter, then dies down. On the other hand, government borrowing sharply increases for a short period from impact and mutely decreases, then goes back to its steady state.

Simulation Alternative Fiscal Rules

Figure 5 depicts the responses of different macroeconomic variables comparing two alternative fiscal rules. Output, private investment, and government capital and deficit responded more to the fiscal rules that embed government capital. Although, there is no discernable difference in the response of labor hours between alternative fiscal rules.

Conclusion

Using DSGE models the simulation provides evidence of the ability of government public investment in infrastructure to influence private capital investment. The simulation results suggest that during episodes of increasing government spending private capital responded positively. In addition, both public and private investment exhibits procyclical behaviors in presence of government spending shock. Lastly, the output is more persistent during episodes of technology shocks than during an increase in government spending.

The estimates also show that the national government is more sensitive to debt to GDP than output or deficits to GDP in presence of a government spending shock.

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