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Abstract

Following Gali[8], Okano and Eguchi[14] develop a small open economy model without iterated government budget constraint and show the money-financed fiscal stimulus is more effective at stabilizing output and inflation in a small open economy than in a closed economy. We introduce iterated government budget constraint into their small open economy model and show that the money-financed fiscal stimulus is less effective as openess incraeses. Even in a liquidity trap, the money-financed fiscal stimulus is less than it in a closed economy.

Keywords: Fiscal Stimulus, Money Financing, Debt Financing, Zero Lower Bound
JEL Classification: E31, E32, E52, E62, F41

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1 Introduction

The Fiscal Theory of the Price Level (FTPL) is a theoretical framework which posits that the government's fiscal policy, encompassing current and future debt and taxes, is the main driver of the price level or inflation, as opposed to the quantity theory of money. This theory underscores the significant role of fiscal policy in influencing economic indicators such as price levels and inflation rates. According to this theory, the government's budget constraint implies that the nominal value of public debt must be equal to the present value of future primary surpluses. Cochrane[5] showed that by using FTPL, not only seigniorage affects price index but bonds issued by government also plays an important role in determining the level of price index.

Dynamic Statistic General Equilibrium (DSGE) model is a macroeconomic modeling framework used by monetary and fiscal authorities for policy analysis, explaining historical time-series data, as well as future forecasting purposes. Up to now, there are many research literatures using that model. Okano and Eguchi[14] analyzes the effectiveness of money-financed MF fiscal stimulus and compares it with the debt- financed DF fiscal stimulus using DSGE model with and without the ZLB on nominal interest rate in a small open economy. However, Okano and Eguchi[14] discusses a government policy that involves the issuance of money, but he does not consider the FTPL. This raises the question of whether the effects of a money-financed fiscal stimulus would still hold if the FTPL were implemented.

We take inspiration from that and extend the model from Okano and Eguchi[14] with transversality conditions added into government budget constraint equation. Then, like Okano and Eguchi[14], I calculate the responses of variables under the MF fiscal stimulus, debt-financed (DF) stimulus. In addition, I also examine response in case of no response under which there is no fiscal stimulus such as tax cut or an increase in government expenditure in response to an adverse demand shock that causes the nominal interest rate to become stuck at the ZLB. The cost of the money-financed MF fiscal stimulus is financed by the issuance of money so that target is keep the government debt stable. In the debt-financed DF fiscal stimulus, through the issuance of government bonds, the government can finance expenditure so that domestic inflation or CPI inflation stay unchanged.

According to Okano and Eguchi[14], in a closed economy, an increase in money supply leads to a rise in inflation. When the degree of openness rises, there is not only domestic goods but also import goods, which is object to have no price rigidity. This results in a severe increase in the level of the inflation index. This leads to a depreciation of the nominal exchange rate and the real interest rate rises. Consequently, the output increases following an increase in the terms of trade.

By extending the small open economy model of Okano and Eguchi[14] with TVC into government budget constraint, we have some findings. The finding is different from this because of applying TVC into government budget constraint. The effect of the government's ability to pay on the inflation rate is stronger. When inflation becomes excessive, the balance of issued bond in the past will decrease. Fiscal surpluses will increase, leading to a reduction in the nominal money supply. In such a scenario, inflation increases, that means the government doesn't need to repay past issued borrowings anymore and the real interest rate decreases. Ultimately, there is no increase in consumption and no change in the terms of trade. As a result, the output and the multiplier both decrease.

The the remainder of this paper is as follows: Section 2 delves into the relevant literature, while Section 3 outlines the model with the steady state, equilibrium dynamics. Section 4 elaborates on the implications of fiscal stimulus during normal times when the Zero Lower Bound (ZLB) is

applied and computes the fiscal multipliers in section 5. Finally, Section 6 provides the conclusion of the paper.

2 Related Literature

The fiscal theory states that the price level is determined by the government budget constraint and surpluses. That fiscal is developed by Leeper[12], Woodford[16], Sims[15] with one-period debt. Leeper[12] explores how monetary and fiscal policies interact in a stochastic maximizing model. The paper defines policy as 'active' or 'passive' depending on how it responds to government debt shocks. The paper shows how different combinations of active and passive policies affect the existence and uniqueness of equilibria, the role of fiscal behavior in determining the effects of monetary shocks on prices, and the interpretation of Friedman's 1948 policy framework. Woodford[16] introduces a "fiscal theory of the price level" and investigates how the price level is determined in different monetary regimes, even when the money supply is endogenous. Christiano and Fitzgerald[3] review the fiscal theory of the price level and particularly emphasis on the theory's implications for the feasibility of price stability. Cochrane[4] extends the fiscal theory to include long-term debt and analyzes the optimal policy. Cochrane[5] shows price level is still determined by the government debt valuation equation in a frictionless economy.

Auerbach and Obstfeld[1] studies the effect of open market operation in raising inflation and output when the economy is at the ZLB due to a temporary adverse shock. Buiter[2] analyzes the impact of a money-financed transfer to households (a "helicopter drop") in a relatively general setting, emphasizing the importance of "irredeemability" of money as the ultimate source of the expansionary effect on consumption of a such a policy. Gali[8] is the extend of Auerbach and Obstfeld[1] and Buiter[2] by comparing the effectiveness of money-financed stimulus and debt-financed stimulus. Okano and Eguchi[14] differs from Gali[8] that analyze effectiveness in a small open economy, which is referred to Gali and Monacelli[11]. However, in both Gali[8] and Okano and Eguchi[14], the FTPL is not considered in the model.

We extend the open economy framework of Okano and Eguchi[14], who examine the effects of fiscal stimulus in a small open economy framework. I adopt the approach of Cochrane[5] and add the transversality condition into the government budget constraint. The analysis compares the effectiveness of money-financed and debt-financed stimulus in both normal times and liquidity trap, like Okano and Eguchi[14].

3 The Model

Similar to Okano and Eguchi[14], we assume a representative household, sticky prices for domestic goods (i.e., Calvo pricing is applied for domestic goods), and flexible wages. A representative household lives in an infinitesimal small open economy with complete international financial markets. In small open economy, the law of one price (LOOP) is applicable and exports elastic to changes in the TOT, similar to Gali and Monacelli[11]. The government (consisting of fiscal and monetary authorities acting in a coordinated way) finances its expenditure through lump-sum taxes and issuing a riskless nominal one-period bond with a nominal interest rate and (non-interest-bearing) money. Different from Okano and Eguchi[14], the government budget constraint is iterated and an appropriate trans versality condition (TVC) is imposed similar to Coochrane[5].

3.1 Equilibrium Dynamics

We approximate the equilibrium around the steady state in which inflation is zero as follows (ignoring the ZLB constraint at this point):

International Risk-sharing Condition

$$\hat{\xi}_t = -(1-\nu)\, s_t + \hat{\xi}_t^* - \zeta_t, \tag{1}$$

Market-clearing Condition

$$\hat{y}_t = \nu\,(2-\nu)\, s_t + (1-\nu)\,\hat{c}_t + \nu \hat{y}_t^* + \hat{g}_t, \tag{2}$$

Consumption Euler Equation

$$\begin{aligned}\hat{\xi}_t = \frac{1}{\chi + b\beta}\Big\{&\beta\,(b+\chi)\left(\hat{\xi}_{t+1} + \hat{i}_t - \pi_{t+1} - \hat{\rho}_t\right) + (1-\beta)\,\hat{\xi}_{t-1} - [b + \chi\,(1-\beta)]\,\hat{i}_{t-1} \\ &+ (b+\chi)\,\pi_t + \beta \hat{b}_t - \hat{b}_{t-1} - \chi\beta \hat{l}_{t-1} + \beta \widehat{tr}_t - \beta \hat{g}_t + (1-\beta)\,\hat{\rho}_{t-1}\Big\},\end{aligned} \tag{3}$$

Marginal Utility of Consumption

$$\hat{\xi}_t = -\sigma \hat{c}_t + \upsilon \hat{l}_t, \tag{4}$$

First-order Necessary Condition for Firms

$$\pi_{H,t} = \beta \pi_{H,t+1} - \kappa \hat{\mu}_t, \tag{5}$$

Price Markup Gap

$$\hat{\mu}_t = \hat{\xi}_t - \frac{\alpha + \varphi}{1-\alpha}\hat{y}_t - \nu s_t, \tag{6}$$

Money Demand Schedule

$$\hat{l}_t = \hat{c}_t - \eta \hat{i}_t, \tag{7}$$

The Logarithmic First Differential of the Definition of the Real Money Balance

$$\hat{l}_{t-1} = \hat{l}_t + \pi_t - \Delta m_t, \tag{8}$$

Consolidated Government Budget Constraint

$$\hat{b}_t = (1+\rho)\,\hat{b}_{t-1} + (1+\rho)\, b \hat{i}_{t-1} - (1+\rho)\, b\pi_t + \hat{g}_t - \widehat{tr}_t - \chi \Delta m_t, \tag{9}$$

A Combination of the Logarithmic First Differential of the Definition of the CPI and TOT

$$\pi_t = \pi_{H,t} + \nu\,(s_t - s_{t-1}), \tag{10}$$

Definition of the Trade Balance

$$\widehat{nx}_t = \hat{y}_t - \nu s_t - \hat{c}_t - \hat{g}_t, \tag{11}$$

Definition of the TOT

$$s_t = e_t + p_t^* - p_{H,t}, \tag{12}$$

Definition of Domestic Inflation

$$\pi_{H,t} = p_{H,t} - p_{H,t-1}, \tag{13}$$

Definition of Import Inflation

$$\pi_{F,t} = p_{F,t} - p_{F,t-1}, \tag{14}$$

A Combination of the (Logarithmic) Definition of the TOT with the (Logarithmic) Definition of Domestic and Import Inflation

$$\pi_{F,t} = s_t - s_{t-1} + \pi_{H,t}, \tag{15}$$

with $\kappa \equiv \frac{(1-\theta\beta)(1-\theta)\Theta}{\theta}$, $\Theta \equiv \frac{1-\alpha}{(1-\alpha)+\alpha\epsilon}$, $\varphi \equiv \frac{V_{nn}N}{V_n}$, $\upsilon \equiv \frac{U_{cl}L}{U_c}$, $\sigma \equiv -\frac{U_{cc}C}{U_c}$, where $\beta \equiv \frac{1}{1+\rho} \in (0,1)$ denotes the subjective discount factor, ρ denotes the rate of time preference, $\nu \in [0,1]$ denotes openness, $\mu \equiv \log\left(\frac{\epsilon}{\epsilon-1}\right)$ denotes the constant (desired) price markup, $\eta \equiv \frac{\epsilon_{lc}}{\rho}$ with $\epsilon_{lc} \equiv \frac{1}{\sigma_l+\upsilon}$ and $\sigma_l \equiv \frac{U_{ll}L}{U_l}$ denotes the elasticity of substitution between consumption and real balances, $\chi \equiv \frac{L}{Y}$ is the inverse income velocity of money, $b \equiv \frac{\mathcal{B}}{Y}$ denotes the steady-state share of government debt to output, and Δ is the difference operator. We assume $Z_t^* = 1$ and $Z_{t+1} = Z_t^{\varrho}$ with $\varrho = 0$. Thus, $\hat{\rho}_t = \log Z_t = \zeta_t$. The presentation of the model and notation closely parallel the model of Okano and Eguchi[14] and Gali[8]. Table 1 presents the notation of the variables.

Eqs. (1) to (7), (9), and (11) to (14) are derived by log-linearizing the international risk-sharing condition, market-clearing condition, Euler equation, marginal utility of consumption, first-order necessary condition for firms, definition of the marginal cost, money demand schedule, consolidated government budget constraint, definition of the trade balance, definition of the TOT, definition of domestic inflation, and definition of import inflation.

Although Eqs. (12) to (15) play no essential role in deciding the dynamic paths, they are necessary to calculate the nominal exchange rate and import inflation. We use a logarithmic definition of the LOOP $p_{F,t} = e_t + p_{F,t}^*$ to derive Eq. (12). Plugging this into Eq. (12), Eq. (12) becomes $s_t = p_{F,t} - p_{H,t}$.

Our log-linearized model inherits the features of the small open economy of Gali and Monacelli[10], whose model consists of not only the New Keynesian IS and Philips curves, but also the international risk-sharing condition. In addition, the market-clearing condition and average markup include the TOT. Then, both consumption and output are affected by changes in the TOT. Thus, in contrast to Gali[8], not only the real consumption interest rate, but also the TOT is involved in monetary–fiscal policy interactions.

3.2 Fiscal and Monetary Policies

3.2.1 Government Budget Constraint and Financing Regime

As in Gali[8], we assume the following simple (Ricardian) tax rule throughout the analysis:

$$\widehat{tr}_t = \psi_b \hat{b}_{t-1} + \hat{\varsigma}_t, \tag{16}$$

which shows that tax variations have two components. The first is $\psi_b \hat{b}_{t-1}$, which is endogenous and varies in response to deviations in the debt ratio from its long-run target, where $\psi_b > \rho$ is a tax adjustment parameter that guarantees that $\lim_{k\to\infty} \mathrm{E}_t\left(b_{t+k}\right) = 0$ (i.e., the debt ratio converges

to its long-run target). The other is $\hat{\varsigma}_t$, which is independent of the debt ratio and represents the exogenous component of the tax rule.[1]

3.2.2 Experiments

Following Gali[8], we analyze two stylized fiscal interventions announced in period zero and implemented from that period onward. The first intervention consists of an exogenous tax cut as $\hat{\varsigma}_t = -\delta^t < 0$, for $t = 0, 1, 2, ...$, where $\delta \in [0, 1)$ measures the persistence of the exogenous fiscal stimulus. Symmetrically, the second takes the form of an exogenous increase in government expenditure as $\hat{g}_t = \delta^t > 0$, for $t = 0, 1, 2, ...$ In both cases, we normalize the size of the stimulus to correspond to 1% of steady-state output in period zero.

Similar to Gali[8], we analyze the effects of each type of fiscal intervention under the *MF* and *DF* schemes. We define the *MF* scheme, which is our focus, as the one in which seigniorage is adjusted every period to keep real debt $\mathcal{B}_t$ unchanged. Plugging $\hat{b}_t = 0$ into Eq. (9), we have

$$\Delta m_t = \frac{1}{\chi}\left[\hat{g}_t - \hat{\varsigma}_t + (1+\rho)\, b\left(\hat{i}_{t-1} - \pi_t\right)\right], \tag{17}$$

for $t = 0, 1, 2, ...$, where we use Eq. (16). The previous assumptions, combined with Eq. (16), imply that under the *MF* regime, the government does not need to adjust taxes as a result of an increase in government expenditure, either in the short or in the long run, relative to their initial level. Alternatively, in the case of a tax cut, taxes decrease temporarily by δ^t. In other words, under the *MF* regime, the government does not need to raise taxes or debt in response to the fiscal interventions considered here. In both cases, monetary policy must give up control of the nominal interest rate and instead adjust the money supply to meet the government's financing needs.

Under the *DF* scheme, the fiscal authority issues debt to finance the fiscal stimulus, eventually adjusting the path of taxes to attain the long-run debt target $\mathcal{B}$, as the tax rule in Eq. (16) implies. We assume that the monetary authority pursues an independent price stability mandate. For concreteness, we assume that if feasible, it conducts policy; hence,

$$\pi_{H,t} = 0, \tag{18}$$

$$\pi_t = 0, \tag{19}$$

for all t.[2] Either DIT (see Eq. (18)) or CIT (see Eq. (19)) is applicable under the *DF* scheme. The money supply and thus seigniorage then adjust endogenously to bring about the interest rate required to stabilize prices, as well as the regime generally assumed in the New Keynesian literature on the effects of fiscal policy.

[1] Accordingly, the government's transversality condition $\lim_{k\to\infty} \Lambda_{t,t+k}\mathcal{B}_{t+k} = 0$ is satisfied for any price path as long as the discount factor $\Lambda_{t,t+k}$ converges to zero as $k \to \infty$, which is the case in all the experiments considered below. We assume the previous property, often referred to as Ricardian (or passive) fiscal policy (e.g., Leeper[12]), as in standard specifications of the New Keynesian model, and must be combined with active monetary policy (as implicitly assumed below) to guarantee a local unique equilibrium.

[2] A class of the Taylor rule in Corsetti et al.[7] and others can represent the *DF* scheme instead of Eq. (19), although we adopt Eq. (18) or (19) to adhere to Gali's[8] setting.

3.3 Calibration

Our parameterization is consistent with that of Gali[8], except for the parameters specific to an open economy, namely, openness ν (Table 2).[3] [4] We set this parameter following Monacelli[13].

Both our implied assumptions of perfect substitution between domestic and import goods and our benchmark parameterization of relative risk aversion attain balanced trade; that is, $\widehat{nx}_t = 0$ for all t as long as the demand shock $\hat{\rho}_t$ does not hit the economy.

4 The Effects of the Fiscal Stimulus in Normal Times

4.1 Sensitivity Analysis

We now discuss the sensitivity of some of the above qualitative findings in terms of the effectiveness of fiscal policies. We focus on the parameter measuring the degree of openness ν, a feature of small open economies not present in closed economies, instead of focusing on the degree of price stickiness θ and persistence of the shock δ, as Gali[8] does. Focusing on openness is important to understand how the assumption of a small open economy affects the effectiveness of a fiscal stimulus.

Following Gali[8], we define the cumulative output multiplier $(1-\delta)\sum_{t=0}^{\infty}\hat{y}_t$. Figure 1 depicts the cumulative output multipliers for a tax cut and an increase in government expenditure as a function of openness ν. The multipliers are on the vertical axis, while the level of openness is on the horizontal axis. The red line with circles, magenta line with pluses, and blue line with diamonds are the multipliers under the *MF* fiscal stimulus, *DF* fiscal stimulus scheme with DIT, and *DF* fiscal stimulus scheme with CIT, respectively. Panel 1 depicts the fiscal multipliers to a tax cut, while Panel 2 plots these for an increase in government expenditure. On the left of each figure, openness is zero (i.e., $\nu = 0$); that is, the multipliers shown on the extreme left correspond to those in a closed economy, as Gali[8] assumes.

4.1.1 Fiscal Multipliers and a Tax Cut

Firstly, in the context of a DIT (both DIT and CIT) regime, a tax cut does not influence the multiplier, irrespective of an increase in the degree of openness. This is due to the Ricardian equivalence, which posits that consumers anticipate future tax liabilities corresponding to a tax cut and adjust their savings, accordingly, leaving their consumption patterns unchanged.

Fiscal multiplier under a tax cut with MF regime strongly decreases in terms of the degree of openness. Due to FTPL economy, the fiscal multiplier shows a declining trend in relation to openness. This is primarily due to the occurrence of a fiscal surplus, which eliminates the need for the government to inject additional funds into the economy. Consequently, despite the general expectation of a decrease, the interest rate increases. This scenario implies that there is no significant growth in consumption and imported goods, and the terms of trade remain unchanged. This results in a reduction in output, which in turn signifies a decrease in the fiscal multiplier.

In Okano and Eguchi[14], the government finances its expenditure by releasing more money, which subsequently leads to an increase in the domestic inflation index. As the degree of openness

[3] Gali[8] does not clarify the value of relative risk aversion σ. We infer that Gali[8] might set the value to 1, similar to Monacelli[13], because the responses of our macroeconomic variables in a closed economy resemble those in Gali[8]. Accordingly, we set the value to 1, following Monacelli[13], to generate more convenient results.

[4] If there is capital accumulation, α can be regarded as the capital share of output. However, there is no capital accumulation in the model and we term α as the index of decreasing returns to labor, as in Table 2, following Gali and Monacelli[11].

rises, imported goods, which are not subject to price rigidity, contribute significantly to the inflation index due to $p_t = (1-\nu)\, p_{H,t} + \nu p_{F,t}$. This increase leads to the depreciation of the nominal exchange rate, which implies that the domestic currency is worth less compared to other countries' currencies. Simultaneously, this also results in an increase in TOT and an increase in output.

4.1.2 Fiscal Multipliers for an Increase in Government Expenditure

As under a tax cut, multiplier decrease in case of an increase in government expenditures under money - financed (MF) fiscal due to fiscal surplus. In the context of DIT regime, the fiscal multipliers are the same as in close economy. Plugging Eqs.(1), (4), (6) into (5) yields:

$$\hat{y}_t = \frac{(1-\alpha)\,\nu}{1+\varphi}\zeta_t + \frac{1-\alpha}{1+\varphi}\hat{g}_t, \tag{20}$$

which means output in DIT regime is not affected by the degree of openness and depend on government expenditures as long as ζ_t does not shift the logarithmic international risk-sharing condition. With an increase in government expenditure under the DF scheme with CIT, multipliers increase, the same result showed by Okano and Eguchi[14].

5 The Effects of the Fiscal Stimulus in a Liquidity Trap

This section explores the effectiveness of the *MF* fiscal stimulus at stabilizing the economy in the face of a temporary adverse demand shock by comparing it with the effectiveness of the *DF* fiscal stimulus, similar to Gali[8]. We assume that the adverse demand shock is sufficiently large to prevent the central bank from fully stabilizing output and inflation given the ZLB constraint on the nominal interest rate.

Similar to Gali[8], the ZLB constraint takes the form $\hat{i}_t \geq \log\beta$ and the experiment assumes that $\hat{\rho}_t = -\gamma < \log\beta$ for $t = 0, 1, 2, ...T$ and $\hat{\rho}_t = 0$ for $t = T+1, T+2, ...$ This describes a temporary adverse demand shock that takes the natural interest rate into negative territory up to period T. After period T, the shock vanishes. We assume $\gamma = -0.01$ and $T = 5$. The shock is assumed to be fully unanticipated, but once realized, the trajectory of $\{\hat{\rho}_t\}$ and corresponding policy responses are known with certainty.

The ZLB constraint can be incorporated formally into the set of equilibrium conditions above by replacing Eq. (7) with a complementary slackness condition:

$$\left(\hat{i}_t - \log\beta\right)\left(\hat{l}_t - \hat{c}_t + \eta\hat{i}_t\right) = 0,$$

for all t, where

$$\hat{l}_t \geq \hat{c}_t - \eta\hat{i}_t, \tag{21}$$

represents demand for real money balances.

In addition to the previous changes, under the *DF* fiscal stimulus and *no response* benchmark, Eqs. (18) and (19) must be replaced with

$$\left(\hat{i}_t - \log\beta\right)\pi_{H,t} = 0, \tag{22}$$

$$\left(\hat{i}_t - \log\beta\right)\pi_t = 0, \tag{23}$$

for all t, together with Eqs. (18) and (19), which are DIT and CIT, respectively. This is applicable for the period in which the ZLB constraint on the nominal interest rate is unavailable. By contrast, in the *MF* fiscal stimulus case, Eq. (17) determines the money supply for all t. If the nominal interest rate is positive, Eq. (21) holds with equality (but with inequality once the nominal interest rate reaches the ZLB and the real money balances overshoot their satiation level). Thus, given $\beta = 0.995$, the experiment considered corresponds to an unanticipated fall in the natural interest rate to –2% (in annual terms) for six quarters and a subsequent revision back to the initial value of 2% (in annual terms).

Figures 2 to 7 depict the responses in the case of *no response* to a tax cut under the *MF* scheme, an increase in government expenditure under the *MF* scheme, a tax cut under the *DF* scheme, and an increase in government expenditure under the *DF* scheme, respectively. In these figures, the blue line with diamonds shows the responses in a closed economy (i.e., $\nu = 0$), while the red line with circles and magenta line with pluses show the responses in a small open economy with CIT and DIT, respectively. In a small open economy, $\nu = 0.4$ (our benchmark parameterization). In the case of *no response* to the shock (i.e., $\hat{g}_t = \hat{\varsigma}_t = 0$, for $t = 1, 2, 3 \ldots$), monetary policy is described by Eqs. (18) and (22) in DIT, and Eqs. (19) and (23) in CIT as the benchmark. The scenario for the tax cut is that a 1% tax cut lasts for the duration of the adverse shock ($\hat{\varsigma}_t = -0.01$, for $t = 0, 1, \ldots, 5$) in the *MF* and *DF* fiscal stimulus cases, similar to Gali[8]. The scenario for the increase in government expenditure is a 1% increase in the steady-state ratio to output in response to the adverse demand shock that lasts for the duration of the adverse shock ($\hat{g}_t = 0.01$, for $t = 0, 1, \ldots, 5$) in the *MF* and *DF* fiscal stimulus cases, again similar to Gali[8].

5.1 *No Response*

Firstly, I examine the response of variables under the DIT regime. An adverse demand shock leads to a decrease in domestic inflation (Panel 12, Figure2). This, in turn, results in a decrease in the nominal exchange rate and import goods inflation (Panel 10, 13, Figure2), given that Purchasing Power Parity (PPP) holds in the long run. CPI inflation also depreciates due to the contribution of imported goods, which lack price rigidity, in an open economy, while the nominal interest rate decreases. Consequently, there is a depreciation in the terms of trade and a decline in output (Panel 1, 11, Figure2).

In the context of the CIT regime, a decrease in domestic inflation is permitted, resulting in a more significant decline in domestic inflation than in the DIT regime. This decrease exerts greater pressure on the nominal exchange rate to appreciate compared to the DIT regime, despite the nominal interest rate decreasing and becoming stuck at the Zero Lower Bound (ZLB). The appreciation of the nominal exchange rate leads to a decrease in import inflation and a decrease in the TOT. The severe decrease in CPI inflation intensifies the burden of redeeming government debt, resulting in a higher government debt than in a closed economy. Given tax rule, the larger balance of real government debt raises tax revenue in a small open economy. This increased tax revenue completes fiscal consolidation in period four. Seigniorage is no longer necessary, and money growth decreases. Subsequently, the nominal interest rate increases in period five when the adverse demand shock is still in effect.

5.2 *MF* Fiscal Stimulus

5.2.1 Response To a Tax Cut

Under the MF regime, the cost of fiscal stimulus is financed by the issuance of money with a target that the balance of government debt is unchanged. As shown in equation (51), the money supply increases, then results in the decrease of the fiscal surplus with inflation tax (Panel 14, Figure3). As shown in (50), the level of inflation decreases, while the nominal interest rate becomes stuck in ZLB constraint, that means the real consumption rate decreases (Panel 9, Figure3). Then the consumption decreases more than in an open economy. Therefore, this result in a decrease in output cumulative as shown in Panel 2, Figure3. The inflation rate falls, while the nominal interest rate is constrained by the ZLB, which implies a lower real consumption interest rate. Therefore, consumption drops more than in a closed economy (Panel 3, Figure3).

5.2.2 Response To an Increase in Government Expenditure

An increase in government expenditure is quite identical as a tax cut in a small open economy. Like a tax cut, recovery of CPI inflation in a small open economy is faster than in closed economy. Then decline of consumption real interest rate and consumption is lager than in closed economy. The fast recovery of CPI inflation also makes fiscal surplus with inflation tax higher in an open economy.

5.3 *DF* Fiscal Stimulus

5.3.1 Response To a Tax Cut

The responses to a tax cut under the DF (in both DIT and CIT) scheme are identical to those in the case of no response except for taxes and real government debt (i.e., the blue line with diamonds and red line with circles in Figure5, Figure6 are identical to those in Figure2). Ricardian equivalence is attained and there are no effects on any variables except for these variables.

5.3.2 Response To an Increase in Government Expenditure

Unlike the MF fiscal stimulus, an increase in government expenditure under the DF (in both CIT and DIT) scheme in a small open economy is not effective for stabilizing output and CPI inflation when compared with a closed economy. (Panel 1, 4 Figure7 and Panel 1, 4 Figure8). The finding is the same as the conclusion of Okano and Eguchi[14] about response in case of an increase in government expenditure under the DF scheme.

Firstly, I analyze the response under the CIT regime. An increase in government expenditure leads to a decrease in domestic inflation, which in turn results in a decrease in the nominal exchange rate. Consequently, the TOT and output both decrease. Under the CIT regime, the significant decrease in inflation intensifies the burden of redeeming government debt, effectively rendering the government's revenue from inflation tax negative. As indicated by Eq.(16), the higher the government debt, the higher the tax revenue. This increased tax revenue expedites fiscal reconstruction. Seigniorage becomes unnecessary as money growth decreases, leading to a hike and overshoot in the nominal interest rate.

Next, I turn my attention to the response of variables under the DIT regime. An increase in government expenditure under this regime results in a decrease in CPI inflation. This decrease in

CPI inflation is accompanied by an appreciation in the nominal exchange rate. The real consumption rate in this scenario is lower than that in a closed economy due to the swift recovery of CPI inflation. As a result, both the TOT and output decrease.

6 Conclusion

Okano and Eguchi[14] mentions a fiscal policy that government finances its expenditure through lump-sum tax and issuing bonds, however, it lacks a discussion on the FTPL. I extend Okano and Eguchi[14] to an economy that transversality condition is added into government budget constraint. My approach is the same as Gali[8], Okano and Eguchi[14], that examine the effects of a MF fiscal stimulus and compare it with DF stimulus in both normal times and under zero low bound. By incorporating the FTPL, I draw out a contrast result to Okano and Eguchi[14] that clarify the impact of issued bond of central government on the level of price index. The MF fiscal stimulus, whether in the form of a tax cut or an increase in government expenditures, exerts upward pressure on the inflation rate. As the inflation rate increases, the balance of public bond issuance decreases. This leads to a fiscal surplus, eliminating the need for the government to issue additional money to cover its expenditures. The decrease in the real interest rate is less pronounced than in a closed economy, resulting in a smaller increase in both consumption and output compared to a closed economy. Consequently, there is a reduction in multipliers as the degree of openness increases.

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Figure 1: Fiscal Multipliers: The Role of Openness

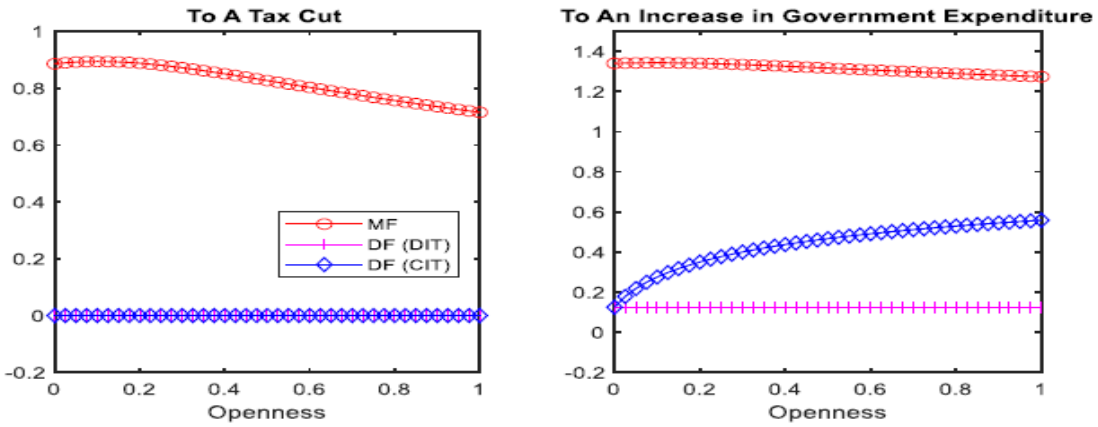

Table 1: Notation of the Variables

Variable	Definition	Description
Y_t		Output
$\hat{y}_t$	$\log\left(\frac{Y_t}{Y}\right)$	
C_t		Consumption
$\hat{c}_t$	$\log\left(\frac{C_t}{C}\right)$	
Z_t		The Exogenous Preference Shifter
$\hat{\rho}_t$	$-\log\left(\frac{Z_{t+1}}{Z_t}\right)$	The Demand Shock
$P_{H,t}$		The Domestic Price
$p_{H,t}$	$\log P_{H,t}$	
$P_{F,t}$		The Import Price in Units of the Domestic Currency
$p_{F,t}$	$\log P_{F,t}$	
$\mathcal{S}_t$	$\frac{P_{F,t}}{P_{H,t}}$	The TOT
s_t	$\log\mathcal{S}_t$	
G_t		Government Expenditure
$\hat{g}_t$	$\frac{G_t}{Y}$	
$U_{c,t}$		The Marginal Utility of Consumption
ξ_t	$\log\left(\frac{U_{c,t}}{U_c}\right)$	
P_t	$P_{H,t}^{1-\nu}P_{F,t}^{\nu}$	The CPI
Π_t	$\frac{P_t}{P_{t-1}}$	(Gross) CPI inflation
π_t	$\log\Pi_t$	
i_t		The Nominal Interest Rate
$\hat{i}_t$	$\log\left(\frac{1+i_t}{1+\rho}\right)$	
M_t		(Non-interest-bearing) Money
m_t	$\log M_t$	
L_t	$\frac{M_t}{P_t}$	Real Money Balance
$\hat{l}_t$	$\log\left(\frac{L_t}{L}\right)$	
B_t		Nominal Risk-less One-period Gov. Debt in the Small Open Economy
$\hat{b}_t$	$\frac{\mathcal{B}_t-\mathcal{B}}{Y}$	
$\mathcal{B}_t$	$\frac{B_t}{P_t}$	Real Government Debt
TR_t		Lump-sum Taxes
$\widehat{tr}_t$	$\frac{TR_t-TR}{Y}$	
NX_t		Net Exports
$\widehat{nx}_t$	$\log\left[\left(\frac{NX_t}{P_{H,t}}\right)/Y\right]$	
Z_t^*		The Preference Shifter in the Foreign Country
ζ_t	$-\log\left(\frac{Z_t^*}{Z_t}\right)$	
Y_t^*		Output in the Foreign Country
$\hat{y}_t^*$	$\log\left(\frac{Y_t^*}{Y^*}\right)$	
$U_{c,t}^*$		The Marginal Utility of Consumption in the Foreign Country
ξ_t^*	$\log\left(\frac{U_{c,t}^*}{U_c^*}\right)$	
P_t^*		The Price in the Foreign Country
p_t^*	$\log P_t^*$	
$\mathcal{E}_t$		The Nominal Exchange Rate (The Price of the Foreign Currency in Units of the Dom. Currency)
e_t	$\log\mathcal{E}_t$	
$\Pi_{H,t}$	$\frac{P_{H,t}}{P_{H,t-1}}$	(Gross) Domestic Inflation

Table 1: Notation of the Variables (cont.)

Variable	Definition	Description
$\pi_{H,t}$	$\log\Pi_{H,t}$	
$\Pi_{F,t}$	$\frac{P_{F,t}}{P_{F,t-1}}$	(Gross) Import Inflation
$\pi_{F,t}$	$\log\Pi_{F,t}$	
MC_t^n		The Nominal Marginal Cost
MC_t	$\frac{MC_t^n}{P_{H,t}}$	The Real Marginal Cost
μ_t	$-\log MC_t$	The Logarithmic Average Markup
$\hat{\mu}_t$	$\mu_t - \mu$	The Price Markup Gap

Note: Variables without a time script are the steady-state values of those variables.

Table 2: Parameterization

Parameter	Description	Value	Source
σ	Relative Risk Aversion	1	Monacelli[13]
ν	Openness	0.4	
β	Discount Factor	0.995	Gali[8]
φ	Curvature of Labor Disutility	5	
α	Index of Decreasing Returns to Labor	0.25	
ϵ	Elasticity of Substitution among Goods	9	
θ	Calvo Index of Price Rigidities	$\frac{3}{4}$	
χ	Steady-state Inverse Velocity	$\frac{1}{3}$	
η	Semi-elasticity of Money Demand	7	
υ	Separability of Real Balances	0	
ψ_b	Tax Adjustment	0.02	
b	Target Debt Ratio	2.4	
δ	Persistence	0.5	

Figure 2: Responses in the Case of *No Response* in a Liquidity Trap

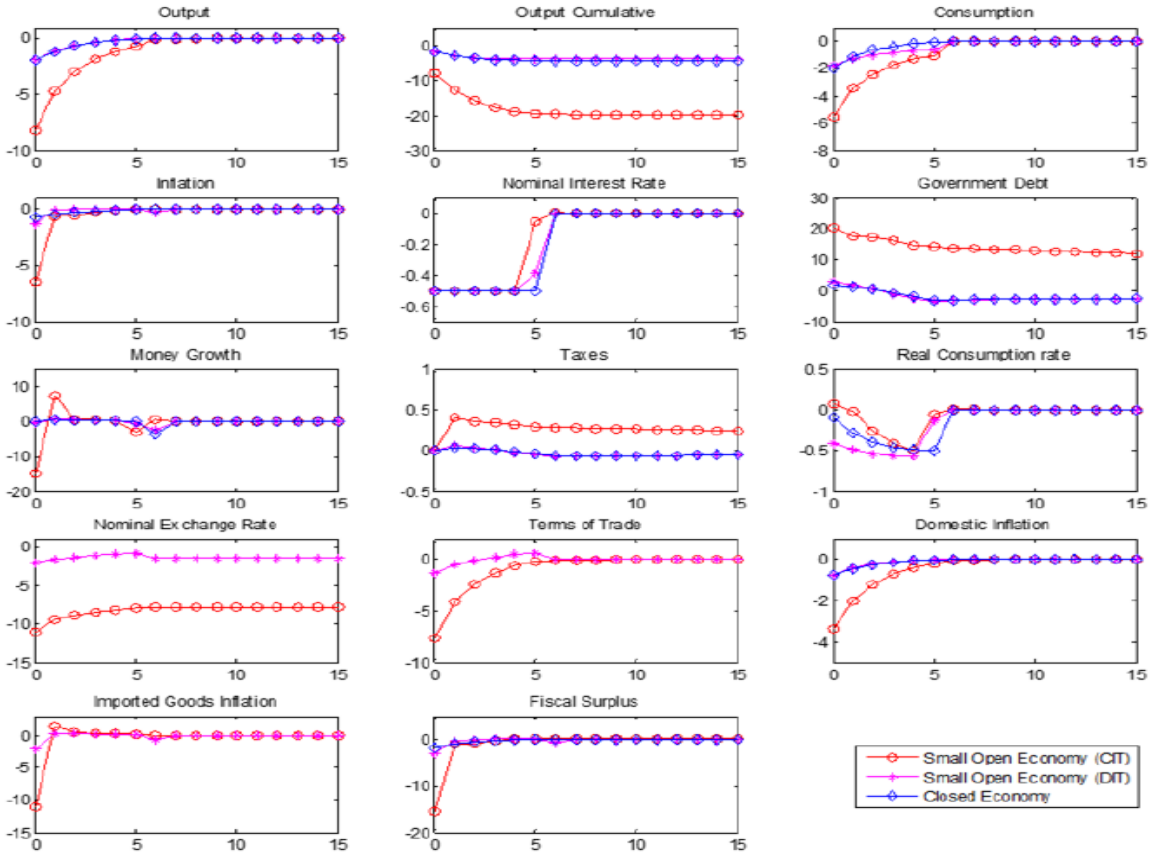

Figure 3: Dynamic Effects of a Tax Cut under the *MF* Fiscal Stimulus in a Liquidity Trap

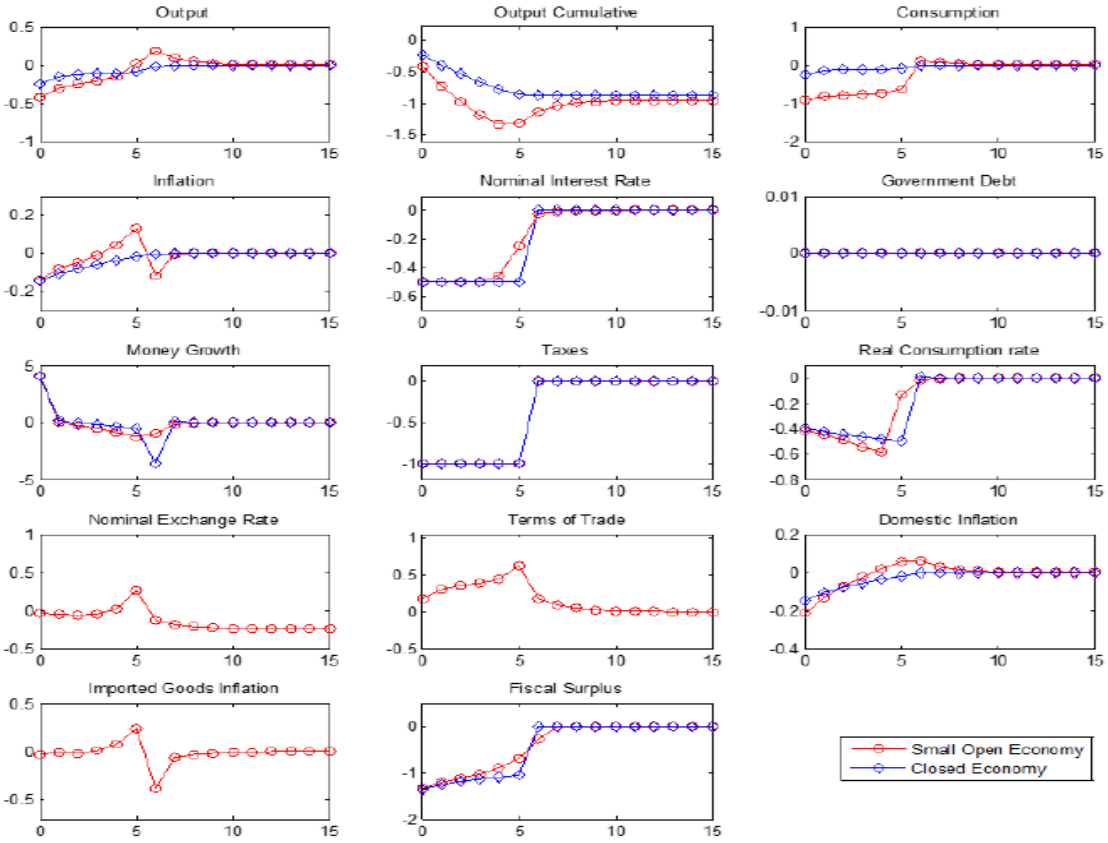

Figure 4: Dynamic Effects of an Increase in Government Expenditure under the *MF* Fiscal Stimulus in a Liquidity Trap

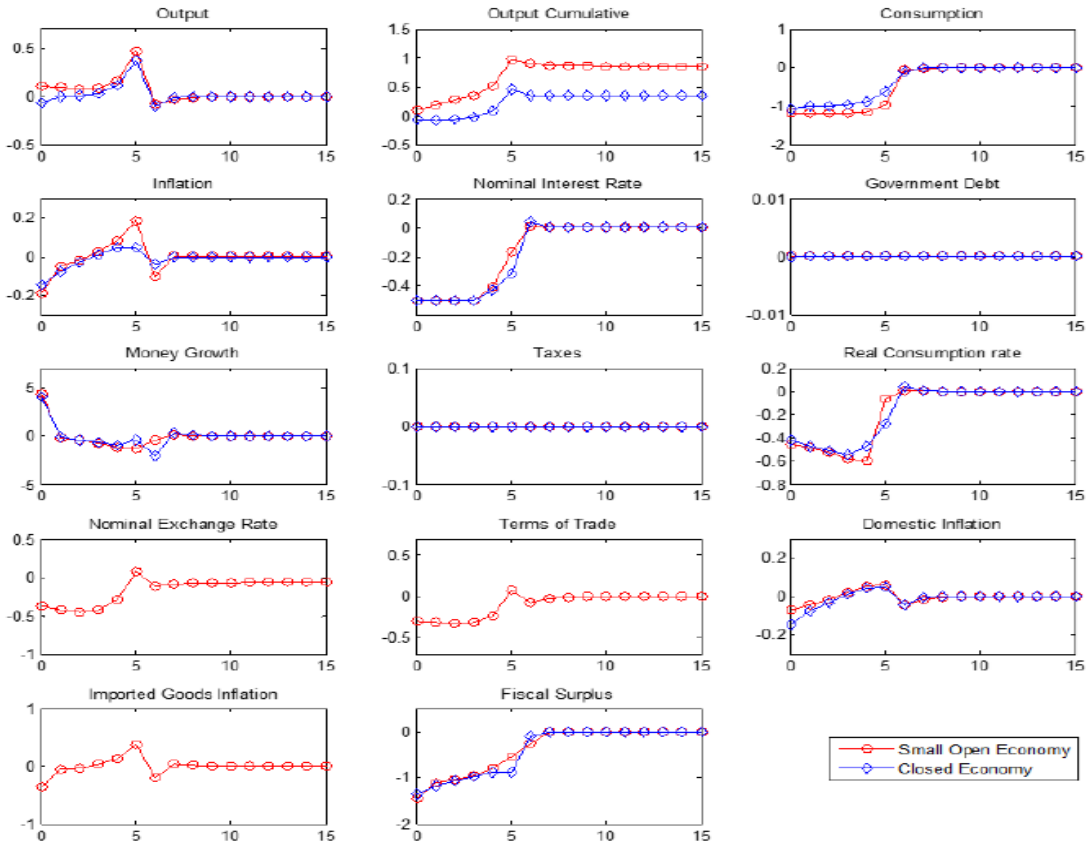

Figure 5: Dynamic Effects of a Tax Cut under the *DF* Scheme in a Liquidity Trap (CIT)

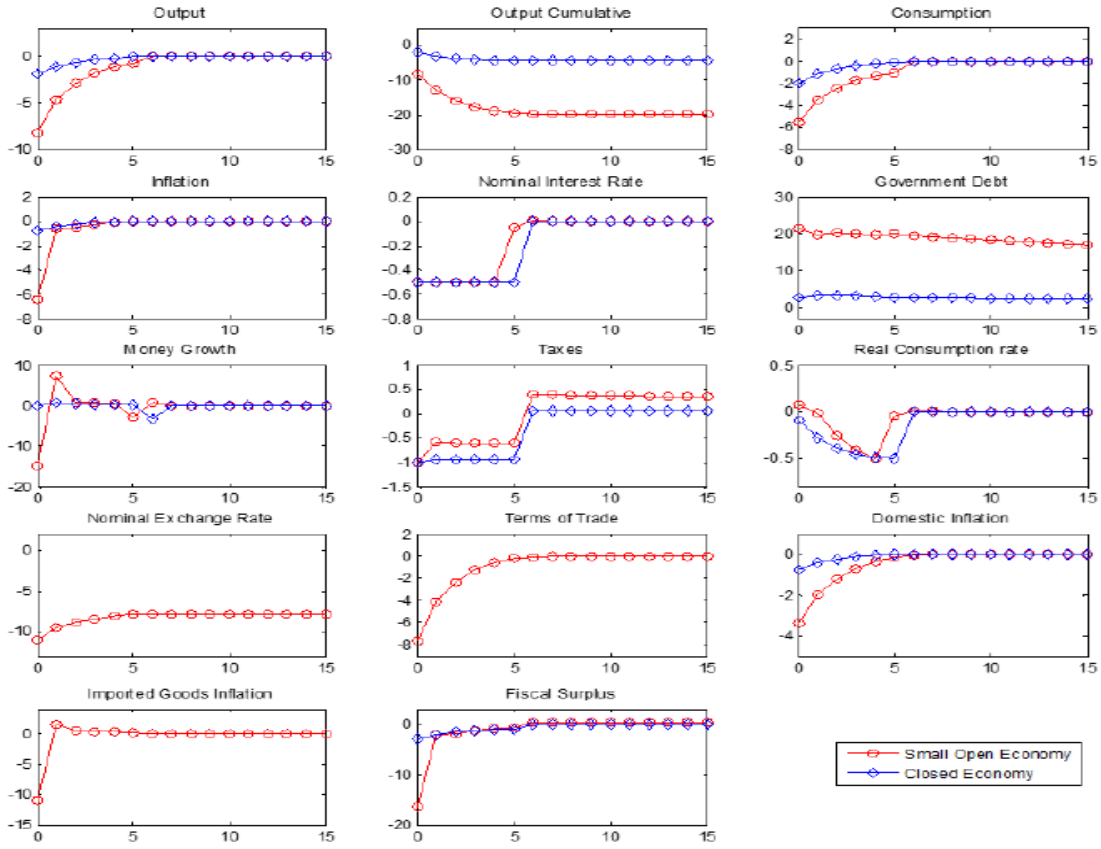

Figure 6: Dynamic Effects of a Tax Cut under the *DF* Scheme in a Liquidity Trap (DIT)

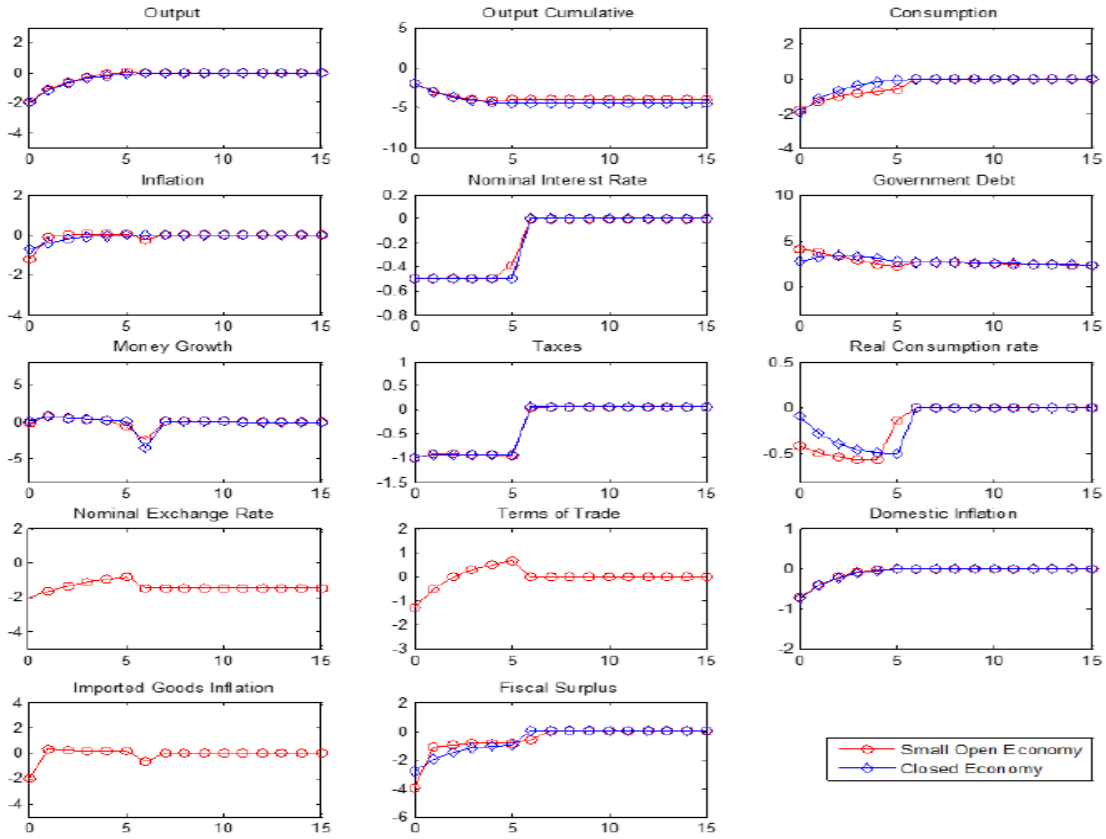

Figure 7: Dynamic Effects of an Increase in Government Expenditure under the *DF* Scheme in a Liquidity Trap (CIT)

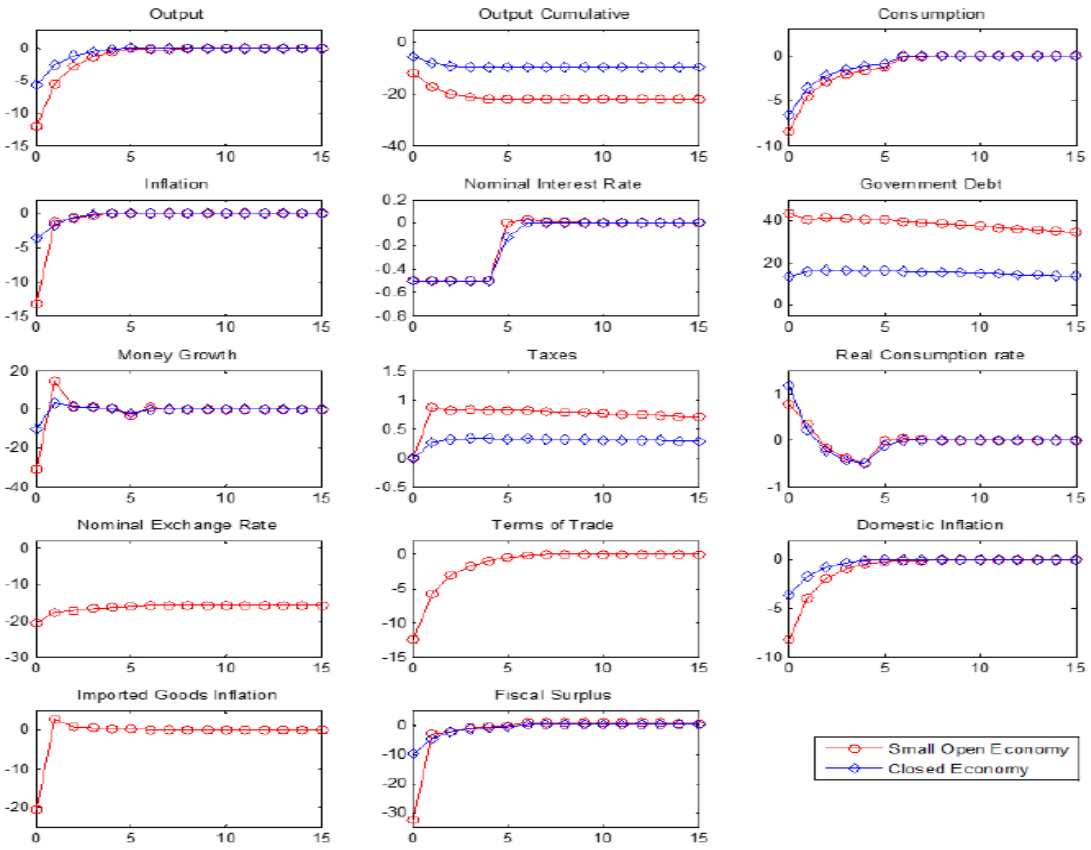

Figure 8: Dynamic Effects of an Increase in Government Expenditure under the *DF* Scheme in a Liquidity Trap (DIT)