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Abstract

This study examines the effect of nominal wage stickiness on the fiscal multiplier in a two-agent new Keynesian model. We find that under fully flexible nominal wages, an increased share of liquidity-constrained (LC) consumers amplifies the fiscal multiplier in the cases of money-financed (MF) and debt-financed (DF) regimes. In the case of sticky nominal wages, an increase in the share of LC consumers drastically decreases the MF fiscal multiplier. We also demonstrate that even in the presence of nominal wage stickiness and LC consumers, the fiscal multiplier under an MF regime outperforms that under a DF regime. Furthermore, this paper shows that under the fiscal stimulus via a tax cut, an increased share of LC consumers magnifies the fiscal multiplier in the cases of MF and DF regimes. Finally, the degree of nominal price stickiness and the size of government spending are crucial in assessing the effect of fiscal stimulus on output.

JEL codes: E52; E58;

Keywords: Money-financed regime; Debt-financed regime; Nominal wage stickiness; Liquidity-constrained consumers; Two-agent new Keynesian model;

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1 Introduction

This study examines the effect of nominal wage stickiness on the fiscal multiplier in a two-agent new Keynesian (TANK) model. Several studies have examined the effectiveness of fiscal policy in insulating the economy during a recession.[1] Several studies have generally pointed out that the impact of fiscal stimulus on output is mitigated by a crowding-out effect via a rise in the real interest rate unless the nominal interest rate hits the zero lower bound (ZLB) floor. Indeed, as argued by Eggertsson (2011) and Woodford (2011), the fiscal multiplier becomes generally larger in an economy where the nominal interest rate faces the ZLB. However, even in the case of the ZLB, whether government spending has a substantial effect on the real economy remains debatable (Blanchard, 2023). Thus, as disputed in Galí (2020a), we need to argue whether the fiscal authority can stimulate the real economy without lowering the nominal interest rate by increasing government spending or cutting taxes.

How can the fiscal authority enhance the effectiveness of fiscal policy without relying on a lower nominal interest rate? The basic concept of fiscal policy implies that the fiscal stimulus provided by government spending or a tax cut is accompanied by a future tax increase. Furthermore, such a fiscal stimulus is typically accompanied by an increase in the real interest rate, leading to the crowding-out effect that is likely to dampen the impact of fiscal stimulus on output. To address this issue, several studies proposed a money-financed (MF) fiscal stimulus. An ancestor discussion of the MF fiscal stimulus should be linked to the idea proposed by Friedman (1969), who mentioned the possibility of this policy regime often known as the "helicopter money".[2] Moreover, Bernanke (2003) specified the role of an MF fiscal stimulus as a potential tool for lifting the real economy when the nominal interest rate faces the ZLB floor. Moreover, some authors argued that the occurrence of the COVID-19 shock motivates the consideration of the MF fiscal stimulus (Galí, 2020b). Reis and Tenreyro (2022) reviewed the related literature on the role of the MF fiscal stimulus and highlighted the possibility of its different meanings in the literature.

As previously stated, although many studies have attempted to consider fiscal policy effectiveness, whether the fiscal stimulus has a significant impact on the real economy remains

[1] Recently, Cochrane (2022) argued the role of fiscal policy in terms of the price level determination of the fiscal policy.

[2] See also Turner (2015) for a detailed discussion about an MF fiscal regime.

unclear. In particular, Galí (2020a) found the significant role of nominal price stickiness in evaluating the effectiveness of fiscal policies. In addition to the role of nominal price stickiness, several studies have found the importance of nominal wage stickiness in a sticky price model (Christiano, Eichenbaum and Evans, 2005, Erceg, Henderson and Levin, 2000).[3] Some recent studies have also argued the wage inequality problem in Europe during the COVID-19 crisis (Palomino, Rodríguez and Sebastian, 2020). Moreover, whether the degree of nominal wage stickiness affects the magnitude of the fiscal multiplier remains unclear. Furthermore, the standard real business cycle (RBC) model and the representative-agent NK (RANK) model predict that government spending has a smaller effect on output. Several studies have suggested the importance of household heterogeneity in generating the significant impact of government spending on output. In particular, some authors considered introducing liquidity-constrained (LC) consumers to build a tractable NK model with household heterogeneities, known as the TANK model.[4] Galí et al. (2007) found that in the TANK model, the government spending multiplier increases more than in the RANK model. Although Galí (2020a) argued the role of an MF fiscal stimulus, he did not focus on the role of household heterogeneities.

This study aims to evaluate the efficacy of the fiscal stimulus in the TANK model with nominal price and wage rigidities. This is accomplished by incorporating nominal wage stickiness and LC consumers into the framework of Galí (2020a). More precisely, following Ascari, Colciago and Rossi (2017), we incorporate the role of nominal wage rigidity and LC consumers into the framework of Galí (2020a). As a result, we can construct the tractable TANK model to explore the effect of the fiscal multiplier under the cases of MF and debt-financed (DF) regimes. In our model, we focus on demonstrating how a change in the degree of nominal wage stickiness affects fiscal policy effectiveness in terms of evaluating the fiscal multiplier under the

[3]For instance, Erceg et al. (2000) showed that the central bank does not overcome a policy trade-off between price inflation, wage inflation, and output gap by implementing strict inflation targeting. Several studies have also highlighted the importance of considering the effect of nominal wage stickiness on monetary policy in an open economy new Keynesian (NK) model (Campolmi, 2014, Ida and Okano, 2022, Ida, 2023, Rhee and Turdaliev, 2013).

[4]Unless otherwise specified, we refer to LC consumers as households that do not have free access to financial assets. Several studies proposed different naming schemes for LC households. For instance, Galí, López-Salido and Javier (2007) referred to LC households as rule-of-thumb households. We also label households with free access to financial assets as Ricardian households. This type of household is referred to as optimized households in several studies.

MF and DF regimes.

The main findings of this paper are summarized as follows. First, under fully flexible nominal wages, an increased share of LC consumers amplifies the fiscal multiplier under the cases of MF and DF regimes. Second, in the presence of sticky nominal wages, an increase in the share of LC consumers drastically decreases the MF fiscal multiplier in contrast to the flexible wages case. Third, even in the presence of nominal wage stickiness and LC consumers, the fiscal multiplier under an MF regime always outperforms that under a DF regime. Fourth, in the case of MF and DF regimes, an increased share of LC consumers increases the fiscal multiplier under fiscal stimulus via a tax cut. Finally, as pointed out by Galí (2020a), the degree of nominal price stickiness and the size of government spending are important factors in assessing the effect of fiscal stimulus on output.

The intuition behind these results is as follows. In the case of flexible nominal wages, as we will show, government spending generates a higher wage growth rate, which pushes up the consumption of LC consumers. Because a government spending shock is generally expected to cause a crowding-out effect, a rise in the real interest rate reduces Ricardian consumption. In the case of flexible nominal wages, an increased share of LC consumers directly stimulates aggregate consumption because a rise in LC consumers' consumption outweighs a decline in Ricardian consumption. This result is consistent with the finding of Galí et al. (2007). However, introducing nominal wage stickiness makes nominal wages less responsive to the government spending shocks. This implies that an increase in the consumption of LC consumers is dampened by nominal wage rigidity. Meanwhile, a drop in Ricardian household consumption becomes smaller because the presence of nominal wage stickiness substantially offsets a rise in the real interest rate. In particular, government spending causes the real interest rate to fall under an MF regime, thus significantly boosting Ricardian household consumption. When the share of LC consumers is considerably small, the fiscal authority can obtain a larger fiscal multiplier under an MF regime. A similar discussion applies to the case of a DF regime, with the exception of a drop in the real interest rate under an MF regime.

The remainder of this paper is constructed as follows. Section 2 reviews previous studies to address this paper's contribution, and Section 3 develops the TANK model with nominal wage stickiness. Section 4 summarizes the paper's main results. This section explores the effect of nominal wage stickiness on fiscal multiplier in a TANK model for MF and DF regimes. Section

5 explores several sensitivity experiments. Section 6 examines the effect of a change in nominal wage rigidity on the fiscal stimulus through tax cuts. Finally, Section 7 concludes the paper.

2 Related literature

This section presents the literature review on how our study relates to previous studies on a fiscal multiplier in a sticky price model.[5] According to the standard RBC model, government spending reduces aggregate consumption, which is regarded as the puzzle (Blanchard and Perotti, 2002).[6] Similar to the standard RBC model, Galí et al. (2007) argued that the standard NK model also suffers from the fiscal policy puzzle. One solution to the fiscal policy puzzle is the TANK model, which assumes the inclusion of LC consumers in the NK model. In fact, Galí et al. (2007) found that government spending causes a positive response in aggregate consumption by increasing the LC consumers' consumption in the TANK model. Additionally, as previously stated, they showed that the fiscal multiplier is greater in the TANK model than in the RANK model. However, they did not consider the effect of nominal wage stickiness on the fiscal multiplier.

This study is related to the work of Colciago (2011), who pointed out the role of nominal wage stickiness in accounting for the effect of government spending on the real economy.[7] Our study is different from Colciago (2011) in the following points. First, he did not address the impact of changes in nominal wage stickiness on the fiscal multiplier. Second, unlike his study, the present study addresses the impact of nominal wage stickiness on the fiscal multiplier under MF and DF regimes. Third, he did not focus on the role of a tax cut, whereas we show the interaction effect between nominal wage stickiness and the degree of LC consumers on the

[5] As previously noted, Eggertsson (2011) and Woodford (2011) examined whether government spending becomes an effective tool for stimulating the real economy under the ZLB. Meanwhile, Liu, Huang and Lai (2022) examined the paradox of toil at the ZLB in a TANK model. Kopiec (2022) provided an analytical derivation of the fiscal multiplier in a heterogenous-agent NK (HANK) model.

[6] They observed that the response of real consumption becomes negative after a positive government spending shock when estimating the vector-autoregression (VAR) model. In the VAR estimation, they refer to this phenomenon as the fiscal policy puzzle.

[7] Bilbiie (2008) found that an increased share of LC consumers is likely to render the rational expectations equilibrium indeterminate. Colciago (2011) argued that the presence of LC consumers alleviates the TANK model's indeterminacy problem.

multiplier under a tax cut.

Our study is related the most to Galí (2020a), who investigated the effect of an MF fiscal stimulus in the standard NK model. He argued that nominal price stickiness should be considered when evaluating the effect of fiscal stimulus through government spending or tax cuts. Moreover, he demonstrated that the fiscal multiplier is generally larger in the case of an MF regime than in the case of a DF regime.[8] However, he did not consider the role of nominal wage stickiness. Furthermore, although we consider the importance of household heterogeneity in an NK model, he examined the effect of an MF fiscal stimulus in a standard sticky price model. This paper shows that the degree of nominal wage stickiness influences the fiscal multiplier in a TANK model.

This study is also related to the work of Punzo and Rossi (2022) who examined the effect of an MF fiscal stimulus in the TANK model. They focused on the effect of an MF fiscal stimulus on the fiscal policy's redistribution channel and considered the welfare implications of the MF fiscal stimulus based on the central bank's loss function derived from the second-order approximation of the household's utility function. However, they did not account for the role of nominal wage stickiness and the magnitude of the fiscal multiplier in their model. In contrast to their study, we argue that the degree of nominal wage stickiness plays a significant role in evaluating the fiscal stimulus in a TANK model.

Finally, we note that although Galí (2020a) argued the role of nominal price stickiness when it comes to fiscal policy effectiveness, none of the studies pay close attention to the role of nominal wage rigidity. Indeed, as previously stated, a large number of studies have highlighted the role of nominal wage stickiness in a sticky price model (Christiano et al., 2005, Erceg et al., 2000, Galí, 2013). Also, Keynes (1936) paid attention to the role of downward nominal wage rigidity in assessing the effectiveness of fiscal policy during a liquidity trap.

In summary, to the best of our knowledge, none of the studies attempt to address the role of nominal wage stickiness when considering the impact of fiscal stimulus on the real economy. Therefore, our study makes legitimate contributions to previous research.

[8] Tsuruga and Wake (2019) explored the effect of an MF fiscal stimulus in an NK model in which the transmission lags regarding government spending are introduced. Moreover, Okano and Eguchi (2021) extended the framework of Galí (2020a) to the case of a small-open economy.

3 Model

This section provides the model description. Our model extends the framework of Galí (2020a) to the TANK model with nominal wage stickiness. More concretely, following Ascari et al. (2017), we incorporate the role of nominal wage stickiness into the standard TANK model. Then, following Galí (2020a), we examine the role of MF fiscal stimulus. Section 3.1 describes the non-policy blocks, which include households and firms. Section 3.2 describes the fiscal and monetary authorities' policy blocks. Finally, based on Galí (2020a), the structural model is constructed by the assumption of perfect foresight.

3.1 Non-policy blocks

3.1.1 Households

Following Bilbiie (2008) and Galí et al. (2007), we consider the standard TANK model. More concretely, a fraction $1-\lambda$ of households can access financial markets, whereas the remaining share λ cannot. On the one hand, a fraction of $1-\lambda$ is comprised of Ricardian households that can freely access financial markets. They have access to the complete set of state-contingent securities available in the financial market. On the other hand, a fraction of λ represents LC consumers that cannot trade financial assets in the financial market. Regarding wage determination, following Ascari et al. (2017), this paper assumes that the nominal wage is determined by a labor union and that each union faces Calvo-type nominal wage rigidity. As a result, the presence of a staggered nominal wage becomes the source of the wage NK Phillips curve. The following sections explain the household optimization problem and wage setting in a labor union.

Households obtain utility from consumption, real money balances, and disutility from supplying labor.[9]

$$\begin{aligned} U_{k,t} &= \sum_{t=0}^{\infty} \left[u(C_{k,t}) + h(L_{k,t}) - v(N_{k,t}(j)) \right] Z_t, \\ &= \sum_{t=0}^{\infty} \left[\frac{C_{k,t}^{1-\sigma}}{1-\sigma} + \frac{L_{k,t}^{1-\mu}}{1-\mu} - \frac{N_{k,t}(j)^{1+\varphi}}{1+\varphi} \right] Z_t, \end{aligned} \tag{1}$$

[9]Similar to Galí (2020a), we assume the money in the utility function. See Tsuruga and Wake (2019) for a detailed discussion of the model in which households face a cash-in-advance constraint.

where for $k = o, r$. $C_{k,t}$, $L_{k,t}$ and $N_{k,t}(j)$ denote consumption, real money balances, and the labor supply for type j, respectively. Moreover, the subscripts o and r represent Ricardian and LC consumers, respectively.

Labor market

Following Ascari et al. (2017), we consider that the nominal wage earned by each household is set by the labor type-specific union, indexed by j ($j \in [0, 1]$). The nominal wage is fixed by union j. The labor supply $N_t(j)$ is given by:

$$N_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\epsilon_w} N_t^d, \tag{2}$$

where $N_t(j)$ denotes the labor supply in union j, $W_t(j)$ is the nominal wage set by union j, and the parameter ϵ_w is the elasticity of substitution for individual labor. Following Ascari et al. (2017), we ignored the discrepancy in the wage difference between households because of the assumption that $N_t(j)$ is identical for both Ricardian and LC consumers:

$$N_t = \int_0^1 N_t(j)dj. \tag{3}$$

Thus, we obtain the following common labor income:

$$\int_0^1 W_t(j)N_t(j)dj = N_t^d \int_0^1 W_t(j)\left(\frac{W_t(j)}{W_t}\right)^{-\epsilon_w} dj. \tag{4}$$

Ricardian households

A fraction of $1 - \lambda$ corresponds to a share of Ricardian households. The Ricardian household maximizes the aforementioned utility function, subject to the following budget constraint:

$$P_t C_{o,t} + Q_{t,t+1}B_{o,t+1} + M_{o,t+1} = B_{o,t} + M_{o,t} + N_t^d \int_0^1 W_t(j)\left(\frac{W_t(j)}{W_t}\right)^{-\epsilon_w} dj + \Gamma_{o,t} - T_{o,t},$$

where $B_{o,t}$ represents nominal bonds held for one period, and $\Gamma_{o,t}$ denotes the dividends earned from domestic firms. $M_{o,t}$ and $T_{o,t}$ denote nominal money stock and lump-sum tax held in Ricardian households, respectively. We assume Ricardian households have access to state-contingent bonds traded in a complete domestic and international market, and we introduce the following stochastic discount factor $Q_{t,t+1}$:

$$Q_{t,t+1} = \frac{1}{1 + i_t}, \tag{5}$$

where i_t is the short-term nominal interest rate.

From the utility maximization problem, we obtain the following optimal conditions:

$$\frac{1}{1+i_t} = \beta\left[\frac{u_c(C_{o,t+1})}{u_c(C_{o,t})}\frac{P_t}{P_{t+1}}\right], \tag{6}$$

$$\frac{h_l(L_{o,t})}{u_c(C_{o,t})} = \frac{i_t}{1+i_t}. \tag{7}$$

Equation (6) represents the consumption Euler equation, and Equation (7) implies the money demand function.

Liquidity-constrained households

A fraction of λ cannot access financial markets. As previously stated, they have the same periodic utility function as Ricardian households, but their budget constraints are given by:

$$P_t C_{r,t} + M_{r,t+1} = M_{r,t} + N_t^d \int_0^1 W_t(j)\left(\frac{W_t(j)}{W_t}\right)^{-\epsilon_w} dj - T_{r,t}, \tag{8}$$

where $M_{r,t}$ and $T_{r,t}$ denote nominal money stock and lump-sum tax held in LC households, respectively. Unlike Ricardian households, LC households consume their entire disposable income every period because they cannot implement intertemporal consumption smoothing by trading state-contingent bonds in bond markets.

3.1.2 Wage setting in a labor union

Both Ricardian and LC households delegate the determination of nominal wage to a labor union. Following Ascari et al. (2017), the nominal wage setting is subject to Calvo-type staggered wage contracts. Thus, a fraction of $1-\theta_w$ can change nominal wages in its union, whereas a remaining fraction of θ_w cannot do so. Accordingly, the labor union solves the following maximization problem:

$$\max_{\tilde{W}_t} \sum_{s=0}^{\infty} (\theta_w \beta)^s \Big[(1-\lambda)u(C_{o,t+s}) + \lambda u(C_{r,t+s}) - V(N_{t+s})\Big].$$

The first-order condition of this problem is given by:

$$\sum_{s=0}^{\infty} (\theta_w \beta)^s V_n(N_{t+s}) N_{t+s}^d W_{t+s}^{\epsilon_w}\left[\left(\frac{\lambda}{MRS_{o,t+s}} + \frac{1-\lambda}{MRS_{r,t+s}}\right)\frac{\tilde{W}_t}{P_{t+s}} - \mu_w\right] = 0, \tag{9}$$

where $\mu_w = \epsilon_w/(\epsilon_w - 1)$ and $\tilde{W}_t$ denotes the optimal nominal wage. The aggregate wage index is defined as follows:

$$W_t = \left[\int_0^1 W_t(j)^{1-\epsilon_w} dj \right]^{\frac{1}{1-\epsilon_w}}. \tag{10}$$

Under a Calvo-type wage setting, this equation can be rewritten as follows:

$$W_t = \left[(1-\theta_w)\tilde{W}_t^{1-\epsilon_w} + \theta_w W_{t-1}^{1-\epsilon_w} \right]^{\frac{1}{1-\epsilon_w}}. \tag{11}$$

Log-linearizing optimal nominal wage leads to the following wage NK Phillips curve:

$$\pi_t^w = \beta \pi_{t+1}^w - \delta_w \mu_t^w, \tag{12}$$

where π_t^w (=$\log(W_t/W_{t-1})$). Also, the average wage markup is given by

$$\mu_t^w = \hat{w}_t - \left(\sigma + \frac{\varphi}{1-\alpha} \right) \hat{Y}_t, \tag{13}$$

where $\hat{w}_t$ denotes wage inflation and log-linearized real wage. The coefficient δ_w is defined by

$$\delta_w = \frac{(1-\theta_w)(1-\theta_w\beta)}{\theta_w(1+\varphi\epsilon_w)}.$$

Unless otherwise specified, hatted variables in this paper represent the logarithmic deviation from the steady state. More precisely, the log-linearized variables around the steady state are represented by $\hat{H}_t = \log(H_t/H)$, where H denotes the steady-state value.

3.1.3 Firms

There are two production sectors: the final and intermediate goods sector. The final goods sector produces final goods using intermediate goods and is characterized by perfect competition. Meanwhile, the intermediate goods sector is characterized by monopolistic competition and Calvo (1983)'s price setting.

Final goods firms

The final goods sector produces final goods according to the following constant elasticity of substitution (CES) aggregate:

$$Y_t = \left[\int_0^1 Y_t(z)^{\frac{\epsilon_p - 1}{\epsilon_p}} dz \right]^{\frac{\epsilon_p}{\epsilon_p - 1}}, \tag{14}$$

where Y_t is aggregate output, $Y_t(z)$ is demand for intermediate goods produced by firm z, and ϵ_p is the elasticity of substitution. Under the CES aggregate, the demand function is given by:

$$Y_t(z) = \left(\frac{P_t(z)}{P_t}\right)^{-\epsilon_p} Y_t, \tag{15}$$

and the price level is defined as follows:

$$P_t = \left[\int_0^1 P_t(z)^{1-\epsilon_p} dz\right]^{\frac{1}{1-\epsilon_p}}, \tag{16}$$

where $P_t(z)$ is the price for intermediate goods produced by firm z.

Intermediate goods firms

Firm z's production function is given by

$$Y_t(z) = A_t N_t(z)^{1-\alpha}, \tag{17}$$

with

$$N_t(z) = \left[\int_0^1 (N_t(j,z))^{\frac{\epsilon_w - 1}{\epsilon_w}} dj\right]^{\frac{\epsilon_w}{\epsilon_w - 1}}. \tag{18}$$

Also, A_t denotes an aggregate productivity disturbance.

Following Calvo (1983), we assume that nominal price rigidity exists in the intermediate goods sector. A fraction $1-\theta_p$ of all firms adjusts their price, whereas the remaining fraction of firms θ_p does not. We now consider intermediate firms that can adjust their prices. When revising their prices, these firms account for the uncertainty of when they will be able to adjust prices next. In this case, the intermediate firm's optimization problem for the home country is given by:

$$\sum_{s=0}^{\infty} \theta_p^s Q_{t,t+s} Y_{t+s}(z)(P_t^* - P_{t+s} MC_{t+s,t}), \tag{19}$$

where P_t^* is the firm's optimal price and $MC_{t+s,t}$ denotes the real marginal cost in period $t+s$ for a firm which last reset its price in period t. The first-order condition of this maximization problem is as follows:

$$\sum_{s=0}^{\infty} \theta_p^s Q_{t,t+s} Y_{t+s}(z)(P_t^* - \mu_p P_{t+s} MC_{t+s,t}) = 0. \tag{20}$$

where the variable $\mu_p = \epsilon_p/(\epsilon_p - 1)$ is the price markup. Log-linearizing optimal nominal prices yields the following price NK Phillips curve:

$$\pi_t = \beta \pi_{t+1} - \zeta_p \hat{\mu}_t^p, \tag{21}$$

the variable μ_t^p denotes the average price markup, which is given by

$$\mu_t^p = -\frac{\alpha}{1-\alpha}\hat{Y}_t - \hat{w}_t, \tag{22}$$

also

$$\zeta_p = \frac{(1-\theta_p)(1-\theta_p\beta)}{\theta_p}\frac{1-\alpha}{1-\alpha+\alpha\epsilon_p}.$$

3.2 Policy blocks

Except for the presence of a tax rule for both Ricardian and LC consumers, the policy blocks are similar to those considered in Galí (2020a). The following are brief descriptions of policy blocks and equilibrium conditions.

Fiscal and monetary authorities

Except for the specification of tax rules, following Galí (2020a), we assume that under the coordinated fiscal and monetary authorities, the government finances its expenditures through three resources: (i) lamp-sum taxes for Ricardian and LC consumers, (ii) issuing risk-free nominal bonds, and (iii) issuing non-interest bearing money. The consolidated government budget constraints are given as follows:

$$P_t G_t + B_{t-1}(1 + i_{t-1}) = P_t T_t + B_t + \Delta M_t, \tag{23}$$

where $T_t = (1-\lambda)T_{o,t} + \lambda T_{r,t}$ and $M_t = (1-\lambda)M_{o,t} + \lambda M_{r,t}$. Dividing both sides by P_t, the government budget constraints can be rewritten as the real term:

$$G_t + \mathcal{B}_{t-1}\mathcal{R}_{t-1} = T_t + \mathcal{B}_t + \frac{\Delta M_t}{P_t}, \tag{24}$$

where $\mathcal{B}_t = B_t/P_t$ and $\mathcal{R}_t = (1+i_t)P_t/P_{t+1}$. As supposed in Galí (2020a), we also assume that zero-seigniorage holds at the steady state with $\Delta M = 0$. The consolidated budget constraints at the steady state are given as follows:

$$T = G + \rho\mathcal{B},$$

where $\mathcal{R} = 1 + \rho$ and ρ denotes a time preference rate.

Following Galí (2020a), we provide the level of seigniorage expressed in terms of steady-state output as follows:

$$\frac{\Delta M_t/P_t}{Y} = \left(\frac{\Delta M_t}{M_{t-1}}\right)\left(\frac{P_{t-1}}{P_t}\right)\frac{L_{t-1}}{Y} \simeq \chi \Delta m_t, \tag{25}$$

where $L_t = M_t/P_t$, $m_t = \log M_t$, and $\chi = L/Y$.

Let $\hat{b}_t = (\mathcal{B}_t - \mathcal{B})/Y$, $\hat{g}_t = (G_t - G)/Y$, and $\hat{t}_t = (T_t - T)/Y$. Log-linearizing the consolidated budget constraints leads to

$$\hat{b}_t = (1+\rho)\hat{b}_{t-1} + b(1+\rho)(\hat{i}_{t-1} - \pi_t) + \hat{g}_t - \hat{t}_t - \chi \Delta m_t, \tag{26}$$

where $b(= \mathcal{B}/Y)$ represents the target debt ratio. Also, the other variables are defined as $\hat{t}_t = (1-\lambda)\hat{t}_{o,t} + \lambda \hat{t}_{r,t}$, $\hat{t}_{k,t} = (T_{k,t} - T)/Y$ (for $k = o, r$), $\hat{i}_t = \log[(1+i_t)/(1+\rho)]$. Variable π_t $(= \log(P_t/P_{t-1}))$ denotes price inflation.

Unlike the RANK model, our model is based on the TANK model. Therefore, we can consider that the government levies tax rates on both Ricardian and LC consumers. Specifically, we assume that the tax rates for both consumers are as follows:

$$\hat{t}_{k,t} = \psi_{k,b}\hat{b}_{t-1} + \hat{t}^*_t, \tag{27}$$

for $k = o, r$ and $\hat{t}^*_t$ denotes the exogenous tax shock.

Substituting Equations (27) into Equation (26) leads to

$$\hat{b}_t = \Big[1 + \rho - (1-\lambda)\psi_{o,b} - \lambda\psi_{r,b}\Big]\hat{b}_{t-1} + b(1+\rho)(\hat{i}_{t-1} - \pi_t) + \hat{g}_t - \hat{t}_t - \chi\Delta m_t. \tag{28}$$

We assume the condition $(1-\lambda)\psi_{o,b} + \lambda\psi_{r,b} > \rho$, so that the debt ratio converges to its long-run target value $\mathcal{B}$.

Experiments

Following Galí (2020a), we consider two fiscal interventions in the preceding model. The first intervention is characterized by a tax cut, which is assumed by

$$\hat{t}^*_t = -\delta^t < 0, \tag{29}$$

where $t = 0, 1, 2, \cdots$. $\delta \in [0,\ 1)$ indicates the persistence of the exogenous fiscal stimulus. The second intervention is characterized by government spending, which is assumed by

$$\hat{g}_t = \delta^t > 0, \tag{30}$$

where $t = 0, 1, 2, \cdots$.

Also, following Galí (2020a), we implemented these two interventions under two alternative policy regimes for the government to meet its financing needs. We classify an MF fiscal stimulus as a first regime, assuming that seigniorage is adjusted every period to keep real debt constant. Thus, to satisfy $\hat{b}_t = 0$ for all t, we adjusted the money stock by the following rule:

$$\Delta m_t = \frac{1}{\chi}\left[\delta^t + b(1+\rho)(\hat{i}_{t-1} - \pi_t)\right], \tag{31}$$

In this regime, the government is not required to increase both taxes and debts in response to a change in government spending or a tax cut. Conversely, the central bank adjusts the money stock to satisfy government's financing needs at the expense of controlling the nominal interest rate.

Subsequently, although we mainly examine the impact of wage flexibility on an MF regime, we also consider the DF fiscal stimulus as a second regime. As Galí (2020a) assumed, the fiscal authority in this regime issues government debt to finance its fiscal spending. Therefore, it eventually adjusts the tax path for both Ricardian and LC consumers to meet the long-run debt target. In this regime, the central bank controls the nominal interest rate using the standard Taylor rule (Taylor, 1993), which is given by

$$\hat{i}_t = \phi_\pi \pi_t, \tag{32}$$

where ϕ_π denotes the inflation stabilization coefficient in the Taylor rule.[10] Therefore, under a DF regime, the money stock is endogenously adjusted via a money demand function:

$$\hat{l}_{k,t} = \eta_c \hat{C}_{k,t} - \eta_r \hat{i}_t, \tag{33}$$

for $k = o, r$. The parameters η_c and η_r denote the income and interest elasticity of money demand, respectively.[11] Note that in contrast to Galí (2020a), the money demand function in our study is characterized by Ricardian and LC consumers.

[10] In contrast to our study, Galí (2020a) considered strict inflation targeting instead of using a Taylor rule.

[11] This equation holds unless the nominal interest rate reaches its zero lower bounds.

3.3 Equilibrium conditions

Finally, with the exception of policy and non-policy blocks, we briefly explain the equilibrium conditions. The remaining equilibrium conditions are given as follows:

$$Y_t = C_t + G_t, \tag{34}$$

$$C_t = (1-\lambda)C_{o,t} + \lambda C_{r,t}, \tag{35}$$

$$B_t = (1-\lambda)B_{o,t}, \tag{36}$$

$$\Gamma_t = (1-\lambda)\Gamma_{o,t}. \tag{37}$$

Equation (34) represents the goods market clearing condition, and Equation (35) denotes aggregate consumption. The conditions (36) and (37) denote bond market clearing and aggregate dividend, respectively.

4 Main results

This section provides this study's main results. Section 4.1 provides the calibrated values used in this paper. Section 4.2 examines the effect of government spending under an MF regime, and Section 4.3 reports the government spending multiplier under a DF regime. Based on our main results, Section 4.4 argues about the effect of the degree of nominal wage stickiness on the multiplier.

4.1 Calibration

We explain the values of the deep parameters calibrated in this paper. We adopt the calibrated values from previous studies. With the exception of the proportion of LC households and the degree of nominal wage rigidity, the majority of the calibrated values are based on those used by Galí (2020a). The parameters σ and φ are set to 1.0 and 5.0, respectively. Concerning the degree of nominal price stickiness, we set θ_p to 0.75 as a benchmark calibrated value. For the value of the money demand function for Ricardian and LC consumers, η_c and η_r are set to 1.0 and 4.0, respectively. The elasticity of substitution (ϵ_p) is set to 9.0. Moreover, the elasticity of substitution for labor services (ϵ_w) is set to 9.0.

Subsequently, we will explain how to choose the value of the degree of nominal wage rigidity. We set θ_w to 0.75 as a benchmark value. This value is consistent with previous research on the

standard NK model with nominal wage rigidity (Christiano et al., 2005, Erceg et al., 2000). Because we explore how wage flexibility affects the impact of an MF regime on macroeconomic dynamics in both normal and liquidity trap times, we also consider the parameter range of θ_w from 0 to 1.

Now, we discuss how to calibrate the proportion of LC households that corresponds to the share of LC consumers. Kaplan, Violante and Weidner (2014) argued that for the United States, Canada, Australia, the United Kingdom (UK), Germany, France, Italy, and Spain, the share of LC households ranges from 20% to 35%.[12] In addition, Almgren, Gallegos, Kramer and Lima (2019) illustrated that the fraction of LC consumers ranges from 10% in Malta to almost 65% in Latvia. In this paper, we set λ to 0.25 as a benchmark value and check the robustness of the results by employing several alternative values in Section 6.

Finally, we explain how to calibrate the policy block parameters. In the Taylor rule, the inflation stabilization coefficient is fixed to 1.5 (Taylor, 1993, Woodford, 2003). To examine the impact of wage flexibility on an MF regime as simply as possible, we assume that $\psi_b^o = \psi_b^r$. Then, following Galí (2020a), we set the tax adjustment parameter ψ_b^k (for $k = o, r$) to 0.02. The target debt ratio b is set to 2.4. We set the persistence parameter δ to 0.5.

4.2 Money-financed regime

We first examine the impulse responses of several key macro variables to increases in government spending. Figure 1 shows the impulse responses to government spending shocks when LC consumers and nominal wage rigidities are taken into account. As shown in Figure 1, the increase in output is greater with nominal wage stickiness than with fully flexible nominal wages. Interestingly, given nominal wage stickiness, the response of output to government spending shocks is greater in an economy lacking LC consumers than in one with them. Furthermore, regardless of the presence of LC consumers, the response of price inflation to the shock is smaller under sticky nominal wages than under fully flexible nominal wages.

[Figure 1 around here]

Moreover, unlike fully flexible nominal wages, the nominal interest rate decreases in response to a government spending shock under an MF regime. Therefore, when compared with flexible

[12] See Kaplan et al. (2014) for a detailed discussion about the empirical issue on the share in LC consumers.

nominal wages, the real interest rate falls even further under an MF regime. Consequently, aggregate consumption increases in our model; hence, the fiscal policy puzzle pointed out by Blanchard and Perotti (2002), who argued that government spending decreases consumption, does not emerge. In contrast to Galí (2020a), we found that an increase in aggregate consumption is larger under sticky nominal wages than under flexible ones. Notably, in the absence of LC consumers, the response of aggregate consumption is greater than in the presence of LC consumers under an MF regime. In summary, with the exception of the presence of LC consumers, in our model, the effect of an MF fiscal stimulus on output is greater in the NK model with sticky nominal wages than in those with flexible nominal wages. This result is not observed in the framework of Galí (2020a).

We then examine the effect of the degree of nominal wage stickiness on the government spending multiplier under an MF regime. Following Galí (2020a), we calculate the cumulative output multiplier, $(1-\delta)\sum_{t=0}^{\infty}\hat{y}_t$, as the measure of the effectiveness of fiscal policy.[13] Figure 2 illustrates how the degree of nominal wage stickiness influences the government spending multiplier under an MF fiscal stimulus. Consider the case of fully flexible nominal wages. On the one hand, a higher proportion of LC consumers magnifies the impact of government spending on output. On the other hand, the multiplier becomes smaller as the share of LC consumers decreases. Note that under an MF fiscal stimulus, the multiplier exceeds 1 even in the case of $\lambda = 0$. This result is consistent with Galí (2020a).

[Figure 2 around here]

Then, we explore how the degree of nominal wage stickiness affects the government spending multiplier under an MF regime. First, when the proportion of LC consumers is considerably large (i.e., $\lambda = 0.75$), the multiplier drastically decreases as nominal wages become stickier. The multiplier appears to be unaffected by an increase in θ_w when this parameter exceeds 0.4. Second, the multiplier decreases with an increased value of θ_w when λ is less than 0.5. Third, in contrast to the previous two cases, for a smaller proportion of LC consumers, the cumulative effect of government spending on output increases significantly, as θ_w becomes a higher value. In other words, the magnitude of how wage stickiness affects the fiscal multiplier is entirely determined by the share of LC households.

[13] In the case of the MF and DF regimes, we employ this metric.

The intuition of this result is as follows. When nominal wages are sticky, a rise in price inflation reduces the real wages because nominal wages are unaffected by government spending. Accordingly, a decrease in real wages offsets an increase in LC consumers' consumption. We call it the *negative income effects* of price inflation on LC consumers' consumption. Meanwhile, the Ricardian consumption increases steadily after government spending because lowering the nominal interest rate decreases the real interest rate. The Ricardian households increase their consumption via an intertemporal substitution effect in their consumption Euler equation. Hence, as long as the share of LC consumers is small, an increase in Ricardian consumption outweighs a decrease in LC consumer consumption. Consequently, the output response to government spending becomes larger under sticky nominal wages than under flexible ones. Conversely, an increased share of LC consumers offsets the impact of government spending on output even when sticky nominal wages are introduced. We label this mechanism as *the sticky wage channel of fiscal stimulus*.

We summarized the preceding results as follows. In a TANK model, the presence of nominal wage stickiness substantially affects the impact of government spending on output. We demonstrated that an increase in government spending under the MF regime causes intertemporal substitution effects in the Ricardian household consumption via a change in the real interest rate. However, we found that the negative income effects on LC household consumption occur via the fiscal stimulus's sticky wage channel. Our model shows that the magnitude of the fiscal multiplier is determined by the relative impacts of these two effects.

4.3 Debt-financed regime

We examine the effect of a government spending shock on macrovariables under a DF regime to consider the role of an MF regime. Figure 3 depicts the DF regime's impulse response to a government spending shock. First, consider the case for flexible nominal wages. An increase in government spending stimulates output while decreasing consumption. This implies the fiscal policy puzzle pointed out by Blanchard and Perotti (2002) and occurs even when the presence of LC consumers is assumed.[14] This is because the shock raises the nominal interest rate, which increases the real interest rate despite rising inflation. Under a DF regime, the real debt rises in

[14]The discussion about eliminating this puzzle in our model is beyond the scope of this paper. See Bilbiie (2009) for a detailed discussion about the fiscal price puzzle in terms of theoretical aspects.

response to an increase in government spending. In contrast to the case of no LC consumers, an increase in LC consumer share generates additional output and mitigates a drop in aggregate consumption. This response is consistent with Galí et al. (2007).

[Figure 3 around here]

Then, we explore the case for sticky nominal wages. First, an increase in output occurs regardless of the presence of LC consumers. Furthermore, while wage inflation no longer responds to a government spending shock, price inflation rises. The response of a nominal interest rate is much smaller under sticky nominal wages than under flexible nominal wages because the response of price inflation is dampened. This results in a smaller drop in aggregate consumption. The result that the presence of sticky nominal wages dampens a decline in aggregate consumption in a TANK model is consistent with Colciago (2011). In other words, the presence of nominal wage rigidity aids in the resolution of the fiscal policy puzzle. Interestingly, the response of macrovariables under sticky wages (vs. flexible nominal wages) appears to be unaffected by the degree of LC consumers.

Figure 4 shows the multiplier of government spending under a DF regime. First, consider the case for flexible nominal wages. A higher share of LC consumers generates a larger fiscal multiplier, as in the case of an MF regime. For instance, in the case of $\lambda = 0$, the multiplier becomes 1.9 under an MF regime, whereas it takes a value of 1.6 under a DF regime. When the LC consumers are removed from the model, the multiplier falls to 0.6. Next, consider the case for sticky nominal wages. Notably, unlike in the MF regime, the multiplier in the absence of LC consumers does not dominate the multiplier in the presence of LC consumers as long as moderate nominal wage stickiness exists. Figure 4 also shows that similar to the MF regime, an increased value of θ_w lowers the multiplier under a DF regime. Furthermore, the multiplier becomes larger in the case of no LC consumers than in the case of $\lambda = 0.75$ when nominal wages are predominately sticky.

[Figure 4 around here]

The intuition of this result is as follows. When nominal wages are sticky, a rise in price inflation causes a decrease in real wages because government spending does not affect nominal wages. Therefore, a reduction in real wages leads to a decrease in LC consumer consumption.

Meanwhile, the Ricardian household consumption remains nearly unchanged by government spending because a smaller increase in the nominal interest rate attenuates a rise in the real interest rate. This matches the findings of Colciago (2011). Hence, as long as the share of LC consumers is small, the effect of preventing a drop in Ricardian consumption outweighs the effect of preventing a decline in LC consumer consumption. Consequently, the output response to government spending becomes larger under sticky nominal wages than under flexible ones. In this case, similar to an MF regime, an increased share of LC consumers weakens the impact of government spending on output as nominal wages become stickier.

Finally, we contrast the impact of government spending under an MF versus a DF regime. Figure 5 illustrates the comparison of the government spending multiplier under two different regimes. Figure 5 shows that a lower fiscal multiplier is always achieved under a DF regime than under an MF regime, even when both LC consumers and nominal wage rigidity are considered in the model. This result is consistent with that obtained in Galí (2020a), who found that the effect of an MF regime generally dominates that of a DF regime. Furthermore, because of the disparity in the share of LC consumers within the regime, the DF fiscal stimulus is less responsive to an increase in nominal wages. In contrast to Figure 2, Figure 5 portrays that in the case of sticky nominal wages, the multiplier with no LC consumers becomes larger than that with $\lambda = 0.25$.

[Figure 5 around here]

Our result underlines the importance of both LC consumers and nominal wage stickiness. This implies that under a DF regime, for the value of $\lambda = 0.25$, the multiplier of government spending is less sensitive to the degree of nominal wage stickiness. Conversely, in the MF regime, as long as the value of θ_w is considerably small, there appears to be negligible difference between the case for $\lambda = 0.25$ and no LC consumer case. Notably, the difference between the two cases becomes larger as the value of θ_w increases. Particularly, when nominal wages are extremely sticky, a significant difference emerges. Therefore, unlike previous studies on fiscal multipliers in the NK model, this paper emphasizes the significant role of nominal wage rigidity in accounting for the macroeconomic impact of fiscal stimulus. In other words, to the best of our knowledge, none of the studies attempt to account for the effect of both LC consumers and nominal wage stickiness on the fiscal multiplier.

4.4 Discussion

Our TANK model shows that the fiscal multiplier of an MF regime is larger than that of a DF regime. As shown in Galí (2020a), the impact of real interest rates on fiscal stimulus captures the key difference between MF and DF. In the RANK model with sticky prices and flexible wages, the authority manipulates nominal interest rates to stabilize inflation under the DF regime. If the fiscal stimulus triggers inflation, the central bank raises the nominal interest rates to control it. Such a monetary contraction raises real interest rates, thereby reducing the Ricardian consumers' current consumption. On the contrary, the money supply should be increased to offset the increase in real government debt under the MF regime. As a result, an increased money supply leads to inflation and a decrease in real interest rates, stimulating Ricardian consumers' current consumption.

More importantly, we emphasize the importance of considering the fact that nominal wage stickiness has a significant impact on the fiscal multipliers of the MF and DF regimes. In particular, our main message is that in order to fully benefit from the MF regime's fiscal stimulus, we need to have conditions in which (1) nominal wages are fully flexible and the share of LC consumers is large, or (2) nominal wages are sticky and the share of LC consumers is small. The degree of nominal wage rigidity in our model is set to 0.75 as a benchmark parameter value. This value is based on the standard NK model with nominal wage stickiness (Christiano et al., 2005, Erceg et al., 2000, Galí, 2011). Additionally, as noted earlier, Kaplan et al. (2014) specified that the proportion of households facing liquidity constraints in the USA, Canada, Australia, the UK, Germany, France, Italy, and Spain is between 20% and 35%. Almgren et al. (2019) reported that the fraction of LC consumers ranges from 10% in Malta to almost 65% in Latvia. Hence, a value of λ that exceeds 0.5 seems not supported by the empirical analyses estimating the share of LC consumers.

Therefore, our model suggests that for empirically plausible parameter values, the MF fiscal stimulus becomes a more effective tool for stimulating the real economy than the DF regimes. This could be the same conclusion as that derived from Galí (2020a). However, Galí (2020a) did not show how the magnitude of the MF fiscal stimulus is affected by the degree of nominal wage stickiness in a TANK model. Indeed, the combination of nominal wage stickiness and LC consumers are addressed in Ascari et al. (2017). Unlike Galí (2020a), we can clearly state that the finding that nominal wage stickiness and LC consumers have a significant impact on fiscal

stimulus effectiveness is not trivial.

We also showed that, regardless of fiscal regimes, nominal wages are less responsive to a fiscal stimulus in the case of sticky nominal wages.[15] Particularly, if a higher share of LC consumers is realized in the economy, boosting output through an increase in LC consumers' consumption is dampened because fiscal stimulus has a smaller impact on LC consumers' disposable income. Put differently, the larger share of LC consumers generates substantial negative income effects via the sticky wage channel of fiscal stimulus.

We found that this mechanism is unaffected by the fiscal authority's choice of fiscal regime. Nonetheless, we show in our model that MF fiscal stimulus outperforms DF fiscal regimes even in the case of sticky nominal wages. Unlike LC consumers, Ricardian households benefit from current consumption because the MF fiscal stimulus reduces the real interest rate, which significantly boosts Ricardian households' consumption via the intertemporal substitution effect of the interest rate.

Accordingly, our results have significant implications for fiscal policy. Thus, in the case of sticky nominal wages, the MF fiscal stimulus is reinforced by a smaller share of LC consumers. However, even in the case of sticky nominal wages, an increased share of LC consumers dampens the fiscal multiplier under the MF regime. Therefore, in contrast to Galí et al. (2007), our findings suggest that the presence of a higher share of LC consumers does not always result in a large fiscal multiplier when the role of nominal wage stickiness is non-negligible. This policy prescription applies to both the DF and MF regimes.

5 Sensitivity experiments

This section provides several sensitivity experiments. Galí (2020a) specified that the degree of nominal price stickiness and the magnitude of a fiscal shock affect the government spending multiplier. In this section, we look at how changes in the degree of nominal wage stickiness impact the fiscal multiplier in the TANK model, taking into account the degree of nominal price stickiness and the size of a fiscal shock. More specifically, in Section 5.1, we consider how a change in the degree of nominal price stickiness affects the previous section's results. Meanwhile, Section 5.2 considers how the magnitude of a fiscal shock influences the impact of

[15] See also Colciago (2011) for a detailed discussion about this point.

a fiscal multiplier when the degree of nominal wages varies.

5.1 The degree of price stickiness

First, we consider the role of nominal price stickiness in assessing the effect of nominal wage stickiness on the fiscal multiplier under the MF and DF regimes. Indeed, Galí (2020a) found the significant impact of nominal price stickiness on the fiscal multiplier. More concretely, Galí (2020a) demonstrated that flexible nominal prices result in a lower fiscal multiplier, whereas stickier nominal prices increase the MF fiscal multiplier. However, he did not consider the role of nominal price stickiness in a TANK model with nominal wage stickiness. This subsection aims to examine whether the impact of nominal wage stickiness on the fiscal multiplier is affected by a change in the degree of nominal price stickiness in a TANK model.

Figure 6 depicts the fiscal multiplier under an MF regime when considering several parameterizations of θ_p. In this figure, the case of $\theta_p = 0.75$ corresponds to the benchmark result obtained in the previous section. A low level of nominal price stickiness results in a smaller fiscal multiplier. Consider the case of $\theta_p = 0.2$. The multiplier is close to zero in the case of no LC consumers under flexible nominal wages, and this result is consistent with Galí (2020a). Even in the case of flexible nominal prices, an increased share of LC consumers results in a higher fiscal multiplier under fully flexible nominal wages. As shown in the previous section, a smaller share of LC consumers drives a higher fiscal multiplier as the degree of nominal wage stickiness increases.

[Figure 6 around here]

Next, consider the case of higher sticky nominal prices. Compared with a smaller degree of the parameter θ_p, sticky nominal prices magnify the multiplier for government spending. This is in line with the findings of Galí (2020a). In addition to his finding, our model demonstrates that a rise in the parameter value of λ enhances the fiscal multiplier as long as nominal wages are fully flexible. This figure reveals that in the case of $\lambda = 0.75$, the multiplier takes 1.5 in the case of $\theta_p = 0.5$, whereas it takes roughly 2.8 in the case of $\theta_p = 0.9$. However, the fiscal multiplier for a larger value of λ is lowered by an increased degree of nominal wage stickiness. Notably, in the case of $\theta_p = 0.9$, the fiscal multiplier when $\lambda = 0$ is not responsive to a change in nominal wage rigidity.

Figure 7 illustrates the impact of the degree of nominal wage stickiness on the DF fiscal multiplier when several parameter values of θ_p are considered. Galí (2020a) found that in a DF regime, the fiscal multiplier is invariant regardless of the degree of nominal price stickiness. However, this paper addresses the role of nominal wage stickiness when the degree of nominal prices changes. For a smaller value of θ_w, a higher value of λ creates a larger DF fiscal multiplier. For instance, in the case of $\theta_w = 0$, the fiscal multiplier takes a value of approximately 2.0 when $\theta_p = 0.2$. The multiplier reaches zero as the parameter λ takes a smaller value, and this result is consistent with Galí (2020a). However, for a higher value of θ_w, an increased value of λ lowers the DF fiscal multiplier, whereas a smaller value of λ enhances it. When nominal wages are predominantly sticky, the multiplier approaches 1.0 regardless of the proportion of LC consumers.

[Figure 7 around here]

In the case of a predominately larger value of θ_p, the smaller the value of the parameter θ_w, the larger the fiscal multiplier when the share of LC consumers is higher. In this case, the fiscal multiplier exceeds 2.0 when the parameter λ takes a value of 0.75. However, as in the case of a smaller value of θ_p, an increased value of θ_w lowers the fiscal multiplier when the share of LC consumers is high. Finally, regardless of the degree of nominal price stickiness, the fiscal multiplier seems to converge to unity when nominal wage stickiness is very high, that is, when θ_w is close to unity.

In sum, as long as nominal wages are fully flexible, as shown in Galí (2020a), in the standard NK model, the degree of nominal price stickiness has no effect on the DF fiscal multiplier. However, when LC consumers and nominal wage stickiness coexist, the degree of nominal price stickiness has a significant influence on the DF fiscal multiplier. Therefore, in a TANK model with nominal wage stickiness, the results of Figures 2 and 4 are robust to changes in the degree of nominal price stickiness.

5.2 The degree of fiscal policy shock

This section examines whether the degree of fiscal policy plays a significant role in our model. Galí (2020a) found that although the DF fiscal multiplier is unaffected by the size of the fiscal policy shock, the larger the size of the government spending shock, the greater the impact of

the MF fiscal stimulus on output. The main purpose of this section is to investigate whether the size of the fiscal shock significantly affects the fiscal multiplier in an NK model with the interaction of LC consumers and nominal wage stickiness under the MF and DF regimes.

Figure 8 depicts the impact of a government spending shock on the MF fiscal multiplier. When the shock size is relatively small, an increased value of λ produces the larger fiscal multiplier under the MF regime in the case of fully flexible nominal wages. The fiscal authority faces a substantial drop in the multiplier as the degree of the parameter θ_w increases. Conversely, a smaller share of LC consumers enhances the MF fiscal multiplier. In particular, if the parameter θ_w is close to unity, the difference between the multipliers of $\lambda = 0$ and $\lambda = 0.75$ is not negligible.

[Figure 8 around here]

In the case of $\delta = 0.9$, under fully flexible nominal wages, the fiscal multiplier approaches unity despite the degree of a share in LC consumers. Except for the presence of LC consumers, this result is consistent with Galí (2020a). Interestingly, a smaller value of λ substantially increases the fiscal multiplier under the MF regime when nominal wages are predominately sticky. For instance, although the multiplier under $\lambda = 0.75$ takes a value of roughly 1.5, that under $\lambda = 0$ achieves a value of approximately 5.5. Therefore, the difference between the multipliers of $\lambda = 0$ and $\lambda = 0.75$ is much larger in the case of $\delta = 0.9$ than in the case of $\delta = 0.01$. This result is not observed in Galí (2020a).

Next, we consider the impact of the size of a government spending shock on the DF fiscal stimulus. Figure 9 shows the impact of varying the magnitude of a government spending shock on the DF fiscal multiplier. In the case of $\delta = 0.01$, under flexible nominal wages, the fiscal multiplier becomes smaller without a share of LC consumers. This result is consistent with Galí (2020a). As the parameter θ_w increases, the larger the degree of λ, the larger the DF fiscal multiplier. However, as the degree of nominal wage stickiness becomes severe, the multiplier under a higher share of LC consumers decreases significantly, whereas it increases under no LC consumers. Consequently, regardless of the share of LC consumers, the multiplier under a DF regime appears to converge to unity in the case of predominately high nominal wage stickiness.

[Figure 9 around here]

When the size of a government spending shock becomes larger (i.e., $\delta = 0.9$), under flexible nominal wages, the DF fiscal multiplier does not exceed unity even with a higher share of LC consumers. Of course, as shown in Galí (2020a), the fiscal multiplier takes a quite smaller value in the case of no LC consumers. Even in this case, under a DF regime, the multiplier becomes larger under a higher share of LC consumers. When the parameter θ_w is close to unity, the multiplier under $\lambda = 0$ exceeds that under $\lambda = 0.75$.

In summary, the results shown in Figures 2 and 4 are robust to changes in the magnitude of a government spending shock. We argue that the interaction between LC consumers and nominal wage stickiness should be considered when evaluating the impact of the size of a government spending shock on the fiscal multiplier in both MF and DF regimes.

6 The case for a tax cut

This section investigates how a change in the degree of nominal wage stickiness affects fiscal stimulus via tax cuts. This exercise corresponds to the robustness check of our result because Galí (2020a) considered the role of a tax cut in accounting for the role of both MF and DF regimes. He demonstrated that, as with government spending, the difference between the multipliers of the MF and DF regimes is significant in the case of a tax cut. In particular, Galí (2020a) found that the DF fiscal multiplier is unresponsive to changes in nominal price stickiness or the size of the fiscal shock. Section 6.1 explores the sensitivity of our results to changes in the degree of nominal price stickiness, and Section 6.2 considers the case for fiscal shock size.

6.1 The degree of nominal price stickiness

Figure 10 depicts the impact of a change in the degree of nominal price rigidity on the MF fiscal multiplier via a tax cut. Under flexible nominal wages, the multiplier close to zero is attained in the absence of LC consumers. This result is consistent with Galí (2020a). Similar to the case of Figure 2, although the multiplier decreases as the proportion of LC consumers increases, an increase in nominal wage rigidity enhances the multiplier in the absence of LC consumers. Unlike Figure 2, however, the fiscal multiplier with $\lambda = 0$ never beats that with $\lambda = 0.75$. When nominal wages are extremely sticky, regardless of the value of λ, the MF fiscal multiplier appears to converge to 0.8.

[Figure 10 around here]

When nominal prices are considerably sticky, the DF multiplier exceeds 2.0 if a higher share of LC consumers is present in an economy with fully flexible nominal wages. However, even with a higher share of LC consumers, an increase in nominal wage stickiness substantially weakens the impact of the DF fiscal stimulus on output. When nominal wages are primarily sticky, the multiplier approaches unity. Regardless of the value of λ. Thus, we can say that our result is robust to the methods of fiscal stimulus.

[Figure 11 around here]

Next, consider the case of the DF fiscal stimulus through a tax cut in Figure 11. First, regardless of the degree of nominal price stickiness, the fiscal multiplier takes zero in the absence of LC consumers, and this result is consistent with Galí (2020a). This is not a surprising result because the Ricardian households expect that the fiscal stimulus provided by current tax cuts will be offset by future tax increases; namely, Ricardian equivalence. However, even in a DF regime, the introduction of LC consumers increases the fiscal multiplier. For instance, in the case of $\theta_p = 0.2$, under fully flexible nominal wages, the multiplier is 1.2. In addition, in a TANK model, given the degree of nominal wage stickiness, an increased degree of nominal prices magnifies the DF fiscal multiplier. Indeed, under fully flexible nominal wages, the multiplier takes a value of 1.7 in the case of $\theta_p = 0.9$. In addition, regardless of the degree of nominal price stickiness, the multiplier approaches 0.8 when extreme nominal price stickiness is introduced.

6.2 The size of a fiscal shock

In this section, we focus the role of the size of a government spending shock in the case of a tax cut. Figure 12 illustrates the impact of a change in the shock size on the MF fiscal multiplier. Contrary to government spending, the fiscal multiplier without LC consumers never exceeds the fiscal multiplier with LC consumers. Figure 12 depicts that in the case of a smaller shock size, an increase in nominal wages lowers the MF fiscal multiplier in our TANK model. Unlike in the case of government expenditure in Figure 8, the multiplier still becomes larger in the case of higher λ than that in the case of no LC consumers. For instance, the multiplier is roughly 0.5 in the case of $\lambda = 0$, whereas it takes a value of unity when $\lambda = 0.75$.

[Figure 12 around here]

In the case of $\delta = 0.9$, regardless of the value of λ, the fiscal multiplier becomes unity under fully flexible nominal wages. Similar to government spending, an increase in nominal wages amplifies the fiscal multiplier via a tax cut. Notably, when nominal wages are predominantly sticky, as shown in Figure 8, the fiscal multiplier of a tax cut is lower than that of government spending. In summary, even when nominal wage stickiness is introduced into a TANK model, as specified by Galí (2020a), the MF fiscal multiplier generally dominates the DF multiplier.

Finally, consider how the shock size affects the impact of the DF fiscal stimulus on output under a tax cut. Figure 13 shows the effect of the shock size on the DF fiscal multiplier in the case of a tax cut. In contrast to Figure 9, which depicts an MF regime, Figure 13 shows that regardless of the value of θ_w, the DF multiplier under LC consumers always dominates that under no LC consumers. In addition, as in Galí (2020a), the multiplier is zero in the case of a RANK model. For a smaller value of δ, the multiplier under $\lambda = 0.75$ exceeds unity under fully flexible nominal wages. However, in the case of $\delta = 0.9$, given the degree of nominal wage stickiness, the multiplier does not exceed unity no matter the value of λ. When $\delta = 0.9$, as long as λ is not zero, an increased degree of nominal wage stickiness magnifies the DF fiscal multiplier under a tax cut. However, when the parameter θ_w exceeds 0.8, the multiplier decreases.

[Figure 13 around here]

7 Conclusions

This paper examined how a change in nominal wage stickiness influences the effect of the fiscal stimulus via government spending in the TANK model. When evaluating the fiscal multiplier under both MF and DF regimes, we addressed the significant role of nominal wage rigidity. Although previous research has primarily focused on the effectiveness of fiscal policy in the standard NK model, the novelty of this paper is that it demonstrates in detail how the degree of nominal wage stickiness affects the fiscal multiplier in the tractable TANK model.

The main findings of this paper are summarized as follows. First, in the case of MF and DF regimes, an increased share of LC consumers amplifies the fiscal multiplier under fully flexible nominal wages. Second, in the presence of sticky nominal wages, an increase in the share of LC consumers drastically decreases the MF fiscal multiplier. In that case, the MF fiscal multiplier

becomes larger in the case of no LC consumers. Third, even in the presence of nominal wage stickiness and LC consumers, the fiscal multiplier under an MF regime always outperforms that under a DF regime. Fourth, in the case of MF and DF regimes, an increased share of LC consumers increases the fiscal multiplier under fiscal stimulus via a tax cut. Finally, in our model, the degree of nominal price stickiness and the size of government spending play a significant role in evaluating the effect of the fiscal stimulus on output for both government spending and a tax cut.

We would like to mention unsolved issues, as limitations of this study. Although we consider the effect of fiscal policy in an economy without the transmission lag of government spending, whether our main results are affected by the presence of such transmission lag is worth investigating. Moreover, we abstracted from the introduction of capital accumulation. Therefore, we can consider the effect of an MF fiscal stimulus in a medium-scale dynamic stochastic general equilibrium model. Moreover, to keep the model as tractable as possible, this study examined the role of an MF fiscal stimulus in a simple TANK model. However, several studies focus on the effect of the fiscal stimulus on output in a HANK model. For instance, whether the introduction of household heterogeneity significantly affects the impact of an MF fiscal stimulus on output in a HANK model is worthy of investigation. These issues should be considered as future works.

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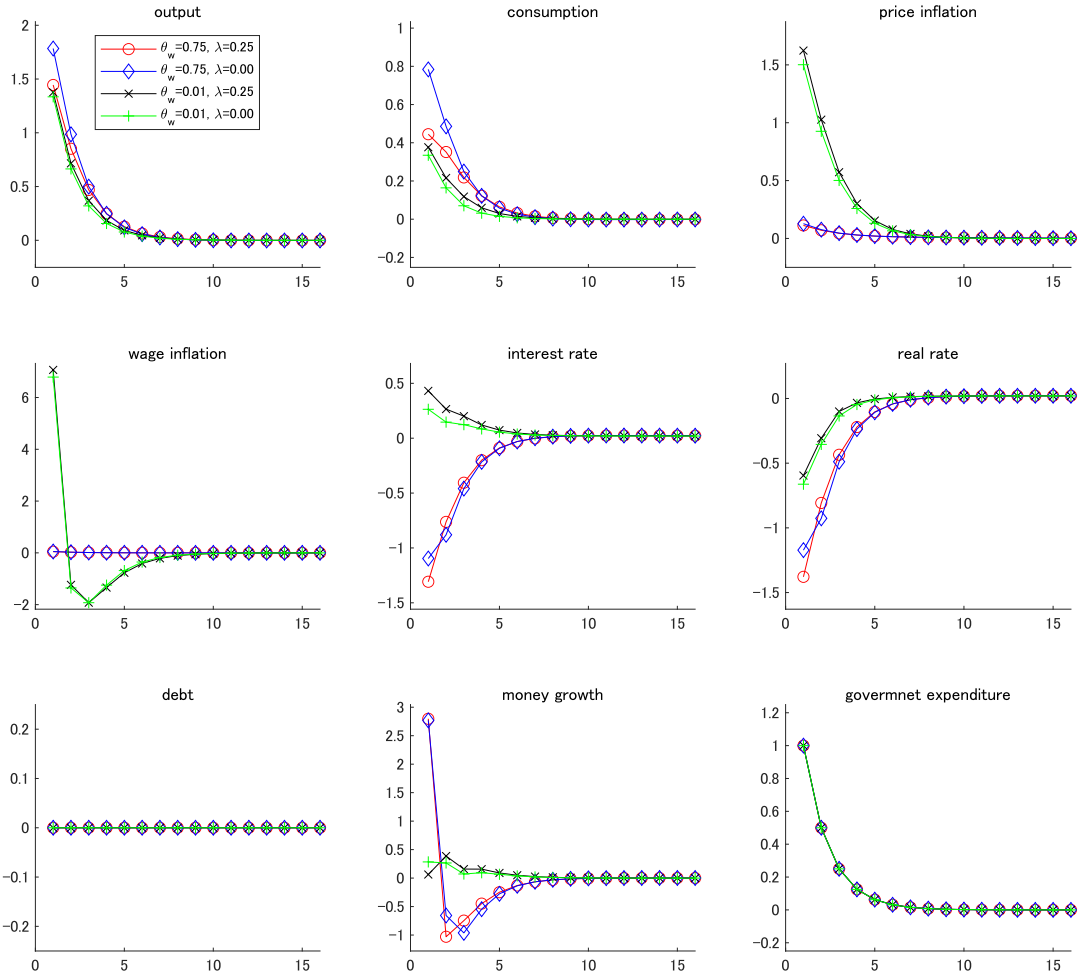

Figure 1: The effect of money-financed fiscal stimulus: Government spending

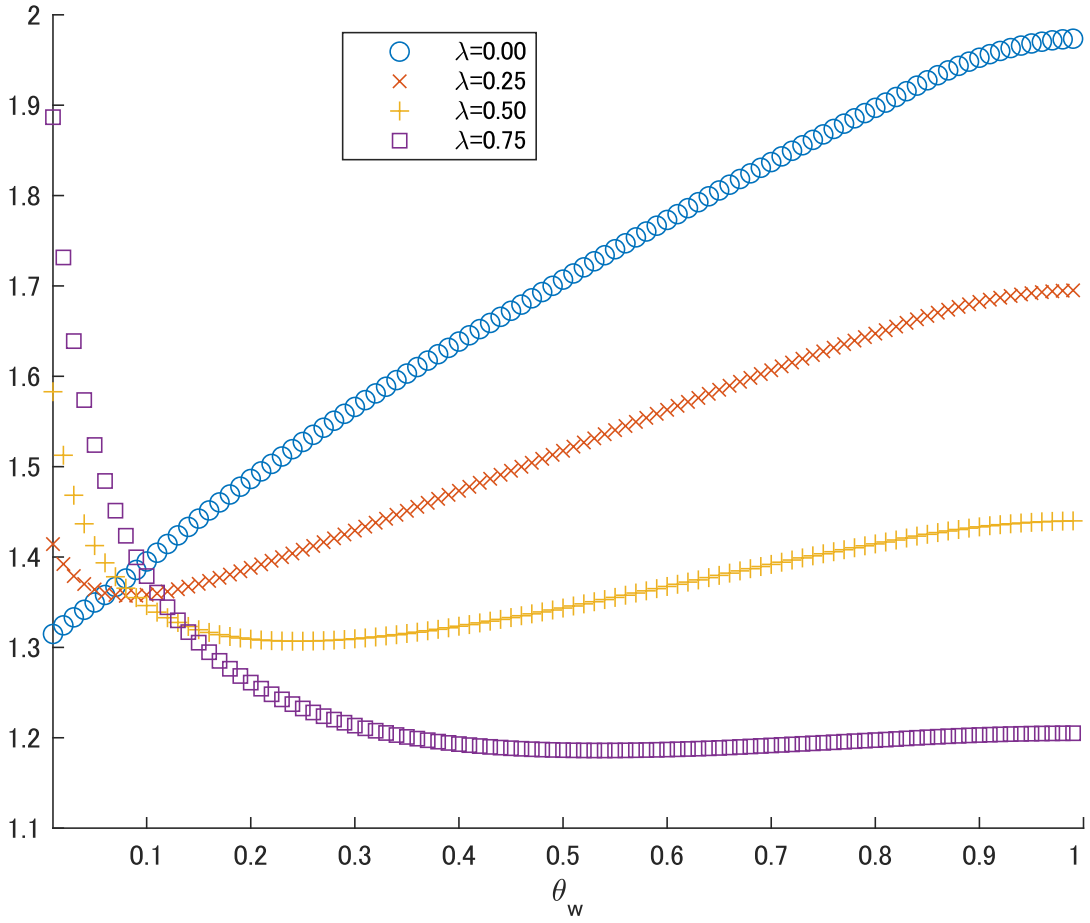

Figure 2: Fiscal multiplier under money-financed fiscal stimulus: The role of nominal wage rigidity

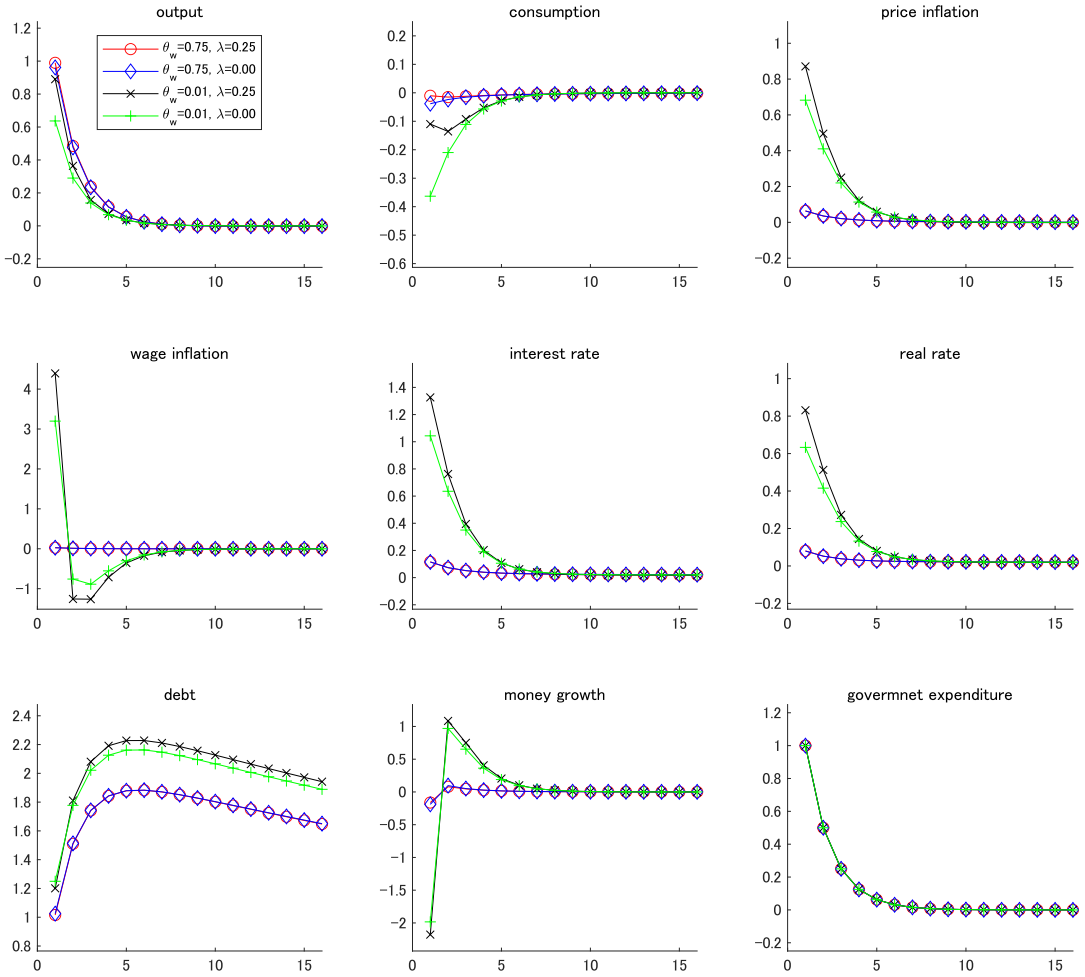

Figure 3: Debt financed fiscal stimulus: Government spending

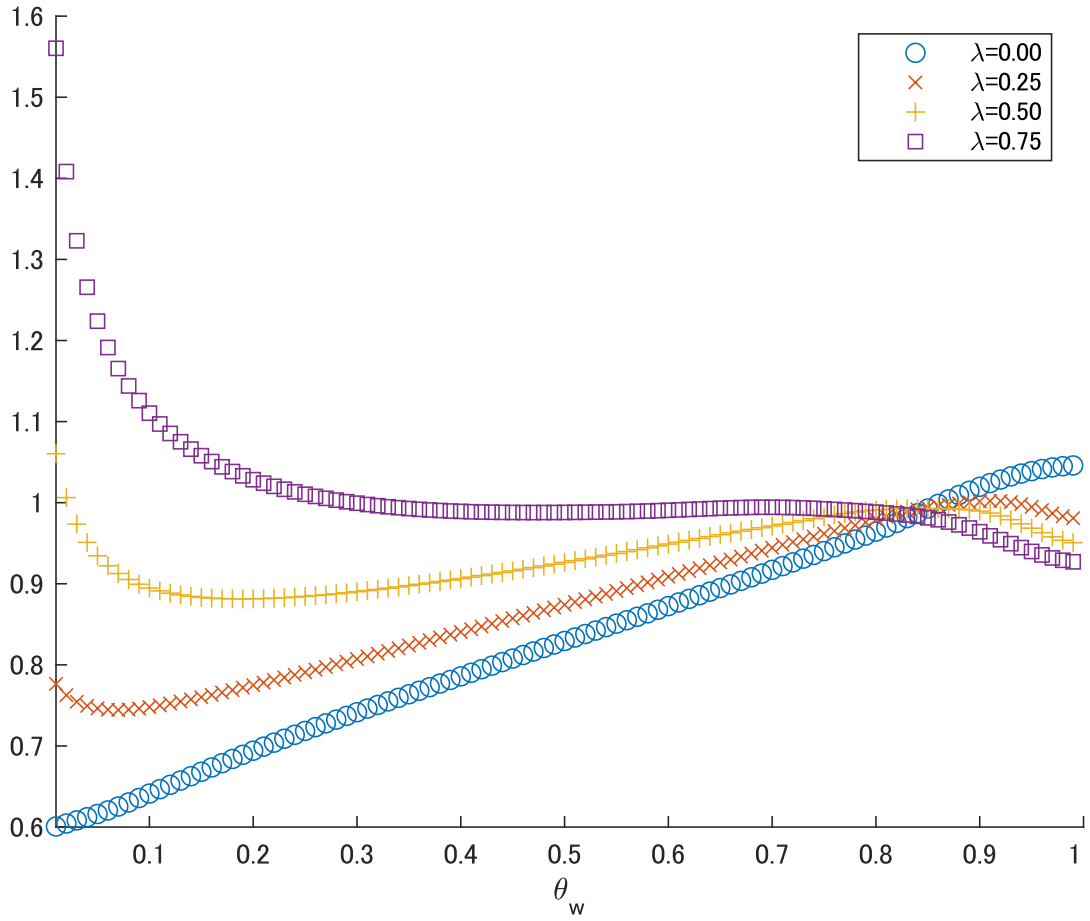

Figure 4: Fiscal multiplier under debt-financed fiscal stimulus: The role of nominal wage rigidity

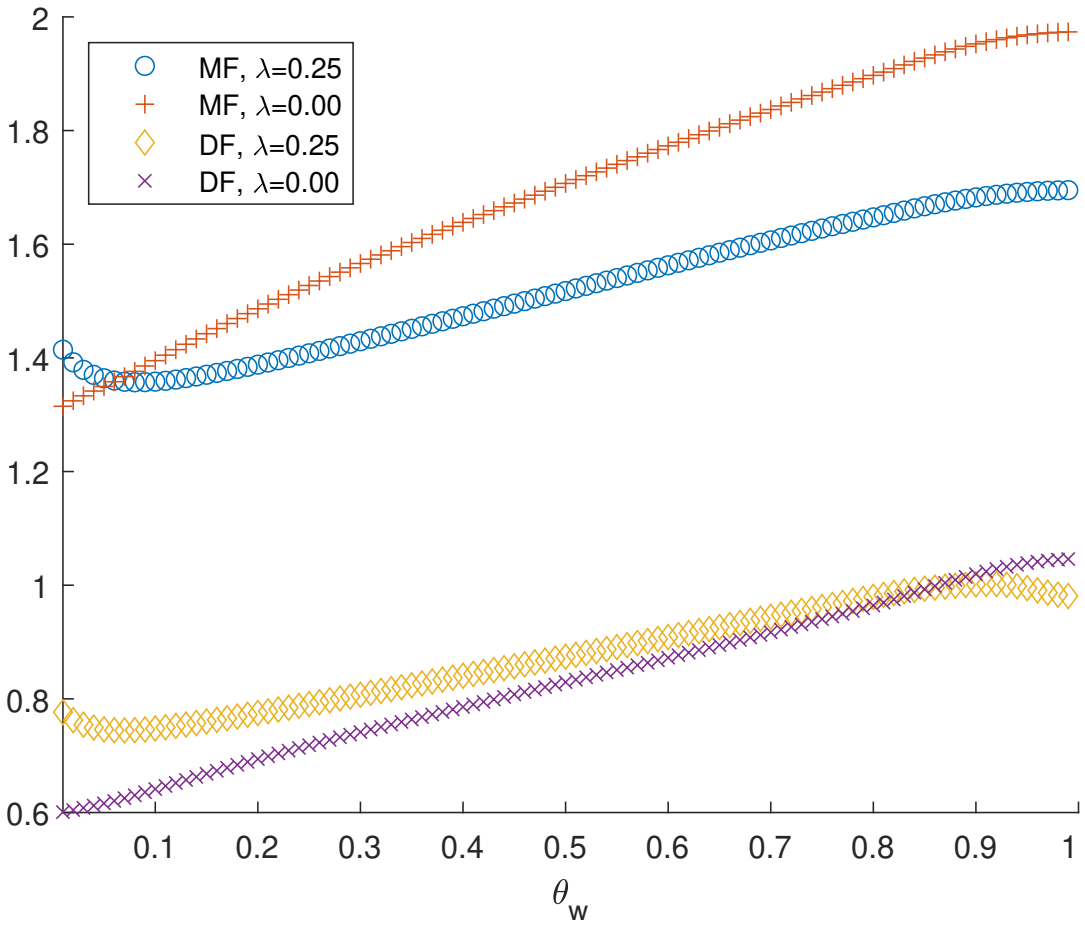

Figure 5: Comparison between money-financed and debt-financed regimes: The role of liquidity-constrained consumers

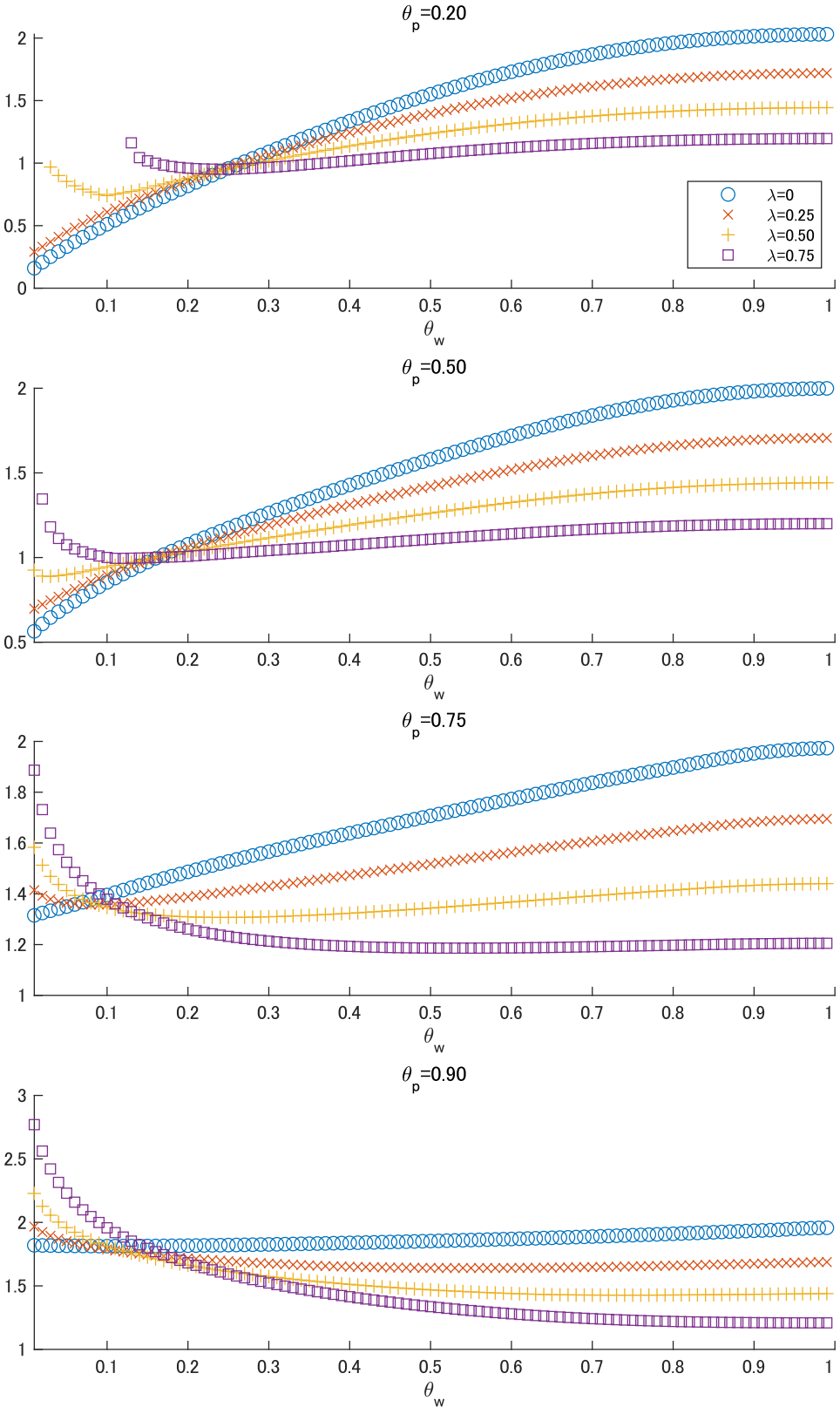

Figure 6: Fiscal multiplier under money-financed regime: The role of price stickiness

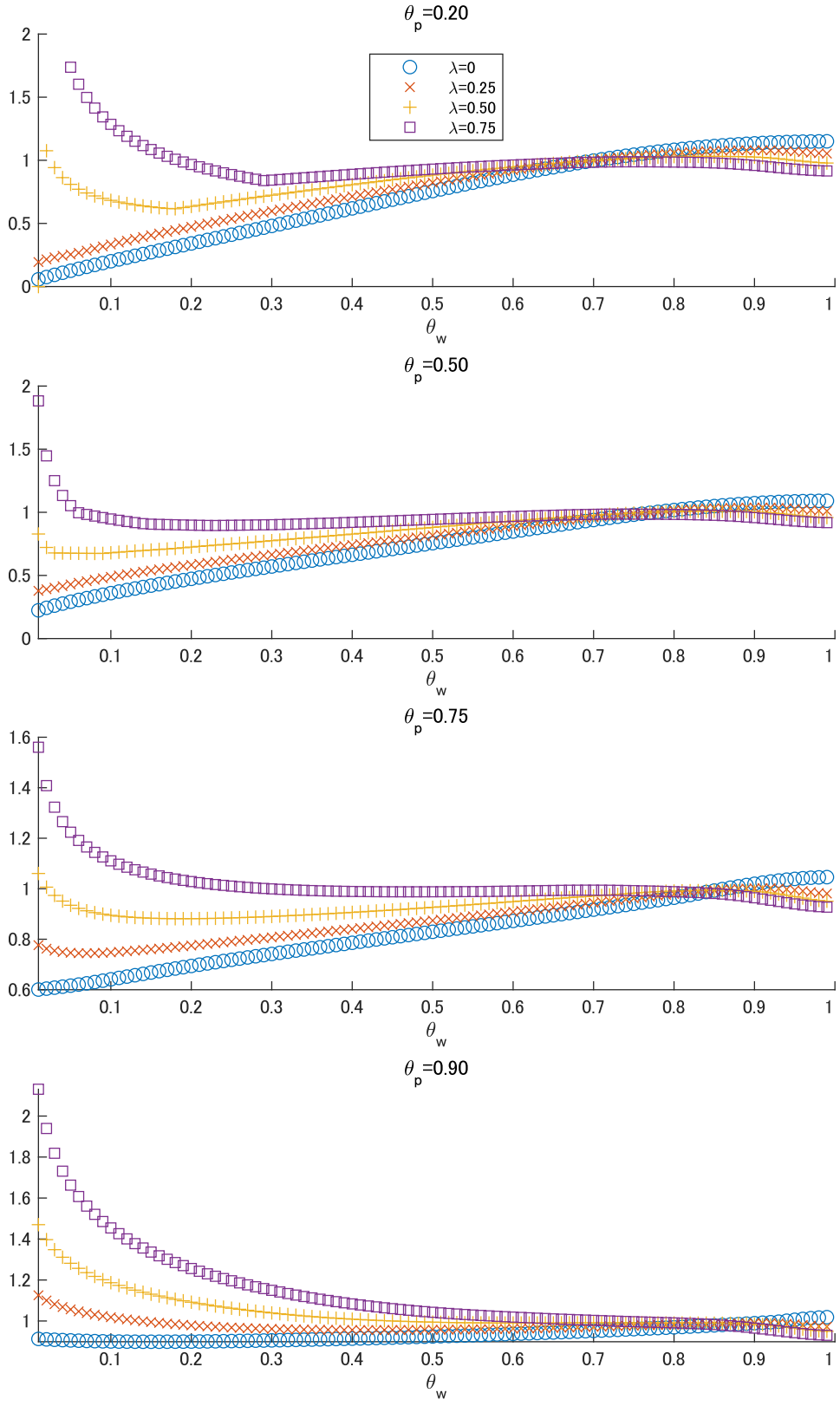

Figure 7: Fiscal multiplier under debt-financed regime: The role of price stickiness

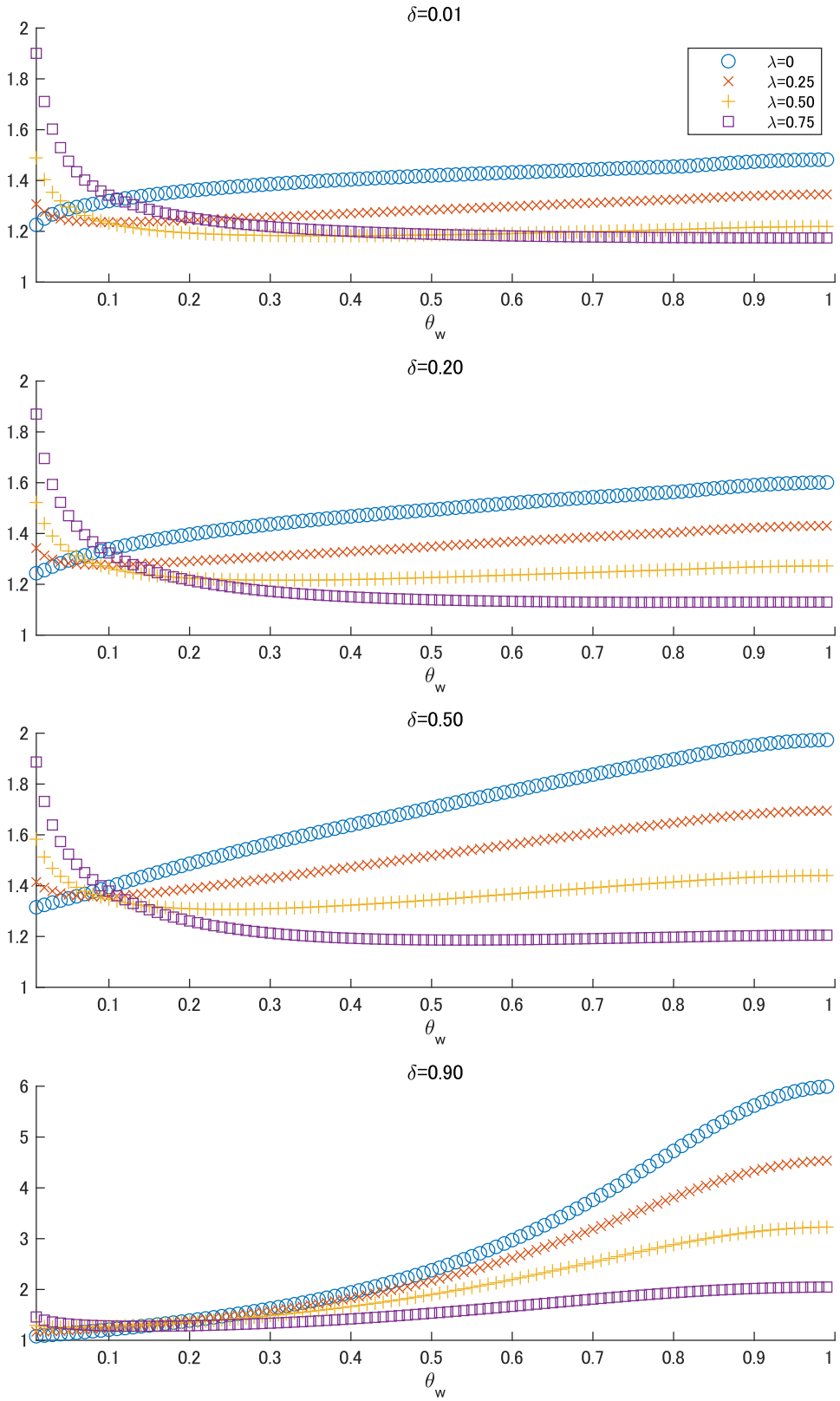

Figure 8: Fiscal multiplier under money-financed regime: Size of fiscal shocks

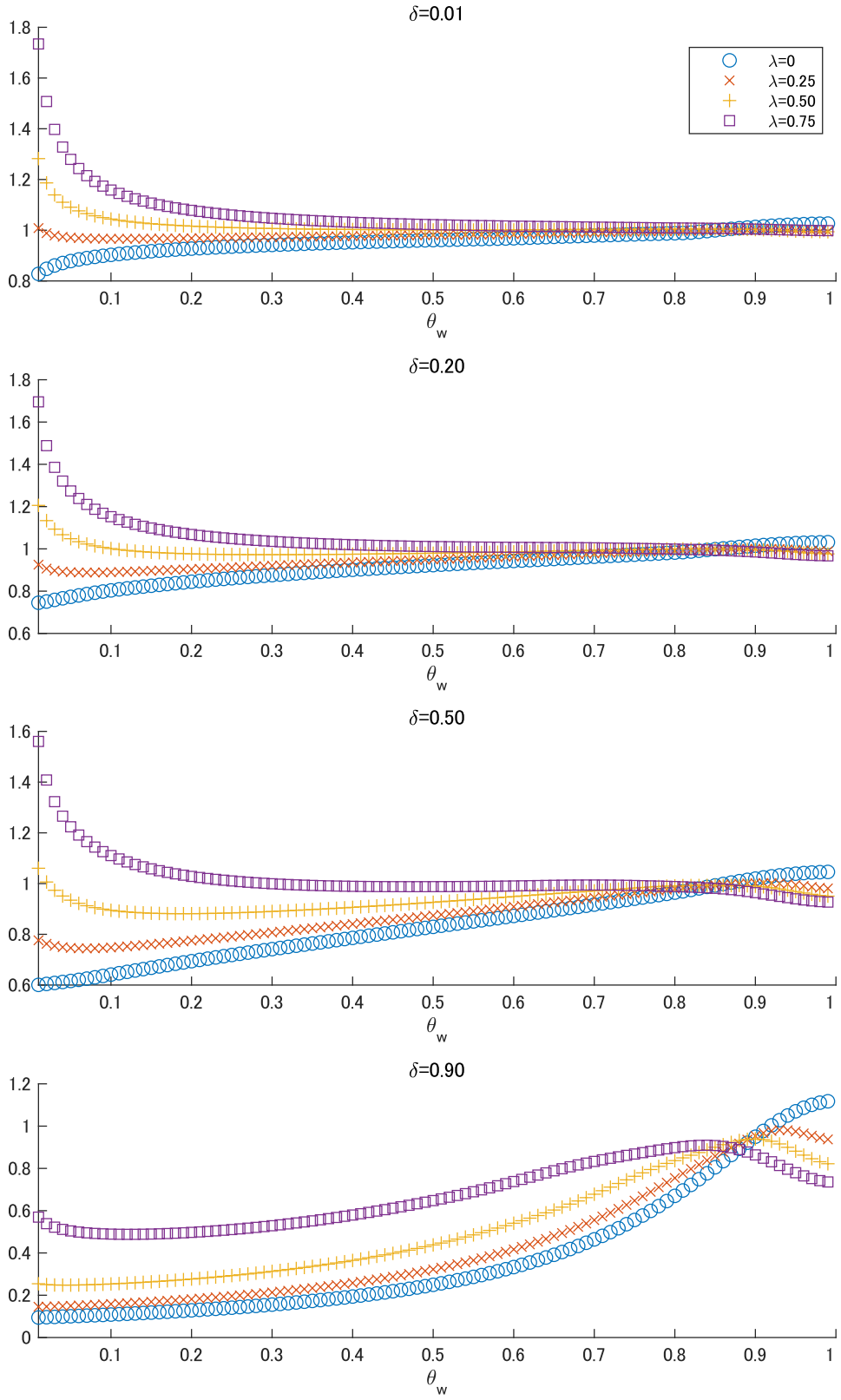

Figure 9: Fiscal multiplier under debt-financed regime: Size of fiscal shocks

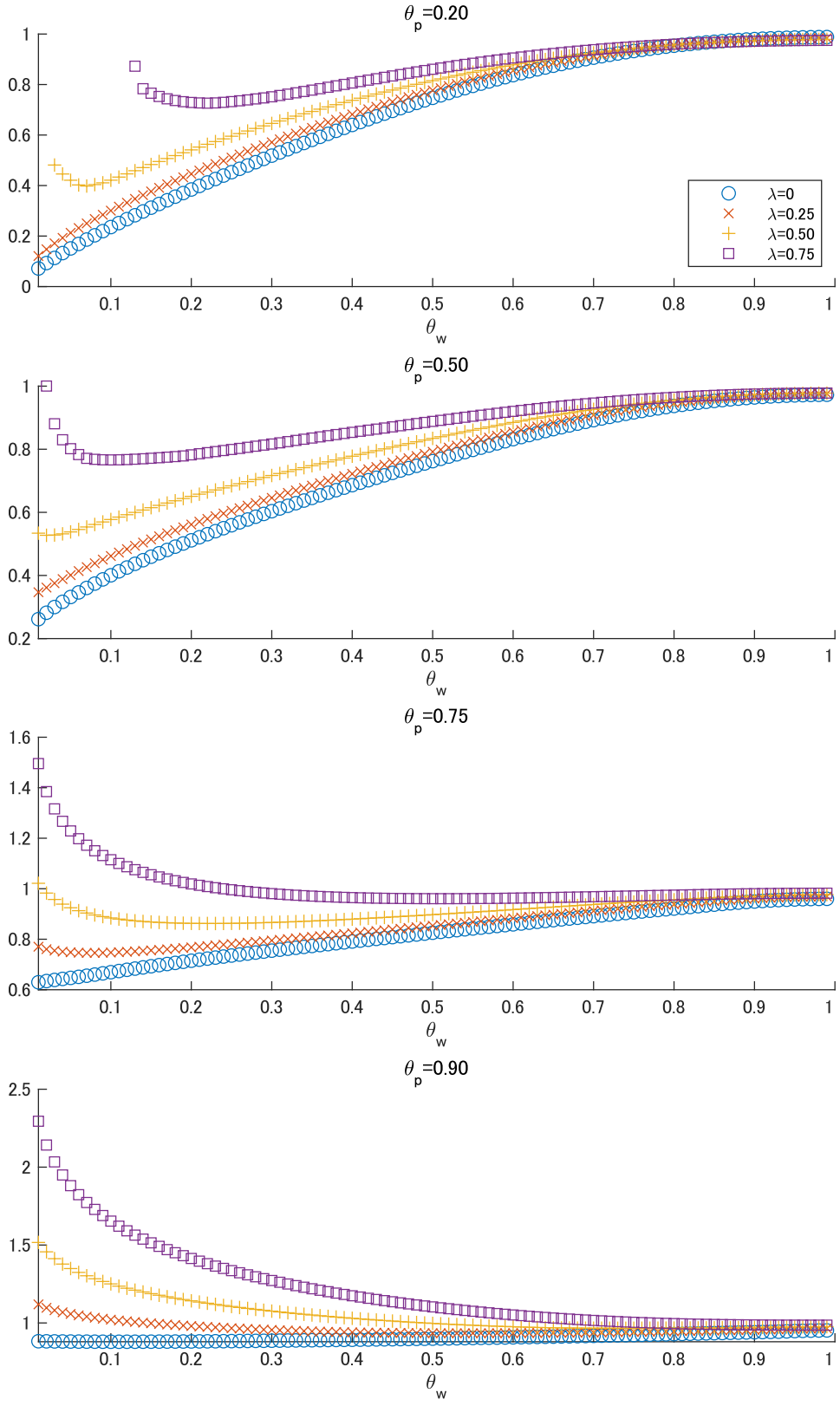

Figure 10: Fiscal multiplier of tax cut under money-financed regime: The role of price stickiness

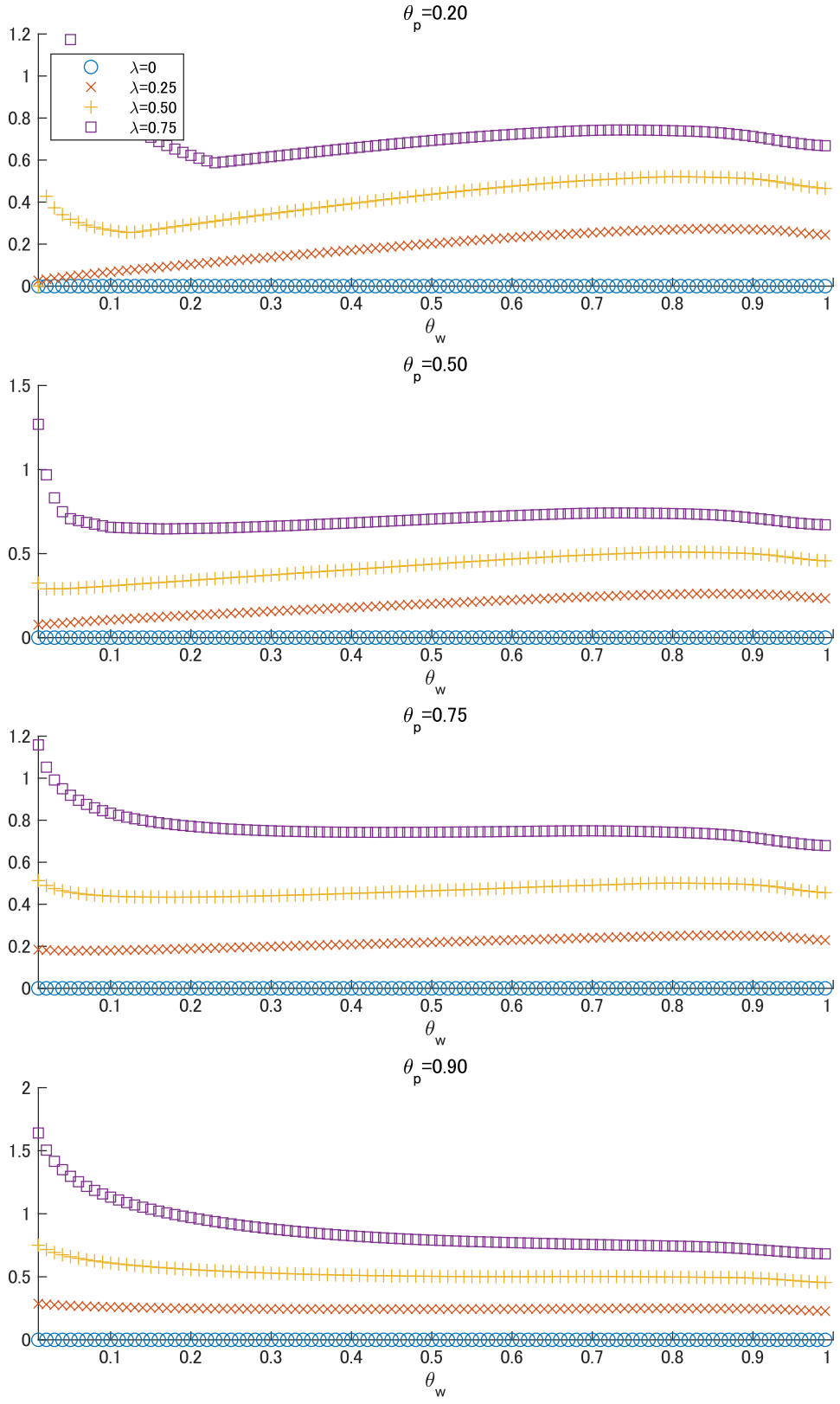

Figure 11: Fiscal multiplier of tax cut under debt-financed regime: The role of price stickiness

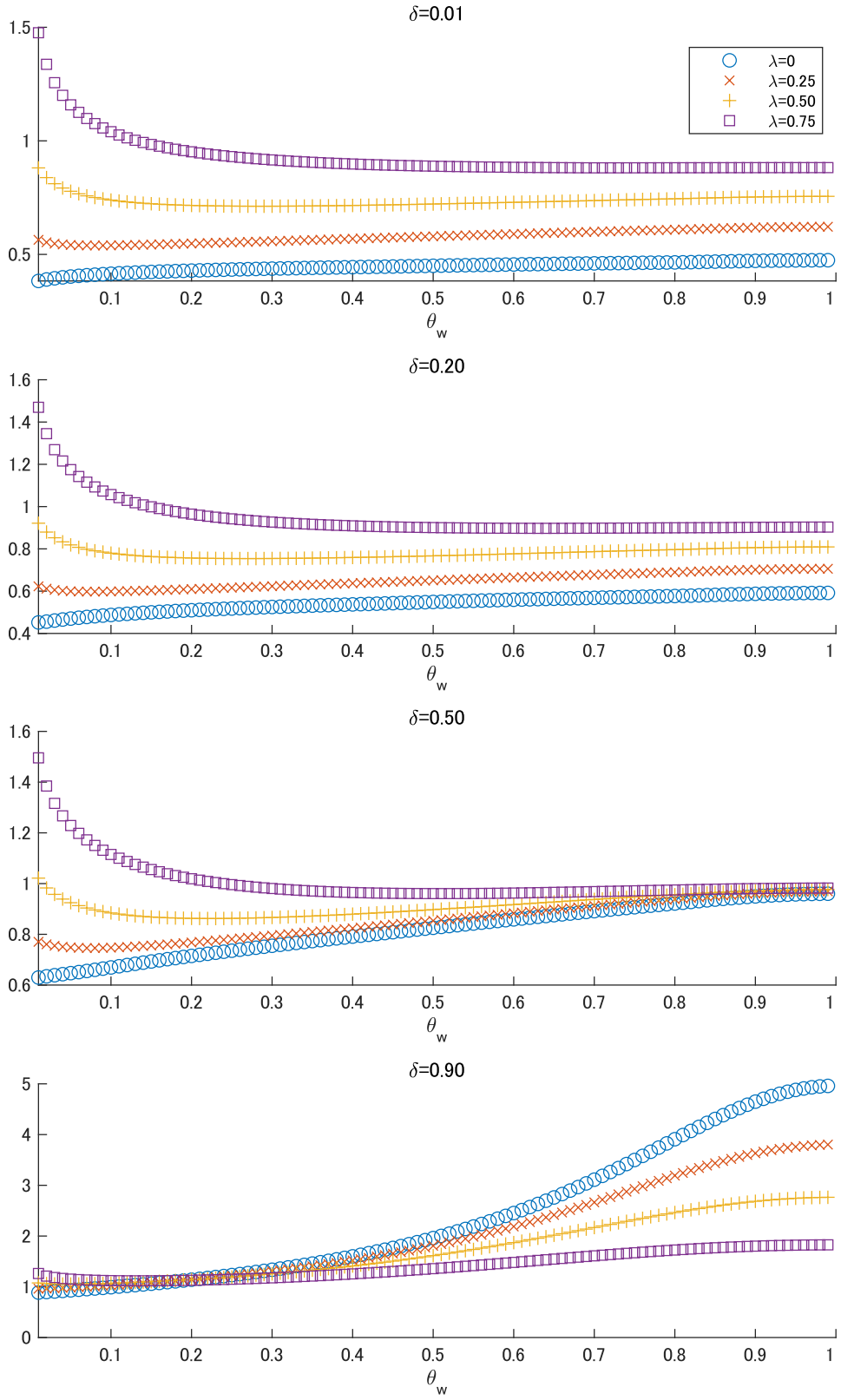

Figure 12: Fiscal multiplier of tax cut under money-financed regime: Size of fiscal shocks

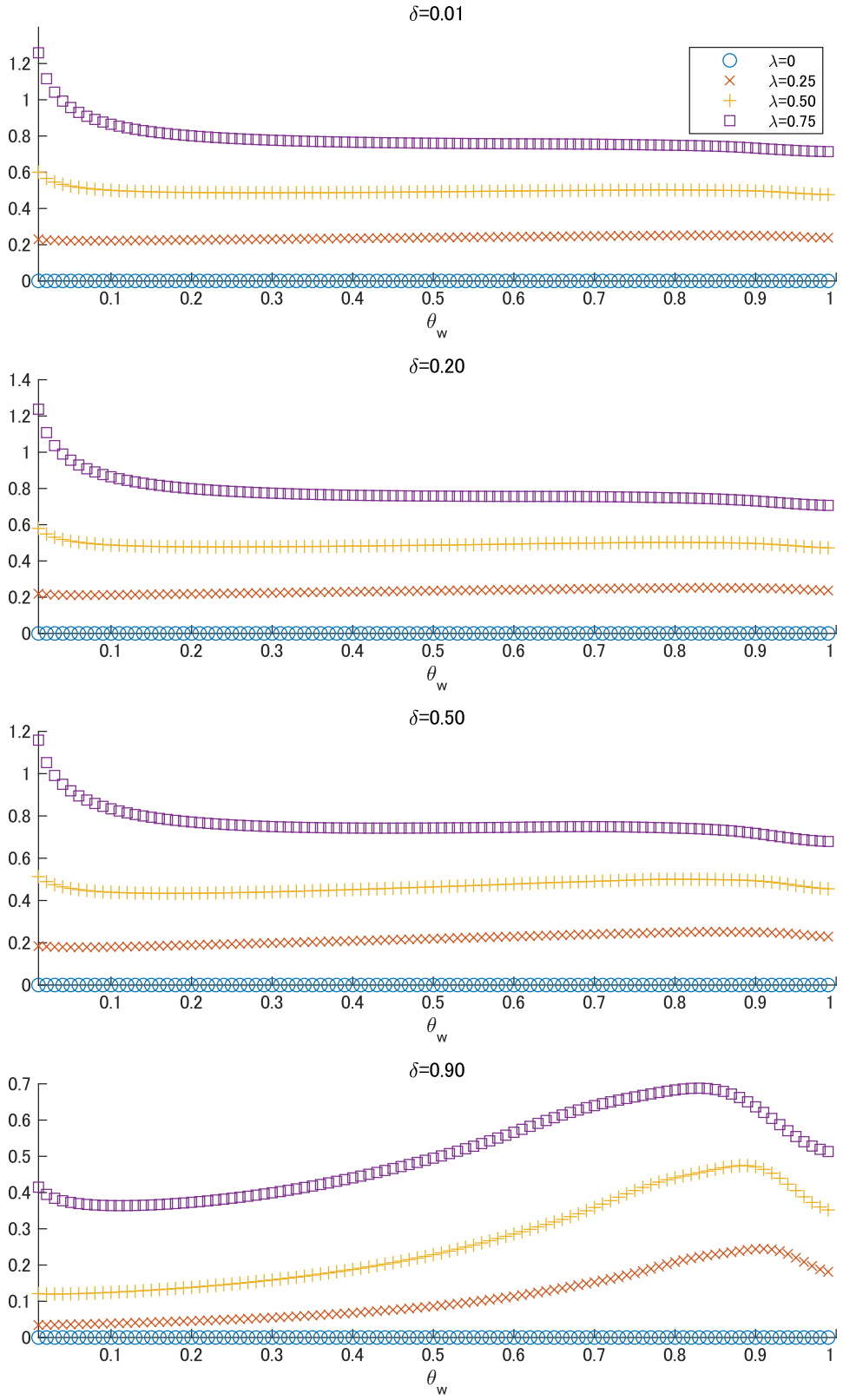

Figure 13: Fiscal multiplier of tax cut under debt-financed regime: Size of fiscal shocks