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Assessing the Effects of Fiscal Policy in Japan with Estimated and Calibrated DSGE Models*

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Abstract

In this paper, we assess the effects of fiscal policy in Japan using two dynamic stochastic general equilibrium (DSGE) models. One is a medium-scale DSGE model of Japan's economy ("M-JEM," Fueki et al., 2010) estimated using Bayesian techniques. The other is the IMF's multi-region "GIMF (Global Integrated Monetary and Fiscal)" model (Kumhof et al., 2010) calibrated to data for Japan and other countries. The government consumption multiplier calculated from the former model is larger than that from the latter, mainly because the negative effects of the resulting increase in the interest rate are larger in the latter model. In both models, however, the effect of a positive government consumption shock on real GDP becomes substantially smaller when the government targets a fiscal surplus by raising tax rates. The effectiveness of endogenous adjustment of the tax policy in response to non-fiscal shocks is not so much different between the two models and is not much affected by changes in the interest rate.

Keywords: Fiscal Policy; Dynamic Stochastic General Equilibrium Model; Global Integrated Monetary and Fiscal (GIMF) Model
JEL classification: E62; E17

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1 Introduction

Many developed countries recently launched aggressive fiscal stimulus packages to tackle the global financial crisis. Japan is no exception, but had already deployed large-scale fiscal stimulus long before this crisis. In the 1990s, when Japan's economy experienced a slowdown and a domestic financial crisis, fiscal policy measures were aggressively pursued, resulting in large government budget deficits and a rapid increase in public debt. Given the already high level of public debt, the government's policy stance on fiscal consolidation may affect the effectiveness of fiscal policy measures and the impacts of financial crises on the economy.

In this paper, we assess the effects of fiscal policy in Japan using two dynamic stochastic general equilibrium (DSGE) models. One is a medium-scale DSGE model of Japan's economy (Fueki et al., 2010) estimated using Bayesian techniques. The other is the International Monetary Fund (IMF)'s "Global Integrated Monetary and Fiscal (GIMF)" model (Kumhof et al., 2010) calibrated to data for Japan and other countries. The latter, though not estimated, is a multi-region model that can consider the effects of foreign shocks and the international spillover of fiscal policy effects.

Many recent studies have used DSGE models to analyze the effects of fiscal stimulus packages.[1] The main advantage of using structural models is the large amount of identifying information that allows us to trace the transmission mechanisms of various fiscal policy measures. Coenen et al. (2011) compare seven structural models that have been regularly used in policymaking institutions, and show that there is substantial agreement across models on the sizes of fiscal multipliers and that the sources of differences across these multipliers are fairly straightforward to identify. Cogan et al. (2010) compare a standard New Keynesian DSGE model with a practically used "old" Keynesian model, and show that the fiscal multipliers are very different between these models due to differences in underlying theories. Other studies examine how the sizes of fiscal multipliers depend on the fiscal shock

[1] Meanwhile, there have also been empirical studies using structural vector autoregression models on this issue, including Blanchard and Perotti (2002).

processes, the zero lower bound on the nominal interest rate, and several key features of model structures.[2]

Following these recent studies, we assess and compare the effects of fiscal policy calculated from the two different types of DSGE models under different conditions and situations. In particular, taking into account the current state of Japan's economy, we examine how the government's policy stance on fiscal consolidation influences the effects of fiscal policy shocks. Moreover, unlike previous studies, we also assess the effectiveness of endogenous adjustments of fiscal instruments in response to non-fiscal shocks.

As for the effects of exogenous fiscal policy shocks, we first examine the multiplier in a situation *without* a fiscal policy rule that considers fiscal consolidation. The government consumption multiplier calculated from our estimated model is above one while that from the GIMF model is below one. The latter is smaller mainly because the increase in the interest rate caused by the fiscal expansion has a larger negative effect on domestic private investment and also leads to a decline in exports through a real appreciation of the domestic currency. Meanwhile, in our estimated model, the estimated share of non-Ricardian households is around 0.3, which contributes to generating a multiplier above one.

We then assess the effect of a positive shock to government consumption on real GDP in a situation *with* an endogenous fiscal policy rule. In both models, the effect becomes substantially smaller when the government targets a fiscal surplus by raising tax rates. The effect becomes even smaller or negative when the government adjusts the speed of consolidation depending on business cycles. This is because under this business-cycle stabilization policy, the government additionally raises tax rates to dampen the boom caused by its spending increase.

The impact of non-fiscal shocks on real GDP also depends on the endoge-

[2] For instance, Corsetti et al. (2009) show that government spending multipliers depend on expectations about offsetting fiscal measures in the future. Christiano et al. (2009), Eggertsson (2011), and Woodford (2011) show that the government spending multipliers become larger when the monetary policy is constrained by the zero lower bound on the nominal interest rate. Fujiwara and Ueda (2010) examine multipliers in an environment where two countries are caught simultaneously in a liquidity trap.

nous adjustment of the government's tax policy. We assess the effectiveness of the endogenous tax policy by focusing on the change in real GDP when the government considers business-cycle stabilization in addition to targeting a surplus. Under this business-cycle stabilization policy, the negative impact of an adverse non-fiscal shock on real GDP becomes smaller as tax rates are cut more aggressively. The effectiveness of this endogenous adjustment of tax rates is not very different between the two models because changes in the interest rate, which cause a substantial difference in the government consumption multiplier between the two models, affect the responsiveness of the endogenous tax rates to non-fiscal shocks rather than the policy effectiveness itself on real GDP. Further, the GIMF model suggests that the effectiveness of the endogenous tax policy does not differ much irrespective of whether a domestic productivity shock or a foreign demand shock is considered.

The remainder of the paper is organized as follows. Section 2 shows the results from our estimated model, while Section 3 shows the results from the GIMF model. Section 4 concludes.

2 Results from Estimated DSGE Model

In this section, we assess the effects of fiscal policy using a Bayesian-estimated DSGE model of Japan's economy. We first provide an overview of the model and then show the impulse responses to fiscal and non-fiscal shocks.

2.1 Model Overview

Our estimated model is a variant of the Medium-scale Japanese Economic Model (M-JEM), which has been developed at Research and Statistics Department, Bank of Japan (Fueki et al., 2010). The model shares many features with recent New Keynesian DSGE models in the literature and those practically used in central banks, especially the Federal Reserve Board's Estimated, Dynamic, Optimization-based (EDO) model (Chung, Kiley, and Laforte, 2010). The M-JEM is a two-sector growth model that takes into account growth rate shocks including investment-goods sector specific technological progress. The two-sector production structure reflects the trends in relative prices and categories of real expenditure apparent in the Japanese data. Meanwhile, the M-JEM does not explicitly consider foreign countries and assumes that export demand follows an exogenous stochastic process.

We add a few features to the M-JEM for the analyses of fiscal policy. First, we introduce liquidity-constrained households who do not have access to asset markets and are forced to consume their after-tax income in every period. Owing to the existence of this type of households ("non-Ricardian" households) in addition to households who optimize their consumption plans subject to intertemporal budget constraints, fiscal policies including transfers have substantial real effects.[3] Second, we assume a simple fiscal policy rule to ensure a non-explosive debt-to-output ratio and to specify the government's fiscal policy stances. Following the GIMF model, which we will compare with this model in the next section, we specify the fiscal policy stance as a targeting rule for the surplus-to-output ratio.[4] The government budget constraint relates the surplus in period t to the evolution of the debt level.

$$\frac{B_t}{R_t} = B_{t-1} - S_t, \tag{1}$$

where B_t is the real government debt, R_t is the real interest rate, and S_t is the real government surplus. The fiscal policy rule is then specified as

$$\frac{S_t}{X_t} = s^* + \omega \tilde{X}_t, \tag{2}$$

where X_t is real GDP, s^* is the target surplus-to-GDP ratio, and $\tilde{X}_t$ is the GDP gap (output gap).[5] Apart from surplus targeting, this rule incorporates a policy-feedback mechanism: setting $\omega > 0$ allows the government to run a temporary fiscal deficit (or below-target fiscal surplus) when economic activity falls below the normal level (the GDP gap is negative). Thus, the pa-

[3] Non-Ricardian households are introduced in many DSGE models for the analysis of fiscal policy, as in Galí et al. (2007) and Coenen and Straub (2005).

[4] Various kinds of policy rules are assumed in DSGE models for the analysis of fiscal policy. Leeper et al. (2010) estimates a DSGE model that incorporates various specifications of fiscal policy rules.

[5] The GDP gap is defined as the gap between the actual and efficient levels of real GDP.

rameter ω represents the policy stance on business-cycle stabilization.[6] Given policy rule (2), the government can use various policy instruments such as taxes, transfers, and spending, to control the surplus. In what follows, however, we assume that the government adjusts only the labor income tax rate to control the surplus.

All other model specifications are essentially the same as in Fueki et al. (2010). The Appendix provides a brief description of this version of the M-JEM. In the estimation of the model, we use quarterly data for Japan from 1981:Q1 to 2009:Q4.[7] The estimation results are summarized in Table 1. A key parameter that determines the effects of fiscal policy is the share of non-Ricardian households. Our posterior mean estimate of this parameter is 0.31, which is generally comparable with the results of previous empirical studies, including Iwata (2009) who estimated a DSGE model using Bayesian techniques. As for the fiscal policy rule, we do not estimate the policy stance on business-cycle stabilization, ω in equation (2), but calibrate it to zero, following the estimation result by Iwata (2009).[8] Our other estimation results are generally consistent with Fueki et al. (2010), in which the non-Ricardian households and the fiscal policy rule are not incorporated.[9]

2.2 Fiscal Policy Effects

Using the M-JEM, we first assess the effects of an unanticipated increase in government consumption.[10] Before considering the policy rule, we check the

[6] The parameter ω may also capture the effectiveness of "built-in" stabilizers such as the progressive tax structures.

[7] As in Fueki et al. (2010), we estimate the model using data that include the period after the short-term nominal interest rate effectively hit the zero lower bound. However, the estimated parameter values in the M-JEM on the monetary policy rule remain largely unchanged irrespective of whether data for the full period or data up to the period just before the Bank of Japan started the zero interest rate policy are used.

[8] In Iwata (2009), the posterior mean estimate of the non-Ricardian share is 0.25, while that of the fiscal policy response to the output gap is 0.07 and not significantly different from zero, although the specification of fiscal policy rule is different from ours.

[9] We use the same calibrated parameter values as Fueki et al. (2010). For comparison with the GIMF model, we also calibrate the parameters for the processes of the productivity and the government consumption shocks.

[10] The M-JEM assumes that government spending is all on consumption goods.

traditional "multiplier," that is, the effect on real GDP when government consumption is increased on a sustained basis by one percent of nominal GDP above the baseline level and policy rule (2) is absent (the labor income tax rate is held fixed regardless of the level of the surplus-to-GDP ratio).[11] Table 2 shows the multipliers calculated from various types of models. The government consumption multiplier calculated from the M-JEM is 1.15 in the first year (the average of the first four quarters), which is larger than that calculated from the large-scale macro-econometric model, "Quarterly Japanese Economic Model (Q-JEM)," developed at Research and Statistics Department, Bank of Japan (Fukunaga et al., 2011).[12]

We then consider the effects of the government consumption increase under policy rule (2). Figure 1 shows the responses to an increase in government consumption by one percent of GDP, which follows an AR(1) process and gradually returns to the initial level as shown in panel (7). All variables shown in the figure are percent deviations from their baseline levels. The three responses for each variable correspond to the policy that fixes the labor income tax ("no fiscal rule") and the two policy stances with the fiscal policy rule: "surplus targeting" rule under which the government simply meets the target surplus-to-GDP ratio in each period without policy feedback from the GDP gap ($\omega = 0$ in equation (2)) and "stabilization" rule under which the government considers business-cycle stabilization ($\omega > 0$) in addition to surplus targeting.[13] In response to the positive government consumption shock, the government simultaneously raises the labor income tax rate to control the surplus following the policy rule, or keeps the tax rate fixed under "no fiscal rule," as shown in panel (2). When the government considers business-cycle stabilization (under the "stabilization" rule), it additionally raises the tax rate to dampen the boom caused by its spending increase.

[11] We assume that the increase on a sustained basis is considered by private agents as the result of repeated unanticipated shocks.

[12] For comparison with other models, the multipliers calculated from the Q-JEM shown in Table 1 are those under the assumption that other fiscal policy instruments (public investment and tax rates) are fixed.

[13] ω is set to 0.9 in Figure 1 (and the following figures).

The effects on real GDP (panel (1)) under the policy rule are much smaller than the effect under "no fiscal rule." Under the "stabilization" rule, the additional tax increase causes real GDP to fall below its baseline level. The labor income tax increase especially dampens the demand for private consumption (panel (3)).[14] Private investment (panel (4)) is also dampened but is still above the baseline level under the "surplus targeting" rule. The positive response of private investment to the government consumption shock is partly due to a modest increase in the policy interest rate (panel (6)). At the same time, the increase in inflation (panel (5)) is also very small.

2.3 Domestic Productivity Shock

Next we assess the effectiveness of the fiscal policy rule in response to non-fiscal shocks. We focus on a negative productivity shock, which may capture the decline in productivity during Japan's "lost decade" in the 1990s. Although there are persistent technology growth rate shocks and temporary technology level shocks in the M-JEM, what we consider here for comparison with the GIMF model is a persistent technology level shock.

Figure 2 shows the impulse responses to a one-percent negative economy-wide productivity shock that causes a permanent decrease in the level of total factor productivity (TFP) as shown in panel (7). Accordingly, real GDP decreases permanently from its baseline level. Meanwhile, inflation slightly accelerates and the policy interest rate is raised modestly.

The government cuts the labor income tax rate both under the "surplus targeting" and the "stabilization" rules, which boosts the demand for private consumption and partly offsets the negative impact of the productivity shock on real GDP. Under the "stabilization" rule, the tax rate cut is larger and the negative impact on real GDP is smaller than under the "surplus targeting" rule, except in the first three quarters after the shock.[15]

[14] While both the Ricardian and the non-Ricardian households reduce their consumption under the policy rule that raises the labor income tax rate, the reduction in consumption of non-Ricardian households is much larger than that of Ricardian households.

[15] For the first few quarters after the shock, the GDP gap temporarily becomes positive because the efficient level of GDP falls immediately when the productivity shifts down.

We assess the effectiveness of the fiscal policy rule in response to the productivity shock by focusing on the difference in the response of real GDP under the "surplus targeting" and the "stabilization" rules. Figure 3 shows two indicators that represent the responsiveness of the labor income tax rate and its effectiveness on real GDP. "Stabilization responsiveness" is defined as the difference in the response of the labor income tax rate under the "stabilization" and the "surplus targeting" rules (panel (2) of Figure 2) divided by the size of the productivity shock. "Stabilization effectiveness" is defined as the difference in the response of GDP under the "stabilization" and the "surplus targeting" rules (panel (1) of Figure 2) divided by the difference in the response of the labor income tax rate under the two policy stances. After the stabilization responsiveness becomes positive (i.e., the tax rate cut becomes larger under the "stabilization" rule), the stabilization effectiveness is stable at around -0.3.[16] For reference, Figure 3 also shows the above indicators in the case where the policy interest rate is constant. Since the response of the policy interest rate in the M-JEM is modest, the two indicators are not much different between the variable and constant interest rate cases.

3 Results from the GIMF Model

We also use the IMF's large-scale "Global Integrated Monetary and Fiscal (GIMF)" model (Kumhof et al., 2010) to assess the effects of fiscal policy in Japan. Although the GIMF model is not estimated, it has several important features that are not considered in our estimated model (M-JEM) in Section 2. Most of all, the GIMF is a multi-region model that can consider the effects of foreign shocks and the international spillover of fiscal policy effects. Moreover, the GIMF considers overlapping generations households as well as liquidity constrained households, the financial accelerator mechanism for the non-financial corporate sector, etc. In this section, we first provide a brief overview of the GIMF model and then show the impulse responses to fiscal and non-fiscal shocks.

[16]By definition, the stabilization effectiveness becomes very unstable when the stabilization responsiveness is near zero.

3.1 Model Overview

The version of the GIMF model we use in this paper is the 5-block version, consisting of the United States, the Euro Area, Japan, emerging Asia, and other countries. Many parameters, including those on fiscal and monetary policy rules, differ across blocks. The details of the model specification and the benchmark calibration are described in Kumhof et al. (2010).[17]

The fiscal policy specifications of the GIMF are very rich, which is one of its main features. However, for simplicity and for the purpose of comparison, we use the same policy rule (2) as in our estimated model.[18] Moreover, as in Section 2, we continue to assume that the government adjusts the labor income tax rate to target a surplus following policy rule (2), although the GIMF contains a rich set of fiscal policy instruments, including lump-sum taxes and transfers, redistribution between agents, and public investment and consumption spending. On the other hand, we maintain the GIMF's assumption that there are overlapping generations households as well as liquidity constrained households, which makes the situations of fiscal policy effects more realistic.

The GIMF model we use in this paper is an annual model. In what follows, we compare the annual impulse responses in the GIMF with the quarterly impulse responses in the M-JEM shown in Section 2.

3.2 Fiscal Policy Effects

Using the GIMF model, we assess the effects of an unanticipated increase in government spending, as in Section 2. We begin by looking at the multipliers in Table 2 again, which shows both the government consumption multiplier and the government investment multiplier calculated from the GIMF. The former is 0.67 in the first year, which is smaller than the government con-

[17]For comparison with the M-JEM, we set different parameter values from the benchmark calibration for the fiscal policy rule. We also change the calibration on elasticity parameters, international spillover parameters, and monetary policy rule parameters, following a revised version of the GIMF used by the IMF.

[18]The government budget constraint in the GIMF is $B_t = R_{t-1}B_{t-1} - S_t$, which is slightly different from (1) in the M-JEM.

sumption multipliers calculated from the M-JEM and the Q-JEM. Meanwhile, the latter is 1.09 in the first year, which is slightly larger than the government investment multipliers calculated from the Q-JEM and the ESRI's large-scale macro-econometric model (Sakuma et al., 2011).[19]

We then consider the effects of the government consumption increase under policy rule (2). Figure 4 shows the responses to an increase in government consumption by one percent of GDP, which follows an AR(1) process and gradually returns to the initial level as shown in panel (7). In response to this government consumption shock, real GDP increases from the baseline level in the first year but then diminishes more quickly than in the M-JEM. A key difference from the M-JEM is the larger increase in the policy interest rate (panel (6)). This increase in the policy interest rate causes the negative response of private investment (panel (4)), which contrasts with the positive response in the M-JEM. Moreover, unlike in the M-JEM, the high interest rate also causes a decline in exports (panel (8)) through the real appreciation of the domestic currency (not shown in the figure). If the policy interest rate were constant, the response of private investment would be positive and the decline in exports would be modest. As a result, the response of real GDP under "no fiscal rule" would be larger by 24 and 92 percent in the first and second year, respectively.[20]

Under the "surplus targeting" and the "stabilization" rules, the labor income tax increase dampens the demand for private consumption, as in the M-JEM. As a result, real GDP returns to the baseline level in the second year. Moreover, using the GIMF model, we examine another policy stance labeled "stabilization & high debt" under which the government follows the "stabilization" rule but starts with a high level of debt that puts the surplus-to-GDP ratio below the target when a shock occurs. Considering the current fiscal situation in Japan, we assume that the government debt-to-GDP ratio is 180% and about 10% above the target level,[21] which implies that the

[19] Unlike the Q-JEM, the GIMF model takes account of the accumulation of public capital that serves as a factor of production.

[20] In the M-JEM, the corresponding figures are only 7 and 12 percent.

[21] Under other situations, we calibrate both the initial and target levels of the debt-to-GDP ratio to 105%, following a revised version of the GIMF model used by the IMF.

surplus-to-GDP ratio is about 0.5% below the target. Under this situation, the government raises the labor income tax rate by more than under the "stabilization" rule. As a result, the first-year real GDP, inflation, and policy interest rate do not increase as much as under the "stabilization" rule.

3.3 Domestic Productivity Shock

Next we assess the effectiveness of the fiscal policy rule in response to non-fiscal shocks. As in Section 2, we first focus on a negative productivity shock.

Figure 5 shows the impulse responses to a one-percent negative domestic productivity shock that causes a persistent decrease in the level of TFP as shown in panel (7).[22] In response to this shock, real GDP, consumption, and investment decrease persistently from their baseline levels. Meanwhile, inflation slightly accelerates and the policy interest rate is raised. The high interest rate causes a persistent decline in exports through the real appreciation of the domestic currency.

Under the "surplus targeting" rule, the government persistently raises the labor income tax rate in order to compensate for the decrease in the tax base. In contrast, under the "stabilization" rule, the government cuts the labor income tax rate, which partly offsets the negative impact of the productivity shock on real GDP. Therefore, the government's policy stance on business-cycle stabilization conflicts with surplus targeting. Meanwhile, under the "stabilization & high debt" situation, the government raises the labor income tax rate so much that real GDP decreases more than under the other policy stances.

Figure 7 shows the stabilization responsiveness and the stabilization effectiveness in the GIMF model. Compared with the M-JEM (Figure 3), the stabilization responsiveness is larger and always positive, while the stabilization effectiveness is slightly smaller in absolute value. Compared with the constant interest rate case, the stabilization responsiveness in the variable

Berkmen (2011) analyzes the impact of fiscal consolidation and structural reforms in Japan using the GIMF model with a target (and steady-state) debt-to-GDP ratio of 87%.

[22] As in the M-JEM, we consider an economy-wide productivity shock, assuming that the same productivity shocks occur in both tradable and non-tradable sectors.

interest rate case is larger because the government needs to cut the tax rate more under the "stabilization" policy in order to offset the negative effect of the interest rate increase on real GDP. Meanwhile, the stabilization effectiveness is not so much different between the variable and constant interest rate cases.

3.4 Foreign Demand Shock

Using the GIMF model, we can also consider a negative foreign demand shock, which corresponds to the recent global financial crisis. Figure 6 shows the impulse responses to such a shock, which is a combination of the shocks to consumption and investment demand in the United States and the Euro Area.[23] The shock causes persistent declines in foreign GDP and in Japan's exports as shown in panels (7) and (8), respectively. In response to this shock, domestic real GDP decreases at first, the inflation rate falls, and the policy interest rate is reduced substantially. Meanwhile, the low interest rate boosts private investment. Then, real GDP returns to the baseline level four years after the shock, and inflation and the policy interest rate start increasing.

Under the "surplus targeting" rule, the government raises the labor income tax rate at first in order to compensate for the decrease in the tax base, while under the "stabilization" rule, the government cuts the labor income tax rate from the first year of the shock. Under the "stabilization & high debt" situation, the government raises the labor income tax rate so much that real GDP, and especially private consumption, decrease more than under the other policy stances.

Figure 7 shows the stabilization responsiveness and the stabilization effectiveness. Compared with the productivity shock scenario, the stabilization responsiveness is smaller (and turns negative four years after the shock), while the stabilization effectiveness is similar (except in the third year). Compared with the constant interest rate case,[24] the stabilization responsiveness in the

[23] In response to this shock, real GDP in the United States and the Euro area is assumed to decrease by about 1.5% and 1%, respectively.

[24] The constant interest rate case could be seen as representing a situation where the monetary policy is constrained by the zero lower bound on the nominal interest rate. Using

variable interest rate case is much smaller because the substantial cut in the policy interest rate boosts the economy and therefore the government does not need to cut the tax rate more under the "stabilization" policy. Meanwhile, the stabilization effectiveness is very similar (except in the third year) between the variable and constant interest rate cases.

4 Concluding Remarks

In this paper, we assessed the effects of fiscal policy in Japan using an estimated and a calibrated DSGE models, the M-JEM and the GIMF. The government consumption multiplier calculated from the former model is larger than that from the latter, mainly because the negative effects of the resulting increase in the interest rate are larger in the latter model. In both models, however, the effect of a positive government consumption shock on real GDP becomes substantially smaller when the government targets a fiscal surplus by raising tax rates. The effectiveness of endogenous adjustment of the tax policy in response to non-fiscal shocks is not so much different between the two models and is not much affected by changes in the interest rate.

Given the current state of Japan's economy, it is important to take into account the government's policy stance on fiscal consolidation in assessing the effects of fiscal policy. In this paper, we only considered a very simple fiscal policy rule with an endogenous adjustment of the labor income tax rate. We did not consider the welfare implications of the policy rule, the interaction between fiscal and monetary policy stances, non-linear dynamics of fiscal consolidation with a fiscal limit, etc. Clearly, there is much room for further investigation of endogenous fiscal policy rules, and DSGE models like those used in this paper would be a useful tool for that purpose.

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the Q-JEM, Fukunaga et al. (2011) show that foreign demand shocks in this case have larger effects on the domestic economy than usual.

Appendix: Description of the M-JEM

This appendix provides a brief description of the version of the M-JEM used in this paper. In this version, we introduce non-Ricardian households in addition to optimizing (Ricardian) households, and a simple fiscal policy rule that targets a fiscal surplus. All other specifications are essentially the same as in Fueki et al. (2010), where a more detailed description of the M-JEM and lists of variables and parameters are provided.

Final goods producers

Final goods producers in the slow-growing sector (sector c) produce the consumption goods X_t^c, and those in the fast-growing sector (sector k) produce the investment goods X_t^k. They face competitive markets and produce the final goods, X_t^s, $s \in \{c, k\}$, combining a continuum of s sector-specific intermediate goods, $X_t^s(j)$, $j \in [0, 1]$, according to the following Dixit-Stiglitz type technology.

$$X_t^s = \left(\int_0^1 X_t^s(j)^{\frac{\Theta_t^{x,s}-1}{\Theta_t^{x,s}}} dj \right)^{\frac{\Theta_t^{x,s}}{\Theta_t^{x,s}-1}}, \quad s = \{c, k\}$$

where $\Theta_t^{x,s}$ is the stochastic elasticity of substitution between the differentiated intermediate goods inputs. Subject to the above aggregation technology, final goods producers in each sector choose the optimal level of each intermediate good to minimize the cost of purchasing them, taking their prices as given.

Intermediate goods producers

Intermediate goods producers in both sectors face a monopolistically competitive market and produce sector-specific intermediate goods $X_t^s(j)$, $s \in \{c, k\}$ with the following production function.

$$X_t^s(j) = [K_t^{u,s}(j)]^{\alpha} [AZ_t^m AZ_t^s L_t^s(j)]^{1-\alpha}$$

where $K_t^{u,s}(j)$ and $L_t^s(j)$ respectively are the effective capital input and the labor input of firm j. Letting $U_t^s(j)$ be the capital utilization rate in sector s, the effective capital input is written as $K_t^{u,s}(j) \equiv K_t^s(j) \times U_t^s(j)$. Further, the labor input of a firm j is the continuum of the differentiated labor input, $L_t^s(j) = [\int_0^1 L_t^s(i,j)^{(\Theta_t^l - 1)/\Theta_t^l} di]^{\Theta_t^l/(\Theta_t^l - 1)}$, where Θ_t^l is the stochastic elasticity of substitution. AZ_t^m is an economy-wide technology shock and AZ_t^s is a sector-specific technology shock. We assume that each of the technology shocks contains two separate stochastic components: one that is stationary in levels and the other that is stationary in growth rates.

An intermediate goods producer j in sector $s \in \{c, k\}$ maximizes the discounted future profit,

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t^c}{P_t^c} \left\{ P_t^s(j) X_t^s(j) - MC_t^s(j) X_t^s(j) - \frac{100 \cdot \chi^p}{2} \left(\frac{P_t^s(j)}{P_{t-1}^s(j)} - \eta^p \Pi_{t-1}^{p,s} - (1-\eta^p) \Pi_*^{p,s} \right)^2 P_t^s X_t^s \right\},$$

subject to the final goods producers' demand schedule,

$$X_t^s(j) = \left(\frac{P_t^s(j)}{P_t^s} \right)^{-\Theta_t^{x,s}} X_t^s,$$

taking as given the marginal cost of production, $MC_t^s(j)$, the aggregate price level for its sector, $P_t^s = \{\int_0^1 [P_t^s(j)]^{(\Theta_t^s - 1)/\Theta_t^s} dj\}^{\Theta_t^s/(\Theta_t^s - 1)}$, and Ricardian households' valuation of a unit of nominal income in each period, Λ_t^c / P_t^c where Λ_t^c is the marginal utility of consumption. The second line in the above discounted future profit represents the quadratic price adjustment cost where $\Pi_t^{p,s} = P_t^s / P_{t-1}^s$ and $\Pi_*^{p,s}$ is time-invariant trend inflation.

Capital owners

Capital stock owners provide capital services to intermediate goods producers in both sectors, receive the rental cost of capital in exchange, and accumulate investment goods. Each capital stock owner k chooses investment expenditure $I_t(k)$ and the amount and utilization of capital in both sectors, $K_t^c(k)$, $U_t^c(k)$, $K_t^k(k)$, and $U_t^k(k)$, to maximize his discounted profit,

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t^c}{P_t^c} \left[R_t^c U_t^c(k) K_t^c(k) + R_t^k U_t^k(k) K_t^k(k) - P_t^k I_t(k) \right],$$

subject to a capital evolution process with quadratic investment adjustment cost and the costs from higher utilization rates,

$$\begin{aligned}
K_{t+1}^c(k) + K_{t+1}^k(k) &= (1-\delta)\left(K_t^c(k) + K_t^k(k)\right) + I_t(k) \\
&\quad - \frac{100\cdot\chi}{2}\left[\frac{I_t(k)A_t^{\varphi} - I_{t-1}(k)\Gamma_t^{z,m}\Gamma_t^{z,k}}{K_t}\right]^2 \left(K_t^c(k) + K_t^k(k)\right) \\
&\quad - \sum_{s=c,k} \kappa \left[\frac{\left(Z_t^U U_t^s(k)\right)^{1+\psi} - 1}{1+\psi}\right] K_t^s(k),
\end{aligned}$$

where A_t^{φ} and Z_t^U are stochastic variations in the adjustment cost and the utilization cost, respectively. $\Gamma_t^{z,m}$ and $\Gamma_t^{z,k}$ are the growth-rate-stationary components of the economy-wide and k sector-specific technology shocks.

Ricardian households

Each Ricardian household $i \in [\lambda, 1]$, $0 < \lambda < 1$, chooses its purchase of consumption goods, $C_t^R(i)$, and its holdings of bonds, $B_t(i)$, to maximize the lifetime utility function,

$$E_0 \sum_{t=0}^{\infty} \beta^t \Xi_t^{\beta} \left\{ \varsigma^c \ln\left(C_t^R(i) - hC_{t-1}^R(i)\right) - \varsigma^l \frac{\left[\left(L_t^c(i) + L_t^k(i)\right)\right]^{1+\nu}}{1+\nu} \right\}$$

subject to its budget constraint,

$$\begin{aligned}
\frac{1}{R_t}B_{t+1}(i) &= B_t(i) + \sum_{s=c,k}(1-\tau_t^L)W_t^s(i)L_t^s(i) + \Omega_t(i) - P_t^c C_t^R(i) \\
&\quad - \sum_{s=c,k}\frac{100\cdot\chi^w}{2}\left\{\frac{W_t^s(i)}{W_{t-1}^s(i)} - \eta^w\Pi_{t-1}^{w,s} - (1-\eta^w)\Pi_*^{w,s}\right\}^2 W_t^s L_t^s \\
&\quad - \frac{100\cdot\chi^l}{2}\left(\frac{L_*^c}{L_*^c + L_*^k}W_t^c + \frac{L_*^k}{L_*^c + L_*^k}W_t^k\right) \\
&\quad \times \left(\frac{L_t^c(i)}{L_t^k(i)} - \eta^l\frac{L_{t-1}^c}{L_{t-1}^k} - (1-\eta^l)\frac{L_*^c}{L_*^k}\right)^2 \frac{L_t^k}{L_t^c},
\end{aligned}$$

where R_t is the nominal interest rate on the bonds, τ_t^L is the labor income tax rate, $W_t^s(i)$ and $L_t^s(i)$ are i's wage and labor supply for sector s, and $\Omega_t(i)$ is i's capital and profits income. The fifth term (in the second line) of the right hand side is the quadratic wage adjustment cost imposed on the deviation of the optimum wage growth from past wage inflation, $\Pi_{t-1}^{w,s}$, and from trend wage inflation, $\Pi_{*}^{w,s}$. The last term of the right hand side is the labor reallocation cost.

Non-Ricardian households

Each non-Ricardian household $i \in [0,\ \lambda]$ does not optimize and simply chooses its nominal consumption equal to the after-tax labor income in every period.

$$P_t^c C_t^N(i) \;\; = \;\; \sum_{s=c,k} (1-\tau_t^L) W_t^s(i) L_t^s(i)$$

Unions

Following Galí et al. (2007) and Coenen and Straub (2005), we assume that there is a continuum of monopolistically competitive unions within all households $i \in [0,\ 1]$. Each union sets its wages for both sectors, $W_t^c(i)$ and $W_t^k(i)$, and supply of labor consistent with each wage, $L_t^c(i)$ and $L_t^k(i)$, given the demand schedule for the differentiated labor supply, $L_t^c(i) = (W_t^c(i)/W_t^c)^{-\Theta_t^l} L_t^c$ and $L_t^k(i) = (W_t^k(i)/W_t^k)^{-\Theta_t^l} L_t^k$, to maximize the above lifetime utility function, which is assumed to be shared by both Ricardian and non-Ricardian households.

Fiscal policy rule

As explained in the text, the fiscal policy rule is specified as follows.

$$\frac{S_t}{X_t} = s^* + \omega \tilde{X}_t,$$

where S_t is the real government surplus, X_t is real GDP, s^* is the target surplus-to-GDP ratio, and $\tilde{X}_t$ is the GDP gap (output gap). The government budget constraint is given by

$$\frac{B_t}{R_t} = B_{t-1} - S_t,$$

where

$$S_t = \sum_{s=c,k} (1-\tau_t^L) \int_0^1 W_t^s(i) L_t^s(i) di - P_t^c G_t.$$

Monetary policy rule

The monetary policy rule is specified as a Taylor-type feedback rule with interest rate smoothing, as follows.

$$
\begin{aligned}
R_t &= (R_{t-1})^{\phi^r} (\bar{R}_t)^{1-\phi^r} \exp(\epsilon_t^r) \\
\bar{R}_t &= R_* \left(\tilde{X}_t\right)^{\phi^{h,gdp}} \left(\frac{\Pi_t^{p,gdp}}{\Pi_*^{p,gdp}}\right)^{\phi^{\pi,gdp}}
\end{aligned}
$$

$\Pi_t^{p,gdp}$ is the inflation rate of the GDP deflator implicitly defined by

$$
\Pi_t^{p,gdp} H_t^{gdp} = \frac{P_t^c X_t^c + P_t^k X_t^k}{P_{t-1}^c X_{t-1}^c + P_{t-1}^k X_{t-1}^k},
$$

where H_t^{gdp} is the growth rate of real GDP calculated as

$$
H_t^{gdp} = \left[\left(\frac{X_t^c}{X_{t-1}^c}\right)^{P_*^c X_*^c} \left(\frac{X_t^k}{X_{t-1}^k}\right)^{P_*^k X_*^k}\right]^{\frac{1}{P_*^c X_*^c + P_*^k X_*^k}}.
$$

Market clearing

At the symmetric equilibrium, each market clears.

$$
\begin{aligned}
X_t^c &= \int_0^\lambda C_t^N(i)di + \int_\lambda^1 C_t^R(i)di + G_t \\
&\quad + \frac{100 \cdot \chi^w}{2} \left[\Pi_t^{w,c} - \eta^w \Pi_{t-1}^{w,c} - (1-\eta^w)\Pi_*^w\right]^2 W_t^c L_t^c \\
&\quad + \frac{100 \cdot \chi^p}{2} \left[\Pi_t^{p,c} - \eta^p \Pi_{t-1}^{p,c} - (1-\eta^p)\Pi_*^{p,c}\right]^2 P_t^c X_t^c \\
&\quad + \frac{100 \cdot \chi^l}{2} \left(\frac{L_*^c}{L_*^c + L_*^k} W_t^c + \frac{L_*^k}{L_*^c + L_*^k} W_t^k\right) \left\{\frac{L_t^c}{L_t^k} - \eta^l \frac{L_{t-1}^c}{L_{t-1}^k} - (1-\eta^l)\frac{L_*^c}{L_*^k}\right\}^2 \frac{L_t^k}{L_t^c},
\end{aligned}
$$

where G_t is government consumption which is assumed to be stochastic.

$$
\begin{aligned}
X_t^k &= \int_0^1 I_t(k)dk + F_t + \frac{100 \cdot \chi^w}{2} \left[\Pi_t^{w,k} - \eta^w \Pi_{t-1}^{w,k} - (1-\eta^w)\Pi_*^w\right]^2 W_t^k L_t^k \\
&\quad + \frac{100 \cdot \chi^p}{2} \left[\Pi_t^{p,k} - \eta^p \Pi_{t-1}^{p,k} - (1-\eta^p)\Pi_*^{p,k}\right]^2 P_t^k X_t^k,
\end{aligned}
$$

where F_t is net exports which is assumed to be stochastic.

$$
\begin{aligned}
L_t^s(i) &= \int_0^1 L_t^s(i,j)dj, \quad \forall i \in [0,1],\ s \in \{c,k\} \\
\int_0^1 U_t^s(k) K_t^s(k) dk &= \int_0^1 K_t^{u,s}(j)dj, \quad s \in \{c,k\}
\end{aligned}
$$

References

[1] Berkmen, S. P. (2011), "The Impact of Fiscal Consolidation and Structural Reforms on Growth in Japan," IMF Working Paper WP/11/13.

[2] Blanchard, O. and R. Perotti (2002), "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," *Quarterly Journal of Economics*, 117(4), 1329–1368.

[3] Christiano, L., M. Eichenbaum, and S. Rebelo (2009), "When is the Government Spending Multiplier Large?," NBER Working Paper 15394.

[4] Chung, H. T., M. T. Kiley, and J.-P. Laforte (2010), "Documentation of the Estimated, Dynamic, Optimization-based (EDO) Model of the U.S. Economy: 2010 Version," Finance and Economics Discussion Series 2010-29.

[5] Coenen, G., C. Erceg, C. Freedman, D. Furceri, M. Kumhof, R. Lalonde, D. Laxton, J. Lindé, A. Mourougane, D. Muir, S. Mursula, C. de Resende, J. Roberts, W. Roeger, S. Snudden, M. Traband, and J. in't Veld (2011), "Effects of Fiscal Stimulus in Structural Models," *American Economic Journal: Macroeconomics* (forthcoming).

[6] Coenen, G. and R. Straub (2005), "Does Government Spending Crowd in Private Consumption? Theory and Empirical Evidence for the Euro Area," *International Finance*, 8(3), 435–470.

[7] Cogan, J. F., T. Cwik, J. B. Taylor, and V. Wieland (2010), "New Keynesian versus Old Keynesian Government Spending Multipliers," *Journal of Economic Dynamics and Control*, 34(3), 281–295.

[8] Corsetti, G., A. Meier, and G. Müller (2009), "Fiscal Stimulus with Spending Reversals," IMF Working Paper WP/09/106.

[9] Eggertsson, G. B. (2011), "What Fiscal Policy is Effective at Zero Interest Rates?," *NBER Macroeconomics Annual 2010*, 59–112.

[10] Fueki, T., I. Fukunaga, H. Ichiue, and T. Shirota (2010), "Measuring Potential Growth with an Estimated DSGE Model of Japan's Economy," Bank of Japan Working Paper 10-E-13.

[11] Fujiwara, I. and K. Ueda (2010), "The Fiscal Multiplier and Spillover in a Global Liquidity Trap," IMES Discussion Paper Series 2010-E-3, Institute for Monetary and Economic Studies (IMES), Bank of Japan.

[12] Fukunaga, I., N. Hara, S. Kojima, Y. Ueno, and S. Yoneyama (2011), "Quarterly Japanese Economic Model (Q-JEM): 2011 Version," Bank of Japan Working Paper (forthcoming).

[13] Galí, J., J. D. López-Salido, and J. Vallés (2007), "Understanding the Effects of Government Spending on Consumption," *Journal of the European Economic Association*, 5(1), 227–270.

[14] Iwata, Y. (2009) "Fiscal Policy in an Estimated DSGE Model of the Japanese Economy: Do Non-Ricardian Households Explain All?," ESRI Discussion Paper Series No. 216, Economic and Social Research Institute (ESRI), Cabinet Office.

[15] Kumhof, M., D. Laxton, D. Muir, and S. Mursula (2010), "The Global Integrated Monetary and Fiscal Model – Theoretical Structure," IMF Working Paper 10/34.

[16] Leeper, E. M., M. Plante, and N. Traum (2010), "Dynamics of Fiscal Financing in the United States," *Journal of Econometrics*, 156(2), 304–321.

[17] Sakuma, T., M. Masujima, S. Maeda, K. Fukawa, and K. Iwamoto (2011) "The ESRI Short-Run Macroeconometric Model of the Japanese Economy (2011 version): Basic Structure, Multipliers, and Economic Policy Analyses," ESRI Discussion Paper Series No. 259, Economic and Social Research Institute (ESRI), Cabinet Office.

[18] Woodford, M. (2011), "Simple Analytics of the Government Expenditure Multiplier," *American Economic Journal: Macroeconomics*, 3(1), 1–35.

Table 1: Estimated Parameter Values in the M-JEM

Parameters	Prior Distribution	Prior Mean	Prior S.D.	Post. Mean	Post. Interval (90%)	
					Lower	Upper
h : Habit persistence	beta	0.5	0.20	0.69	0.52	0.89
ν : Inverse of labor supply elasticity	gamma	2.0	1.00	0.65	0.16	1.13
λ : Non-Ricardian share	beta	0.5	0.04	0.31	0.26	0.36
χ^{p}: Size of adjustment cost in resetting prices	gamma	4.0	2.00	10.40	5.93	14.82
η^{p} : Relative importance of lagged price inflation	beta	0.5	0.15	0.15	0.05	0.24
χ^{w}: Size of adjustment cost in resetting wages	gamma	4.0	2.00	15.20	9.47	20.64
η^{w} : Relative importance of lagged wage inflation	beta	0.5	0.15	0.15	0.04	0.25
χ^{l}: Size of labor sectoral adjustment cost	gamma	2.0	1.00	0.18	0.00	0.51
η^{l} : Relative importance of lagged labor supply	beta	0.5	0.15	0.68	0.45	0.92
χ : Investment adjustment cost	gamma	3.0	1.00	2.56	1.41	3.66
ψ : Elasticity of utilization cost	normal	1.0	1.00	3.31	2.24	4.40
ϕ^{r} : Smoothing parameter in monetary policy rule	beta	0.7	0.15	0.95	0.93	0.97
$\phi^{\pi,gdp}$: Coefficient on inflation in monetary policy rule	normal	0.5	0.15	0.42	0.21	0.64
$\phi^{h,gdp}$: Coefficient on the output gap in monetary policy rule	normal	0.4	0.15	0.03	0.00	0.06

Table 2: Government Spending Multiplier

Effects on real GDP when:

Government spending is increased by 1% of nominal GDP every period (on a sustained basis).
Tax rates and transfers are held fixed.
The policy interest rate follows a Taylor-type monetary policy rule.

	M-JEM	GIMF		Q-JEM		ESRI (2011)
	CG	CG	IG	CG	IG	IG
First Year	1.15	0.67	1.09	1.01	1.01	1.01
Second Year	1.32	0.36	1.05	1.07	1.08	1.02

Note 1: CG refers to the case of a shock to government consumption,
while IG refers to the case of a shock to government investment.

Note 2: Q-JEM refers to "Quarterly Japanese Economic Model" developed at
Research and Statistics Department, Bank of Japan.

Note 3: ESRI (2011) refers to the model developed at
Economic and Social Research Institute (ESRI), Cabinet Office.

Figure 1: Positive Government Consumption Shock in the M-JEM

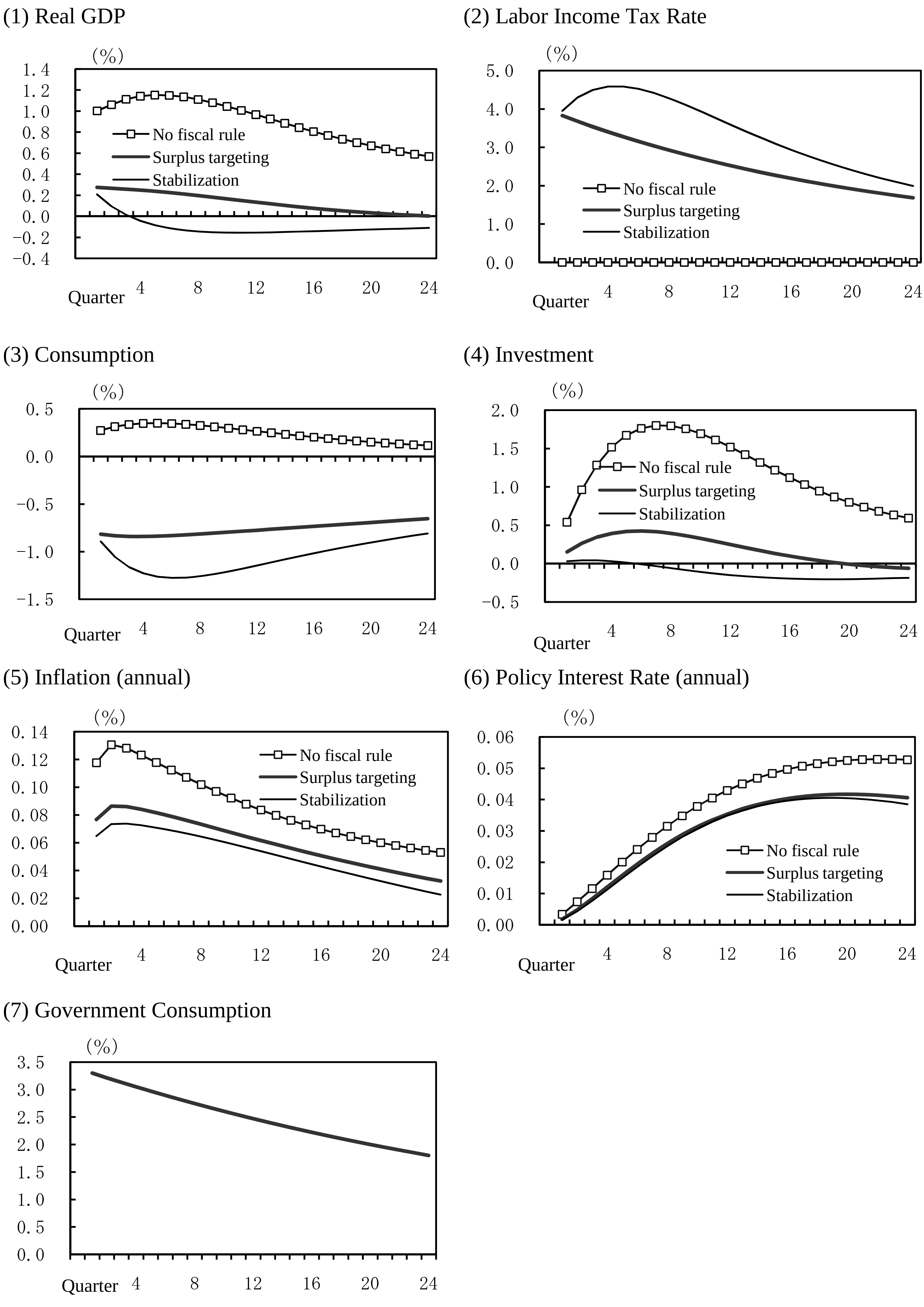
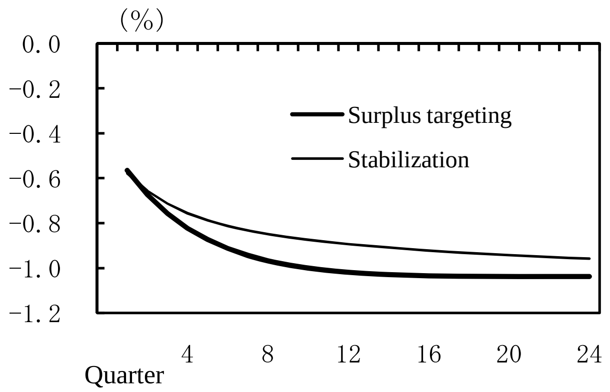
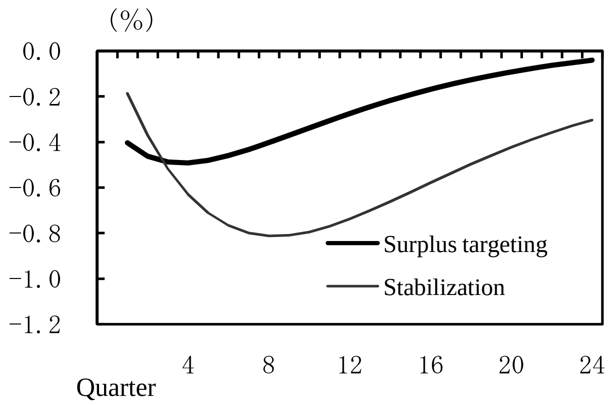


Figure 2: Negative Productivity Shock in the M-JEM

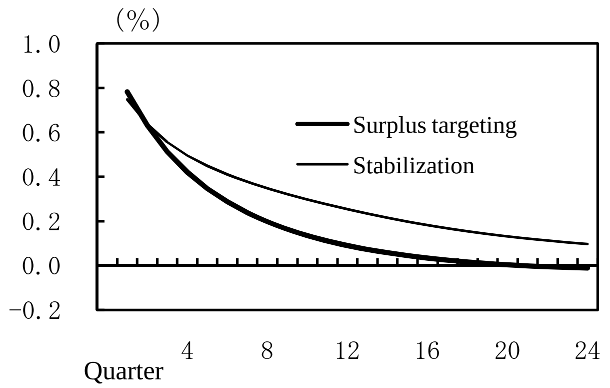
(1) Real GDP



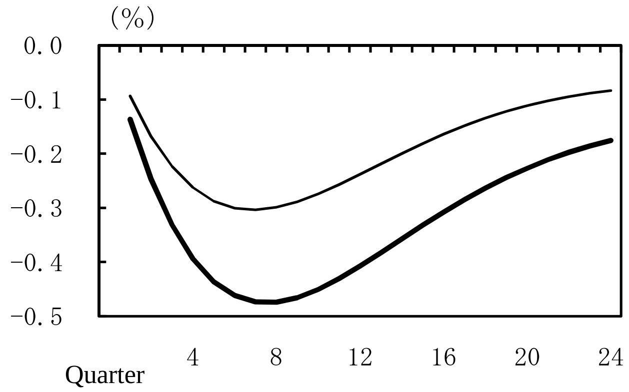
(2) Labor Income Tax Rate



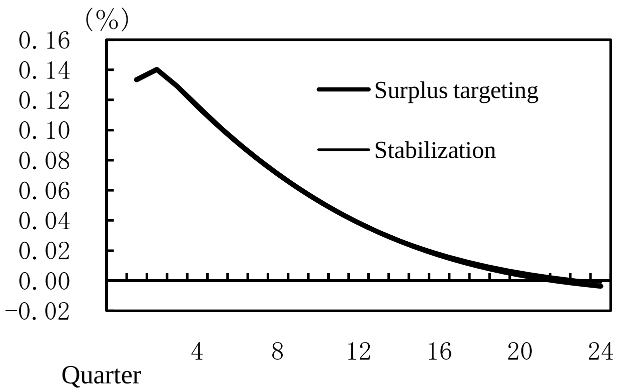
(3) Consumption



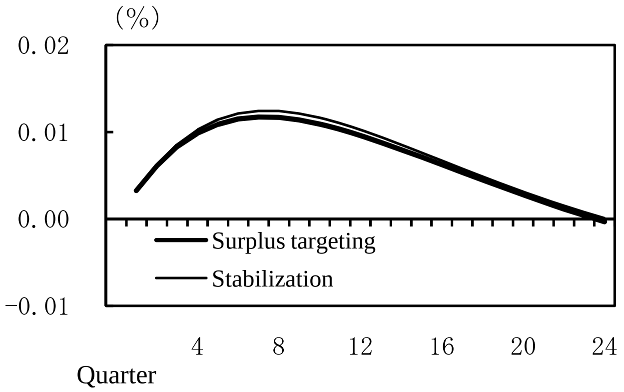
(4) Investment



(5) Inflation (annual)



(6) Policy Interest Rate (annual)



(7) TFP

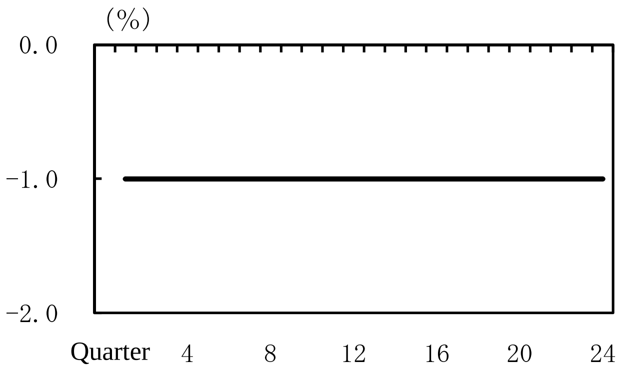
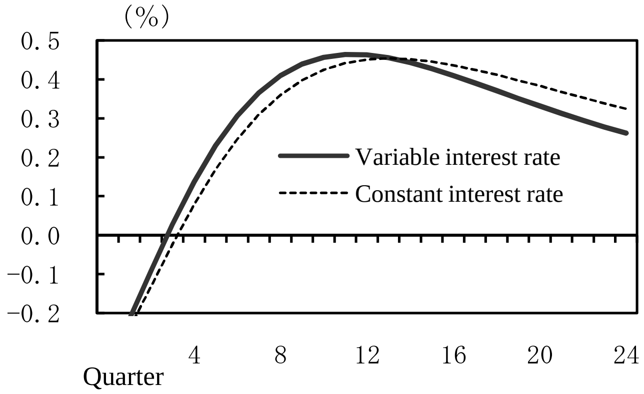


Figure 3: Stabilization Responsiveness and Effectiveness in the M-JEM

(1) Stabilization Responsiveness

Labor Income Tax Rate under Stabilization Rule(%)—Labor Income Tax Rate under Surplus Targeting Rule(%)
/
Size of Shock(%)

Productivity Shock



(2) Stabilization Effectiveness

GDP under Stabilization Rule—GDP under Surplus Targeting Rule (% deviation)
/
Labor Income Tax Rate under Stabilization Rule(%)—Labor Income Tax Rate under Surplus Targeting Rule(%)

Productivity Shock

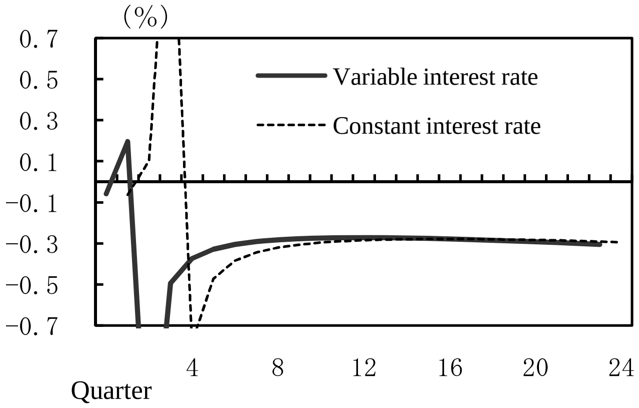


Figure 4: Positive Government Consumption Shock in the GIMF

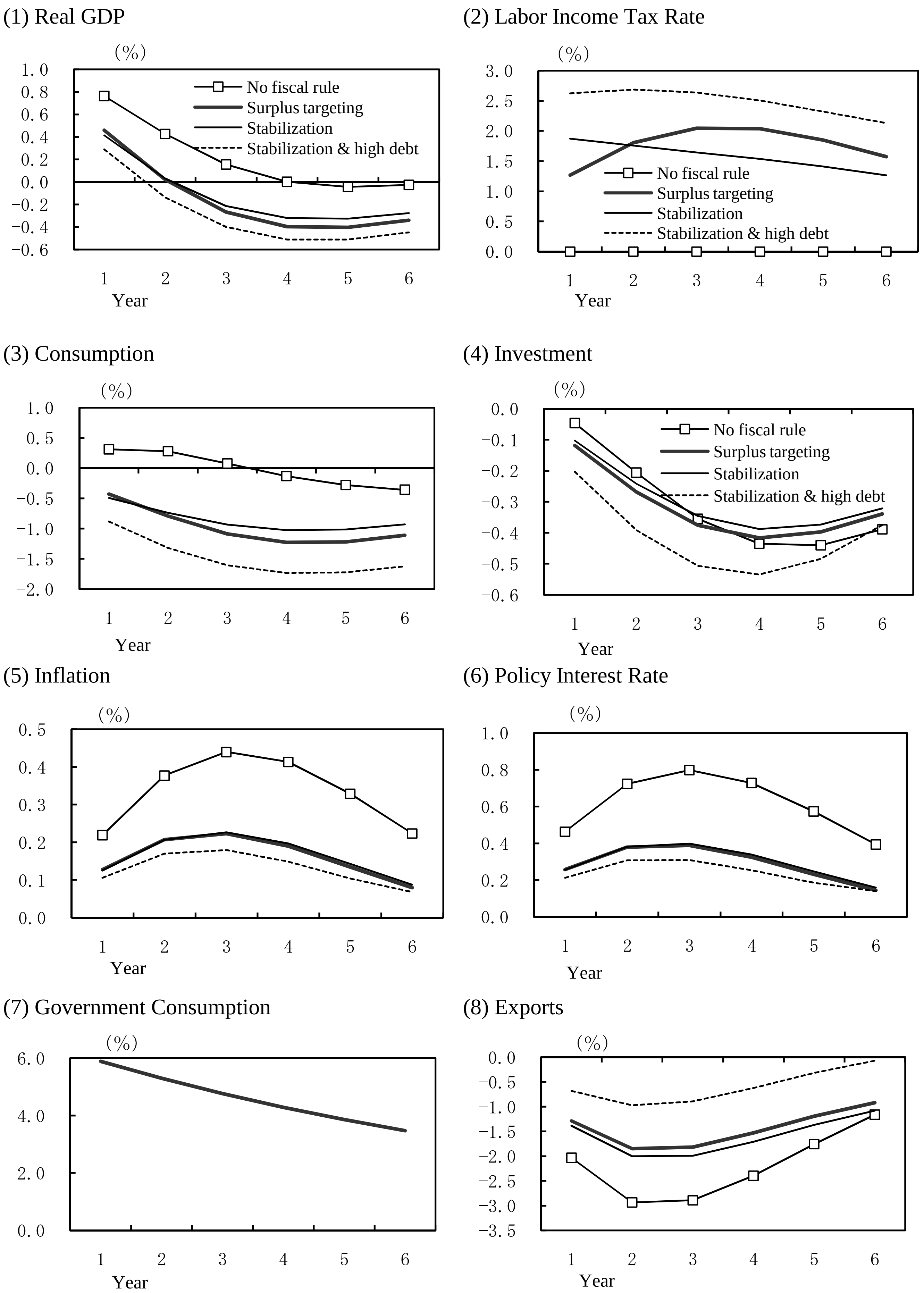
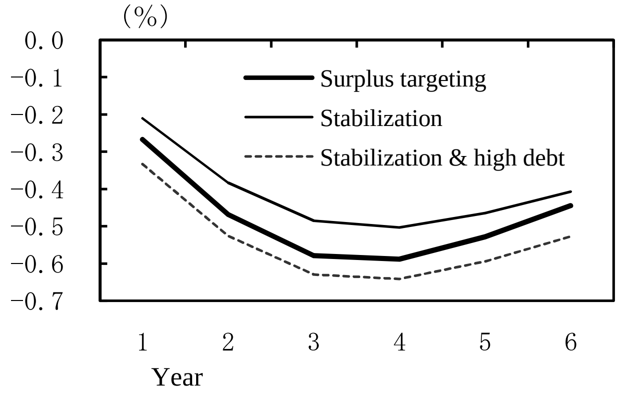
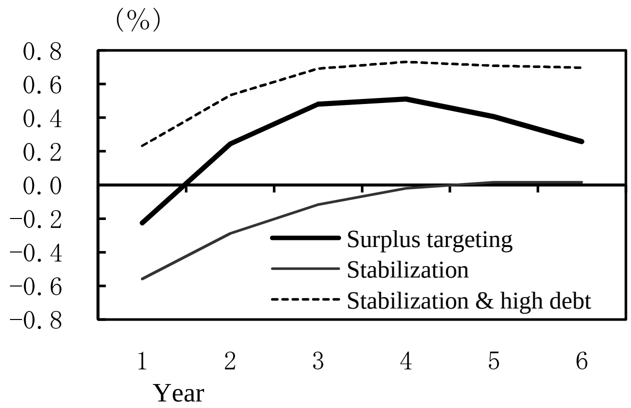


Figure 5: Negative Productivity Shock in the GIMF

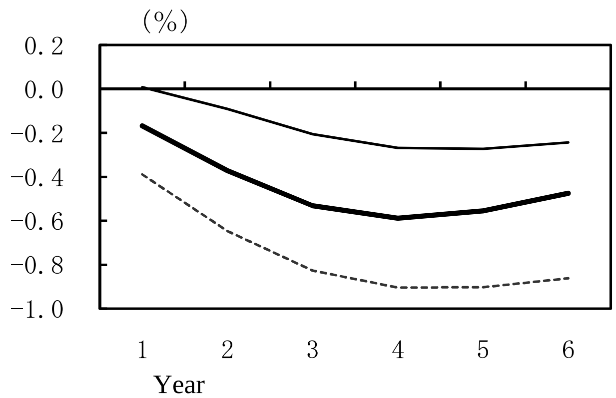
(1) Real GDP



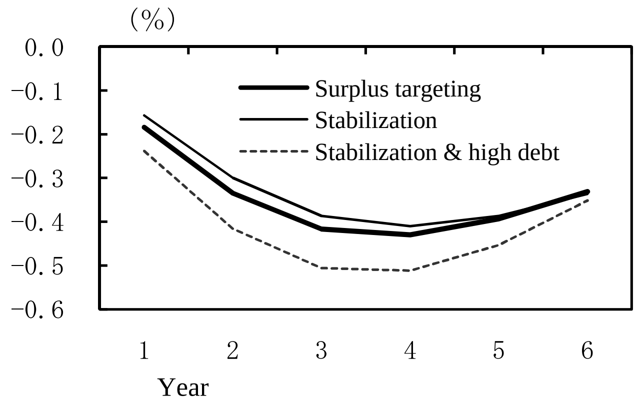
(2) Labor Income Tax Rate



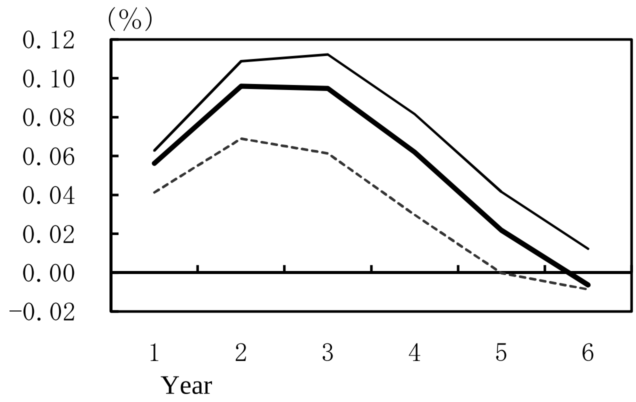
(3) Consumption



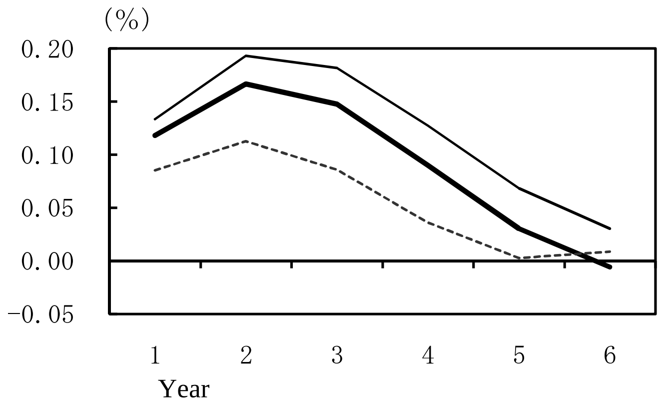
(4) Investment



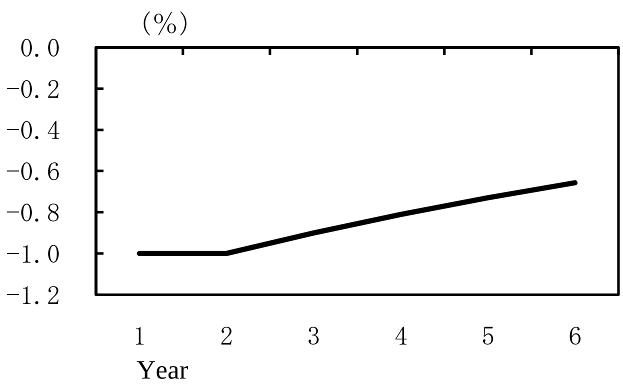
(5) Inflation



(6) Policy Interest Rate



(7) TFP



(8) Exports

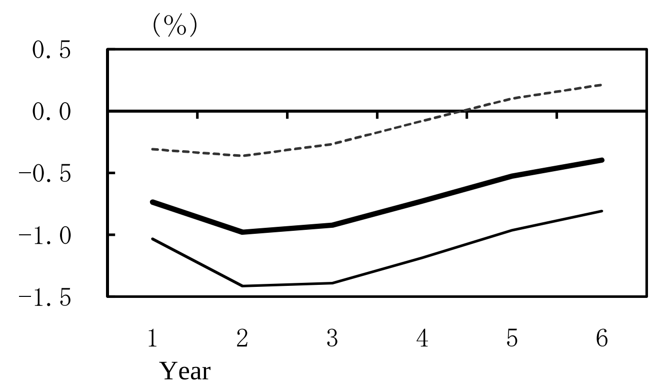
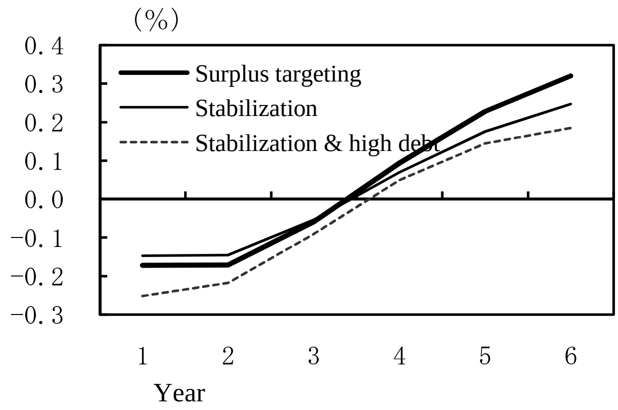
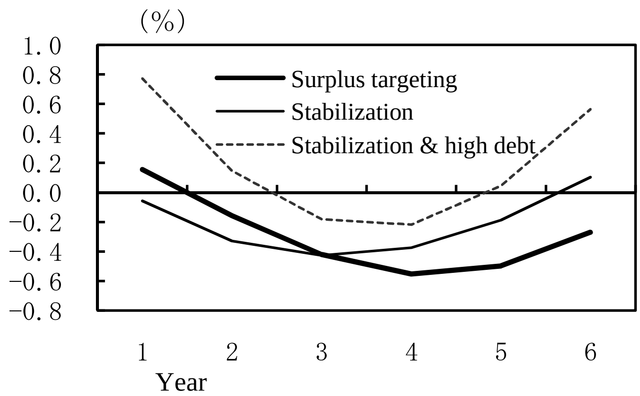


Figure 6: Negative Foreign Demand Shock in the GIMF

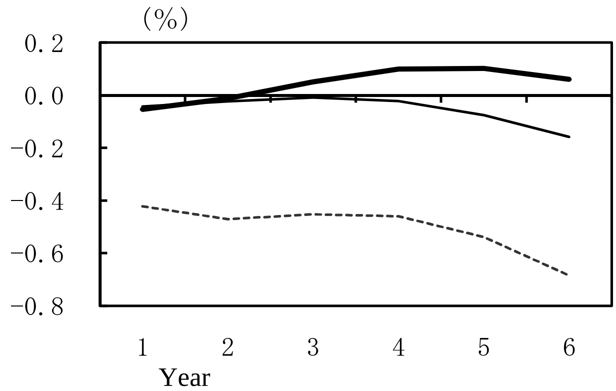
(1) Real GDP



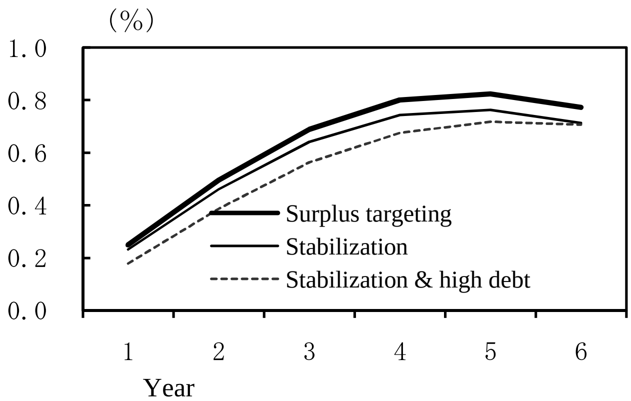
(2) Labor Income Tax Rate



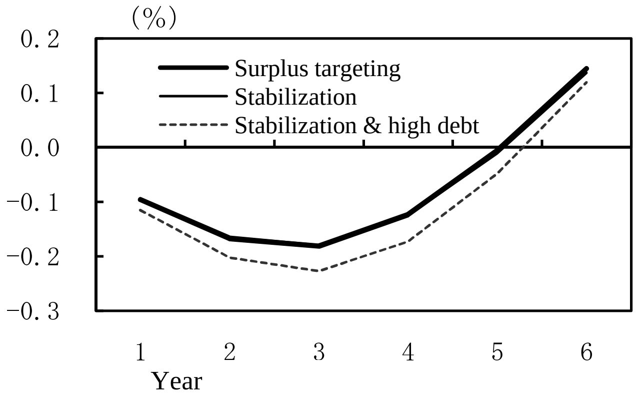
(3) Consumption



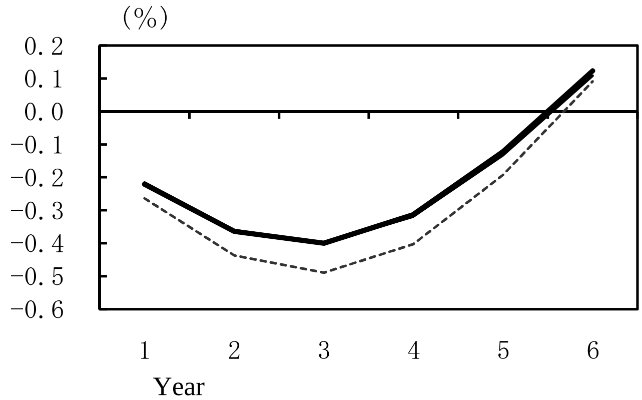
(4) Investment



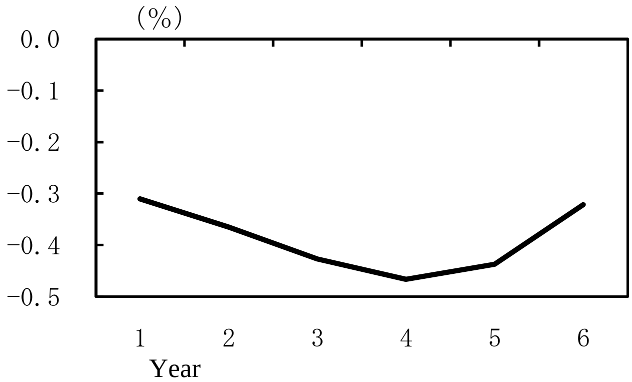
(5) Inflation



(6) Policy Interest Rate



(7) Foreign GDP



(8) Exports

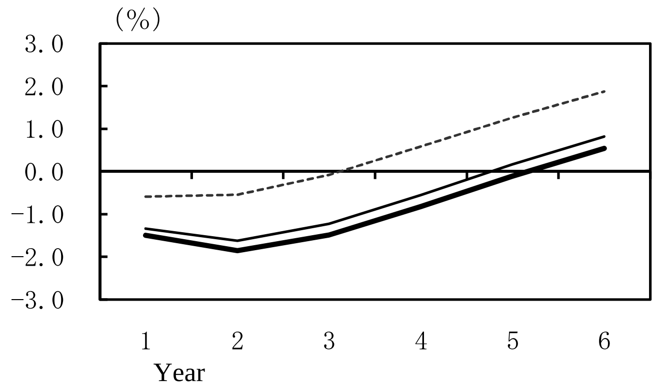
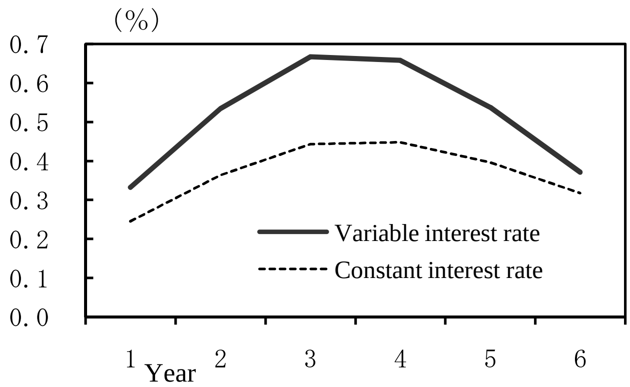


Figure 7: Stabilization Responsiveness and Effectiveness in the GIMF

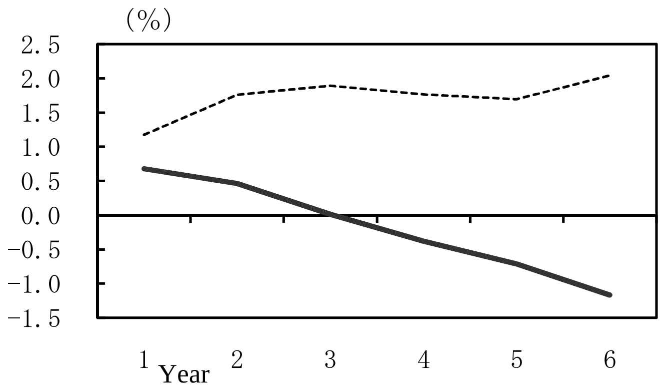
(1) Stabilization Responsiveness

$$\frac{\text{Labor Income Tax Rate under Stabilization Rule(\%)—Labor Income Tax Rate under Surplus Targeting Rule(\%)}}{\text{Size of Shock(\%)}}$$

Productivity Shock



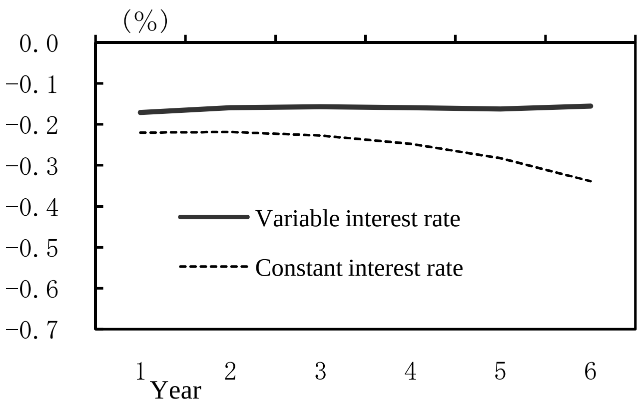
Foreign Demand Shock



(2) Stabilization Effectiveness

$$\frac{\text{GDP under Stabilization Rule—GDP under Surplus Targeting Rule (\% deviation)}}{\text{Labor Income Tax Rate under Stabilization Rule(\%)—Labor Income Tax Rate under Surplus Targeting Rule(\%)}}$$

Productivity Shock



Foreign Demand Shock