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"Complementarity between Merit Goods and Private Consumption: Evidence from estimated DSGE model for Japan"

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Complementarity between Merit Goods and Private Consumption: Evidence from estimated DSGE model for Japan[*]

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Abstract

This study constructs a dynamic stochastic general equilibrium model and empirically investigates the effects of fiscal policy in Japan with focus on the functional difference in government expenditures. Specifically, we divide government consumption into merit and public goods and examine their external effect on private consumption. Our estimation using Japanese quarterly data from 1981:Q1 to 2012:Q4 indicates that merit goods are complements for private consumption, while public goods are substitutes, and consequently, the expenditure on merit goods has greater positive effects on the economy than public goods. Furthermore, we show that Japanese government expenditures are highly persistent and their response to the GDP gap and national debt accumulation is limited. These findings suggest that the complementarity between private consumption and merit goods is a major factor causing a fiscal crowding-in effect on private consumption.

JEL Classification: C11; E32; E62

Keywords: Edgeworth complementarity; Fiscal policy; DSGE modeling; Bayesian estimation

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1. Introduction

In response to prolonged stagnation since the 1990s and its aging population, Japan increased its government spending and as a result, the gross debt-to-GDP ratio has risen to more than 200 percent as of 2017. These conditions warrant fiscal policies that are more efficient, and therefore, it is imperative to investigate the effects of government spending. This study empirically examines the effect of fiscal policy in Japan with focus on differences stemming from types of government spending. More specifically, we construct a dynamic stochastic general equilibrium (DSGE) model with two categories of government consumption, that is, merit goods and public goods, and government investment and estimate their effects using Bayesian techniques.

Differences in the effects of government expenditures in a model can be attributed to two channels. First is their non-wasteful properties. In terms of government investment, accumulated social capital has a positive external effect on production (e.g., Baxter and King, 1993). Meanwhile, the non-wasteful nature of government consumption is Edgeworth complementarity or substitutability between public and private consumption. If they are complements (substitutes), an increase in government consumption crowds in (out) private consumption and consequently, enhances (diminishes) the positive effect on output. Therefore, the effect of government consumption expenditure largely depends on whether the relationship is complementary or substitutive. While some empirical studies such as Aschauer (1985) and Ahmed (1986) report substitutability, Karras (1994), Evans and Karras (1996), and recent DSGE studies focusing on the United States (Bouakez and Rebei, 2007; Fève et al., 2013) and the euro area (Coenen et al., 2013) show complementarity. Similarly, studies on Japan suggest complementarity (Okubo, 2003; Iwata, 2013).

While the above-mentioned works focus on total government consumption, Fiorito and Kollintzas (2004) stress the differing nature of goods within it. They divide government consumption into two categories, merit and public goods, and investigate their individual relationship with private consumption. While merit goods are represented by healthcare, education, and social protection spending, which are rival in private consumption and affect welfare through distribution policies, public goods comprise spending on general public services, defense, and so on and are mostly non-rival in nature. Fiorito and Kollintzas (2004) demonstrate the complementarity of merit goods and substitutability of public goods in 12 European countries.

The second factor causing the differing effects of government expenditure is policy rules. While in most previous studies, fiscal policy rules include terms related to a lag, output gap, and government debt, the specification is not uniform.[1] However, the specification of spending rules plays an important role in evaluating policy effects. Corsetti et al. (2012) point out the importance of "spending reversals," which indicate that government expenditure decreases with government debt accumulation. Spending reversals reduce future inflation resulting from a government spending shock and the rise in interest rate through the monetary policy rule, and therefore, increase the effect of a fiscal expansion.[2] Furthermore, Fève et al. (2013) show that an estimation without a countercyclical output gap term in fiscal policy rules underestimates the degree of Edgeworth complementarity. Previous studies, such as Lane (2003), Abbott and Jones (2011, 2012), and Frankel et al. (2013), provide empirical evidence on the cyclicality of government spending in developed countries as follows: (1) total government spending is countercyclical or acyclical and (2) certain spending categories demonstrate procyclicality.

This study investigates the degree of complementarity or substitutability of merit goods and

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[1] For example, Bouakez and Rebei (2007), Galí et al. (2007), and Kato and Miyamoto (2013) adopt the simple first-order autoregressive rules. Iwata (2011) includes lag and output gap terms in the rules and in Iwata (2013), government expenditures respond to the previous ones and debt-to-GDP ratio. Coenen et al.'s (2013) policy rules comprise lag, output gap, debt-to-GDP ratio terms, and moving average of policy shocks.

[2] Although spending reversals enlarge the positive effect of government spending also by mitigating the negative wealth effect on households, Corsetti et al. (2012) conclude that this mechanism seldom works in quantitative terms.

public goods in Japan by conducting a Bayesian estimation using a DSGE model. In analyzing the effect of fiscal policy in Japan, separating merit goods from public goods is crucial. As shown in Fig. 1, merit goods expenditure as a share of nominal GDP rapidly increased since the mid-2000s because of the growth in healthcare and social protection spending. This growth possibly reflects the rapid increase in the aging population and evaluating the effects of merit goods expenditure contributes to the discussion on present and future policy design under severe fiscal conditions.[3] Following the above-mentioned studies, we specify fiscal spending rules, including output gap and debt-to-GDP ratio terms, and examine whether fiscal policy in Japan includes spending reversals and if it is pro- or countercyclical.

[Fig. 1]

Additionally, our study is related to the well-known “puzzle” of the relationship between government spending and private consumption. While standard dynamic general equilibrium models predict the negative effect of government spending on private consumption, previous empirical studies, such as Blanchard and Perotti (2002), show a positive one.[4] Drawing on the literature, our DSGE model includes the following four factors to overcome this puzzle: (1) productive social capital (Baxter and King, 1993), (2) household under liquidity constraint (Galí et al., 2007), (3) spending reversals rule of government spending (Corsetti et al., 2012), and (4) Edgeworth complementarity between government spending and private consumption (Bouakez and Rebei, 2007; Ganelli and Tervala, 2009; Fève et al., 2013). This study, thus, provides some insight into which of these factors contributes to the positive response of private consumption to government

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[3] Population estimates by the Statistics Bureau, Ministry of Internal Affairs and Communications, show that those aged 65 years and above as a share of total population increased from 17.5% to 23.2% during 2000–2010 (http://www.stat.go.jp/english/data/jinsui/2.htm).

[4] In standard dynamic general equilibrium models, a decline in private consumption in response to government spending is caused by the negative wealth effect of the current and/or future rise in the tax burden. A more detailed explanation is provided by, for example, Baxter and King (1993) and Galí et al. (2007).

spending shocks.

For the Bayesian estimation, we employ data from 1981:Q1 to 2012:Q4 and show that merit goods are complements for private consumption, while public goods are substitutes. In addition, we suggest that the degree of complementarity or substitutability largely affects the quantitative evaluation of government spending. Further, we conduct a time-series analysis using a vector autoregressive (VAR) model to support the quantitative difference in effects between merit and public goods expenditure. However, the estimated complementarity should be carefully interpreted because it possibly stems not from household preference but from the characteristics of Japan's national care system, under which people incur only a part of their health and long-term care costs and the remaining is paid by government.[5] In this case, the degree of complementarity can be overestimated because an increase in private consumption partly involves additional expenditure on merit goods. Therefore, we conduct several robustness checks for the complementarity. The results confirm the complementarity, although the degree is smaller than that in the main result. Throughout the analyses, the multipliers during 1981–2012 for expenditures on merit goods, public goods, and government investment are approximately 1.75–1.91, 0.25–0.48, and 0.93, respectively. Furthermore, we find that the behavior of government expenditures in Japan can be mostly explained by the inertia and the influences of spending reversals and cyclicality are quantitatively small.

The remainder of this paper is organized as follows. Section 2 provides the empirical result for a VAR model. Section 3 presents a DSGE model with Edgeworth complementarity (or substitutability) between government and private consumption. Section 4 estimates a DSGE model using a Bayesian technique and shows the result. Section 5 conducts robustness checks on the results, and Section 6 concludes.

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[5] Iwata (2013) presents a similar discussion on the complementarity between total government consumption and private consumption.

2. Time-series analysis

Preceding the analysis using a DSGE model, we perform a time-series analysis. To investigate the effects on the basis of types of government spending, we individually consider government consumption and investment and further divide government consumption into merit and public goods. The VAR model includes the following ten variables: real GDP, real private consumption, real private investment, hours worked, inflation rate, nominal interest rate, real wage, and three government spending variables. These variables are common to the Bayesian estimation of the DSGE model in Section 4.

2.1 . Data and Methodology

We employ the following quarterly data in Japan for 1981:Q1–2012:Q4. Data for nominal GDP, nominal consumption, nominal investment, and nominal government expenditures are obtained from the Cabinet Office. As for government consumption, we define merit goods expenditure as individual consumption expenditure by the general government, most of which comprises spending on healthcare, social protection, and education, and public goods expenditure as collective consumption expenditure.[6] Data for nominal wages and hours worked are obtained from the monthly labor survey conducted by the Ministry of Health, Labour and Welfare, and inflation rate is the log difference of the consumer price index (CPI) published by the Ministry of Internal Affairs and Communications. As nominal interest rate, we use the unsecured overnight call rate available in statistics by the Bank of Japan.[7]

GDP, consumption, investment, and three government expenditures are per worker terms, and

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[6] Collective consumption by the general government also includes spending on healthcare, education, and social protection (e.g., expenditures on R&D); however, their fractions in government collective consumption are considerably smaller than those in government individual consumption.

[7] We use data on the secured overnight call rate as the nominal interest rate prior to 1985:Q2.

these six variables and wage are in logs and deflated by CPI. All series, except nominal interest rate, are seasonally adjusted. In addition, all series are one-sided Hodrick–Prescott (HP) filtered because the augmented Dickey–Fuller test and Phillips–Perron test suggest they have unit roots and the impulse response analysis based on the present DSGE model (see Section 4) employs de-trended variables.[8]

The Schwartz criterion suggests that the optimal number of lags in the VAR model is 1. To identify the government spending shock, we adopt Cholesky decomposition and order each government spending variable first, similar to previous works such as Bouakez and Rebei (2007), Galí et al. (2007), and Kato and Miyamoto (2013). This implies that government spending shocks are more exogenous and pre-determined than other variables.

2.2. Impulse responses

Figs. 2 and 3 illustrate the impulse responses of key variables to positive merit goods and public goods expenditure shocks, respectively. The shapes of impulses are similar in both cases, and almost all variables increase.

[Fig. 2]

[Fig. 3]

On the other hand, the significance tends to differ, and in particular, the effects of public goods shock on output, private consumption, labor, and wage are more ambiguous than those of merit goods shock. Therefore, the results suggest that the positive effect of merit goods spending on the economy is larger than that of public goods spending. We do not present a figure for government

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[8] The one-sided HP filter is a version of the HP filter that does not use future values of data series in the de-trending operation (see Stock and Watson (1999)). The nature of the standard HP filter that uses all of the information presented by the sample periods conflicts with that of the recursive presentation, which depends on past and present information. Therefore, Bouakez and Rebei (2007) employ the one-sided version in their time-series analysis. We conduct this procedure using Meyer–Gohde’s (2010) MATLAB code.

investment because the shapes of impulses are similar to those for positive merit goods and public goods expenditure shocks and this study focuses on the difference between the effects of merit and public goods.[9]

3. Model

Our model is similar to Hirose and Kurozumi's (2012) DSGE model, which is based on Smets and Wouters (2007). We exclude investment-specific technology from their model and instead, incorporate the following: (1) fiscal policy rules, (2) public capital that enhances the productivity of intermediate goods producers, (3) non-Ricardian households under liquidity constraint, and (4) Edgeworth complementarity (or substitutability) between the government and private consumption of Ricardian households. More specifically, following Fiorito and Kollintzas (2004), we divide government consumption into merit goods and public goods and introduce the effective consumption of Ricardians that allows for non-separable government consumptions. Furthermore, similar to Erceg et al. (2006), Hirose and Kurozumi (2012), and Iwata (2013), our model includes a balanced growth trend.

3.1. Households

There is a continuum of infinitely lived households whose sum is unity. Households are divided into two types: fraction $1-\omega$ is Ricardian households who can freely access financial markets and optimize their intertemporal behavior, and the remaining are non-Ricardian households under liquidity constraints.

The utility function of Ricardian household $h \in [\omega, 1]$ is given by

[9] Following are the minor differences in the effects of government consumption and investment shocks: government investment significantly decreases private investment and the effects on labor and wage are more ambiguous than those of government consumption shocks.

$$\mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t e^{z_t^b} \left\{ \frac{\left(C_t^e(h) - \theta C_{t-1}^e(h)\right)^{1-\sigma}}{1-\sigma} - \frac{Z_t^{1-\sigma} e^{z_t^l} l_t(h)^{1+\chi}}{1+\chi} + V_{gm}(G_t^m) + V_{gp}(G_t^p) \right\}, \tag{1}$$

where $C_t^e(h)$ and $l_t(h)$ are the effective consumption and labor supply of Ricardian household h, respectively. Z_t is the technology level following the non-stationary stochastic process $\log Z_t = \log z + \log Z_{t-1} + z_t^z$, where z is the gross steady-state growth rate and z_t^z is a technology shock. z_t^b and z_t^l are shocks to the discount factor $\beta \in (0,1)$ and labor supply, respectively. $\sigma > 0$ denotes the inverse of the elasticity of the intertemporal substitution, $\chi > 0$ is the inverse of the elasticity of labor supply, and $\theta \in (0,1)$ measures the degree of habit formation in consumption. We define the effective consumption of Ricardian household h as follows:

$$C_t^e(h) = C_t^R(h) + \nu^{gm} G_t^m + \nu^{gp} G_t^p,$$

where $C_t^R(h)$ is the private consumption of Ricardian household h, and G_t^m and G_t^p represent two types of government consumption, merit goods and public goods. If $\nu^i, i \in \{gm,\ gp\}$ is negative (positive), the marginal utility of private consumption is increasing (decreasing) in government consumption, implying complementarity (substitutability) between private and government consumption.[10] Functions V_{gm} and V_{gp} in Eq. (1) satisfy $V'_{gm} > 0$ and $V'_{gp} > 0$, ensuring that the marginal utility of government consumption is positive.

The budget constraint of Ricardian household h is given by

$$C_t^R(h) + I_t^R(h) + B_t^R(h) = W_t(h) l_t(h) + R_t^k u_t(h) K_{t-1}^R(h) + \frac{R_{t-1}^n}{\pi_t} B_{t-1}^R(h) + D_t(h) - T_t^R, \tag{2}$$

where $I_t^R(h)$ is private investment, $B_t^R(h)$ is government bonds, $u_t(h)$ is the capital utilization rate, $K_{t-1}^R(h)$ is the capital stock at the beginning of period t, $D_t(h)$ is the dividend from intermediate goods firms, and T_t^R is the lump-sum tax levied on Ricardian households. π_t, $W_t(h)$, R_t^k, and R_{t-1}^n, respectively, denote the gross inflation rate of final goods price P_t, real wage, gross

[10] For analytical convenience, we employ the linear specification of effective consumption, as in Karras (1994) and Iwata (2013). Fiorito and Kollintzas (2004), Bouakez and Rebei (2007), and Coenen et al. (2013) adopt a more general constant elasticity of the substitution function.

real rental rate of capital, and gross nominal return on the government bond. The first-order conditions for $C_t^R(h)$ and $B_t^R(h)$ are given by

$$\Lambda_t = e^{z_t^b}(C_t^e - \theta C_{t-1}^e)^{-\sigma} - \beta\theta \mathbf{E}_t e^{z_{t+1}^b}(C_{t+1}^e - \theta C_t^e)^{-\sigma},$$

$$\Lambda_t = \beta \mathbf{E}_t \Lambda_{t+1} \frac{R_t^n}{\pi_{t+1}},$$

where Λ_t is the Lagrangean multiplier. Index h is omitted because all Ricardians face the same decision-making problem regarding $C_t^R(h)$ and $B_t^R(h)$ in the presence of a complete insurance market.

Under the monopolistic competition, households supply their differentiated labor services, given the labor demand by intermediate goods firms. According to Galí et al. (2007), we assume that intermediate goods firms uniformly demand differentiated labor services from both types of households. Then, the demand for labor service $i \in [0,1]$ is expressed as

$$l_t(i) = \left(\frac{W_t(i)}{W_t}\right)^{-\theta_t^w} l_t. \tag{3}$$

Here, l_t is the aggregate labor demand defined as an aggregation technology $l_t = \left(\int_0^1 l_t(i)^{(\theta_t^w - 1)/\theta_t^w} di\right)^{\theta_t^w/(\theta_t^w - 1)}$, where $\theta_t^w > 1$ is the elasticity of substitution across labor services. W_t denotes the aggregate wage satisfying

$$W_t = \left(\int_0^1 W_t(i)^{1-\theta_t^w} di\right)^{1/(1-\theta_t^w)}. \tag{4}$$

Ricardian households set their wage as per Calvo (1983); they have the opportunity to re-optimize their wage with probability $1 - \xi^w$ in each period. Meanwhile, Ricardians cannot set an optimal wage with probability ξ^w and then, choose their nominal wage on the basis of both gross steady-state growth rate and a weighted average of past and steady-state inflation. Specifically, unoptimized nominal wage rule is denoted by

$$P_t W_t(h) = z\, \pi_{t-1}^{\gamma^w} \pi^{1-\gamma^w} P_{t-1} W_{t-1}(h),$$

where π is the steady-state inflation rate and $\gamma^w \in [0,1]$ is the relative weight on past inflation. The optimal wage is chosen to maximize

$$\mathbf{E}_t \sum_{j=0}^{\infty} (\beta\xi^w)^j \left[\Lambda_{t+j} l_{t+j}(h) z^j W_t(h) \prod_{k=1}^{j} \left\{ \left(\frac{\pi_{t+k-1}}{\pi} \right)^{\gamma^w} \frac{\pi}{\pi_{t+k-1}} \right\} - \frac{e^{z^b_{t+j}} e^{z^l_{t+j}} Z^{1-\sigma}_{t+j} l_{t+j}(h)^{1+\chi}}{1+\chi} \right]$$

subject to Eq. (3). Representing the optimal wage as W_t^*, the first-order condition for $W_t(h)$ is

$$\mathbf{E}_t \sum_{j=0}^{\infty} (\beta\xi^w)^j \frac{\Lambda_{t+j} l_{t+j}}{\lambda^w_{t+j}} \left[\frac{z^j W_t^*}{W_{t+j}} \prod_{k=1}^{j} \left\{ \left(\frac{\pi_{t+k-1}}{\pi} \right)^{\gamma^w} \frac{\pi}{\pi_{t+k}} \right\} \right]^{-\frac{1+\lambda^w_{t+j}}{\lambda^w_{t+j}}} \left\{ z^j W_t^* \prod_{k=1}^{j} \left\{ \left(\frac{\pi_{t+k-1}}{\pi} \right)^{\gamma^w} \frac{\pi}{\pi_{t+k}} \right\} \right.$$

$$\left. - \left(1+\lambda^w_{t+j}\right) \frac{e^{z^b_{t+j}} e^{z^l_{t+j}} Z^{1-\sigma}_{t+j}}{\Lambda_{t+j}} \left(l_{t+j} \left[\frac{z^j W_t^*}{W_{t+j}} \prod_{k=1}^{j} \left\{ \left(\frac{\pi_{t+k-1}}{\pi} \right)^{\gamma^w} \frac{\pi}{\pi_{t+k}} \right\} \right]^{-\frac{1+\lambda^w_{t+j}}{\lambda^w_{t+j}}} \right)^{\chi} \right\} = 0,$$

where $\lambda_t^w \equiv 1/(\theta_t^w - 1)$ denotes the wage markup. Moreover, we assume that non-Ricardian households earn aggregate wage in each period.[11] Then, Eq. (4) can be expressed as

$$W_t^{-\frac{1}{\lambda_t^w}} = (1-\xi^w) \left((W_t^*)^{-\frac{1}{\lambda_t^w}} + \sum_{j=1}^{\infty} (\xi^w)^j \left[z^j W_{t-j}^* \prod_{k=1}^{j} \left\{ \left(\frac{\pi_{t-k}}{\pi} \right)^{\gamma^w} \frac{\pi}{\pi_{t-k+1}} \right\} \right]^{-\frac{1}{\lambda_t^w}} \right).$$

Ricardian household h optimally chooses $u_t(h)$, $I_t^R(h)$, and $K_t^R(h)$ under Eq. (2) and the following law of motion of capital stock:

$$K_t^R(h) = \Big(1 - \delta\big(u_t(h)\big)\Big) K_{t-1}^R(h) + \left(1 - S\left(\frac{I_t^R(h)}{I_{t-1}^R(h)} \frac{e^{z_t^i}}{z} \right) \right) I_t^R(h), \tag{5}$$

where function δ denotes the depreciation rate of capital and satisfies $\delta' > 0$, $\delta'' > 0$, $\delta(1) = \delta \in (0,1)$, and $\delta'(1)/\delta''(1) = \mu$. Thus, higher utilization further depreciates capital stock. Function S represents the adjustment cost of investment and is given by $S(x) = (x-1)^2/(2\zeta)$. z_t^i denotes a shock to the adjustment cost of investment. The first-order conditions for $u_t(h)$, $I_t^R(h)$, and

[11] This assumption ensures that the wage and labor supply decision by Ricardian households is the same as in the case without non-Ricardian households.

$K_t^R(h)$ are given by

$$R_t^k = q_t \delta'(u_t),$$

$$1 = q_t \left\{ 1 - S\left(\frac{I_t^R}{I_{t-1}^R}\frac{e^{z_t^i}}{z}\right) - S'\left(\frac{I_t^R}{I_{t-1}^R}\frac{e^{z_t^i}}{z}\right)\frac{I_t^R}{I_{t-1}^R}\frac{e^{z_t^i}}{z} \right\} + \beta \mathbf{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} q_{t+1} S'\left(\frac{I_{t+1}^R}{I_t^R}\frac{e^{z_{t+1}^i}}{z}\right)\left(\frac{I_{t+1}^R}{I_t^R}\right)^2 \frac{e^{z_{t+1}^i}}{z},$$

$$q_t = \beta \mathbf{E}_t \frac{\Lambda_{t+1}}{\Lambda_t}\left\{ R_{t+1}^k u_{t+1} + q_{t+1}\big(1 - \delta(u_{t+1})\big) \right\}.$$

Here, q_t is defined as $q_t \equiv \Lambda_t^k / \Lambda_t$, where Λ_t^k is the Lagrangean multiplier with respect to Eq. (5). Index h can be omitted since decisions for $u_t(h)$, $I_t^R(h)$, and $K_t^R(h)$ are common to all Ricardian households.

Fraction ω of households includes non-Ricardian households who are under liquidity constraints and do not possess any asset. The budget constraint of a non-Ricardian household is denoted by

$$C_t^{NR} = W_t l_t - T_t^{NR},$$

where C_t^{NR} and T_t^{NR} denote private consumption and lump-sum tax. As noted above, all non-Ricardians earn the aggregate wage and supply labor services equal to aggregate labor. It follows that they obtain equal disposable income and consume it all. As a result, non-Ricardian households can be regarded as homogenous rule-of-thumb consumers. The greater the number of non-Ricardian households, the larger the impact of fiscal expansion because unlike Ricardian households, they consume all of the increment in disposable income. For simplicity, we assume that lump-sum tax is evenly levied on both households, that is, $T_t^R = T_t^{NR} = T_t$.

3.2. Firms

A final goods firm in the perfectly competitive market produces a final good with the following constant returns technology:

$$Y_t = \left(\int_0^1 Y_t(f)^{\frac{\theta_t^p - 1}{\theta_t^p}} df \right)^{\frac{\theta_t^p}{\theta_t^p - 1}},$$

where Y_t is a final good available for consumption and investment; $Y_t(f)$ is an intermediate good produced by the intermediate goods firm f, which is continuously and uniformly distributed on [0,1]; and $\theta_t^p > 1$ is the elasticity of substitution across intermediate goods. Given the intermediate goods price $P_t(f)$, the demand function for $Y_t(f)$ is derived as

$$Y_t(f) = \left(\frac{P_t(f)}{P_t} \right)^{-\theta_t^p} Y_t \tag{6}$$

and the relationship between the final goods price and intermediate goods prices is then represented by

$$1 = \left(\int_0^1 \left(\frac{P_t(f)}{P_t} \right)^{1-\theta_t^p} df \right)^{\frac{1}{1-\theta_t^p}}. \tag{7}$$

Each monopolistically competitive intermediate goods firm has the following production function:

$$Y_t(f) = Z_t^{1-\alpha-\nu} \left(u_t K_{t-1}(f) \right)^{\alpha} l_t(f)^{1-\alpha} \left(K_{t-1}^g \right)^{\nu} - \Phi Z_t, \tag{8}$$

where $\alpha \in (0,1)$, $\nu > 0$, and $\alpha + \nu < 1$. K_{t-1}^g is public capital at the beginning of period t, and $\Phi > 0$ represents fixed cost. This specification is employed in numerous previous studies, such as Baxter and King (1993) and Iwata (2013); implies there are constant returns to scale in privately provided factors; and is the positive externality of the public capital. This productivity-enhancing property increases the effectiveness of government investment through the accumulation of public capital.

Cost minimization for intermediate goods firms leads to the following condition:

$$mc_t = \left\{ \frac{W_t}{(1-\alpha) Z_t} \right\}^{1-\alpha} \left(\frac{R_t^k}{\alpha} \right)^{\alpha} \left(\frac{K_{t-1}^g}{Z_t} \right)^{-\nu},$$

where mc_t is the Lagrangean multiplier and can be interpreted as the marginal cost of an intermediate goods firm. Index f is omitted since all firms face the same problem. Furthermore, using Eqs. (6) and (8) and first-order conditions for cost minimization, we obtain the aggregate output as follows:

$$Y_t \int_0^1 \left(\frac{P_t(f)}{P_t}\right)^{-\theta_t^p} df = Z_t^{1-\alpha-\nu}(u_t K_{t-1})^\alpha l_t^{1-\alpha}\left(K_{t-1}^g\right)^\nu - \Phi Z_t,$$

where $K_{t-1} \equiv \int_0^1 K_{t-1}(f)df$ and $l_t \equiv \int_0^1 l_t(f)df$.

Intermediate goods firms follow the Calvo price-setting rule. While intermediate goods firms can optimize their price with probability $1-\xi^p$ in each period, they set their price according to the following rule:

$$P_t(f) = \pi_{t-1}^{\gamma^p}\pi^{1-\gamma^p}P_{t-1}(f),$$

with probability ξ^p. Parameter $\gamma^p \in [0,1]$ represents the relative weight on the previous inflation rate. The optimal price is chosen to maximize

$$\mathbf{E}_t \sum_{j=0}^{\infty} (\xi^p)^j \left(\frac{\beta^j \Lambda_{t+j}}{\Lambda_t}\right) \left[\frac{P_t(f)}{P_{t+j}} \prod_{k=1}^{j} \left\{\left(\frac{\pi_{t+k-1}}{\pi}\right)^{\gamma^p} \pi\right\} - mc_{t+j}\right] Y_{t+j}(f)$$

subject to Eq. (6). Representing the optimal price as P_t^*, the first-order condition for $P_t(f)$ is

$$\mathbf{E}_t \sum_{j=0}^{\infty} (\beta\xi^p)^j \frac{\Lambda_{t+j}}{\Lambda_t \lambda_{t+j}^p} \left[\frac{P_t^*}{P_t} \prod_{k=1}^{j} \left\{\left(\frac{\pi_{t+k-1}}{\pi}\right)^{\gamma^p} \frac{\pi}{\pi_{t+k}}\right\}\right]^{-\frac{1+\lambda_{t+j}^p}{\lambda_{t+j}^p}} Y_{t+j} \left[\frac{P_t^*}{P_t} \prod_{k=1}^{j} \left\{\left(\frac{\pi_{t+k-1}}{\pi}\right)^{\gamma^p} \frac{\pi}{\pi_{t+k}}\right\}\right.$$

$$\left. - \left(1+\lambda_{t+j}^p\right) mc_{t+j}\right] = 0,$$

where $\lambda_t^p \equiv 1/(\theta_t^p - 1)$ denotes the price markup. Then, Eq. (7) can be written as

$$1 = (1-\xi^p)\left(\left(\frac{P_t^*}{P_t}\right)^{-\frac{1}{\lambda_t^p}} + \sum_{j=1}^{\infty} (\xi^p)^j \left[\frac{P_{t-j}^*}{P_{t-j}} \prod_{k=1}^{j} \left\{\left(\frac{\pi_{t-k}}{\pi}\right)^{\gamma^p} \frac{\pi}{\pi_{t-k+1}}\right\}\right]^{-\frac{1}{\lambda_t^p}}\right).$$

3.3. Monetary and fiscal authorities

Monetary policy is implemented according to the following standard rule:

$$\log R_t^n = \phi^r \log R_{t-1}^n + (1-\phi^r)\left\{\log R^n + \phi_\pi^r \left(\frac{1}{4}\sum_{j=0}^{3} \log \frac{\pi_{t-j}}{\pi}\right) + \phi_y^r \log \frac{Y_t}{Y_t^*}\right\} + z_t^r,$$

where R^n is the gross nominal interest rate in the steady state and z_t^r denotes a monetary policy shock. Y_t^* denotes potential output and is defined as

$$Y_t^* = Z_t^{1-\alpha-\nu}(ukZ_{t-1})^\alpha l^{1-\alpha}(k^g Z_{t-1})^\nu - \Phi Z_t,$$

where u and l represent the steady-state values of the capital utilization rate and labor. k and k^g are steady-state values of de-trended private capital K_t/Z_t and de-trended social capital K_t^g/Z_t, respectively.

We consider two types of government consumption, merit goods and public goods, and government investment. They are financed by government bonds and lump-sum tax levied on households. The government budget constraint is then

$$B_t = \frac{R_{t-1}^n}{\pi_t} B_{t-1} + G_t^m + G_t^p + G_t^i - T_t,$$

where B_t is the aggregate government bond and G_t^i is government investment. Social capital is accumulated by government investment as follows:

$$K_t^g = (1-\delta^g)K_{t-1}^g + G_t^i,$$

where δ^g is the depreciation rate of social capital.

Fiscal policy rules are defined by

$$\log G_t^m = \phi^{gm}(\log G_{t-1}^m + \log z) + (1-\phi^{gm})\left(\log Z_t g^m + \phi_y^{gm} \log \frac{Y_{t-1}}{Y_{t-1}^*} + \phi_b^{gm} \log \frac{B_{t-1}/Y_{t-1}}{b^{tar}}\right) + z_t^{gm},$$

$$\log G_t^p = \phi^{gp}(\log G_{t-1}^p + \log z) + (1-\phi^{gp})\left(\log Z_t g^p + \phi_y^{gp} \log \frac{Y_{t-1}}{Y_{t-1}^*} + \phi_b^{gp} \log \frac{B_{t-1}/Y_{t-1}}{b^{tar}}\right) + z_t^{gp},$$

$$\log G_t^i = \phi^{gi}\left(\log G_{t-1}^i + \log z\right) + \left(1-\phi^{gi}\right)\left(\log Z_t g^i + \phi_y^{gi}\log\frac{Y_{t-1}}{Y_{t-1}^*} + \phi_b^{gi}\log\frac{B_{t-1}/Y_{t-1}}{b^{tar}}\right) + z_t^{gi},$$

where $g^j,\ j \in \{m,p,i\}$ denotes the steady-state values of G_t^j/Z_t and b^{tar} is the target share of government bond in aggregate output. $z_t^j,\ j \in \{gm,gp,gi\}$ are shocks to each fiscal policy. In our model, government spending rules include a smoothing term and respond to output gap and the deviation of the debt-to-output ratio from its target in the previous period. As pointed out by Fève et al. (2013), an estimation without a countercyclical component underestimates the effect of Edgeworth complementarity and consequently, the fiscal multiplier. The positive (negative) sign of $\phi_y^j,\ j \in \{gm,gp,gi\}$ denotes the procyclicality (countercyclicality) of government spending. Moreover, if $\phi_b^j < 0,\ j \in \{gm,gp,gi\}$, government expenditure decreases in response to an increase in government debt. Such “spending reversals” rules (Corsetti et al., 2012) reduce future inflation by government spending shocks and a rise in interest rate through the monetary policy rule. This mechanism induces an increase in private consumption.

The taxation rule is denoted by

$$\log T_t = \phi^T(\log T_{t-1} + \log z) + (1-\phi^T)\left(\log Z_t\tau - \phi_y^T\log\frac{Y_{t-1}}{Y_{t-1}^*} - \phi_b^T\log\frac{B_{t-1}/Y_{t-1}}{b^{tar}}\right),$$

where τ represents a steady-state value for T_t/Z_t. Analogous to fiscal policy rules, lump-sum tax depends on its own lagged value, output gap, and debt-to-output ratio.

3.4. Market clearing, aggregation, and structural shocks

The market clearing condition is denoted by

$$Y_t = C_t + I_t + G_t^m + G_t^p + G_t^i + xZ_te^{z_t^x}.$$

Here, C_t and I_t are aggregate consumption and aggregate investment satisfying

$$C_t = \omega C_t^{NR} + \int_\omega^1 C_t^R(h)dh,$$

$$I_t = \int_\omega^1 I_t^R(h)dh.$$

x denotes the other de-trended demand factor, such as net exports at a steady state, and z_t^x is the exogenous demand shock. Private capital and government bond are aggregated as follows:

$$K_t = \int_\omega^1 K_t^R(h)dh,$$

$$B_t = \int_\omega^1 B_t^R(h)dh.$$

Finally, each structural shock follows a first-order autoregressive process with an i.i.d.- normal error term:

$$z_t^j = \rho^j z_{t-1}^j + \epsilon_t^j, \qquad \epsilon_t^j \sim N(0, \sigma_j^2),$$

where $j \in \{b, l, z, i, r, gm, gp, gi, x\}$.

As noted above, our model contains a balanced growth trend. Specifically, C_t^R, C_t^{NR}, C_t^e, C_t, I_t^R, I_t, K_t^R, K_t, K_t^g, Y_t, Y_t^*, B_t^R, B_t, G_t^m, G_t^p, G_t^i, T_t, W_t, and W_t^* increase at gross rate z on the balanced growth path. In estimating the model parameters, we de-trend and log-linearize the model. The de-trended and log-linearized model is presented in Appendix.

4. Bayesian estimation

The model parameters are estimated with a standard Bayesian technique based on the Markov Chain Monte Carlo (MCMC) method. Using the solution equations of the log-linearized model and observation equations linking the model variables to data, we can evaluate the log likelihood function using the Kalman filter. Furthermore, combining the log likelihood with the prior distribution of parameters, we perform MCMC sampling on the basis of a Metropolis–Hastings algorithm to obtain the posterior distribution. We generate two Markov chains with 500,000 draws and discard the first 200,000 draws as burn-in draws.

4.1. Data, calibration, and priors

Most studies on Japanese DSGE models with Bayesian estimations adopt data prior to 1999 to exclude the zero interest rate periods (e.g., Sugo and Ueda, 2008; Iwata, 2011, 2013; Hirose and Kurozumi, 2012). A zero lower bound (ZLB) constraint for interest rate faces problems of non-linearity and indeterminacy (e.g., Braun and Waki, 2006). Furthermore, a Bayesian estimation based on a Kalman filter cannot be applied to non-linear models.[12] Meanwhile, conducting a Monte Carlo simulation, Hirose and Inoue (2016) show that an estimation neglecting the ZLB constraint has limited effects on posterior mean estimates and impulse responses. Therefore, we use a dataset with more recent information and estimate the model using data prior to 1999 in the robustness analysis.

We employ ten quarterly data series in Japan from 1981:Q1 to 2012:Q4, as follows: real GDP, real private consumption, real private investment, real wage, real merit goods consumption, real public goods consumption, real government investment, labor hour, inflation rate, and nominal interest rate.[13] These series are related to model variables through the following observation equations:

$$\begin{bmatrix} \Delta\ln Y_t \\ \Delta\ln C_t \\ \Delta\ln I_t \\ \Delta\ln W_t \\ \Delta\ln G_t^m \\ \Delta\ln G_t^p \\ \Delta\ln G_t^i \\ \ln l_t \\ \Delta\ln P_t \\ \ln R_t^n \end{bmatrix} = \begin{bmatrix} z^* + z_t^z \\ z^* + z_t^z \\ z^* + z_t^z \\ z^* + z_t^z \\ z^* + z_t^z \\ z^* + z_t^z \\ z^* + z_t^z \\ l \\ \pi^* \\ r^* + \pi^* \end{bmatrix} + \begin{bmatrix} \tilde{y}_t - \tilde{y}_{t-1} \\ \tilde{c}_t - \tilde{c}_{t-1} \\ \tilde{\imath}_t - \tilde{\imath}_{t-1} \\ \tilde{w}_t - \tilde{w}_{t-1} \\ \tilde{g}_t^m - \tilde{g}_{t-1}^m \\ \tilde{g}_t^p - \tilde{g}_{t-1}^p \\ \tilde{g}_t^i - \tilde{g}_{t-1}^i \\ \tilde{l}_t \\ \tilde{\pi}_t \\ \tilde{r}_t^n \end{bmatrix},$$

[12] Kitamura (2010) employs a particle filter technique and estimates a DSGE model considering the ZLB constraint.

[13] Since our model allows the balanced growth trend, data series are not HP filtered in Bayesian estimation, unlike the VAR analysis in Section 2.

where lower-case letters with tildes denote the log-deviation of de-trended variables from their steady-state level; z^*, π^*, and r^* are the net growth rate of technology, net inflation rate, and net real interest rate at steady state, respectively; and l is the steady-state level of labor hour.

Following Sugo and Ueda (2008) and Hirose and Kurozumi (2012), certain parameters and steady-state values are calibrated as follows. The capital elasticity of output α and the steady-state depreciation rate of capital δ are set at 0.37 and 0.015. The output ratios of merit goods consumption g^m/y, public goods consumption g^p/y, and government investment g^i/y are 0.083, 0.067, and 0.05, respectively.[14] The target debt-to-output ratio b^{tar}, output ratio of external demand at steady state x/y, and depreciation rate of social capital δ^g are set at 0.6, 0.1, and 0.01, respectively.

While the priors of most estimated parameters are selected on the basis of previous works on Japan, such as Sugo and Ueda (2008), Hirose and Kurozumi (2012), and Iwata (2013), we adopt the following priors regarding the parameters of our interest. To neutrally evaluate the degree of Edgeworth complementarity or substitutability, the priors of ν^{gm} and ν^{gp} are normal distributions with mean 0 and standard deviation 1.5. While Fève et al. (2013) show that the cyclicality of government spending affects the estimation of complementarity parameters, to the best of our knowledge, there is no consensus on whether each government spending rule in Japan is countercyclical or procyclical. Therefore, we choose normal distributions with mean 0 and standard deviation 0.5 as priors of ϕ_y^{gm}, ϕ_y^{gp}, and ϕ_y^{gi}. Moreover, to investigate whether the spending reversals effect of government expenditures are observed, ϕ_b^{gm}, ϕ_b^{gp}, and ϕ_b^{gi} are ex ante assumed to follow normal distributions with mean 0 and standard deviation 0.5. Finally, unlike previous studies, we estimate the parameter of wage markup λ^w and choose a normal distribution with mean 0.2 and standard deviation 0.1 as the prior.

[14] We set the output ratio of total government consumption at 0.15 and determine the ratio of merit goods consumption to public goods consumption on the basis of the average of the sample period.

4.2. Posterior distributions

Table 1 presents the priors, posterior means, and 90% credible intervals. Most of the posterior means of the standard structural parameters are similar to those of previous studies that do not account for zero interest rate periods. The estimated posterior means of ν^{gm} and ν^{gp} are -1.62 and 0.9, respectively. These results indicate that merit goods are complements for private consumption, while public goods are substitutes, similar to Fiorito and Kollintzas (2004) who focus on European countries. The posterior mean of ν is 0.11, which is larger than Iwata's (2013) result. The estimated mean value of the fraction of non-Ricardian households ω is 0.08, which is considerably smaller than that in Iwata (2011).[15]

[Table 1]

Our estimation indicates that all government spending in Japan are highly persistent and fluctuate not by GDP gap and debt-GDP ratio but by shocks because the posterior means of ϕ^{gm}, ϕ^{gp}, and ϕ^{gi} are, respectively, 0.98, 0.97, and 0.96. The estimated posterior means of ϕ_y^{gm}, ϕ_y^{gp}, and ϕ_y^{gi} are 0.4, 0.36, and -0.02, respectively, indicating that government consumption and investment are weakly procyclical and countercyclical, respectively. According to Fève et al. (2013), the estimated relationship between government and private consumption are more likely to be substitutive under a procyclical spending rule. However, the influence of the procyclicality of government spending on the estimation of complementarity parameters is considered to be negligible because, as shown above, the coefficients of lag variables are sufficiently large and the 90% credible intervals of coefficients for output gap terms include zero in all cases. The posterior means of

[15] The estimates of Japan's non-Ricardian share vary across previous studies. For example, the share is estimated to be 0.4–0.5 during 1970–1983 (Ogawa, 1990) and about 0.25 during 1980–1998 (Iwata, 2011). More recently, employing data from a Japanese household survey conducted during 1989–2009, Hara et al. (2016) report that the share is approximately 0.13 and the majority of them are "wealthy" hand-to-mouth households who have substantial wealth held in illiquid assets, such as housing, but behave like traditional hand-to-mouth households.

ϕ_b^{gm}, ϕ_b^{gp}, and ϕ_b^{gi} are, respectively, −0.19, −0.07, and 0.18, and the spending reversals effect is significantly observed only in merit goods. Similar to the result for GDP gap terms, the spending reversals effects have a limited impact on the effect of fiscal expansion given the strong inertia in spending rules.

4.3. Impulse responses and fiscal multipliers

Figs. 4 and 5 present the impulse responses of key economic variables to merit goods and public goods expenditure shocks. Private consumption increases in response to a merit goods shock and slightly decreases to a public goods shock. This opposite response stems from the degree of complementarity of merit goods and public goods because both estimated spending rules, and therefore, their spending streams generated by shocks are almost the same. This result does not completely replicate that of the above VAR analysis because the impulse responses in Section 2 show that both merit and public goods shocks significantly increase private consumption. Meanwhile, both analyses suggest that a merit goods shock has a more positive effect on private consumption than a public goods one.

Furthermore, although Galí et al.'s (2007) numerical analysis shows that the fraction of non-Ricardian households ω is required to be roughly 0.25 to induce the crowding-in of private consumption by fiscal expansion in the case where the rule-of-thumb household is the only source of crowding-in, our result indicates that crowding-in arises through Edgeworth complementarity even if ω = 0.08. This suggests that the complementarity between private and government consumption is quantitatively a significant factor in explaining the crowding-in of private consumption.

[Fig. 4]

[Fig. 5]

As for other variables, the shapes of impulses are similar in both figures. However, the effects of a public goods shock are more ambiguous than those of merit goods, particularly on output and labor. These trends are similar to those of time series analysis results.

The fiscal multipliers for merit goods and public goods are 1.91 and 0.26, reflecting the estimates of complementarity parameters. This result indicates that the effect of fiscal expansion largely varies by type of fiscal spending and merit goods expenditure has a large positive effect on the economy. The fiscal multiplier for public investment is 0.92, which is similar to the multiplier reported in previous studies.

Next, we examine the medium- and long-term effects of government expenditures. Fig. 6 depicts the present-value multipliers defined by Mountford and Uhlig (2009). The effect of both government consumptions monotonically decreases and has a negative impact in the medium and long run. In particular, the effect of public goods expenditure is negative in approximately the fourth period and the cumulative negative impact is maintained in the long run. On the other hand, the government investment maintains a positive effect in the long run through the positive external effect of social capital.

[Fig. 6]

5. Robustness checks

This section conducts a robustness analysis and scrutinizes the complementarity between merit goods and private consumption found in the previous section. Specifically, we estimate models with certain alternative specifications and different datasets and then, compare the results.

5.1. Alternative specifications

We now estimate the model on the basis of the two following alternative specifications. First, as discussed by Iwata (2013), the estimated complementarity between merit goods and private consumption can stem from Japan's national care system, in which people incur only a part of their health and long-term care payments, rather than household preferences. In this case, the complementarity between merit goods and private consumption can be overestimated. To consider this institutional effect, we modify the observation equation of merit goods as follows:

$$\Delta \ln G_t^m = z^* + z_t^z + \tilde{g}_t^m - \tilde{g}_{t-1}^m + \phi_c^{gm}(z^* + z_t^z + \tilde{c}_t - \tilde{c}_{t-1}), \tag{9}$$

where $\phi_c^{gm} > 0$. This equation exhibits that the observed variation in merit goods expenditure is partially associated with that in private consumption.

Second, we assume that the complementarity parameters regarding merit and public goods are common, that is, $\nu^{gm} = \nu^{gp}$. This specification assumes a situation in which merit and public goods are not distinguished as in Okubo (2003) and Iwata (2013).[16] We then show how the division of government consumption affects the estimation result and discuss the validity of specifications.

Table 2 presents the estimation results for the selected parameters under alternative specifications and in the baseline model presented in the previous section. Column 1 presents the result for the case in which the observation equation for merit goods expenditure is replaced by Eq. (9) and the absolute value of the posterior mean of ν^{gm} is smaller than that in the baseline model. This indicates that the complementarity between merit goods and private consumption is weaker and as a result, the multiplier for merit goods is smaller. Meanwhile, since the log data density in the baseline model is greater than that in the model with Eq. (9), the degree of complementarity in the baseline may not be necessarily overestimated.[17] The estimation results of the other parameters are almost the same as those in the baseline model, except for ν^{gp}. ν^{gp}, the degree of substitutability

[16] Note that the policy rules differ between merit and public goods, which is similar to the above analysis. Therefore, the difference in the effects of merit and public goods in this model can be attributed to their policy rules.

[17] We further test several specifications other than Eq. (9) to consider the effect of health and long-term care insurance systems on the estimates of complementarity. As alternative specifications, we adopt certain modified merit goods spending rules wherein merit goods expenditure increases with a rise in private consumption. In these cases, the estimation results are almost the same as those for the baseline case, and thus, the effects of modifications are not captured.

between public goods and private consumption, is estimated to be smaller. Therefore, the multiplier for public goods increases.

[Table 2]

Column 2 presents the estimation results in the case where complementarity parameters are common to merit and public goods. The posterior mean of ν^{gc} is −0.47, indicating that government consumption is a complement of private consumption and the degree is smaller than that of merit goods in the baseline model. This result is almost the same as Iwata's (2013) estimates and suggests that the complementarity of merit goods is partially offset by the substitutability of public goods and, consequently, total government consumption seems to be weakly complemented with private consumption. Moreover, in this specification, the log data density is smaller than that in the baseline model, and thus, the baseline specification can better explain the data series.

5.2. Different datasets

In this subsection, we estimate our model using two datasets. First, we limit the sample period to 1998:Q4. From 1999 to 2012, Japan experienced a rapid increase in its aging population and in 2000, it launched the public long-term care insurance system. These events have induced an increase in health and long-term care payments by households, and consequently, in merit goods expenditure through the systems. In this case, complementarity can be overestimated because spending on merit goods can be more positively correlated with private consumption when a higher number of elderly people access these institutions. Moreover, those who care for their aged relatives could increase private consumption, such as eating out, by utilizing the public long-term care system. This could have caused the complementarity to strengthen since 2000. Therefore, the estimated Edgeworth complementarity is expected to be weaker when using data prior to 1999. In addition, as noted above, estimations that neglect the ZLB constraint can cause a bias in the results. Thus, we investigate whether the complementarity is observed even when considering various factors since 1999.

Second, to further examine the effects of Japan's institutions on the complementarity, we conduct an estimation using an alternative private consumption series, which exclude household spending on healthcare, insurance, and education. In this environment, an increase in private consumption does not involve additional merit goods expenditure, and therefore, if complementarity is observed, it reflects the positive external effect of merit goods expenditure on private consumption that is irrelevant to health, insurance, and educational spending.

Table 3 presents the estimation results of the parameters in interest when using different datasets. Column 1, which shows the results for sample period 1981:Q1–1998:Q4, shows that the complementarity of merit goods is smaller than that in the baseline model, as expected. Thus, when the sample period is extended to 2012:Q4, an increase in the aging population and establishment of long-term care insurance system can increase the estimates of merit goods' complementarity. This result seems to be consistent with that of Iwamoto et al. (2010), who show that since the introduction of long-term care insurance, even if households include a family member with a disability, they decrease their consumption to less than the previous level. Meanwhile, the substitutability of public goods is weaker and the causes are ambiguous because it appears that an ageing society and long-term care insurance system are not directly relevant to the preference for public goods. Furthermore, the social capital effect of government investment is estimated to be smaller.

As for spending rules, the posterior mean of the coefficients of lag variables are smaller and the spending reversals effects are observed for all expenditure types. A decrease in the persistency of government spending alleviates the negative wealth effect, and as Corsetti et al. (2012) point out, the spending reversals effect constraints the rise in interest rate through the monetary policy rule. Both these effects increase that of fiscal expansions. As a result, compared with the baseline case, the multipliers for merit goods and government investment decrease to 1.23 and 0.88, respectively, and for public goods, it rises to 0.84.[18] While the change in the complementarity or substitutability parameter estimates reduce the difference in the effects of merit and public goods, merit goods expenditure stimulates the economy more than public goods expenditure also in the periods 1981:Q1–1998:Q4.

[Table 3]

Column 2 presents the results in the case where data on private consumption are replaced. In this case as well, the complementarity of merit goods is significant, and merit goods have a positive external effect on private consumption excluding healthcare, insurance, and education. Meanwhile, the degree marginally decreases to less than that in the baseline case, and therefore, the multiplier reduces to 1.84. The estimation results for other variables are almost the same.

6. Concluding Remarks

This study constructs a DSGE model and empirically investigates the effects of fiscal policy in Japan with focus on the functional difference in government expenditures. Specifically, we divide government consumption into merit and public goods and examine each external effect on private consumption. Our estimation indicates that merit goods are complements for private consumption, while public goods are substitutes. Consequently, expenditure on merit goods more positively affects the economy than public goods. Furthermore, we show that Japanese government expenditures are highly persistent and their response to a GDP gap and national debt is limited. These findings suggest that Edgeworth complementarity is the major factor causing a fiscal crowding-in effect on

[18] Although not shown in Column 1 of Table 3, when the sample period ranges from 1981:Q1 to 1998:Q4, the mean estimate of the persistency of monetary policy ϕ^r decreases from 0.71 to 0.61, which indicates that the monetary policy rule is estimated such that it responds more flexibly when the sample does not include zero interest rate periods. This is consistent with the finding of recent studies that focus on ZLB (e.g., Hirose and Inoue, 2016). As Christiano et al. (2011) point out, the effect of fiscal expansion is smaller when ZLB constraint is not binding and the interest rate is flexible.

private consumption.

Some additional analyses show that the complementarity between merit goods and private consumption is robust even when accounting for the influence of public health and the long-term care system and the recently growing aging population. In addition, our results also suggest that the complementarity has strengthened since 1999 and merit goods expenditure complements private consumption excluding healthcare, insurance, and education.

While we focus on the different effects of fiscal expenditure on several functional categories, this study can be extended, at least, in the two following manners. First, in addition to expenditure schemes, taxation schemes should be considered. Since value-added, labor income, and capital income taxes differently distort households' decision making, examining how government expenditure is financed can change our estimation results and policy effects. Second, heterogeneity in households is an important issue. Heterogeneity in income and asset can generate different policy outcomes through mechanisms not considered in the representative agent model. This extension would be of particular significance when richer taxation schemes are incorporated in the model. Moreover, introducing age heterogeneity allows us to directly examine the effect of demographic change on public and private spending. These are interesting and important future research topics.

Appendix

Here, we present the log-linearized version of our model. The non-stationary variables in period t are de-trended by technology level Z_t and represented by lowercase letters with subscript t. Their steady-state levels are presented without subscripts. On the other hand, the log-deviations from steady-state levels are written in lowercase letters with a tilde and subscript t. For example, $y_t \equiv Y_t/Z_t$ and $\tilde{y}_t \equiv \log y_t - \log y$.[19]

[19] The de-trended version of the Lagrangean multiplier is defined as $\lambda_t \equiv \Lambda_t Z_t^{\sigma}$. Moreover, the shocks z_t^w and z_t^p

$$\frac{c^e}{y}\tilde{c}_t^e = \frac{c^R}{y}\tilde{c}_t^R + \frac{\nu^{gm}g^m}{y}\tilde{g}_t^m + \frac{\nu^{gp}g^p}{y}\tilde{g}_t^p$$

$$\left(1-\frac{\theta}{z}\right)\left(1-\frac{\beta\theta}{z^\sigma}\right)\tilde{\lambda}_t = -\sigma\left\{\tilde{c}_t^e - \frac{\theta}{z}(\tilde{c}_{t-1}^e - z_t^z)\right\} + \left(1-\frac{\theta}{z}\right)z_t^b$$

$$+\frac{\beta\theta}{z^\sigma}\left\{\sigma\left(\mathbf{E}_t\tilde{c}_{t+1}^e + \mathbf{E}_t z_{t+1}^z - \frac{\theta}{z}\tilde{c}_t^e\right) - \left(1-\frac{\theta}{z}\right)\mathbf{E}_t z_{t+1}^b\right\}$$

$$\tilde{\lambda}_t = \mathbf{E}_t\tilde{\lambda}_{t+1} - \sigma\mathbf{E}_t z_{t+1}^z + \tilde{R}_t^n - \mathbf{E}_t\tilde{\pi}_{t+1}$$

$$\widetilde{w}_t - \widetilde{w}_{t-1} + \tilde{\pi}_t - \gamma^w\tilde{\pi}_{t-1} + z_t^z = \beta z^{1-\sigma}(\mathbf{E}_t\widetilde{w}_{t+1} - \widetilde{w}_t + \mathbf{E}_t\tilde{\pi}_{t+1} - \gamma^w\tilde{\pi}_t + \mathbf{E}_t z_{t+1}^z)$$

$$+\frac{1-\xi^w}{\xi^w}\frac{(1-\xi^w\beta z^{1-\sigma})\lambda^w}{\lambda^w + \chi(1+\lambda^w)}\left(\chi\tilde{l}_t - \tilde{\lambda}_t - \widetilde{w}_t + z_t^b\right) + z_t^w$$

$$\tilde{k}_t = \frac{1-\delta}{z}\left(\tilde{k}_{t-1} - z_t^z\right) - \frac{R^k}{z}\tilde{u}_t + \left(1-\frac{1-\delta}{z}\right)\tilde{\imath}_t$$

$$\tilde{u}_t = \mu\left(\tilde{R}_t^k - \tilde{q}_t\right)$$

$$\frac{\tilde{\imath}_t - \tilde{\imath}_{t-1} + z_t^z + z_t^i}{\zeta} = \tilde{q}_t + \frac{\beta z^{1-\sigma}(\mathbf{E}_t\tilde{\imath}_{t+1} - \tilde{\imath}_t + \mathbf{E}_t z_{t+1}^z + \mathbf{E}_t z_{t+1}^i)}{\zeta}$$

$$\tilde{q}_t = \mathbf{E}_t\tilde{\lambda}_{t+1} - \tilde{\lambda}_t - \sigma\mathbf{E}_t z_{t+1}^z + \frac{\beta}{z^\sigma}\left\{R^k\mathbf{E}_t\tilde{R}_{t+1}^k + (1-\delta)\mathbf{E}_t\tilde{q}_{t+1}\right\}$$

$$\frac{c^{NR}}{y}\tilde{c}_t^{NR} = \frac{wl}{y}\left(\widetilde{w}_t + \tilde{l}_t\right) - \frac{\tau}{y}\tilde{\tau}_t$$

$$\tilde{y}_t = (1+\phi)\left\{(1-\alpha)\tilde{l}_t + \alpha\left(\tilde{u}_t + \tilde{k}_{t-1} - z_t^z\right) + \nu(\tilde{k}_{t-1}^g - z_t^z)\right\}$$

$$\widetilde{w}_t - \tilde{R}_t^k = \tilde{u}_t + \tilde{k}_{t-1} - \tilde{l}_t - z_t^z$$

$$\widetilde{mc}_t = (1-\alpha)\widetilde{w}_t + \alpha\tilde{R}_t^k - \nu(\tilde{k}_{t-1}^g - z_t^z)$$

$$\tilde{\pi}_t - \gamma^p\tilde{\pi}_{t-1} = \beta z^{1-\sigma}(\mathbf{E}_t\tilde{\pi}_{t+1} - \gamma^p\tilde{\pi}_t) + \frac{(1-\xi^p)(1-\xi^p\beta z^{1-\sigma})}{\xi^p}\widetilde{mc}_t + z_t^p$$

$$(\lambda^p - \phi)\tilde{d}_t = \lambda^p\tilde{y}_t - (1+\phi)\widetilde{mc}_t$$

$$\tilde{R}_t^n = \phi^r\tilde{R}_{t-1}^n + (1-\phi^r)\left\{R^n + \phi_\pi^r\left(\frac{1}{4}\sum_{j=0}^{3}\tilde{\pi}_{t-j}\right) + \phi_y^r(\tilde{y}_t - \tilde{y}_t^*)\right\} + z_t^r$$

$$\tilde{y}_t^* = -(1+\phi)(\alpha+\nu)z_t^z$$

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are defined as $z_t^w \equiv (1-\xi^w)(1-\xi^w z^{1-\sigma})\lambda^w\left(\tilde{\lambda}_t^w + z_t^l\right)/[\xi^w\{\lambda^w + \chi(1+\lambda^w)\}]$ and $z_t^p \equiv (1-\xi^p)(1-\beta\xi^p z^{1-\sigma})\tilde{\lambda}_t^p/\xi^p$.

$$b^{tar}\tilde{b}_t = \frac{b^{tar}}{\beta z^{1-\sigma}}\left(\tilde{R}^n_{t-1} - \tilde{\pi}_t - z^z_t + \tilde{b}_{t-1}\right) + \frac{g^m}{y}\tilde{g}^m_t + \frac{g^p}{y}\tilde{g}^p_t + \frac{g^i}{y}\tilde{g}^i_t - \frac{\tau}{y}\tilde{\tau}_t$$

$$\tilde{k}^g_t = \frac{1-\delta^g}{z}\left(\tilde{k}^g_{t-1} - z^z_t\right) + \left(1 - \frac{1-\delta^g}{z}\right)\tilde{g}^i_t$$

$$\tilde{g}^m_t = \phi^{gm}(\tilde{g}^m_{t-1} - z^z_t) + (1-\phi^{gm})\left\{\phi^{gm}_y(\tilde{y}_{t-1} - \tilde{y}^*_{t-1}) + \phi^{gm}_b\left(\tilde{b}_{t-1} - \tilde{y}_{t-1}\right)\right\} + z^{gm}_t$$

$$\tilde{g}^p_t = \phi^{gp}(\tilde{g}^p_{t-1} - z^z_t) + (1-\phi^{gp})\left\{\phi^{gp}_y(\tilde{y}_{t-1} - \tilde{y}^*_{t-1}) + \phi^{gp}_b\left(\tilde{b}_{t-1} - \tilde{y}_{t-1}\right)\right\} + z^{gp}_t$$

$$\tilde{g}^i_t = \phi^{gi}(\tilde{g}^i_{t-1} - z^z_t) + \left(1-\phi^{gi}\right)\left\{\phi^{gi}_y(\tilde{y}_{t-1} - \tilde{y}^*_{t-1}) + \phi^{gi}_b\left(\tilde{b}_{t-1} - \tilde{y}_{t-1}\right)\right\} + z^{gi}_t$$

$$\tilde{\tau}_t = \phi^T(\tilde{\tau}_{t-1} - z^z_t) + (1-\phi^T)\left\{\phi^T_y(\tilde{y}_{t-1} - \tilde{y}^*_{t-1}) + \phi^T_b\left(\tilde{b}_{t-1} - \tilde{y}_{t-1}\right)\right\} + z^T_t$$

$$\frac{c}{y}\tilde{c}_t = \frac{(1-\omega)c^R}{y}\tilde{c}^R_t + \frac{\omega c^{NR}}{y}\tilde{c}^{NR}_t$$

$$\tilde{y}_t = \frac{c}{y}\tilde{c}_t + \frac{i}{y}\tilde{\imath}_t + \frac{g^m}{y}\tilde{g}^m_t + \frac{g^p}{y}\tilde{g}^p_t + \frac{g^i}{y}\tilde{g}^i_t + \frac{x}{y}z^x_t$$

$$z^j_t = \rho^j z^j_{t-1} + \epsilon^j_t,$$

$$\epsilon^j_t \sim N\left(0, \sigma^2_j\right), j \in \{b, w, p, z, i, x, r, gm, gp, gi, T\}$$

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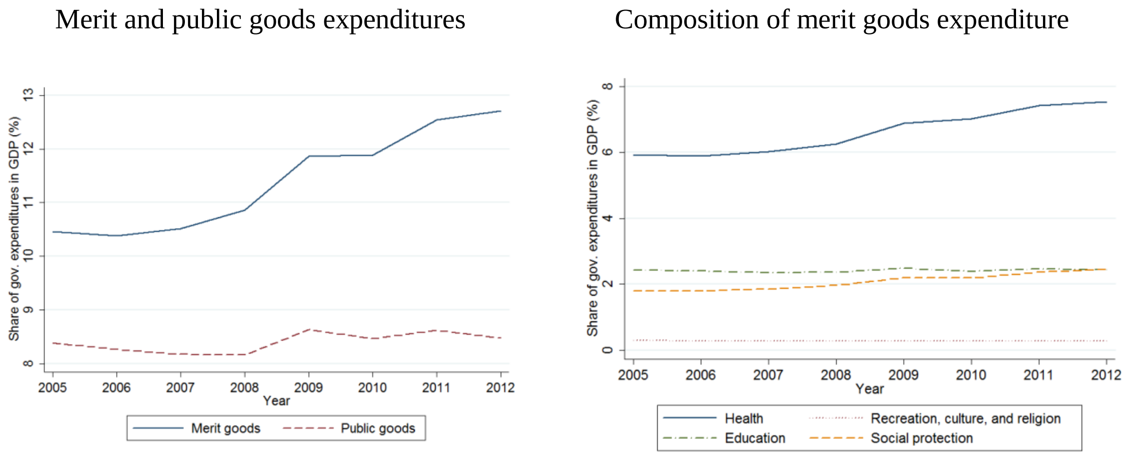

Fig. 1. Government expenditure as a share of GDP in Japan. *Note:* The left panel depicts merit goods (solid line) and public goods (dashed line) expenditures as a share of GDP for 2005–2012. Data for merit and public goods expenditures are respectively those of individual and collective consumption expenditures of the general government and are obtained from the Cabinet Office. The right panel depicts the composition of merit goods expenditure during the same period: health (solid line); recreation, culture, and religion (dotted line); education (dashed-dotted line); and social protection (dashed line) expenditures as a share of GDP.

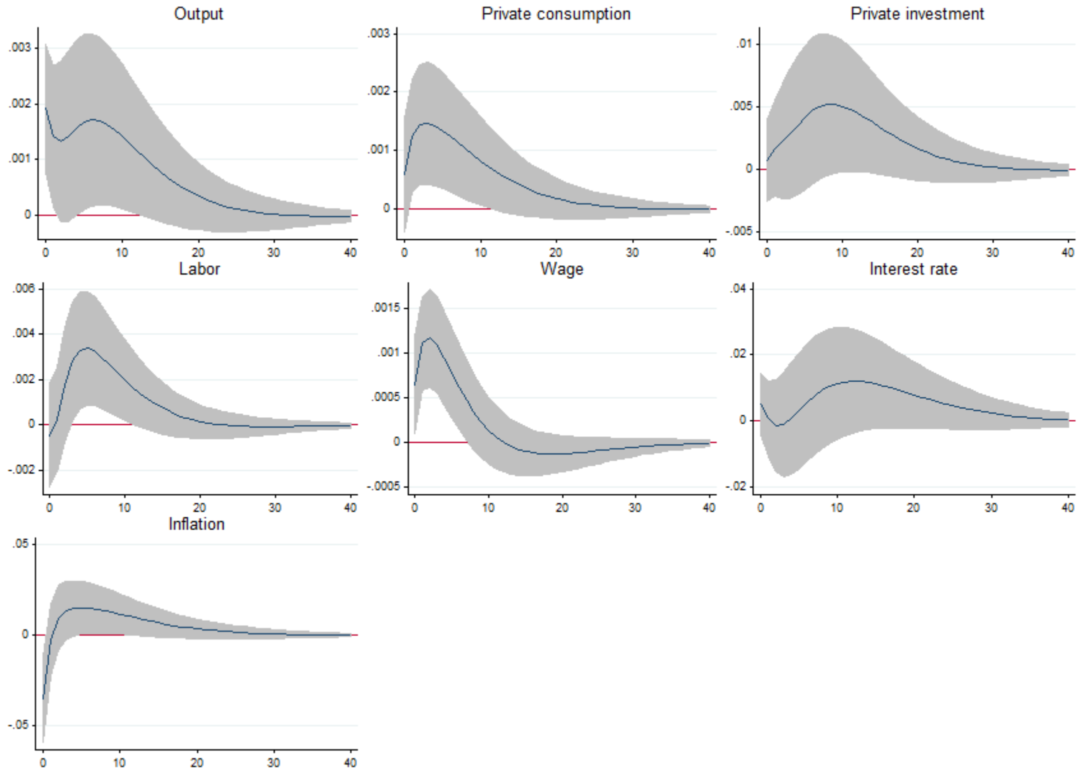

Fig. 2. Impulse responses to a merit goods expenditure shock. *Note:* The panels show the impulse responses that are based on the VAR model to a one standard deviation shock of merit goods expenditure. The bands indicate the 90% confidence interval.

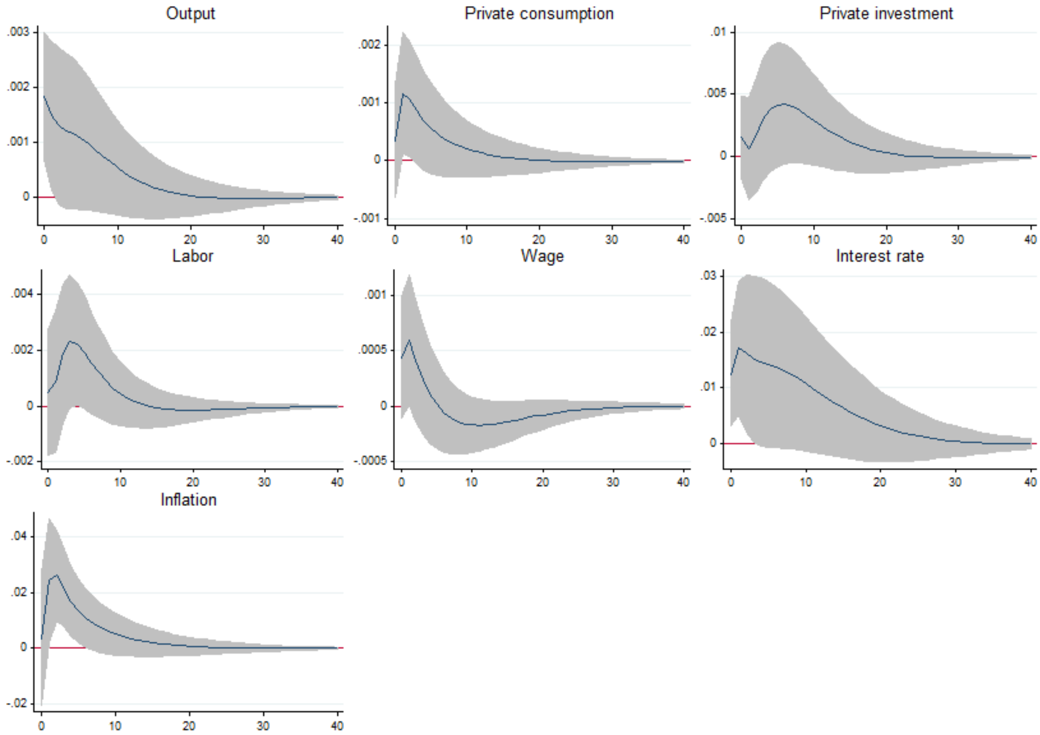

Fig. 3. Impulse responses to a public goods expenditure shock. *Note:* The panels show the impulse responses that are based on the VAR model to a one standard deviation shock of public goods expenditure. The bands indicate the 90% confidence interval.

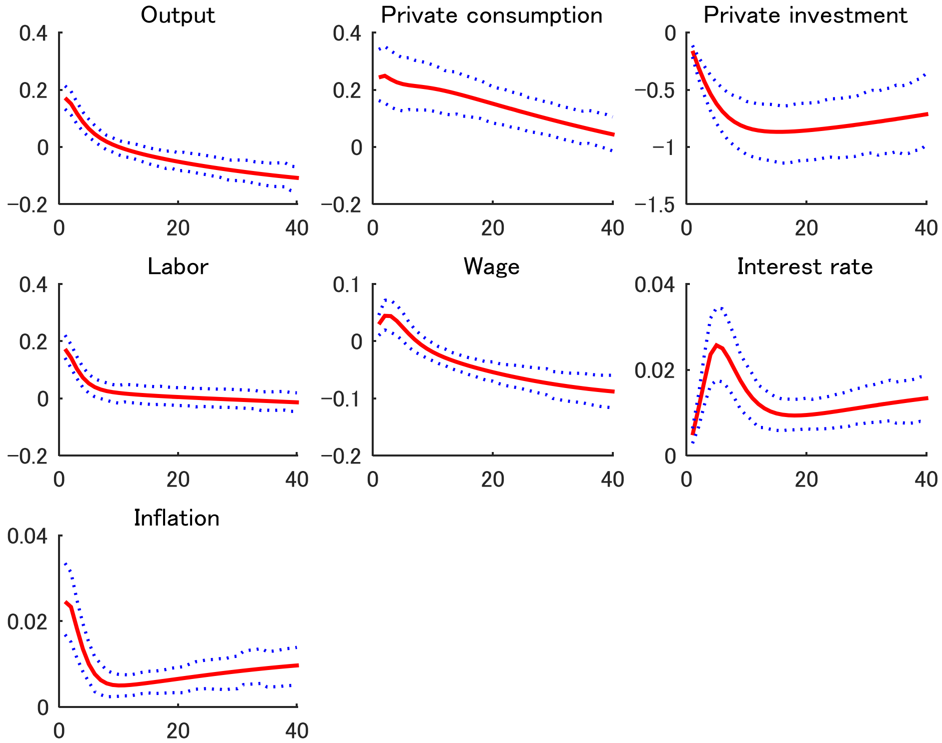

Fig. 4. Impulse responses to a merit goods expenditure shock in DSGE model. *Note:* The panels show the impulse responses that are based on the DSGE model to a one standard deviation shock of merit goods expenditure. The dotted lines indicate the 90% credible interval.

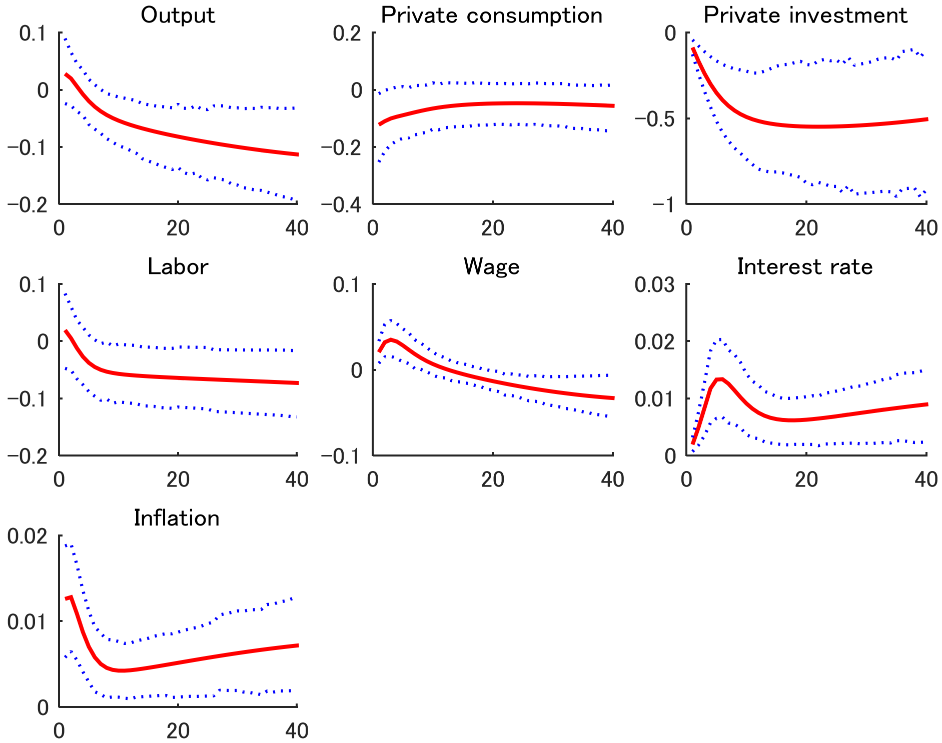

Fig. 5. Impulse responses to a public goods expenditure shock in DSGE model. *Note:* The panels show the impulse responses that are based on the DSGE model to a one standard deviation shock of public goods expenditure. The dotted lines indicate the 90% credible interval.

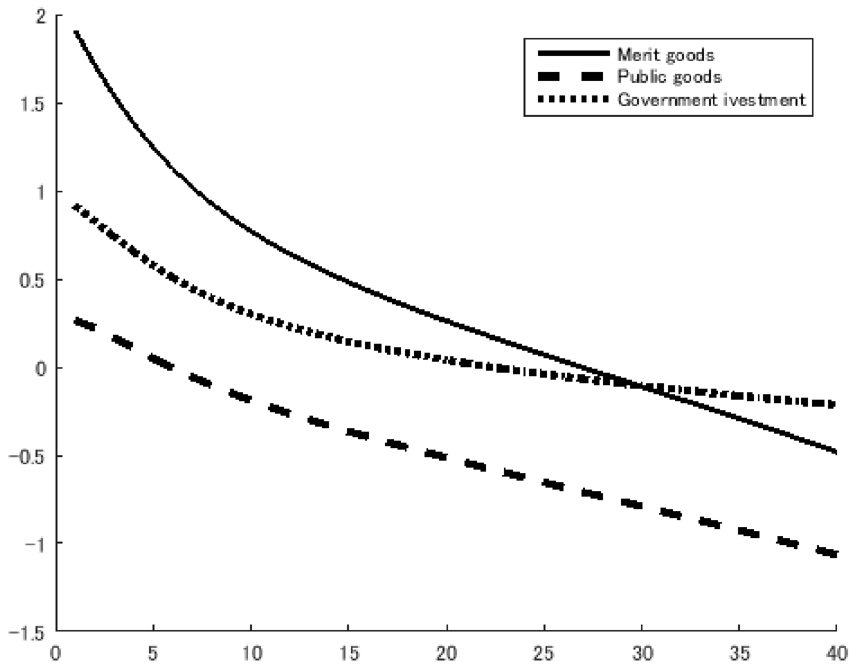

Fig. 6. Present-value multipliers. *Note:* The present-value multiplier is defined following Mountford and Uhlig (2009). We compute the multipliers using the posterior mean of parameters and standard deviation of each policy shock. Solid, dashed, and dotted lines represent the present-value multipliers for merit goods, public goods, and government investment spending, respectively.

Table 1

Prior and posterior distributions.

	prior			posterior		
	type	mean	s. d.	mean	90% interval	
ν^{gm}	Normal	0	1.5	-1.620	-2.140	-1.088
ν^{gp}	Normal	0	1.5	0.902	0.070	1.790
ν	Gamma	0.1	0.025	0.113	0.070	0.157
ω	Beta	0.25	0.1	0.077	0.027	0.129
σ	Gamma	1	0.375	2.353	1.960	2.735
θ	Beta	0.7	0.15	0.400	0.276	0.537
χ	Gamma	2	0.75	5.009	3.640	6.298
$1/\zeta$	Gamma	4	1.5	6.325	3.597	8.967
μ	Gamma	1	1	0.937	0.443	1.428
ϕ	Gamma	0.075	0.0125	0.071	0.051	0.090
γ^w	Beta	0.5	0.25	0.499	0.158	0.851
ξ^w	Beta	0.375	0.1	0.335	0.234	0.440
λ^w	Gamma	0.2	0.1	0.225	0.092	0.358
γ^p	Beta	0.5	0.25	0.139	0.004	0.263
ξ^p	Beta	0.375	0.1	0.720	0.681	0.761
λ^p	Gamma	0.15	0.05	0.483	0.346	0.626
z^*	Gamma	0.19	0.05	0.154	0.097	0.209
l^*	Normal	0	0.05	0.001	-0.078	0.081
π^*	Gamma	0.175	0.05	0.183	0.101	0.266
r^*	Gamma	0.498	0.05	0.527	0.452	0.598
ϕ^r	Beta	0.8	0.1	0.702	0.641	0.769
ϕ_π^r	Gamma	1.7	0.1	1.796	1.639	1.944
ϕ_y^r	Gamma	0.125	0.05	0.030	0.013	0.046
ϕ^{gm}	Beta	0.8	0.1	0.977	0.966	0.989
ϕ_y^{gm}	Normal	0	0.5	0.399	-0.434	1.243
ϕ_b^{gm}	Normal	0	0.5	-0.190	-0.271	-0.110
ϕ^{gp}	Beta	0.8	0.1	0.968	0.941	0.996
ϕ_y^{gp}	Normal	0	0.5	0.358	-0.525	1.256
ϕ_b^{gp}	Normal	0	0.5	-0.071	-0.146	0.004
ϕ^{gi}	Beta	0.8	0.1	0.955	0.933	0.974
ϕ_y^{gi}	Normal	0	0.5	-0.018	-0.777	0.725

ϕ_b^{gi}	Normal	0	0.5	0.175	0.067	0.280
ϕ^T	Beta	0.8	0.1	0.790	0.662	0.921
ϕ_y^T	Normal	0	0.5	0.003	-0.516	0.488
ϕ_b^T	Normal	0	0.5	0.012	-0.016	0.038
ρ^z	Beta	0.5	0.2	0.071	0.014	0.123
ρ^b	Beta	0.5	0.2	0.330	0.127	0.535
ρ^i	Beta	0.5	0.2	0.287	0.165	0.411
ρ^w	Beta	0.5	0.2	0.187	0.055	0.312
ρ^p	Beta	0.5	0.2	0.974	0.954	0.994
ρ^x	Beta	0.5	0.2	0.931	0.892	0.972
ρ^r	Beta	0.5	0.2	0.664	0.567	0.763
ρ^{gm}	Beta	0.5	0.2	0.115	0.019	0.205
ρ^{gp}	Beta	0.5	0.2	0.059	0.009	0.110
ρ^{gi}	Beta	0.5	0.2	0.153	0.044	0.259
σ_z	Inv. gamma	0.5	Inf	2.226	1.918	2.551
σ_b	Inv. gamma	0.5	Inf	3.554	2.297	4.654
σ_i	Inv. gamma	0.5	Inf	3.827	3.309	4.335
σ_w	Inv. gamma	0.5	Inf	0.600	0.510	0.698
σ_p	Inv. gamma	0.5	Inf	0.157	0.113	0.196
σ_x	Inv. gamma	0.5	Inf	5.954	5.259	6.609
σ_r	Inv. gamma	0.5	Inf	0.102	0.090	0.113
σ_{gm}	Inv. gamma	0.5	Inf	1.085	0.955	1.194
σ_{gp}	Inv. gamma	0.5	Inf	1.575	1.407	1.739
σ_{gi}	Inv. gamma	0.5	Inf	3.921	3.509	4.339

Note: The posterior distribution is based on two Markov chains with 500,000 draws obtained using the Metropolis–Hastings algorithm. The first 200,000 draws are dropped as burn-in draws.

Table 2

Estimation results for selected parameters under alternative specifications.

	Specification 1	Specification 2	Baseline model
	post. mean	post. mean	post. mean
	[90% interval]	[90% interval]	[90% interval]
ν^{gm}	-1.388		-1.620
	[-1.953, -0.815]	-0.522	[-2.140, -1.088]
ν^{gp}	0.529	[-0.760, -0.276]	0.902
	[-0.218, 1.315]		[0.070, 1.790]
ν	0.124	0.129	0.113
	[0.080, 0.168]	[0.081, 0.174]	[0.070, 0.157]
ω	0.079	0.093	0.077
	[0.026, 0.130]	[0.030, 0.154]	[0.027, 0.129]
ϕ^{gm}	0.983	0.983	0.977
	[0.973, 0.993]	[0.974, 0.993]	[0.966, 0.989]
ϕ_y^{gm}	0.237	0.247	0.399
	[-0.588, 1.042]	[-0.541, 1.033]	[-0.434, 1.243]
ϕ_b^{gm}	-0.245	-0.214	-0.190
	[-0.378, -0.124]	[-0.314, -0.111]	[-0.271, -0.110]
ϕ_c^{gm}	0.145		
	[0.062, 0.225]		
ϕ^{gp}	0.955	0.918	0.968
	[0.911, 0.994]	[0.854, 0.979]	[0.941, 0.996]
ϕ_y^{gp}	0.540	0.908	0.358
	[-0.396, 1.575]	[-0.086, 1.833]	[-0.525, 1.256]
ϕ_b^{gp}	-0.095	-0.105	-0.071
	[-0.168, -0.025]	[-0.159, -0.049]	[-0.163, 0.012]
ϕ^{gi}	0.957	0.953	0.955
	[0.933, 0.982]	[0.931, 0.976]	[0.933, 0.974]
ϕ_y^{gi}	0.016	-0.120	-0.018
	[-0.746, 0.806]	[-0.882, 0.629]	[-0.777, 0.725]
ϕ_b^{gi}	0.213	0.188	0.175
	[0.077, 0.354]	[0.071, 0.309]	[0.067, 0.280]
ρ^{gm}	0.114	0.093	0.115
	[0.019, 0.206]	[0.014, 0.164]	[0.019, 0.205]
ρ^{gp}	0.062	0.070	0.059

	[0.009, 0.114]	[0.009, 0.127]	[0.009, 0.110]
ρ^{gi}	0.154	0.154	0.153
	[0.044, 0.257]	[0.040, 0.259]	[0.044, 0.259]
g^m multiplier	1.748	1.178	1.910
g^p multiplier	0.482	1.269	0.264
g^i multiplier	0.925	0.930	0.916
log data density	-1715.90	-1713.08	-1708.26

Note: The estimation results are based on two Markov chains with 500,000 draws obtained using the Metropolis–Hastings algorithm. The first 200,000 draws are dropped as burn-in draws. Priors are common to all models. The first column lists the estimation result for the model in which the observation equation of merit goods is modified. The prior of ϕ_c^{gm} is a gamma distribution with mean 0.5 and standard deviation 0.2. The second column presents the estimation result for the model in which the complementarity or substitutability parameter is common to two types of government consumption. The third column is the result in Table 1. Government multipliers are calculated on the basis of the posterior mean estimates and mean impulse to government spending shocks. Log data density is calculated on the basis of the modified harmonic mean.

Table 3

Estimation results using different datasets.

	Dataset 1	Dataset 2	Baseline model
	post. mean	post. mean	post. mean
	[90% interval]	[90% interval]	[90% interval]
ν^{gm}	-0.619	-1.461	-1.620
	[-2.161, 0.812]	[-2.081, -0.883]	[-2.140, -1.088]
ν^{gp}	0.050	0.991	0.902
	[-1.383, 1.541]	[0.018, 2.005]	[0.070, 1.790]
ν	0.080	0.106	0.113
	[0.047, 0.111]	[0.065, 0.146]	[0.070, 0.157]
ω	0.097	0.061	0.077
	[0.027, 0.167]	[0.018, 0.101]	[0.027, 0.129]
ϕ^{gm}	0.946	0.977	0.977
	[0.905, 0.990]	[0.966, 0.989]	[0.966, 0.989]
ϕ_y^{gm}	0.386	0.441	0.399
	[-0.374, 1.192]	[-0.402, 1.277]	[-0.434, 1.243]
ϕ_b^{gm}	-0.142	-0.182	-0.190
	[-0.277, -0.014]	[-0.264, -0.102]	[-0.271, -0.110]
ϕ^{gp}	0.937	0.971	0.968
	[0.893, 0.992]	[0.949, 0.994]	[0.941, 0.996]
ϕ_y^{gp}	0.292	0.260	0.358
	[-0.478, 1.096]	[-0.514, 1.083]	[-0.525, 1.256]
ϕ_b^{gp}	-0.122	-0.071	-0.071
	[-0.359, 0.096]	[-0.157, 0.013]	[-0.163, 0.012]
ϕ^{gi}	0.896	0.947	0.955
	[0.785, 0.989]	[0.922, 0.973]	[0.933, 0.974]
ϕ_y^{gi}	0.265	-0.013	-0.018
	[-0.608, 1.154]	[-0.846, 0.796]	[-0.777, 0.725]
ϕ_b^{gi}	-0.205	0.155	0.175
	[-0.897, 0.294]	[0.055, 0.255]	[0.067, 0.280]
ρ^{gm}	0.120	0.102	0.115
	[0.016, 0.219]	[0.019, 0.176]	[0.019, 0.205]
ρ^{gp}	0.105	0.061	0.059
	[0.015, 0.186]	[0.007, 0.114]	[0.009, 0.110]

ρ^{gi}	0.280	0.159	0.153
	[0.090, 0.468]	[0.041, 0.267]	[0.044, 0.259]
g^m multiplier	1.227	1.839	1.910
g^p multiplier	0.842	0.245	0.264
g^i multiplier	0.875	0.940	0.916

Note: The estimation results are based on two Markov chains with 500,000 draws obtained using the Metropolis–Hastings algorithm. The first 200,000 draws are dropped as burn-in draws. The priors are common to all analyses. The first column presents the estimation result using dataset from 1981:Q1 to 1998:Q4. The second column shows the estimation result using dataset from 1981:Q1 to 2012:Q4, where the private consumptions series is replaced by one excluding household spending on healthcare, insurance, and education. The third column lists the result provided in Table 1. The government multipliers are calculated using the posterior mean estimates and mean impulse to government spending shocks.