# Debt-financed fiscal policy, public capital, and endogenous growth

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# Debt-Financed Fiscal Policy, Public Capital, and Endogenous Growth*

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**Abstract**

This study investigates the conflicting effects of a debt-financed fiscal policy on endogenous growth in an overlapping generations model with public capital and debt. Although an accumulation of public capital enhances the production efficiency of private capital, it also impedes private capital accumulation by distorting savings allocations through public debt issuance. With a low deficit ratio, the fiscal policy brings new equilibria to an unstable economy. Meanwhile, a debt-financed fiscal policy with a higher deficit ratio causes a fiscal collapse and secular stagnation.

*Keywords*: Fiscal Sustainability; Public Debt; Public Capital; Secular Stagnation
*JEL classification*: E62; H54, H62; O40

## 1 Introduction

Today, most advanced economies face a chronic policymaking dilemma: the balance between budget deficits and expansionary fiscal policies. Since the middle of 1970s, most OECD countries have faced serious budget deficits and a declining economic growth. Fig. 1 overviews the trends in real GDP and public debt-to-GDP ratio over 1980–2010 in the U.S., marking a relatively stable economic growth, and Japan, suffering from a long recession

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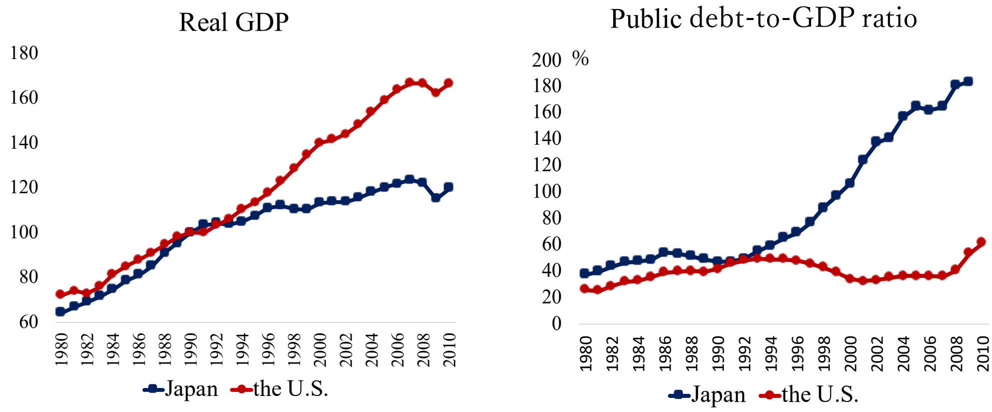
with the highest public debt-to-GDP ratio among major advanced economies.




World Bank (2021) World Development Indicators. OECD (2021) OECD Statistics.

Fig. 1. Trends in real GDP and public debt-to-GDP ratio

(Real GDP of both countries is indexed at 100 as of 1990)

Since the seminal paper of Aschauer (1989), productive expenditure on infrastructure like roads, ports, and highways is widely recognized to contribute to output. According to Modigliani (1961), however, an excessive bond issuance distorts the savings allocation to investment and reduces the economic growth rate by inhibiting capital accumulation.

Most theoretical studies incorporating government bond issuance into their models have focused mainly on long-run fiscal sustainability under a specific policy of interest without necessarily considering the direct impacts of bond issuance on economic growth. Carlberg (1995) and Bräuninger (2005) made first theoretical contributions on this. Subsequently, Yakita (2008), Arai (2011), Teles and Mussolini (2014), Minea and Villieu (2012), and Agénor and Yilmaz (2017) explicitly introduced productive public expenditure and analyzed the long-run dynamics of public debt and growth. This study, instead, investigates the medium-run effects of a debt-financed fiscal policy on endogenous growth in an overlapping generations model and offers a theoretical framework to reveal the conditions under which such a policy may cause a serious crowding out, fiscal collapse, and secular stagnation.

## 2 Model

### 2.1 Production Sector

Assume an economy that produces a final good with labor, private capital, and productive public capital. Part of the government expenditure is accumulated as a production factor and contributes directly to output. Numerous identical firms exist that manufacture a single commodity, and the aggregated production function becomes the following Cobb–Douglas production function:

$$Y_t = \Phi {Z_t}^{\alpha} {K_t}^{\beta} (EN)^{1-\alpha-\beta}, \tag{1}$$

where $Y_t$ denotes output, $\Phi$, total factor productivity, $Z_t$, public capital, $K_t$, private capital, and $N$, labor. Index $t$ represents the period.[1] Assume that $N$ is constant and normalized as $N = 1$. $\alpha, \beta \in (0,1)$ denote the elasticity of public capital and private capital share, respectively. Following Romer (1986), the average capital per worker, $E \equiv \frac{K_t}{N}$, has a positive spillover effect on labor productivity. Futagami et al. (1993) define public–private capital ratio as $\Omega \equiv \frac{Z_t}{K_t}$ and assume it to be constant considering that the long-run equilibrium level of $Z_t$ remains proportionate to the accumulated private capital as shown in Yakita (2008). Therefore, the production function can be simplified to an AK-type production function.

$$Y_t = \Phi \Omega^{\alpha} K_t. \tag{2}$$

The goods and factors markets are perfectly competitive. Noting that ${Z_t}^{\alpha}$ in production function (1) is an externality for firms, the profit maximization conditions are:

$$r_t = \beta \Phi \Omega^{\alpha}, \tag{3}$$

$$w_t = (1 - \alpha - \beta) \Phi \Omega^{\alpha} K_t, \tag{4}$$

where $r_t$ and $w_t$ denote the rental price of capital and real wage rate, respectively. Equations (3) and (4) indicate that the relative public capital $\Omega$ enhances the marginal productivity of both factors, thereby facilitating private capital accumulation and leading to a higher real wage rate.

### 2.2 Household Sector

Assume an overlapping generations model in which individuals live for two periods. The representative individual's utility function depends on the consumption per worker in the working and retirement periods $c_t^Y$ and $c_{t+1}^O$, respectively.

[1] Assume that one period is approximately 30 years, which is compatible with the overlapping generations model for the household sector.

$$u = (1-\theta)\log c_t^Y + \theta \log c_{t+1}^O, \tag{5}$$

where $\theta \in (0,1)$ denotes intertemporal weights of utility. Young workers earn wage income, which is partly allocated to consumption, the remaining being stored as savings. On ageing, individuals do not work; they receive capital income from private and public assets. The return they earn from one asset is equivalent to that from the other under non-arbitrage conditions. The intertemporal budget constraint is $c_t^Y + \frac{c_{t+1}^O}{1+(1-\tau_{t+1})r_{t+1}} = (1-\tau_t)w_t$, where $\tau_t$ denotes the constant income tax rate. With utility maximization, savings $s_t = (1-\tau_t)w_t - c_t^Y$ can be optimized as follows:

$$s_t = (1-\tau_t)(1-\alpha-\beta)\theta\Phi\Omega^\alpha K_t. \tag{6}$$

### 2.3 Government Sector

The government balances total revenues and expenditures by adjusting the tax rate $\tau_t$.

$$B_t + \tau_t(Y_t + r_t D_t) = G_t + r_t D_t. \tag{7}$$

The government spends a share of the national income $Y_t$ as government expenditure $G_t$, defined as $G_t = gY_t$, where $g \in (0,1)$ is given exogenously. After excluding interest expenses, $G_t$ is divided into productive capital expenditure and nonproductive government consumption, that does not directly impact the production process, such as social security costs. $D_t$ denotes public debt accumulated in the current period $t$; the government pays interest $r_t D_t$ to households. The revenue consists of tax on gross income $Y_t + rD_t$ and a new government bond $B_t$, defined as $B_t = bY_t$, where $b \in (0,1)$. Defining the public debt-to-capital ratio as $x_t \equiv \frac{D_t}{K_t}$, we obtain $\tau_t = \frac{g-b+\beta x_t}{1+\beta x_t}$, and the savings amount of the whole economy $S_t$ is,

$$S_t = s_t N = \frac{\theta(1+b-g)(1-\alpha-\beta)}{1+\beta x_t}\Phi\Omega^\alpha K_t. \tag{8}$$

$S_t$ is divided into public debt and private capital in the next period: $S_t = D_{t+1} + K_{t+1}$.

### 2.4 Fiscal Consolidation Policy

Assume that $m \in (0,1)$ denotes the redemption rate of public debt, and the difference between $D_{t+1}$ and $(1-m)D_t$ corresponds to the new government bond $B_t$. Accordingly, we obtain

$$\frac{D_{t+1}}{D_t} = 1 - m + \frac{b\Phi\Omega^{\alpha}}{x_t}, \tag{9}$$

$$\frac{K_{t+1}}{K_t} = \Phi\Omega^{\alpha}\left[\frac{\theta(1+b-g)(1-\alpha-\beta)}{1+\beta x_t} - b\right] - (1-m)x_t. \tag{10}$$

Transforming the equation $\frac{D_{t+1}}{D_t} = \frac{K_{t+1}}{K_t}$ in the steady state where $x_t$ converges to a certain positive value, we re-define new functions $P(x_t, \Omega)$ and $Q(x_t, \Omega)$ as follows:

$$P(x_t, \Omega) \equiv (1-m)(1+x_t) + \frac{b\Phi\Omega^{\alpha}}{x_t}, \tag{11}$$

$$Q(x_t, \Omega) \equiv \Phi\Omega^{\alpha}\left[\frac{\theta(1+b-g)(1-\alpha-\beta)}{1+\beta x_t} - b\right]. \tag{12}$$

$P(x_t, \Omega)$ is a downward convex curve with $\lim_{x_t \to 0} P(x_t, \Omega) = \infty$ and $\lim_{x_t \to \infty} P(x_t, \Omega) = \infty$. $Q(x_t, \Omega)$ is monotonically decreasing function of $x_t$ with constant intercepts of $x_t$-axis and P-axis, latter of which depends on $\Omega$. As Carlberg (1995) and Bräuninger (2005) describe, this model can have multiple steady states, given the following conditions: a lower stable equilibrium $x_L^*$ and an upper unstable equilibrium $x_H^*$. When public debt $D_t$ is lower than private capital $K_t$, $x_t$ converges to $x_L^*$ and fiscal sustainability can be maintained (Fig. 2). If $x_t$ in the initial period is higher than $x_H^*$, the public debt-to-capital ratio $x_t$ keeps rising over time and diverges to infinity.

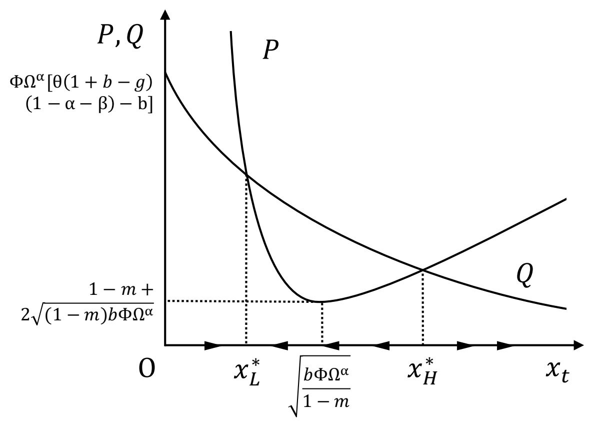



Fig. 2. Multiple equilibria and stability

Since $\frac{\partial P}{\partial m} < 0$, $\frac{\partial Q}{\partial m} = 0$, and $\frac{\partial\left(\frac{K_{t+1}}{K_t}\right)}{\partial x_t} < 0$, the fiscal consolidation policy brings a sustainable economic growth in this model. A rise in the redemption rate $m$ shifts the function $P(x_t, \Omega)$ downward, while $Q(x_t, \Omega)$ remains unchanged, which lowers $x_L^*$ further and enhances the growth rate. Through a change in savings allocation, the rise in $m$ decreases the share of current savings in refinancing the public debt accumulated in the previous period, thereby indirectly promoting private capital investment.

### 2.5 Debt-financed Fiscal Policy

While public capital accumulation enhances the production efficiency of private capital and increases output, it also impedes private capital accumulation by distorting savings allocations through public debt issuance. We consider the impact of public investment on economic growth through a change in the public–private capital ratio $\Omega$. Thus,

$$\frac{\partial P}{\partial \Omega} = \frac{\alpha b \Phi}{x_t \Omega^{1-\alpha}} > 0, \tag{13}$$

$$\frac{\partial Q}{\partial \Omega} = \frac{\alpha \Phi}{\Omega^{1-\alpha}}\left[\frac{\theta(1+b-g)(1-\alpha-\beta)}{1+\beta x_t} - b\right]. \tag{14}$$

From Equations (13) and (14), when $x_t$ is close to zero, $\frac{\partial P}{\partial \Omega}$ diverges to infinity, whereas $\frac{\partial Q}{\partial \Omega}$ takes a constant value. Moreover, when $x_t$ is close to the $x_t$-axis intercept $\tilde{x} = \frac{\theta(1+b-g)(1-\alpha-\beta)-\mathrm{b}}{b\beta}$, $\frac{\partial P}{\partial \Omega}$ takes a constant positive value, whereas $\frac{\partial Q}{\partial \Omega}$ changes to zero. Thus, $\lim_{x_t \to 0} \frac{\partial P}{\partial \Omega} > \lim_{x_t \to 0} \frac{\partial Q}{\partial \Omega}$ and $\lim_{x_t \to \tilde{x}} \frac{\partial P}{\partial \Omega} > \lim_{x_t \to \tilde{x}} \frac{\partial Q}{\partial \Omega}$ hold true. The shift speeds of the two functions vary with $x_t$ areas and can be analyzed using the following inequality:

$$\frac{\partial P}{\partial \Omega} \gtreqless \frac{\partial Q}{\partial \Omega} \Leftrightarrow (1+\beta x_t)\left(1+\frac{1}{x_t}\right) \gtreqless \frac{\theta(1+b-g)(1-\alpha-\beta)}{b}. \tag{15}$$

Denoting left and right hand sides by $\Psi_L(x_t)$ and $\Psi_R(b)$, respectively, $\Psi_L(x_t)$ is a downward convex curve with $\lim_{x_t \to 0} \Psi_L(x_t) = \infty$ and $\lim_{x_t \to \infty} \Psi_L(x_t) = \infty$ and $\Psi_R$ is a constant positive value. Let $x_t$-coordinates satisfying $\Psi_L(x_t) = \Psi_R(b)$ be $\underline{x}(b)$ and $\overline{x}(b)$ $(\underline{x} < \overline{x})$. As Fig. 3 shows, in the range of $x_t \in (0, \underline{x})$ and $x_t \in (\overline{x}, \infty)$, $P(x_t, \Omega)$ shifts upward faster than $Q(x_t, \Omega)$ does with public investment, and vice versa in the range of $x_t \in (\underline{x}, \overline{x})$. In addition, since $\frac{\partial \Psi_R(b)}{\partial b} = -\frac{\theta(1-g)(1-\alpha-\beta)}{b^2} < 0$, the rise in $b$ shifts $\Psi_R(b)$ downward, which narrows the range for $\frac{\partial P}{\partial \Omega} < \frac{\partial Q}{\partial \Omega}$ and eventually, makes it disappear.

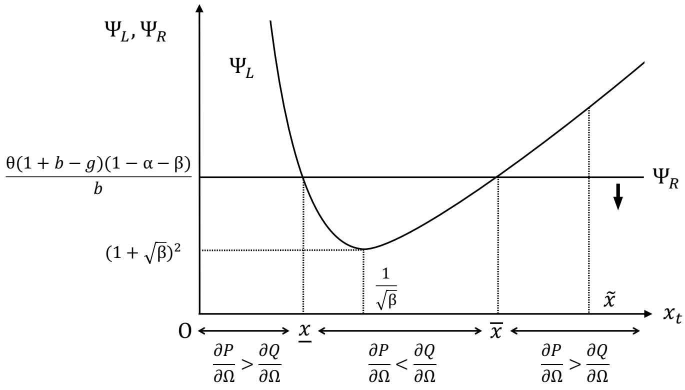



Fig. 3. The shift speeds variation

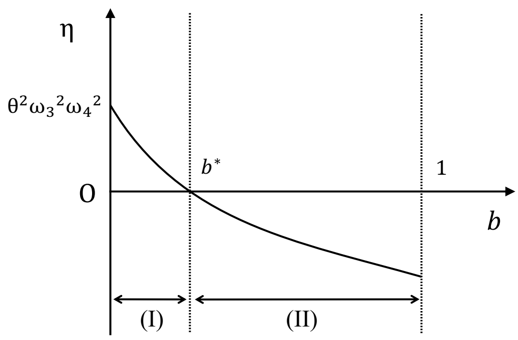



Fig. 4. The discriminant equation

Thus, the width and existence of region $x_t \in (\underline{x}, \overline{x})$ depend on the level of $b$, and the discriminant equation $\eta(b)$ for $\Psi_L(x_t) = \Psi_R(b)$ is given as follows:

$$\eta(b) = [\omega_1{}^2 - 2\theta\omega_2\omega_3 + \theta^2\omega_3{}^2]b^2 - 2[\theta\omega_2\omega_3\omega_4 - \theta^2\omega_3{}^2\omega_4]b + \theta^2\omega_3{}^2\omega_4{}^2, \tag{16}$$

where $\omega_1 = 1-\beta$, $\omega_2 = 1+\beta$, $\omega_3 = 1-\alpha-\beta$, and $\omega_4 = 1-g$; $\omega_1$, $\omega_3$, and $\omega_4 \in (0,1)$, and $\omega_2 > 1$. From Equation (16), $\eta(0) = \theta^2\omega_3{}^2\omega_4{}^2 > 0$ and $\frac{\partial\eta}{\partial b}\Big|_{b=0} = -2\theta\omega_3\omega_4[\omega_2 - \theta\omega_3] < 0$. Supposing that $\omega_1{}^2 < \theta\omega_3(1+\omega_4)[2\omega_2 - \theta\omega_3(1+\omega_4)]^2$, both $\eta(1) < 0$ and $\frac{\partial\eta}{\partial b}|_{b=1} < 0$ hold true. Therefore, in the range of $b \in (0, 1)$, the discriminant equation $\eta(b)$ is a monotonically decreasing function of $b$ and crosses $b$-axis at $b^* = \frac{\theta\omega_3\omega_4}{\omega_2 - \theta\omega_3 + 2\sqrt{\beta}}$ when $\frac{\partial^2\eta}{\partial b^2} > 0$, or $b^* = \frac{\theta\omega_3\omega_4}{\omega_2 - \theta\omega_3 + 2\sqrt{\beta}}$ when $\frac{\partial^2\eta}{\partial b^2} < 0$. Figure 4 suggests that when $b$ lies in the range of $b \in (0, b^*)$, the region for $\frac{\partial P}{\partial \Omega} < \frac{\partial Q}{\partial \Omega}$ exists. Meanwhile, when $b$ is higher than the threshold $b^*$, $\frac{\partial P}{\partial \Omega} > \frac{\partial Q}{\partial \Omega}$ holds true in the whole area of $x_t$.

When $b$ is higher than a certain threshold $b^*$, the economy is classified into (I), public debt acceleration type. In this type, a debt-financed fiscal policy produces a greater divergence between $P(x_t, \Omega)$ and $Q(x_t, \Omega)$. With public investment, the public debt ratio $\frac{D_{t+1}}{D_t}$ further exceeds the private capital ratio $\frac{K_{t+1}}{K_t}$. Consequently, the rise in $x_t$ accelerates over time, and fiscal stability cannot be sustained (Fig. 5). As the share of $D_{t+1}$ in the savings increases, less savings are allocated to private capital $K_{t+1}$ in the following period. This implies that this economy faces a serious crowding out, and the rise in $x_t$ directly hinders growth, with private capital $K_t$ not accumulating sufficiently.

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[2] In the numerical simulation in Section 3 based on U.S. and Japan, this assumption holds true.

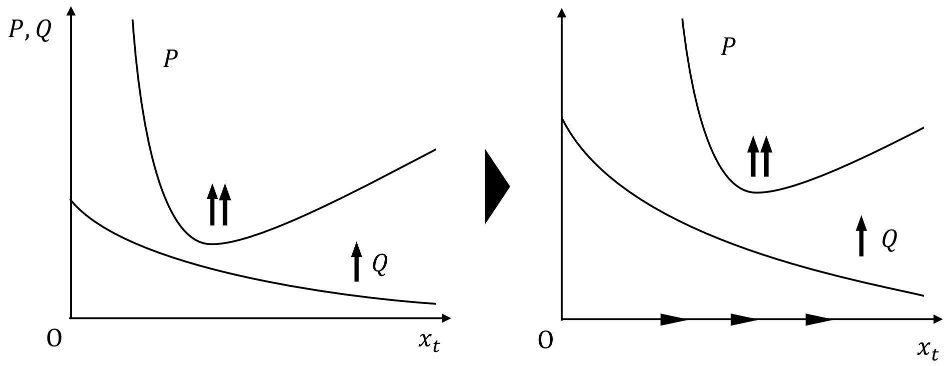


Fig. 5. Public debt acceleration-type economy

Contrariwise, with (II), the private capital acceleration type with $b \in (0, b^*)$, the economy always grows with public investment. Suppose the economy has no steady state during the initial period. Although the rise in $\Omega$ shifts both functions upward, the shift speeds of both functions depend on areas of $x_t$. With $x_t$ sufficiently greater than zero or smaller than intercept $\tilde{x}$, the shift speed of $Q(x_t, \Omega)$ is higher than that of $P(x_t, \Omega)$. By contrast, when $x_t$ is close to zero or the intercept, $\frac{\partial P}{\partial \Omega} > \frac{\partial Q}{\partial \Omega}$ holds true as stated above. Therefore, this twisted shift speed diminishes the gap between the two functions in the middle area of $x_t$ and increases it in other areas. Consequently, unlike Bräuninger (2005), both functions eventually cross, and multiple steady states appear even with no equilibrium in the initial period.

Moreover, the economy simultaneously achieves fiscal stability and economic growth. Figure 6 suggests that a continuous rise in $\Omega$ gradually decreases $x_L^*$ and increases $x_H^*$, which enlarges the stable range of $x_t$, leading to a convergence and generating a fiscally more solid economy. In addition, because a lower level of $x_L^*$ increases $\frac{K_{t+1}}{K_t}$, a higher public investment facilitates economic growth through private capital accumulation.

Finally, as $\frac{\partial P}{\partial m} < 0$ and $\frac{\partial Q}{\partial m} = 0$, when the economy is classified as type I with $\frac{\partial P}{\partial \Omega} > \frac{\partial Q}{\partial \Omega}$, this implies that the government needs to execute a fiscal consolidation policy as well as public investment to direct the economy to the private capital acceleration type. In other words, the level of relative public capital and redemption rate also play significant roles in determining multiple equilibria and fiscal stability in this model.

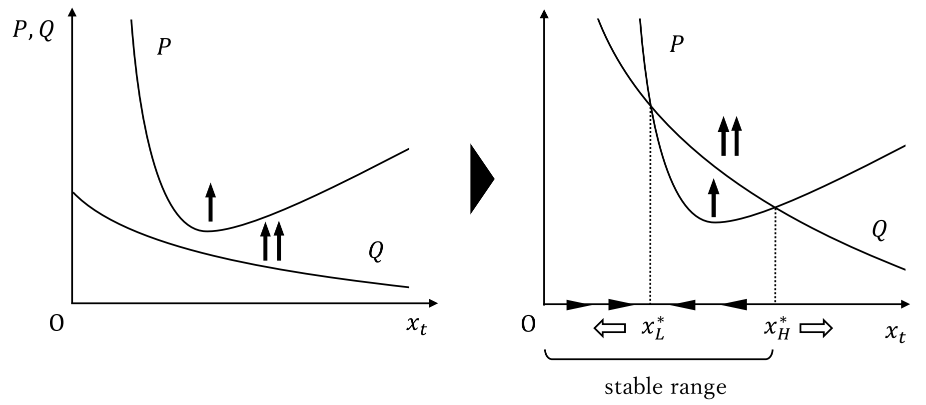


Fig. 6. Private capital acceleration-type economy

**3 Numerical simulations**

Table 1 Calibration of variables

| variables | the U.S. | Japan | grounds |
|---|---|---|---|
| $\boldsymbol{\alpha}$ | 0.25 | | Bom and Ligthart (2013) conducted a cross-sectional survey analysis of 67 empirical studies over 1983–2008 and found that the average elasticity of public capital was 0.268 when considering spillover effects across regions over time. |
| $\boldsymbol{\beta}$ | 0.25 | | The capital share in factor values in major industrialized countries, including the U.S. and Japan, has remained stable at approximately one-thirds over 2013–2017. |
| $\boldsymbol{b}$ | 0.03 | 0.08 | The deficit ratio is assumed to be 0.03 and 0.08 with the fiscal conditions in the U.S. and Japan, respectively, considering both countries' SNA statistics over 2012–2019. |
| $\boldsymbol{g}$ | 0.2 | | The average government spending–output ratio in both countries is approximately 20% in the U.S. and Japan over 2012–2019. |
| $\boldsymbol{\theta}$ | 0.4 | | Evans and Sezer (2004) estimated the long-term time preference rates for the U.S., Japan and Australia to be 1.5 % considering disaster risk. Considering that one period lasts 30 years, the estimated time preference rate is $\left(\frac{1}{1.015}\right)^{30} \approx 0.640$. The discount factor satisfies $1: 0.640 = 1 - \theta : \theta$ and can be estimated to be approximately 0.4. |

In this section, we present numerical simulations for two contrasting advanced economies, the U.S. and Japan. Table 1 quantifies the variables; $b$ and $g$ are calculated based on fiscal data over 2012–2019 to exclude the fiscal impact of the global financial crisis and Covid-19[3].

When $b = 0.08$, reflecting the severe Japanese fiscal situation, the economy is categorized as (I), the

[3] Since both Japan and the U.S. show upward trends in public debt accumulation, the redemption rate $m$ is assumed to be zero and total factor productivity $\Phi$ is set to 15 in this simulation.

public debt acceleration type with no steady state; an active public capital investment does not contribute to sustained economic growth. Rather, the burden of the new public bond issue hinders private capital accumulation and negatively affects growth.

Next, when $b = 0.03$, reflecting the fiscal situation of the more stable U.S. economy, the result is (II), a private capital acceleration. Table 2 presents results of numerical simulation of the U.S. economy: as the relative public capital $\Omega$ increases, the private capital accumulates and economic growth rate increases. Furthermore, because the level of the lower stable $x_L^*$ continues declining and that of the upper unstable $x_H^*$, increasing, the stable range of $x_t$ leading to convergence widens.

Table 2 Results of numerical simulation of the U.S. economy

| $\Omega$ | $x_L^*$ | $x_H^*$ | growth rate |
|---|---|---|---|
| 7.5 | 0.610 | 0.692 | 2.69% |
| 8.0 | 0.552 | 0.774 | 2.92% |
| 8.5 | 0.524 | 0.825 | 3.06% |
| 9.0 | 0.504 | 0.866 | 3.17% |

## 4 Conclusion

This study theoretically analyzes a debt-financed fiscal policy and its impact on private capital accumulation and economic growth. While an increase in public capital enhances the production efficiency of private capital and increases output, it also impedes private capital accumulation by distorting savings allocation through public debt issuance. With a relatively low deficit ratio, the fiscal policy promotes capital accumulation and brings steady states to the economy, even when there is no equilibrium in the initial period. When the deficit ratio exceeds a threshold, public investment has serious crowding-out effects and decreases the growth rate. This implies that a fiscal policy that depends heavily on public debt issuance will not promote economic growth but rather cause a fiscal collapse and secular stagnation.

## Appendix

Table A.1 Annual fiscal data of the U.S.

(In millions of dollars)

| Fiscal year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| (1)Nominal GDP | 16,197,007 | 16,784,849 | 17,527,164 | 18,238,301 | 18,745,076 | 19,542,979 | 20,611,861 | 21,433,225 |
| (2)Outlays | 3,526,563 | 3,454,881 | 3,506,284 | 3,691,850 | 3,852,616 | 3,981,630 | 4,109,044 | 4,446,956 |
| (3)Reciepts | 2,449,990 | 2,775,106 | 3,021,491 | 3,249,890 | 3,267,965 | 3,316,184 | 3,329,907 | 3,463,364 |
| (4)Interest payments (net) | 220,408 | 220,885 | 228,956 | 223,181 | 240,033 | 262,551 | 324,975 | 375,158 |
| Government spending/GDP [(2)-(4)]/(1) | 20% | 19% | 19% | 19% | 19% | 19% | 18% | 19% |
| Deficit ratio [(2)-(3)]/(1) | 7% | 4% | 3% | 2% | 3% | 3% | 4% | 5% |

The Office of Management and Budget (2021) Historical Tables.

World Bank (2021) World Development Indicators.

Table A.2 Annual fiscal data of Japan

(In 100 millions of yen)

| Fiscal year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| (1)Nominal GDP | 4,943,698 | 5,072,552 | 5,182,352 | 5,327,860 | 5,368,508 | 5,475,480 | 5,481,216 | 5,524,997 |
| (2)Outlays | 903,339 | 926,115 | 958,823 | 963,420 | 1,000,087 | 974,547 | 977,128 | 1,014,571 |
| (3)Interest payments | 98,546 | 99,027 | 101,319 | 101,472 | 88,278 | 91,605 | 90,275 | 88,502 |
| (4)Public debts | 442,440 | 428,510 | 412,500 | 368,630 | 371,820 | 343,698 | 336,922 | 326,605 |
| Government spending/GDP [(2)-(3)]/(1) | 16% | 16% | 17% | 16% | 17% | 16% | 16% | 17% |
| Deficit ratio (4)/(1) | 9% | 8% | 8% | 7% | 7% | 6% | 6% | 6% |

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